Linking Mitigation and Adaptation in Carbon Forestry Projects: Evidence from Belize

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1. INTRODUCTION

The latest IPCC report (2014) states that both mitigation and adaptation actions are required to respond effectively to climate change. In some instances, adaptation measures can purposively or indirectly foster mitigation, or vice versa, resulting in positive outcomes regarding both objectives and contributing to climate resilient pathways (Denton et al., 2014; Fleurbaey et al., 2014). However, mitigation and adaptation measures often differ in both sector and scale of implementation, as well as in assessment periods and metrics. For example, while emission-reduction projects and programs are often targeted at energy-intensive activities, with impacts expected in relatively short periods of time, adaptation actions can be more diverse in their aims, expectations, and evaluation criteria, with varying degrees of involvement by public, private, and civil-society sectors, as with the construction of sea defenses or the take-up of drought-resistant seed varieties by local farmers. These differences explain why mitigation and adaptation have traditionally been distinguished as separate domains (Klein et al., 2005; Swart & Raes, 2007; Tol, 2005).

Integrating mitigation and adaptation should nonetheless remain a relevant concern in forestry and agriculture, where combining them appears to be essential in order to prevent ‘maladaptation’ and ‘malmitigation’ and produce synergies instead (Kongsager et al., in press). Forestry projects are relevant to both mitigation and adaptation, with potential synergies or trade-offs (Ilmian et al., 2013; Locatelli et al., 2011; Matecha et al., 2012; Ravindranath, 2007). Concerning mitigation, land-use changes contributed to 12.5% of global carbon emissions from 1990 to 2010, mainly through tropical deforestation (Houghton et al., 2012). Regarding adaptation, measures are needed to adapt forests to future climates, since forest ecosystems can be vulnerable to climate variability and climate change (Keenan, 2015; Reyer et al., 2009). In addition, forests contribute significantly to rural livelihoods in many countries (Angelsen et al., 2014) and so are central to the adaptive strategies of local communities. For example, forests provide ecosystem services that reduce the vulnerability of local communities and the wider society to climate variations (Pramova et al., 2012).

However, Kongsager et al. (in press) show that linking mitigation and adaptation in agriculture and forestry projects worldwide has not yet been realized in practice, even though approaches to ‘climate-smart’ development are proliferating (Someshwar, 2008). Research to establish the conditions under which mitigation and adaptation can be effectively integrated is required (Dang et al., 2003; Duguma et al., 2014; Locatelli et al., 2011; Verchot et al., 2007), but case studies of the actual or potential integration of mitigation and adaptation in land-use projects are lacking. Knowledge is thus needed to contribute to the growing number of studies documenting...
the outcomes of projects and programs under the Reducing Emissions from Deforestation and forest Degradation initiative, including the enhancement of carbon stocks and of sustainable forest management (REDD+) (Caplow et al., 2011; Merger et al., 2012; Murdiyarso et al., 2012; Mustalathi & Rakotonarivo, 2014).

In this article we look at carbon forestry projects through the lens of adaptation, examining in particular the linking of mitigation and adaptation in three projects in Belize. The adaptation lens was chosen because a lack of social and ecological adaptation is likely to limit the mitigation success of forest carbon projects (Reyer et al., 2009). Here we develop an analytical framework to study mitigation and adaptation linkages, relying on both qualitative and quantitative data from project documents and interviews to inform our research. We hypothesize that the separation of mitigation and adaptation in policies and funding is mirrored at the project level and that there is great potential for increasing this integration, but that incentives to harness synergies and avoid trade-offs between mitigation and adaptation may be insufficient. Hence, we aim to understand: (1) if adaptation is relevant in forest carbon sequestration projects in Belize; (2) if such projects include adaptation in their design and implementation; and 3) what the motivations are for including or excluding adaptation concerns.

2. A FRAMEWORK FOR EXPLORING ADAPTATION IN LAND-USE CARBON SEQUESTRATION PROJECTS

In the early 1990s, the United Nations Framework Convention on Climate Change (UNFCCC) laid the foundations of carbon markets and promoted the idea that carbon emitted in developed countries could be offset by emission reduction projects in developing countries. The UNFCCC Activities Implemented Jointly pilot phase represented a learning-by-doing period in the implementation of carbon offsetting projects, which increased in number and scope with the enactment of the Kyoto Protocol’s Joint Implementation and Clean Development Mechanism (CDM) programs and the emergence of voluntary carbon markets (Corbera et al., 2009). Project development in both markets has been refined over time, and project developers have increasingly adopted independent standards either to inform the development of their projects, particularly in the voluntary market segment, or to reinforce their environmental and social value in the CDM market.

The most commonly applied standards used in marketing carbon credits from forestry projects are the Verified Carbon Standard (VCS) and the Climate Community & Biodiversity Standard (CCB) (Kongsager et al., in press). These standards add value to the offsetting activities supported voluntarily by private and public companies or individual citizens. A combination of VCS and CCB is preferred today in voluntary forestry projects that cover a wide range of activities, from avoided deforestation projects that have never been eligible under the CDM to afforestation and reforestation activities (Boyd et al., 2008). In the past, research revealed challenges regarding the potential for leakage, permanence, additionality, reference levels, monitoring, and verification in forestry projects, particularly in those geared at conserving rather than enhancing standing biomass (Angelsen et al., 2014). In the last few years, and in the context of a flourishing REDD+ framework, the adaptation agenda has increased in relevance in the standards’ procedures, for example, the CCB now requires social and/or ecological adaptation to be addressed in order to obtain Gold Level certification (Narasimhan et al., 2014). This quest for integration should be seen as a signal that both developers and market players are recognizing that forest ecosystems and communities (inside the project area or in its buffer zones) will most likely need to adapt to climate and other stressors over the project’s lifespan.

