COMMUNITY CAPACITY AND RESILIENCE IN LATIN AMERICA

Edited by Paul R. Lachapelle, Isabel Gutierrez-Montes and Cornelia Butler Flora

First published 2021

ISBN: 9781138084896 (hbk)
ISBN: 9781138084902 (pbk)
ISBN: 9781315111605 (ebk)

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DOI: 10.4324/9781315111605-3

The funder of the Open Access of this chapter is Claudia Bouroncle

Routledge
Taylor & Francis Group
NEW YORK AND LONDON

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Current impacts of climate change on Mesoamerican ecosystems and rural communities are undeniable, as evidenced by scientific studies (Castellanos et al., 2013; Harvey et al., 2015; Robalino, Jiménez, & Chacón, 2015) and the perception of smallholder farmers (Forero, Hernández, & Zafra, 2014; Vélez-Torres, Santos-Ocampo, Tejera-Hernández, & Monterroso-Rivas, 2016). Livelihood diversification and local organization are strategies with which rural families in the region have faced high natural climatic variability for hundreds of years (Altieri, 2013), but increase in the rate of change and intensity of drought conditions and climate variability, plus unprecedented pressures on natural ecosystems and agricultural systems, make adaptation increasingly difficult (Baethgen, Meinke, & Giménez, 2003). Further, information that allows a better understanding of the vulnerability of smallholder farmers to develop adaptation measures is extremely limited in the region (Holland et al., 2017). On the other hand, there is a growing effort to define policy frameworks and strategies for adaptation in the agriculture sector in Mesoamerican countries (UNEP & Euroclima, 2015), which support food security and rural employment and make a substantial contribution to export earnings. These efforts have resulted in adjustments in policy, institutional and financing mechanisms (Donatti, Harvey, Martinez-Rodriguez, Vignola, & Rodriguez, 2017). However, adaptation is mostly a local process. Therefore, processes that allow linkage of these efforts with local requirements are needed.

Here we present a summary of a methodological proposal for the participatory building of local strategies for adaptation to climate change (ELACCs, by its Spanish acronym) based on the Community Capitals Framework (CCF) (Flora, 2004). We review the results of its application between 2014 and 2016

DOI: 10.4324/9781315111605-3

in five micro-watersheds of the Pacific slope of Mexico, El Salvador and Costa Rica using three criteria: first, the consistency of the perceptions of exposure to climate processes and impacts on livelihoods (Pearce et al., 2010; Simelton et al., 2013); second, the constraints in the adaptation process (Imbach & Prado, 2014); and third, the transformational level of the adaptation measures proposed (Rickards & Howden, 2012). Finally, we identify some conclusions and recommendations for the implementation of the ELACCs proposal. As far as we know, this is the only methodological proposal based on the CCF within the emerging body of methodologies for local planning for adaptation to climate change (e.g., Adapt-Chile & Euroclima, 2015; Diesner, 2013; Frankel-Reed, Fröde, Porsché, Eberhardt, & Svendsen, 2013).

We focused on subsistence farming livelihoods, the predominant form of smallholder agriculture in the study region, where it is expected that climate suitability for coffee, maize, beans and even extensive cattle ranching will decrease in many areas in the coming years (Baca, Läderach, Haggar, Schroth, & Ovalle-Rivera, 2014; Bouroncle et al., 2017; Eitzinger et al., 2012; Thornton, Steeg, Notenbaert, & Herrero, 2009). Subsistence farming livelihoods are in general highly vulnerable to climate change, due to their reliance on rainfall and ecosystem services and limited access to financial and technical assistance (Holland et al., 2017).

Developing and Reviewing the Local Strategies

Sites Selection and Description

We carried out the ELACCs to answer specific requests from governmental organizations, sponsored by a regional cooperation agency and an international NGO. The sites were selected according to the predominance of subsistence farming livelihoods (Table 3.1). Livelihoods based on coffee (site or S1, S2, S3 and S4), staple grains (beans and maize; S1, S3 and S4) and livestock farming for dairy and beef production (S1, S3, S4 and S5) predominate.

TABLE 3.1 Study sites and predominant rural livelihoods.

Site, Country (site code)	*Altitudinal Range (masl)*	*Predominant Livelihoods*
Jalponga, El Salvador (1)	100–2000	Coffee (U), livestock, basic grains (M)
Pirrís, Costa Rica (2)	1000–2000	Coffee (U, M)
Coapa-Pijijiapan, Mexico (3)	60–2400	Coffee (U), basic grains (M), livestock (M-Lo)
El Tablón, Mexico (4)	800–2550	Coffee (U); livestock, basic grains (M-Lo)
Lagartero, Mexico (5)	0–2400	Livestock (U, M, Lo)