To investigate the inclusion of adaptation in carbon forestry projects and to investigate systematically which aspects of adaptation are affected by a land use-based carbon forestry project, we have developed an analytical framework (Figure 1) which moderates the aspects from Kongsager et al. (in press). The first analytical dimension concerns mitigation activities, understood as anthropogenic interventions to reduce the sources or enhance the sinks of greenhouse gases and to provide global benefits in the long term (IPCC, 2007). Since mitigation is considered the main driver of implementation in carbon forestry projects, it figures superior in our framework. Below mitigation we have clusters of adaptation, understood as adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects to provide essentially local benefits in both the short and long term (IPCC, 2007), as well as broader actions that make ecosystems and societies more robust to changes, including, but not limited to, those caused by climate change (Pieke, 2005; Pieke et al., 2007). In this regard, our framework distinguishes clusters related to (i) ecological adaptation and (ii) agricultural systems adaptation, together with another cluster related to (iii) the livelihood, institutional and well-being aspects of buffering communities (labeled social adaptation). The latter refers to aspects that determine people’s potential and willingness to develop mitigation activities, which in turn influences their vulnerability and adaptive capacity to environmental and climate change.

The aspects identified under each of the four clusters correspond to those identified in the literature as activities that can potentially be included or affected by the implementation of land use-based carbon forestry projects. These involve six aspects for mitigation, four for ecological adaptation, four for agricultural adaptation, and ten for social adaptation (see Online Resource 1 for further details of each aspect). The references chosen for each aspect include the two most recent IPCC reports (AR4: 2007 and AR5: 2014) and other published review papers, which were accompanied with a few more specific papers to cover certain topics. For instance, Börner and Wunder (2012) helped substantiate the mitigation effects of different forest and agriculture conversion opportunities, while Ravindranath (2007) provided evidence of the mitigation, biodiversity, and socio-economic impacts of 24 different activities, practices, and management systems in the forest sector.

It is well known that land-use mitigation activities can result in both additional benefits and in costs for social-ecological systems. For instance, agroforestry activities can contribute to reducing emissions by sequestering carbon dioxide while promoting landscape biodiversity and resulting in socio-economic benefits for land managers (e.g., Ravindranath, 2007, p. 847). In contrast, other forest conservation activities can also result in positive ecological outcomes, such as avoiding soil erosion or conserving certain species, but they can be detrimental for local populations if they restrict access to land and resources and increase people’s vulnerability (Pramova et al., 2012, p. 590). Forest plantations, in turn, can reduce groundwater availability and increase soil pollution, but simultaneously also result in jobs and increased income for local populations. These interactions are indicative of the fact that the mitigation activities considered by our framework might not result in positive outcomes across the three adaptation dimensions and their constitutive elements. These outcomes are likely to be moderated by the
type of mitigation activity implemented, the reality of the local context (e.g., in terms of security of land tenure), the institutional conditions under which mitigation activities are developed (e.g., with more or less funding), and the scale of analysis (e.g., within or beyond the project’s socio-ecological boundaries). The framework is meant to be applied qualitatively, but we acknowledge that some of its aspects, particularly those focused on mitigation, could be explored quantitatively. The framework can also be used to investigate ‘broadness’, i.e., the number of aspects addressed by a project for both design and evaluation purposes.

3. INTERROGATING CARBON FORESTRY PROJECTS IN BELIZE

(a) Case study country

Belize is the second smallest country in Central America, with a land area of 22,963 km² and a population of only 322,453 (55% rural). The population increased by over 30% from 2000 to 2010 due to fertility increases and immigration. Belize is extraordinary ethnically diverse and land tenure can be divided into four broad categories: national land (owned by the government, including lease land), forest reserves (administered by the government), private land and Indian reservations. Companies or individuals own most lands (63%), while another 25% is under lease. Reservation land is only found in the Toledo District, where most Mayan population lives (SIB (Statistical Institute of Belize), 2011). Disputes over tenure are frequent and particularly acute in this district, where demarcating private land and reservations boundaries remains a contested process in many areas (Clark, 2000; Emch, 2003; Steinberg, 1998; Steinberg, 2002; Wilk, 1997).

(b) Relevance of mitigation and adaptation in Belize

Globally, Belize’s emissions are low (UNEP, 2010) and can hardly be held accountable for climate change. However, the expansion of agriculture in many developing countries contributes to climate change through deforestation and unsustainable land management practices (Jarvis et al., 2011). It has been estimated that 92% of greenhouse gas emissions in Belize in 2000 came from land-use change and forestry (Government of Belize, 2011), and, for instance, around 5,000 acres of forest were lost yearly in Toledo District between 1980 and 2010, and forest cover dropped from 85% to 71%. Agriculture has been identified as the primary cause of deforestation, with legal and illegal logging and infrastructure development being secondary drivers (Chomitz & Gray, 1996; Emch et al., 2005; Levasseur & Olivier, 2000; Martinez, 2012). To reduce deforestation, 94 protected areas in 115 management units have been created over the years, and 36% of terrestrial land is under some form of conservation (Meerman, 2005).

Concerning the need for adaptation, Belize is highly vulnerable to natural hazards and climate change. Its long low-lying coastal areas are especially vulnerable to more intense and frequent tropical storms and hurricanes, flood damage, and rising sea levels. The country has experienced frequent natural disasters, such as hurricanes and post-hurricane large-scale fires, which have had an impact on the country’s GDP (World Bank, 2013). The IPCC (2013) 2050-projections for Central America predict increased temperatures with subsequent increased evaporation loss, decreased precipitation (minor), shorter rainy seasons and longer dry seasons, increased frequency and intensity of heavy rain events, stronger hurricanes with increasing disaster losses, and a general increase in extreme events like droughts and floods. Further, extreme weather events will likely continue to impact crop yields and forest cover, thus posing challenges to poverty reduction and development efforts (Government of Belize, 2011).

(c) Selected projects

The three studied projects fall under the ‘Agriculture Forestry and Other Land Use’ sector of the VCS and they are considered ‘Avoided Planned Deforestation’ projects (i.e., REDD). They are located in different areas of the country and are imbedded in the larger protected areas system of Belize (Figure 2). The projects are currently (July 2015) the only approved and certified carbon forestry projects in Belize, though at least three other projects are under development (Forest Carbon Offsets, 2015). The projects are described below, and their key characteristics are presented in Table 1.

The Rio Bravo project accounts for 7% of the Rio Bravo Conservation Management Area, which, at 93,432 ha, is the largest terrestrial protected area in Belize and it is managed in trust by...
the organization Programme for Belize (PfB). The project aims to demonstrate the technical balance between cost-effective carbon sequestration, economically sustainable forest yield and environmental protection. It aims to reduce greenhouse gas emissions through the acquisition and protection of forests that are threatened by agricultural conversion. Selective logging takes place within a restricted area of the project, and deforestation has been avoided through the purchase of land that would have been sold to industrial-scale agricultural farmers. Rio Bravo is an ecologically diverse area and is considered one of the most important areas in the region for commercially valuable tree species. Abundant in wildlife and an important biological corridor, Rio Bravo is home to 200 species of trees, 390 species of birds, 70 species of mammals, and 39 species of con-
Table 1. Main details of the three projects (sources: *VCS and CCB project documents, **VCS database (visited 11 July 2014), ***Markit Registry (visited 8 July 2014)*, ****GIS-layer information)

<table>
<thead>
<tr>
<th>Project</th>
<th>Rio Bravo climate action project</th>
<th>Bull Run overseas forest carbon project: Phase 1</th>
<th>Boden creek ecological preserve forest carbon project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project start date</td>
<td>1996</td>
<td>2009</td>
<td>2005</td>
</tr>
<tr>
<td>Crediting period</td>
<td>2002–21 (20 years)</td>
<td>2009–38 (30 years)</td>
<td>2005–29 (25 years)</td>
</tr>
<tr>
<td>Standard**</td>
<td>VCS</td>
<td>VCS</td>
<td>VCS</td>
</tr>
<tr>
<td>Ownership*</td>
<td>Private area held in trust by NGO (Programme for Belize)</td>
<td>Private area owned by private company (The Aldebaran Company Ltd. Grand Cayman)</td>
<td>Private area owned by private company (Boden Creek Ecological Preserve)</td>
</tr>
<tr>
<td>Project proponent and manager of the property*</td>
<td>Programme for Belize (a Belizean NGO)</td>
<td>The Aldebaran Company Ltd. (Grand Cayman registered company)</td>
<td>Belize Lodge and Excursions (BLE) is the contractor responsible for running an ecotourism operation on the property. Boden Creek Ecological Preserve (BCEP) is the entity owning and in charge of management of the property</td>
</tr>
<tr>
<td>Other entities involved in the Project*</td>
<td>The nature conservancy, Belmopan Belize (project development; financial manager; validation &amp; verification); Winrock International (validation &amp; verification technical advisor)</td>
<td>Forest Carbon Offsets (project developer, implementation, and monitoring of the carbon credits); Conservation Management Institute at Virginia Tech (technical analysis on behalf of FCO)</td>
<td>Forest Carbon Offsets (project developer, implementation, and monitoring of the carbon credits); Conservation Management Institute at Virginia Tech (technical analysis on behalf of FCO)</td>
</tr>
<tr>
<td>Size of project area (ha)*</td>
<td>6,296</td>
<td>369,472 (12,315)</td>
<td>3,980</td>
</tr>
<tr>
<td>Total (and annual) predicted avoided emissions in the project period (tCO2e)*</td>
<td>1,660,260</td>
<td>1,442,957 (57,718)</td>
<td>1,442,957 (57,718)</td>
</tr>
<tr>
<td>Registered - VCU's Issued (tCO2e)**</td>
<td>20,000</td>
<td>133,808</td>
<td>133,808</td>
</tr>
<tr>
<td>Amount of retired credits (% of total)**</td>
<td>11,644 (0.7%)</td>
<td>5,300 (4.0%)</td>
<td>5,300 (4.0%)</td>
</tr>
<tr>
<td>Realized (tCO2e)**</td>
<td>7,763</td>
<td>193 (0.2%)</td>
<td>0</td>
</tr>
<tr>
<td>Ecosystem and vegetation (UNESCO classification) (main type in the project area)***</td>
<td>Tropical evergreen seasonal broad-leaved lowland forest on calcareous soils + Evergreen broad-leaved lowland shrubland dominated by leguminous shrubs</td>
<td>Tropical evergreen seasonal mixed submontane forest (east) + Tropical evergreen seasonal broad-leaved lowland hill forest on steep karstic terrain (west)</td>
<td>Tropical evergreen broad-leaved lowland forest on poor or sandy soils</td>
</tr>
<tr>
<td>Precipitation (mm)****</td>
<td>1,550–1,750</td>
<td>1,700–1,850</td>
<td>2,500–3,000</td>
</tr>
<tr>
<td>Altitude (masl)*****</td>
<td>25–50</td>
<td>300–700</td>
<td>20–70</td>
</tr>
</tbody>
</table>

*Figures need to be treated with caution. The purpose of, for example, the VCS database is to provide information about credits that have been issued and retired, but does not include information about transactions (purchase, sale or resale). Further, retirement of a credit does not mean it has not been sold. There are often cases where buyers of credits do not realize they need to retire the credit, or the buyer of the credit has not yet retired it for some unidentified reason. Also, projects without buyers may not issue their credits, as the project will need to pay fees to do this. Consequently, the market is opaque, since only project developers and owners have information on the purchase and sale of credits (Ching, 2014).
servation concern. Furthermore, Rio Bravo contains several watersheds (the Rio Hondo, New River and Belize River basins). PfB has implemented numerous community outreach projects, including the establishment of local community groups to manage income-generating projects, and the social impacts have been stated to be neutral to positive by the VCS audit team (VCS, 2011a).