Note: U: upper watershed, M: middle watershed, Lo: lower watershed

Since rain-fed agriculture on the Pacific slope of Mesoamerica depends on the onset, length and temporal distribution of rainfall (Magaña, Amador, & Medina, 1999), knowledge of current and projected changes of climate is critical for the estimation of the vulnerability of subsistence farming livelihoods. Key characteristics of the regional climate, and relevant to all our study sites, described by these authors are: the bimodal distribution of the rainy season, with peaks of precipitation during May and June and, less pronounced, during September and October; the midsummer drought (*canícula*) during July and August and a dry season from November through April. Intra-annual temperature variation is minor and is associated with stronger trade winds in December through January and July (Taylor & Alfaro, 2005). Rising temperatures and changes in rainfall seasonality have been observed in the region over the last several decades (Aguilar et al., 2005; Hidalgo, Alfaro, & Quesada-Montano, 2017; Rauscher, Giorgi, Diffenbaugh, & Seth, 2008) and climate projections suggest these trends will continue (Magrin et al., 2014; Marengo et al., 2014). This overall climatic context is accentuated in the Dry Corridor, a region with an extended dry season (IICA, 2014) which includes all our study sites except S2.

The sites were located in narrow micro-watersheds of 200–500 km^2, typical of the Mesoamerican Pacific slope. This type of watershed rapidly concentrates run-off and generates high peaks of flow rates after rain events and, eventually, floods. Remnants of natural forests (shade-grown coffee in the case of El Salvador) in the upper watersheds are thus crucial for groundwater recharge and water flow regulation (Calder, Hofer, Vermont, & Warren, 2007). In the Mexican and Costa Rican sites, sectors of these natural forests are in state protected areas.

Stages of the Process of Developing Strategies

We began the process (Stage 1—Scope of the strategy) with the definition of the participation platform, that is, the group of key actors committed to the formulation of the strategy. This platform defines the territorial scope of the process, considering its rural livelihoods and relatively homogeneous environmental, human and social characteristics. We facilitated the development of climate change vulnerability assessments (VAs, Stage 2) using the IPCC (2007) criteria of exposure to climate change, impacts of climate change on livelihoods and adaptive capacity. For these assessments, we used social science research tools to identify relevant aspects of the climate, characterizing the type of climate change impact and documenting the response capacity, according to recommendations of Ford et al. (2010). We registered smallholder farmer perceptions of what is changing in the climate and how (exposure) and trends in quantity and quality of production and investment inputs for each livelihood (current impacts). We then built a description of adaptive capacity based on a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. For the design of the local adaptation strategy (Stage 3), we developed the basic steps of strategic planning for local organizations (see, for example, Terstegen & Willemsen, 2005) through workshops in which representatives of the participatory platforms validated the results of Stage 1 and identified and prioritized the measures

TABLE 3.2 Summary of the Construction Process of a Local Strategy of Adaptation to Climate Change

Stage	*Step*	*Key Questions*	*Main Actors and Participative Tools*
1. Scope of the strategy	1.1 Participation platform	Who is interested in an ELACC? Why?	Meetings with representatives of local organizations.
	1.2 Territorial scope	For which territory will the strategy be built? Why?	
	1.3 Livelihoods	What do people do to live? Where?	
2. Vulnerability assessment	2.1 Exposure to climate change	What are the most obvious climate change trends in the last decade?	Smallholder farmers focus groups and semi-structured interviews with technicians.
	2.2 Livelihoods sensitivity	How do these climate factors affect the different livelihoods of the territory?	
	2.3 Livelihoods adaptive capacity	Which adaptation measures are already implemented in the territory? Are there other measures identified? How is the preparation to implement these measures?	
3. Design of the local strategy	3.1 Business as Usual scenario	What would happen in this territory if everything continues as normal?	Workshop with representatives of the participation platform and different livelihoods.
	3.2 Long-term vision of the territory	What is the desired state of the territory and the different livelihoods?	
	3.3 Long-term objectives and indicators	What are the main changes needed for adaptation? How can they be demonstrated?	
	3.4 Identification of activities	What are the main actions for adaptation? Who are in charge of implementing them?	

Source: Based on PAPDC & LMA (2015)

to be considered in the local strategy. This process followed the principles of the Participatory Rural Appraisal approach (Chambers, 1994). Stage 3 ideally continues with the insertion of the strategy in local development agendas (e.g., local government plans or NGO projects). We show a summary of the process of construction of the local strategies in Table 3.2.

We used three methods to collect and validate information and carry out participative planning: focus groups with smallholder farmers, semi-structured interviews with technical staff who provide assistance to the farmers and planning workshops with representatives of the participation platform. PAPDC and LMA (2015) presents in detail the development of each stage, steps and protocols for each technique applied, and PCCC and PAPD (2014a, 2014b) and Zamora and Urueña (2014, 2015a, 2015b) present the results for each site in detail.

We dedicated an average of three weeks of work in the territory and an additional five weeks for the formulation, review and final writing for each strategy; that was the expected time for these activities. Maintaining the number of weeks, we were able to reduce the facilitation team from three to two people in the last three sites, as we gained experience in applying the methodology. Once finalized, we followed-up the ELACCs implementation through occasional meetings with members of the platforms.