The Bull Run project covers 14% of the Bull Run Overseas property, which encompasses 4,650 ha of tropical pine forests, grasslands, and mature humid broadleaf forest. The goal of the project is protecting the property as a carbon sink, while offering watershed protection, maintaining biodiversity and enhancing local livelihoods. The project aims to avoid the emissions that would have resulted from converting forests into coffee plantations (by the landowner himself) and from ongoing illegal logging, which had historically been inconsequential on the property. CCB Gold Level certification has been granted by virtue of the significant levels of biodiversity maintained and the critical location of the property in the immediate watershed of the Port Honduras Marine Sanctuary (CCB, 2010; VCS, 2011b).

(d) Data collection

Information was collected from the available literature (project documents, articles, case studies, reports), GIS layers of Belize (e.g., infrastructure, protected areas, settlements, hurricane tracks/damage, land use) and population statistics. In addition, we interviewed 99 individuals (Table 2) over a seven-month period of fieldwork (August 2013 to February 2014). These individuals were either directly or indirectly linked to the project and encompassed project staff, government officials or carbon standard managers. Most of them were identified during a reconnaissance trip conducted in January 2013 and others were identified through a contact in the country’s UNDP office. Other individuals were targeted after they were identified during conversations with interviewees.

<table>
<thead>
<tr>
<th>Organizations/persons</th>
<th>Number of interviewees</th>
<th>Number of meetings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project management</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>Government and Multilateral</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>Academia</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Nongovernmental</td>
<td>31</td>
<td>41</td>
</tr>
<tr>
<td>Others</td>
<td>14</td>
<td>30</td>
</tr>
<tr>
<td>Buffering communities</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>99</td>
<td>147</td>
</tr>
</tbody>
</table>
The majority of these interviews were conducted in English face-to-face around Belize by the first author, a few being conducted by Skype. The article findings are predominantly informed by 43 audio-recorded semi-structured interviews (open-ended questions, length from 45 min to 2 h), while the information collected through shorter interviews, informal talks, or meetings has been only used to contextualize the projects’ history and their relevance in relation to land-use sector policies, to triangulate findings and to enrich the discussion. Electronic correspondence was used after the fieldwork to clarify a few points with some of the most relevant informants.

The former group of interviewees were asked to give their consent first, were briefed about the research objectives, and were interviewed differently depending on their organizational affiliation and post, level of education, and level of involvement in national forest policy and in the projects we analyzed, among others. They were thus not given exactly the same questions, but our underlying objectives remained the same: (1) to assess the need for adaptation in and around the project areas (e.g., what have been the impacts of hurricanes on forest and agriculture in the past?); (2) to examine the degree of adaptation integration in the projects and incentives for the inclusion or exclusion of adaptation issues (e.g., how does the project increase the ecological resilience of the forest?); and (3) to determine whether mainstreaming adaptation in carbon forestry projects would facilitate multiple wins (e.g., how is the project affecting diversification in the buffering communities?). NVivo software was applied to organize and analyze the data from semi-structured interviews.

Table 3. Outcomes of implemented project activities

<table>
<thead>
<tr>
<th>Social and agricultural adaptation aspects</th>
<th>Rio Bravo</th>
<th>Bull Run</th>
<th>Boden Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversification</td>
<td>Offering employment opportunities related to monitoring, patrolling, ecotourism, and construction to a limited degree.</td>
<td>Environmental education of local staff. Providing environmental education programs, scholarships and assisting schools with equipment and repair of school buildings.</td>
<td>Environmental education of local staff.</td>
</tr>
<tr>
<td>Education and capacity-building</td>
<td>Environmental education of local staff. Providing environmental education programs, scholarships and assisting schools with equipment and repair of school buildings.</td>
<td>Required the development of staff's children.</td>
<td></td>
</tr>
<tr>
<td>Energy and water</td>
<td>Protecting the local watershed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest and biodiversity adaptation</td>
<td>Human influence</td>
<td>Human influence on forests is reduced through patrolling activities.</td>
<td></td>
</tr>
<tr>
<td>Human influence</td>
<td>Improved simply by the extensive size of the property, and partly through FSC certified timber management activities in selected areas.</td>
<td>Reducing current disturbance levels, which are considered to be high by the project developers.</td>
<td></td>
</tr>
<tr>
<td>Ecological management</td>
<td>Strengthening the Mesoamerican Biological Corridor and avoiding habitat fragmentation, thus improving the long-term viability of fauna and flora populations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change management</td>
<td>Fire management practices, such as building and maintaining a fire tower, having fire crew and equipment, and prescribing fires to reduce the severity of natural fires.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitigation</td>
<td>Avoided deforestation: reduced greenhouse gas emissions through the acquisition and protection of forests threatened by agricultural conversion and illegal logging.</td>
<td>Avoided emissions from deforestation that would have been derived from converting the property into coffee plantations and from ongoing illegal logging.</td>
<td>Avoided emissions from deforestation, as the project will use carbon financing to avoid the potential threat of conversion to citrus, pasture, and/or aquaculture by future landowners.</td>
</tr>
</tbody>
</table>

4. RESULTS

This section is solely based on project documents and interviews (‘i’ refers to the interview Id in Online Resource 2). Table 3 provides an overview of potential project outcomes based on our analytical framework. We explain below which of these outcomes have been realized by projects, while others have been disregarded. As for the latter, and based on interviewees’ insights, we suggest ways of improving project implementation in order to achieve a greater number of outcomes.

(a) Social and agricultural adaptation aspects

All three projects indirectly influence neighboring communities by protecting the local watershed (italics refer to aspects in Figure 1), and all have contributed to diversifying livelihoods by offering employment opportunities related to monitoring the area, patrolling, ecotourism, and construction (i1, 6, 7; CCB, 2010, 2012; VCS, 2011a, 2011b, 2012). However, employment in these projects is limited (i43) and has only benefited a few families in Rio Bravo (i1, 2, 3; Salas & Castillo, 2013) and Bull Run (i6, 92), or benefited many but only for a short period in Boden Creek (i55, 58, 84). Environmental education has been promoted through local staff training. The Bull Run project has provided education to its staff’s children, while Rio Bravo has gone a step further by providing environmental education programs and scholarships and assisting schools by providing materials and repairing the construction to a limited degree. Offering employment opportunities related to monitoring, patrolling, ecotourism, and construction to a limited degree.

(b) Mitigation

Avoided deforestation: reduced greenhouse gas emissions through the acquisition and protection of forests threatened by agricultural conversion and illegal logging.
schools’ buildings (CCB, 2010, 2012; VCS, 2011a, 2011b, 2012). Only Boden Creek is on paper gender-sensitive in its employment strategy by encouraging women to apply for positions (CCB, 2010). There was no evidence or indication of other social adaptation aspects having been taken up by projects.

However, the interviewees mentioned a number of aspects that could potentially be reinforced to foster adaptation and rural development in neighboring project areas. First, it was acknowledged that projects could support either directly (as part of mitigation activities) or indirectly (as complementary actions) the development of more sustainable agricultural practices that might ease the pressure on forests, such as promoting agroforestry or controlling slash-and-burn practices more effectively. The latter would reduce the risk of the uncontrollable, often unintentional fires that destroy large forest tracts in Belize every year (i24, 51, 54–60, 61, 71, 74, 77–78, 84). Supporting agriculture in buffering communities would potentially increase local adaptive capacity by enhancing food security and diversifying agriculture (i81, 83).

Secondly, interviewees also recognized that villagers would benefit from increased land tenure security. Presently, very few villages in project neighboring areas have formal secure ownership, which constrains them in investing in agricultural activities or having access to credit and other forms of entrepreneurship (i63, 65, 67, 71). Securing land tenure for farmers was tried in Slate Creek Preserve, close to Bull Run, by a group of local landowners, but this collapsed as the public authority obstructed the process (i71, 78). Rio Bravo, in turn, could have assisted farmers in San Felipe (i.e., the nearest village to the project area) to maintain their leases or to secure ownership over their agricultural land in exchange for them protecting the northeastern corner of the project area from illegal resource extraction. In this area, farmers are giving up farming due to insecure tenure and working instead for the Mennonites, who are acquiring new properties and developing both intensive and extensive mechanized agriculture around the Rio Bravo protected area, thus reducing any available buffering forests (i1, 27, 36, 43, 53, 55–56, 60, 70–71, 78, 84). Such agricultural expansion has also translated into an increasing number of unpaved roads around and nearby the reserve, thus easing access for poaching activities and illegal logging (i90, 91, 96), which removes carbon and important seed-trees (i1, 15).

Thirdly, interviewees involved in the projects confirmed that more could be done in rationally utilizing forest products in neighboring project areas so as to increase buffer protection from hurricanes and ensure the long-term provision of firewood, construction material, and medicinal plants (ecological management). This might have been realized through increased forest conservation on upper slopes, reforestation and afforestation activities on fallow lands, and sustainable forest management, which would in turn ease pressure on project areas (i22, 27, 46–47, 54–56, 58, 65–66, 68–69, 85). Intervie-

vees also confirmed that neighboring forests are a critical complementary source of income for the local population, even though very few families depend solely on forest-related activities (i1, 10, 14–15, 18–19, 27, 29, 39–40, 43, 46–47, 48, 55, 65, 67–68, 70–71, 79–80, 84–85).

Finally, interviewees agreed that projects should have contributed more to surrounding villages by promoting alternative livelihood activities, such as handicrafts, pig-rearing, or bee-keeping, which have the potential to ease the pressure on forest resources, though there is no guarantee that they would do so. Rio Bravo and other protected areas in Belize have experimented with this approach, but with limited suc-

cess, as many families benefiting from diversification activities continued to exercise pressure on forests (i2, 16, 23, 27, 29–30, 46, 48, 55, 64–65, 69, 84–85). In this regard, some highlighted the need to improve understanding of the commercial potential of new livelihood activities, to promote activities with low investment risk and to support basic training for business management so that adopting households and communities can take ownership of such activities more quickly and effectively (i29, 84).

(b) Ecological adaptation aspects

Generally, none of the projects had considered the need for ecological adaptation to climate variability in the future. Project developers and managers agreed that climate change, especially future hurricanes, could have huge impacts on project areas, but they saw little potential in assessing or avoiding impacts (i1, 6–9). One project owner, for example, stated that scientific knowledge about the consequences of climate change for these forests was rather thin, which precluded him from undertaking management actions with uncertain long-term impacts (i6), while the projects’ technical officers stated that conservation activities would naturally aid forests to adapt to climate change in the long run (i1, 7). Based on project doc-

uments and interview data, however, we think that the four aspects of our framework related to ecological adaptation are somehow being addressed, if nonpurposively, in project design and/or implementation. Human influence on forests is being reduced in the three sites through patrolling activities, although more might be achieved by increasing communication with neighboring communities and making them benefit more tangibly from the project, as noted in previous section. Ecological management in Rio Bravo is likely to improve through FSC-certified timber management activities in selected areas, whereas Boden Creek and Bull Run aim to make forests more resilient by reducing current disturbance levels. All projects contribute to ecosystem connectivity by strengthening the Mesoamerican Biological Corridor and avoiding habitat fragmentation, thus improving the long-term viability of fauna and flora populations. Finally, projects’ ability to reduce climate-related ecological disturbance (climate change management) is partly being achieved in Bull Run and Rio Bravo through the development of fire management practices, such as building and maintaining a fire tower, maintaining a fire crew and equipment, and ignite controlled fires to reduce the severity of natural fires (i1–9; CCB, 2010, 2012; VCS, 2011a, 2011b, 2012).