Stakeholder Participation

All platforms included representatives of smallholder farmers, technical staff from agricultural and environmental governmental agencies, NGOs and leaders of farmer organizations. In Mexico, where there is a common property regime over land, representatives from *ejidos* also participated in the platforms. In El Salvador, the leadership was shared between a project of the Ministry of the Environment and an association of municipalities; in Mexico, the platforms were led by watershed management councils. All these entities had technical staff and planning instruments. At the Costa Rica site, an *ad hoc* committee was established to support the process.

The number of people who participated in the different stages of the process (Table 3.3) varied between 36 (S5) and 100 (S3), depending mainly on the number of focus groups (at least one per livelihood). In all sites a balance was reached between the number of technical staff and farmers (approximately 1:3.5), but the participation of women in all sites was unfortunately meager, varying between 9 and 28% of the participants.

TABLE 3.3 Number of participants involved in different stages of the process of developing strategies.

Site Code	*Interviews (people)*	*Focal Groups (number/people)*	*Workshops (number/people)*	*Total* (people)*
1	11	4 / 42	3 / 25	65
2	16	4 / 21	2 / 21	63
3	15	6 / 75	2 / 30	100
4	7	4 / 39	2 / 39	58
5	8	3 / 19	2 / 27	36

Note: The total number of people involved in the process is less than the sum of people participating in interviews, focus groups and workshops because some participated in more than one space.

Review of the Strategies

For the analysis of the VAs, we assumed that preexisting conditions that determine how the impacts of climate change are experienced and shape coping or adaptation responses must be made explicit (Jurgilevich, Räsänen, Groundstroem, & Juhola, 2017). Consequently, we reviewed the results generated from smallholder farmers focus groups, technician interviews, field observations and secondary sources to identify and describe such non-climate issues. To verify the consistency of climate and impact perceptions, we organized and synthesized qualitative information about climate processes and impacts using procedures proposed by Simelton et al. (2013) and Pearce et al. (2010). Finally, we organized the description of adaptive capacity for each livelihood using the approach of Imbach and Prado (2014), which shows the influence of different capitals from the CCF on successive steps of an adaptation process: cultural capital has a decisive influence on the beginning of the adaptation process, that is, on the perception that climate change is a different process from historical climatic variability; human capital has a greater influence on the identification of adaptation measures; social capital, on the mechanisms and scale of implementation of these measures; and financial and political capital on the management of external support.

For the analysis of planning aspects, we classified the adaptation measures prioritized in the planning workshops according to the adaptation levels proposed by Rickards and Howden (2012) for rural production systems. These levels are 1) incremental adaptation, which involves relatively minor changes in a system (e.g., changing traditional crop varieties for drought-resistant varieties), 2) system adaptation, which involves deeper changes within the system (e.g., introducing an arboreal component in coffee plantations under open sun or hiring labor for more intensive production) and 3) transformational adaptation, which entails much more profound changes in the system (e.g., leaving agricultural production to conserve water sources). The assignment to one level of adaptation or another then depends on whether there are changes in the objective of the production system, the depth, spatial scale and permanence of the change and changes in the relationships between the elements of the system. Also, we classified the prioritized adaptation measures according to their emphasis on different capitals. Likewise, we classified the actors identified for implementation of adaptation measures, as belonging to government agencies, municipal agencies, local producer and community organizations, watershed councils, research and academic organizations, NGOs or the private sector.

Results of the Review

Characterization of Local Livelihoods and Their Vulnerability

Access to land, natural resources and infrastructure, availability of labor force, traditional agricultural practices implementation and non-climate sources of stress and common practices to face them are common preexisting conditions that influence how the impacts of climate change are experienced by different smallholder's groups as described later.

Producers of staple grains cultivate very small plots (under one hectare), as tenants (S1), *avecindados* (people who work the land through an agreement with an *ejidatario* or community member, S3) or *ejidatarios* (S4). Most plots are on highly degraded hillsides because of intensive cultivation with short fallows and lack of soil conservation practices. Apart from small barns, they generally do not have other infrastructure. Most staple grain production is for home consumption, and their primary sources of income are off-farm labor and remittances, except in S3 where most of the production is for sale. Increase in the off-farm labor, migration and selling food reserves are responses to crop failures attributable to climatic hazards, price competition with imported subsidized grains and increasing prices of farm inputs. Coffee farmers cultivate small plots (under five hectares) but are owners or have rights of access, allowing them to maintain perennial crops. Coffee is produced under shade in all sites, a traditional practice largely adopted in Mesoamerica to retain soil moisture and reduce air temperature. The partial adoption of genetically improved varieties, fertilizer use and other practices is a result of governmental extension programs. Most coffee farmers own the necessary infrastructure to process the coffee bean or have access to it through cooperatives. The productivity of these systems is nevertheless rather low. Main stress elements are price fluctuations and, since 2012, the coffee rust epidemic linked to management practices and climate change (Avelino et al., 2015). Cattle ranchers, who are also owners (S1; S3, S4, S5 in lower watershed–Lo) or have rights of access (S3, S4, S5 in middle watershed–M), raise cattle for beef and milk production based on natural paddocks and cultivate forage in small (less than one hectare; S1, S3, S4, S5 in M) and medium plots (between two and five hectares, S4 and S5 in Lo) to feed the animals during the dry season; live fences and scattered trees for shade, are a frequent component of the production system. In three sites cattle ranchers manage genetically improved livestock breeds, have basic infrastructure such as feeders and sheds and access to animal health attention (S3 in M, S4, S5 in M). Selling cattle is a common response to prices fluctuation and climate hazards.

In all places and all livelihoods, production is based on family labor, and wage labor is hired when necessary. A vital source of income for staple grain farmers is the coffee harvest, so the coffee rust also affects them. In some cases, women are in charge of tasks such as the management of the post-harvest process of staple grains (S1) and the sale of milk in the local market (S1). In all sites, we recorded perceptions of adverse effects of high emigration, mostly among young people and affecting mostly staple grains farmers families. Emigration is linked to the lack of profitability and high risk of agricultural activities and better working conditions in urban areas. We also found a range of conditions affecting access to finance, mainly for coping with stress factors. Staple grains producers in S1 rent

TABLE 3.4 Characteristics of products marketing, according to smallholders and technical personnel perceptions.

Added value. Most sell products without value-added, except coffee with special labels (2)
Products diversification for sale.

- fruits (1 C, 2 C, 3 C) and rural tourism (2 C)
- pigs & other farm animals, forage (5 L in Lo)

Sale of products. Most sell their products through private intermediaries ('coyotes'), except

- organized and direct selling of cattle in the local market with the support of the local government (1 L)
- direct selling of forage (5 L in Lo)
- through cooperatives (2 C)

Note: Numbers correspond to site codes, SG: staple grains, L: livestock, C: coffee, U: upper watershed, M: middle watershed, Lo: lower watershed

the land, so they do not have any guarantee to access credits and incentive to invest in strengthening their natural or built capitals. They migrate, increase off-farm labor and sell food reserves in drought years to obtain cash. Coffee farmers in S2, who are owners of their farms, and coffee farmers and cattle ranchers in sites 3, 4 and 5 that have an established communal property regime, are in a much more favorable situation, and some of them can access micro-credits. Off-farm labor, remittances (S1, S3, S4) and government subsidies are important income-generating options of coffee farmers for coping with stress factors. Cattle farmers mainly cope with them by selling animals. Other strategies to access financial resources are adding value (coffee certified as carbon neutral; S2), selling additional products (such as tree fruits that shade the coffee plantations; S1, S2, S3) or selling directly to consumers (livestock farmers; S1, S5) or through cooperatives (S2) (Table 3.4).

Exposure

Smallholder farmers in all sites perceive the same trends of change in the climate (Table 3.5). Except in S2 (outside the Dry Corridor), they perceive an increase in temperature across the year. In S2, a more humid site, they observe an increase in temperature during the dry season and a decrease in the number of cold nights and frost events. Also, in all sites except S2, they observe a delay of up to two months in the onset of the rainy season, and in at least three sites (S3, S4, S5) farmers mention that the rainy season ends earlier. In all cases, the perception is that the rainy season is shorter than before. Across sites, there is agreement that there are more heavy rain events distributed in fewer days and that the *canícula* is more intense, either because it is longer and/or because it is drier and warmer. Finally, they have a common perception that wind intensities have increased, sometimes in association with the onset of the rainy season.

TABLE 3.5 Smallholder farmer perceptions of the changing climatic conditions for most important livelihoods and natural resources.

	Amount	*Frequency*	*Intensity*
Rain season onset	2 weeks later (5) 1–2 month later (1, 3, 4)	Fewer rainy days (all sites) Fewer foggy days (4)	Heavier rains, especially after dry spell (1) Heavier rains (2, 3, 4, 5)
Rain season cessation	1–2 months earlier (3, 4, 5)		Random rains before onset (2, 3, 4)
Temperature		Fewer cooler nights (2, 3) Fewer frost events (2)	Warmer dry season (1, 2, 4, 5) Higher temperatures along the year (1, 3, 4, 5)
Dry spell			Longer (1, 2); drier and warmer (3, 4, 5)
Winds		Fewer windy days (2)	Stronger winds (1, 2, 3, 5); associated with rain season cessation (4, 5) Stronger cold fronts (4)

Note: Numbers correspond to site codes.

Current Impacts

Farmers identify negative impacts of climate change on all livelihoods, regardless of where they are located. Impacts include reduction of the quantity and quality of the harvest and increased costs due to additional supplies or labor. They also describe negative impacts on water, soils and forests. However, some positive impacts are identified by coffee smallholder farmers. In S1, occasional rains at the beginning of the dry season can increase yield from fruit-producing shade trees, at a time when these fruits have high market demand. In S2, the extension of the dry season increases the yield and decreases the quality of the coffee grain at intermediate altitudes but increases the quality at higher altitudes (Table 3.6).