As for the social and agricultural adaptation aspects, interviewees acknowledged that more could be done to increase the resilience of forests and their biodiversity (i1, 3, 6–7, 10, 13–16, 18, 22, 39, 66, 77–78, 80), but project developers were reluctant to add activities that were not required by carbon standards as it implied extra costs (i1, 7, 8, 9). Since all project areas have at some point been hit by hurricanes (i1, 4, 6, 15, 56, 78, 87, 92–99), with models predicting their higher frequency and intensity in the future, replanting or protecting some key tree and understory species would be a good strategy to maximize genetic diversity and species recovery after such events or after intense fires, as well as contributing to increased carbon storage in biomass and soils. Furthermore, actions contributing to species and genetic diversity would also help control insect and disease outbreaks in project areas (i1, 6–7, 15, 78), which in turn might reduce forests’ sensitivity to climate-induced stresses, such as droughts or fires (i15). In a nontargeted project area of the Bull Run property, for example, a pine bark beetle outbreak (2000–02) had devastating effects by killing the
majority of pine trees, causing intense wildfires due to increased fuel loads. In dry years these wildfires can spread to the broadleaf project forest (i6).

Projects have not partnered effectively with local communities to minimize the risk of slash-and-burn fires spreading into forests (i56, 85). Only the Bull Run project has been able to control the spread of fires in one area of the forests during the dry season (i6). Hurricanes and fires impact the forest not only directly, but also indirectly by making the areas more accessible to agricultural expansion and illegal logging, which is why project developers should be more attentive to the impacts of climate shocks on the socio-ecological system outside the project area and plan adaptation measures accordingly. For example, one of the largest landowners in Belize (a timber company) sold 18,000 acres of burnt forest to a farming community in 2013, since Hurricane Richard (2010) and a subsequent fire had significantly reduced the timber value of the area. It is now converted into farmland (i10, 15). In Rio Bravo, in the aftermath of the same hurricane, around a hundred workers on a papaya farm were laid off for nine months and subsequently turned to the property’s forests for both timber extraction and increased farming near the property (i90).

(c) Mitigation aspects

All projects are expected to prevent carbon losses from forests. However, illegal logging continues (particularly in Rio Bravo) because projects have not supported buffered communities with new income-generating activities. If they had done so, the initiatives might have conserved additional carbon and protected precious, large seed-trees, which are important for forest regeneration after disturbances and protect smaller trees from strong winds, which can impact the projects considerably (i3, 15, 16). For example, carbon content in Boden Creek is very low (50–70t/ha) because in 2001 Hurricane Iris reduced standing stocks considerably (i15), and Rio Bravo project expansion plans were postponed when 50% of the expansion area was struck by Hurricane Richard in 2010 (i1, 4).

Afforestation/reforestation, forest enrichment or regeneration of degraded areas (carbon storage in forests) in some of the degraded areas (e.g., the former agricultural area of Boden Creek) have not yet been incorporated in project implementation to increase mitigation outcomes. Planting activities were considered expensive, open to uncertain outcomes, and managers were thus more supportive of leaving open areas to regenerate naturally (i1, 7, 15). Projects have also been unable to reduce emissions from energy sources, including petrol and firewood burning. The latter could have been offset by tree planting in collaboration with communities, while firewood consumption could have been reduced by introducing energy-efficient cooking stoves, which also has health benefits (i72). Carbon storage in agriculture and emissions from agriculture could have been enhanced and reduced respectively by including certain agricultural activities in buffer zones around the project, such as agroforestry or slash-and-mulch instead of slash-and-burn (i51–52, 54–60, 64, 81, 83, 97). Intensifying the current extensive cattle production practices or promoting silvopastoralism on the periphery are also possibilities that have not been taken up by projects, as cattle ranching prevails and continues to increase around project areas (i10, 24, 39, 91, 99).

The additionality requirement is one of the most important issues in a carbon sequestration project, but it is hard to demonstrate (i12), which was evident in relation to the three studied projects. The initiatives use the VCS additionality tool and consider agricultural expansion in these areas (substantiated by the business-as-usual trend in Belize) as the most plausible scenario without the projects (VCS, 2011a, 2011b, 2012). Rio Bravo suggests that conversion to high-technology agricultural lands is the most likely baseline scenario, and claims that the previous owner of the land had put it up for sale to industrial scale farmers (i1–3, 22, 88; VCS, 2011a). However, one of the interviewees (i1) stated that the potential buyer was not willing to pay the asking price. The seller, in turn, explained that he had sold the land to PfB motivated of tax concerns and to maintain access to timber from the area, which was a part of the deal with PfB (i88). Consequently, the threat was likely, but no documents exist to prove the offer made by the potential buyer. The project developer pointed out that rules and guidelines for carbon projects had been less strict in the past and that the deforestation trend was sufficient to justify additionality. He acknowledged that the additionality argument would have to be substantiated further if the project sought registration under any carbon standard nowadays (i3).