Smallholder farmers group the impacts of processes that cause water stress, and when a livelihood develops in different areas of a watershed they observe more negative impacts of these processes in the lower areas. Increased wind can generate water stress, but these impacts were described separately because winds also cause physical damages. No impacts related exclusively to the gradual increase in temperature were described. Farmers also describe impacts from heavier rain events for all livelihoods and natural resources, while the effects of erratic rains only relate to coffee and staple grains. No farmers felt their livelihoods were becoming unsustainable. However, some cattle ranchers from S4 and S5 said that the lengthening and intensification of the dry season and *canícula* made practically impossible to grow maize for family consumption.

TABLE 3.6 Smallholder farmer perceptions of the implications of the changing climate for the most important livelihoods and natural resources.

	Extended and Intensified Dry Season and Canícula	*Stronger Winds*	*Heavier Rain Events*	*Erratic Rains*
Coffee growing	↓Y coffee trees wilting (4) ↓Y loss of leaves, flowers, and fruits (1, 2, 3, 4) ↓Y ↓Q ripening of berries affected (1, 2, 3, 4) ↑Y ↓Q in mid watershed (2), ↑Q in the upper watershed (2) ↓Y pests and diseases, higher susceptibility to coffee rust (1, 2, 3, 4) ↓I pests & diseases control, reseeding and other management practices (2, 3, 4)	↓Y shade trees fall and break coffee trees (2, 3, 4) ↓Y coffee trees wilting (4) ↓Y loss of leaves & flowers (2) ↓Y ↓Q ripening of berries affected (2, 3, 4) ↓I reseeding (3, 4) ↓I grains selection (3) ↓I infrastructure repair (2)	↓Y loss of flowers and berries; ripening of berries affected, empty grains (2, 3, 4) ↓Q spotted grains (3) ↓Y pests and diseases (2) ↓Q taste characteristics (2, 4) ↓I pests & diseases control (2) ↓I road repairs (2)	↓Y flowers loss (1, 3) ↓Y ripening of berries (1, 2) ↓Y pests and diseases (2) ↓Y during harvest time, affects the next blooming (2) ↓Y uneven production (3) ↑Y additional harvest from fruit trees in shade layer (1)
Maize and beans (impacts are for both if not specified)	↓Y it is now difficult to produce maize (4), it is not possible (5) ↓Y↓Q smaller spikes, smaller or empty grains (1, 3, 4) ↓Y↓Q pests and diseases (1, 3, 4) ↓Y harvest (1, 4) ↓I pest & disease control (3, 4)	↓Y loss of flowering (beans) (4) ↓Y maize plants broken (1, 3, 4) ↓Y ↓Q smaller or empty grains (1, 3, 4) ↓I reseeding (3)	↓Y loss of flowering (beans) (3) ↓Y ↓Q diseases, rotting (maize) and fungus (4)	↓Y bean plants germinate and then die (1)
Livestock	↓Y grassland fires (5) ↓Y fodder crops (1, 3, 4, 5) ↓Y cattle lose weight, get sick, some die (3, 4, 5) ↓Y↓Q meat & milk (3, 4, 5) ↓I food & water supplies (1, 3, 4, 5) ↓I pest & disease control (3, 4, 5)	↓Y fodder crops and pastures (3, 5) ↓Y animals lose weight, some die (3, 5) ↓Y↓Q meat & milk (3, 5) ↓I food supplies (3, 5)	↓Y fodder crops and pastures (3, 4) ↓Y pests & diseases (3, 5) ↓Y milk production (3, 4, 5) ↓I pest & disease control (3, 5) ↓I management costs (5)	
Water and soils	↓ wells diminish (3, 4, 5) ↓ reduction of river flow (4)	↓ dry streams (3, 5) ↓ erosion (2, 3, 5) ↓ landslides when winds come with rain (4)	↓ stream siltation, overflows and floods, landslides & gullies (4, 5)	
Trees and forests	↓ wildfires, mainly of pine-oak forests (5)	↓ falling of trees (3, 4, 5) ↓ wildfires (5)	↓ falling of riparian trees (4, 5)	

Note: The sign (↓) or (↑) represents negative or positive effects respectively on yield (Y), quality (Q) and incomes (I) or in characteristics of natural resources. Numbers correspond to site codes.

Perception of Current Processes and Impacts

Smallholder farmers of all livelihoods at all sites are aware of changes in the climate. Moreover, their perceptions are consistent with the published observations of rising temperatures and changes in seasonality and precipitation patterns over the last few decades in Mesoamerica, showing that their perceptions are accurate despite the high historical variability of the climate. Likewise, smallholder farmers who share livelihoods identify the same impacts of climate change on these.

Identification of Adaptation Measures

The first difference in the adaptation process is the identification and implementation of measures that are consistent with climate impacts. The following examples illustrate this result. Coffee farmers in S4 mentioned the importance of local organization for the marketing of coffee and plantation renewal with varieties resistant to coffee rust, measures that had already been implemented in S2, decades ago in the case of local organization. Coffee farmers in S2 also mentioned the importance of greater access to certification mechanisms and, consequently, higher incomes for coping with climate impacts. Cattle ranchers in S1 mentioned the importance of pasture diversification, irrigation and silage, measures that have been adopted by some groups in S3, S4 and S5. Neither staple grains farmers in S1, S3 and S4, nor coffee-growers in S3, identified any adaptation measures for their cropping systems (Table 3.7).