The Bull Run project, in turn, identifies conversion to coffee plantations by the current owner (who is also the project owner) as the most likely alternative land-use scenario (i6–7, VCS, 2012). However, at least two interviewees (i15, 78) and the only company producing coffee in Belize (i11) challenged this argument based on the fact that coffee planting is not a viable economic activity here. This is because: (1) the project area’s altitude (300–700 masl) is unsuitable for producing good quality coffee (i.e., Arabica); (2) huge investments are needed (for seedlings, infrastructure and processing); and (3) the internal market is small, while competition from other Central American countries is high. For these reasons the technical expert in the first auditor team (i15) considered additionality unlikely, which in turn led the project developer to hire a less skeptical auditor. The new auditor approved the project, but pointed out that the VCS additionality tool required some improvement, as it relied too much on the auditor’s subjectivity (i8).

Finally, the Boden Creek project states conversion to agriculture (particularly citrus) as the most likely alternative land-use scenario (i7, 9; VCS, 2011b). Project documentation (CCB, 2010; VCS, 2011b) contains a description of soil characteristics, but lacks robust proof of the suitability and economic viability of potential citrus plantations. Some interviewees contested the validity of this alternative scenario for at least two reasons. First, they argued that poor soil quality is evident on the project property, thus undermining the potential for developing successful and productive agricultural activities. The former landowner had to abandon rice and banana plantations due to rapid drainage of soil nutrients, and farmers in the buffering community of Pine Hill expressed concerns about the low fertility of the land (i55, 87, 99). Secondly, interviewees argued that the citrus industry is generally in decline and, therefore, that any investment under existing biophysical conditions would require infrastructural development (roads and drainage networks) and substantial agricultural inputs. Thirdly, plantations are a risky investment, as they have been severely damaged by hurricanes in the past. These challenges are illustrated by the fact that the former owner of the project’s property tried a banana plantation without success, while a large citrus plantation southwest of the project area was also abandoned due to its low productivity (i48, 55, 88, 87).

All these contextual conditions explain why the VCS auditing team attributed only 40–50% likelihood of the stated additionality in the Boden Creek project (i15). Nonetheless, the team considered that the project’s ‘risk of management failure’ was ‘very low’ (VCS, 2011c), and it was then very unfortunate
that only one and a half year later the project stopped operating. Workers had not been paid on several occasions, and consequently they decided to burn down all the buildings on the property. The project owner flew away and, as of today, the project area remains unmanaged, and encroachments on it are rampant (i7, 9, 54–58, 97). Several interviewees stated that the validation team could have realized this problem if they had spent sufficient time in the area to discover that the property manager had a reputation for controversy (i2, 14, 15, 55, 84).

5. DISCUSSION

The framework introduced in Section 2 has helped us to structure the results above and to highlight the presence or absence of adaptation aspects in the chosen carbon forestry projects. Our analysis reveals that only one of the six mitigation dimensions has been taken into consideration, the agricultural adaptation dimensions have not been addressed at all, the ecological adaptation dimensions have been addressed almost fully, and the social adaptation dimensions only sparsely (Figure 3).

From the perspective of integrating adaptation into the projects, our findings suggest that the rhetoric of the potential linking and realization of both mitigation and adaptation in the land-use sector is not easy to hold because the standards existing today to produce and verify carbon–offsets are very weakly enforced and their mandate does not necessary incorporate adaptation concerns. Compared to mitigation, monitored in detail but weakly quantified, adaptation measures are addressed poorly and with no quantification at all. We found, to use the terms from Locatelli et al. (2011) that all projects include ‘adaptation for forests’ but are not geared toward actively using forest management to foster ‘people’s adaptation’. This is because our study focuses on three avoided deforestation projects, where ecological adaptation benefits might take place almost intrinsically, contrary to what might happen in afforestation and reforestation projects (Reyer et al., 2009).

The achieved and potential impact on communities seems to be neutral, with a few positive effects and almost no negative consequences for the social and agricultural adaptation aspects. Consequently, improvements to people’s capacity to adapt to climate change and other stressors as a result of the projects are unlikely. Our analysis, despite being focused only on three projects and therefore of potentially limited global significance, confirms other research elsewhere. The lack of a link from carbon benefits to socioeconomic co-benefits is akin to the general findings of recent reviews, including an analysis of 20 pre-REDD+ projects (Caplow et al., 2011), a global assessment of 201 land use-related projects (Kongsager et al., in press), an assessment of the co-benefits of agroforestry (Anderson & Zerffi, 2012) and evaluations of how CDM projects have contributed to sustainable development (Boyd et al., 2009; Olsen, 2007). Further, insights from 23 sub-national initiatives in six countries have shown limited ability of REDD+ pilot projects to deliver co-benefits, such as resolving local tenure challenges (Sunderlin et al., 2014a) or achieving other social goals (Sills et al., 2014). In addition, in Tanzania Duguma et al. (2014) found that the emphasis is placed on complementarity (i.e., mitigation projects providing adaptation co-benefits and vice versa), rather than on real synergistic systems in which mitigation and adaptation are optimized as part of multiple functions.

During fieldwork, project developers generally considered that promoting adaptation in neighboring villages, or rural development more broadly, was the responsibility of the government or dedicated NGOs. It was too costly for them to involve villagers more effectively, and that they thought there were limits as to how much both villagers and civil society – including academics – could expect from carbon forestry projects. Villagers were often regarded as a threat to the project rather than as potential partners, hence the importance of patrolling activities. Project owners did not necessarily understand why local communities had to benefit from legitimate carbon forestry projects established on private land. In our view, however, this perspective ignored the fact that what the state considers legitimate will not necessarily be considered legitimate by surrounding villages and peoples. For example, on the border of Boden Creek live Q’eqchi indigenous communities who have historically struggled against the enclosure of agricultural lands in Belize and Guatemala and who are increasingly concerned about such processes as a result of growing land scarcity (Mingorria et al., 2014; Wainwright, 2011). These communities believe that they have an ancestral right to the region’s land, and they understand the latter not as a carbon and biodiversity conservation landscape but as a cultural reproductive space where rotational maize cultivation figures centrally. Dynamic contests over tenure and over the meaning of property are likely to be one of the most important challenges faced by carbon forestry projects and programs.