Preparedness for the Implementation of Adaptation Measures

We also found apparent differences between sites and livelihoods in degrees of local organization (Table 3.7). All groups, except staple grains farmers in S1 and coffee farmers in S3, have some level of organization for the implementation of adaptation measures. However, in five of these groups the organization has the sole purpose of complying with the logistics to receive technical assistance and training from governmental and non-governmental organizations (coffee farmers and cattle ranchers, S1) or sharing this purpose with applications for financial incentives to government organizations (coffee farmers, S3; staple grains farmers, S4; cattle ranchers, S5). In seven groups, there is sufficient organization for the purchase and sharing of supplies (coffee farmers, S2, S4; cattle ranchers, S3, S4, S5 in M and Lo) and to establish joint practices such as irrigation (cattle ranchers, S3, S4, S5 in M and Lo). Additionally, it is essential to consider the organization level that has made it possible to carry out adaptation measures at the landscape scale. In Mexico, the *ejido* organization has supported reforestation campaigns and fire control. In all sites, there is little participation of young people and women in associations, workgroups and cooperatives.

Finally, we also found wide differences in access to specific incentives and technical assistance to face climate impacts provided by government and NGOs

TABLE 3.7 Human, social, financial and political capitals for adaptation, identified by smallholder focus groups.

Human Capital: The smallholders know what to do and put it into practice?	
Already put in practice • conservation and exchange of native seeds (1SG, 3SG, 4 SG) • crops and pastures diversification (1C, 2C, 4C; 5L in M & Lo) • coffee plantation renewal (2C) • crop irrigation (3SG) • pastures irrigation (3L in M, 4L, 5L in M) • silvopastoral practices (3L, 4L, 5L) • silage (4L, 5L in M) • composting (4C) • soil and water conservation practices (2C, 4C, 5L in U & M) • reforestation, forest conservation (2C, 3L, 4L, 4SG, 5L in U & M) • added value (2C)	*New measures identified* • pasture diversification (1L) • coffee plantation renewal (3C, 4C) • pasture irrigation (1L) • silage (1L, 3L in M & Lo, 5L in U) • joint marketing (4C, 4L) • organic certification as special label (2C)
Social Capital: Are smallholders organized to ask for support or to implement adaptation measures?	**Financial and Political Capitals: Do smallholders obtain external support for adaptation? What for?**
To receive technical assistance • all sites, except 1SG, 3C, 4SG, and 5L in U *To establish best practices* • irrigation systems and sowing forage (3L in M, 4L, 5L in M) *To buy and share supplies* • agricultural supplies (2C, 3L) • pulper, storage tanks and others (4C) • forage choppers and other equipment (4L, 5L in M & Lo) *To ask for government incentives* • local or community (ejidos) associations (all livelihoods in 3, 4 and 5) *For purposes other than productive* • water management, risk and/or fire management (all sites, except 5L in U)	*Supplies, credits, and incentives* • seeds and fertilizers from agriculture governmental agencies (1SG, 3SG, 4SG) • micro-credits from development banks, associations or cooperatives (2C, 4L, 5L in M & Lo) • governmental subsidies (3C, 4C) • payment for environmental services (some farmers of each livelihood in 2, 3, 4, and 5) *Technical assistance* • sustainable production programs promoted by ministry of environment (1C), cooperatives (2C), and protected areas administration (3C, 4C; 3 SG, 4 SG; 3 L3, 4 L, 5L except in U) • specific training activities to improve crops and livestock management from governmental agencies and NGOs (all sites)

Note: Numbers correspond to site codes, SG: staple grains, L: livestock, C: coffee, U: upper watershed, M: middle watershed, Lo: lower watershed

(Table 3.7). Credit, financial and technical assistance programs have all been designed by external entities and do not necessarily respond to the adaptation needs and demands of smallholders. For example, staple grains farmers in all sites receive seeds and fertilizers from government programs but mention that these programs are inadequate because the seeds are of hybrid varieties and have low yields (S1), the programs do not include technical assistance (S3) or reach only a small proportion of farmers (S4). Another example is the access to payment for ecosystem services to recover and conserve forests and reduce fires near protected areas and temporary jobs in the construction of soil and water conservation measures (S3, S4, S5). Although several groups of producers perceive these programs to be effective, they do not necessarily make immediate contributions to their livelihoods. It is important to emphasize the influence of technical assistance programs on the adaptation measures implemented since virtually all non-traditional adaptation practices have their origin in these programs and in the incentives that accompany them. Finally, smallholder producers in all sites mention that, if they could influence what kind of help they would like to receive, it would be focused on obtaining credits to add value to their products.

Vulnerability Levels and Main Constraints on Adaptation

We used the information systematized in the previous sections to identify, at each site, different groups of producers according to their level of vulnerability. We assume there are no differences in exposure to climate change, so the elements of vulnerability are mainly focused on preexisting conditions, the impact of climate on production systems and the availability of resources for adaptation (Table 3.8). Also, we do not include aspects related to the perception of changing climatic conditions and their implications, since, as mentioned earlier, smallholder farmers of all livelihoods at all sites are aware of them.

Types of Adaptation Measures and Stakeholder Proposals for Their Implementation

Most of the adaptation measures proposed in the planning stage of the ELACCs correspond to the incremental and system levels according to Rickards and Howden (2012). Only two transformational measures were identified, both related to the conservation and restoration of ecosystem services at the watershed level: the measures themselves related to natural capital and the corresponding financial mechanisms (Table 3.9). On the other hand, the classification of adaptation measures shows they are complementary according to their affinity with different capitals, and that awareness exists in the planning platforms of the importance of strengthening not only the natural and built capital but the strengthening of soft capitals for viability and sustainability.

The responsibility for obtaining the resources and executing the adaptation measures remained mainly with government agencies in all sites; however, the

TABLE 3.8 Vulnerability levels and the main constraints on adaptation as validated by smallholder focus groups.

Site	*Lower Vulnerability*	*Medium Vulnerability*	*Higher Vulnerability*
1	*Coffee* ↓↓ Loss of harvest (N), but ↑↑ additional harvest of fruits ↑ Some adaptation measures in place (H) ↓ No collective actions (S) ↑↑ Incentives and training framed in sustainable production program (F, P)	*Livestock* ↓ Fewer food supplies for animals (N) ↓ Fewer food supplies for animals (N) ↑ Some adaptation measures in place (H) ↓ No collective actions (S) ↑ Some training, but not in an integral manner (P)	*Staple grains* ↓↓ Loss of harvest, (N) ↓ Difficulty in identifying adaptation measures (H) ↓↓ No local organization to support collective actions (S) ↓ No access to incentives and training (F, P).
2	*Coffee* ↓ Quantity and quality of grains diminished (N) ↑ Some adaptation measures in place (H) ↑ Some collective actions (S) ↑↑ Incentives and training framed in sustainable pro-duction program (F, P)		
3	*Livestock* ↓ Fewer food supplies for animals (N) ↑↑ Several adaptation measures in place (H) ↑ Some collective actions (S) ↑↑ Incentives and training framed in sustainable production program (F, P)	*Staple grains* ↓↓ Soil degradation, increase of pests and diseases (N) ↑ Some adaptation measures in place (irrigation) (H) ↓ No collective actions (S) ↓ No access to incentives and training (F, P).	*Coffee* ↓↓ Soil degradation, in-crease of pests and diseases (N) ↓ Difficulty in identifying adaptation measures (H) ↓ No collective actions (S) ↓ No access to incentives and training (F, P).
4	*Livestock* ↓ Fewer food supplies for animals (N) ↑↑ Several adaptation measures in place (H) ↓ Few collective actions (S) ↑↑ Incentives and training framed in sustainable production program (F, P)	*Staple grains* ↓↓ Loss of harvest (N) ↓ Difficulty in identifying adaptation measures (H) ↓ Few collective actions (S) ↑↑ Incentives and training framed in continuous sustainable production program (F, P)	*Coffee* ↓↓ Loss of harvest (N) ↓ Difficulty in identifying adaptation measures (H) ↓ Few collective actions (S) ↓ No access to incentives and training (F, P)
5	*Livestock (M)* ↓ More pests and diseases (N) ↑↑ Several adaptation measures in place (H) ↑ Some collective actions (S) ↑↑ Incentives and training framed in sustainable production program (F, P).	*Livestock (Lo)* ↓ Fewer food supplies for animals (N) ↑ Some adaptation measures in place (H) ↓ Few collective actions (S) ↑ Incentives and training, but not in an integral manner (F, P)	*Livestock (U)* ↓↓ Fewer food supplies for animals, more landslides (N), roads damage (B) ↓ Difficulty in identifying adaptation measures (H) ↓ No collective actions (S) ↓ No access to incentives and training (F, P).

Note: SG: staple grains, L: livestock, C: coffee, N: natural capital, H: human capital, S: social capital, F: financial capital, P: political capital, U: upper watershed, M: middle watershed, Lo: lower watershed.

TABLE 3.9 Adaptation measures proposed in the local strategies according to the levels proposed by Rickards and Howden (2012) and community capitals (Flora, 2004).

Capitals	*Incremental Adaptation Measures*	*System Adaptation Measures*	*Transformational Adaptation Measures*
Natural	• Native seeds (1 SG) • Varieties resistant to water-stress, pests, and diseases (1, 4) • Genetic improvement of cattle for higher resistance and performance (1L, 5L) • Pasture management (5L)	• Crops diversification (1) • Organic or agroecological practices (1C, 2C) • Integrated pest management (1SG, 1C) • Agroforestry systems (1, 3) • Animal health practices (1L)	• Restoration and protection of water recharge areas (1, 2)
Built	• Soil and water conservation works (1, 2, 4, 5) • Diagnosis of the state of systems for water collection, storage, and distribution (1) • Pasture silage (1L) • Grain warehouses (1SG)	• Collection and distribution center of dairy and meat products (5 L)	
Human	• Dissemination of climate change trends and effects (1, 2, 3, 4) • Training on adaptation measures (2, 3)	• Early warning systems (1)	
Cultural	• Native seeds selection & exchange (1SG, 4SG) • Natural capital relevance for adaptation (4, 5) • Dissemination of local adaptation experiences (1, 2, 3, 4)		
Social	• Farmer to farmer extension (5L) • Farmer organization for technical assistance (1, 3) • Participative forest surveillance (3) • Organization of young people and women to intervene in decision making (1, 2)	• Farmer organization for technical and financial support (1, 3, 4, 5) and political lobbying (5) • Collective management of tools and machinery (1)	
Financial	• Incentives to establish organizations of producers (1 SG) • Grants and loans (5)	• Agricultural insurance (1) • Micro-financing programs (2) • Value chain management (1, 4)	• Ecosystem services incentives and payments for forest conservation in the upper watersheds (1, 2, 5)
Political	• Watershed management council establishment/strengthening (3, 4, 5) • Dissemination of adaptation needs between local organizations and institutions (1) • Seeking academic and governmental technical assistance (3, 5)	• Review of plans and projects to support adaptation efforts (1) • Review of policies and regulations to support adaptation efforts (1) • Joint projects between government, private sector, and cooperatives (5)	

Note: Numbers correspond to site codes, SG: staple grains, L: livestock, C: coffee. Measures are for all livelihoods in the site, if not specified.

TABLE 3.10 Proportion of Different Stakeholder Groups Identified to Implement Prioritized Adaptation Measures

	Site 1	*Site 2*	*Site 3*	*Site 4*	*Site 5*
central government	0.24	0.35	0.58	0.40	0.44
municipalities	0.32	0.10	0.08	0.04	0.06
local organizations	0.36	0.35	0.05	0.01	0.16
watershed councils			0.08	0.01	0.09
Academia			0.08	0.28	0.03
NGOs		0.05	0.12	0.21	0.03
private and finance sector	0.08	0.15		0.04	0.19

participation of local organizations, such as development associations, cooperatives and producer associations was important in S1 and S2, where there are less governmental resources. In all sites, little participation was expected from the private sector, though that of academia and NGOs stood out in S4, where several conservation and development projects have been sustained in recent years (Table 3.10).

Follow-up meetings with members of the ELACCs platforms give no evidence that the ELACCs or any individual adaptation measures have been put into practice.

Concluding Remarks

The methodology supports the rapid characterization of vulnerability based on local knowledge and participative processes, generating the programmed results in all its stages. The use of the CCF through the proposed methodology is advantageous to characterize local livelihoods and their vulnerability and to identify the main constraints for its adaptation. Its application highlights interactions between the changing climate and non-climatic factors, as well as the capacity of small producers to adapt, as an input for planning local adaptation. The CCF also shows non-tangible but critical aspects for the viability and sustainability of the adaptation process. However, the planning stage of the methodology is still insufficient for the valuation of this information in such a way that adaptation considers transformational alternatives that address temporal and geographic scales beyond production systems and their cycles. This step is necessary to face up to the reduction of water availability for different uses.

On the other hand, the planning stage is also insufficient to influence the agendas of decision makers. To address this aspect, we recommend the inclusion of fora for capacity building; for example, through the exchange of experiences and to link the ELACCs with direct access to resources for implementing local plans (Sharma, Orindi, Hesse, Pattison, & Anderson, 2014). As an example, the ELACCs could be used as a starting point for the design of programs and projects, recognizing local perspectives and knowledge. Finally, local perception of the benefits of adaptation measures is a crucial factor in sparking a new cycle of adaptation based on successful experiences and lessons learned.

Our review of the ELACCs shows the construction process does not capture differentiated perceptions and opinions of women and men. This is an important knowledge gap because the effects of climate change differ between men and women and are likely to be more serious for the latter, whose access to resources for adaptation is more limited and who are likely to have different response strategies than men (Segnestam, 2017); therefore, the adaptation measures proposed by the strategies may not be appropriate for women. In addition to the mainstreaming of gender in local adaptation planning (see, for example, Edvardsson & Hansson, 2013), we recommend that livelihoods components that are generally managed by women, such as the cultivation of home gardens, are included in the ELACCs. Also, the vulnerability of livelihoods and crisis response strategies should be differentiated by gender, given that the growing migration is reconfiguring the division of labor (Segnestam, 2017). Ultimately, building the capacity of community members to better anticipate, mitigate and adapt to the myriad impacts of a changing climate will only serve to more effectively prepare smallholder farmers of all livelihoods to build resistant and resilient stockpiles of capital to draw on and expend.

Acknowledgments

The authors are grateful for the support of the Regional Gateway for Technology Transfer and Climate Change Action in Latin America and the Caribbean (REGATTA) and the United Nations Environment Program (UN Environment) for the development of the strategies of Honduras, El Salvador and Costa Rica between 2013 and 2014; and for the support of The Nature Conservancy for the development of the strategies of Mexico in 2015. The points of view expressed in this chapter are solely those of the authors and do not necessarily reflect the positions of the aforementioned institutions.

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