Figure 3. Depiction of project’s performance as regards the analytical framework (Figure 1). Black indicates direct and clear presence; gray indicates indirect or weak presence of the aspect in the project; white indicates that the aspect has not been considered in the project. Legend: SA: social adaptation (SA1: diversification, SA2: education and capacity-building, SA3: energy and water); EA: ecological adaptation (EA1: human influence, EA2: ecological management, EA3: ecosystem connectivity, EA4: climate change management); M: mitigation (M1: carbon losses in forests).
including REDD+ (Sunderlin et al., 2014b), and ignoring them might turn out to be counter-productive for project managers in the longer term.

Project developers also justified their limited attention to adaptation on the basis of few or no perceived incentives to enhance the link to social and ecological adaptation more explicitly. The VCS does not require such linkage, and developers perceived no added economic value in linking. As noted in Table 1, Bull Run and Boden Creek combine VCS with CCB to demonstrate, at least on paper, the additional social and biodiversity benefits. However, our analysis has demonstrated that such benefits have barely been realized, thus suggesting that, at least in these cases, adoption of the standard by project developers may only be contributing to ‘greenwashing’ (see e.g., Laufer, 2003).

The weak justification of projects’ additionality and the caveats regarding the validation process in two of the three studied projects are not surprising, since these very same weaknesses have been documented in other analyses of voluntary, pilot-REDD+ and CDM carbon projects (Ankersen et al., 2015; Caplow et al., 2011; Müller et al., 2014; Schneider, 2009). The projects in Belize identify agricultural development as the major driver behind deforestation and show that agricultural investments are expanding as a result of Mennonites’ activities and foreign investments. However, we have shown that this argument can be challenged if the contextual conditions for each project are grasped. It has generally been argued that the use of ‘business-as-usual’ models in agricultural and land use futures should be contested on the basis that land use patterns can change relatively quickly as a result of political, economic, and cultural trends, as well as ecological change and thresholds (Müller et al., 2014). Consequently, business is often not as usual, as tipping points and shocks are difficult to anticipate, and Belize has indeed experienced unforeseen fluctuations and regime shifts in the agricultural sector in the past related, for example, to cattle and rice, often coupled with changes in market preference in Mexico, the USA and Europe. Furthermore, changes in the forest–agricultural frontier tend to be related more to access (e.g., roads) than to sectoral economic trends (Lin et al., 2012).

Regarding validation, our findings suggest that auditors may have a disincentive to submit negative validations, as this may affect their reputation in the business. However, we acknowledge that the VCS has recently modified its auditing requirements, now providing more details about additionality reporting by auditing teams. The standard now also rotates verifiers across projects by ensuring that the private entity doing the first validation or verification cannot do the next one (VCS, 2013). These steps should help both the VCS and potential buyers to distinguish more clearly between robust and weak projects, at least from a mitigation perspective. Overall, however, it is undeniable that the lack of additionality, coupled with validation problems and the projects’ limited engagement with purposive mitigation activities (other than conservation), casts doubt on the long-term mitigation potential of these projects. This challenge has again been documented for other forestry mitigation projects (Bumpus & Liverman, 2011; Corbera & Friedli, 2012; Müller et al., 2014) and explains why new approaches to land-use mitigation promoted by the UNFCCC involve larger policy interventions at the national level and beyond the forestry sector (de Sassi et al., 2015).

Our framework has enabled us to prove the relative lack of attention being given to adaptation in these three carbon forestry projects, as well as the weaknesses concerning mitigation objectives. The projects contribute to conserving biodiversity, protect watersheds, and potentially avoid future land-use emissions, but they have not made a deliberate effort to integrate climate-friendly ecological management or desirable social adaptation objectives. Projects are owned, managed and developed by large landowners and project developers, who exhibit little sensitivity to the existing relationship between forests and local communities. Boden Creek and Bull Run seem to be designed as business projects, whereas Rio Bravo seems to have a wider encompassing approach taking into account both conservation and social development. This evidence demonstrates that carbon sequestration and its potential benefit flows can be privately appropriated for the benefit of a few landowners and result in no or limited benefits for neighboring populations (Corbera et al., 2011). The projects analyzed represent instances of what Fairhead et al. (2012) have referred to as ‘green grabbing’. As elsewhere, such ‘green grabs’ can contribute to reducing the land available for peasant farming, and they can also restrict rural households’ access to forest resources (Golub et al., 2013; Hussein et al., 2013).

Research on the commodification of nature’s ecosystem services has also shown inevitable contradictions with development and poverty reduction goals (Bohm & Dubhi, 2009; Corbera et al., 2007; McAlfee, 2012). In Belize, the projects we examined are also illustrative in this regard, as there are apparent contradictions between achievements to date and, for example, the realization of social safeguards and local development objectives. We can thus consider these projects to be examples of ‘malmitigation’, that is, initiatives that, while potentially reducing greenhouse gas emissions, ignore or pay little attention to the well-being of those affected and/or surrounding people and local realities. Our analysis also contributes to old but ongoing debates around the tensions between conservation and development (Adams et al., 2004; Kaimowitz & Sheil, 2007; Terborgh, 2004), reiterating the need to foster more inclusive partnerships with local communities to maximize environmental and social development outcomes (Roe et al., 2013). Recent research has in fact shown that community-based forest projects can potentially link mitigation and adaptation better than other forms of formal conservation, such as protected areas, since joint ownership of project goals and means can trigger co-responsibility and lead to better enforcement (Porter-Bolland et al., 2012).

The land-use sector in any developing country is probably too complex for one-size-fits-all standards. Thus, the choice of a given conservation strategy is not an either-or question, but rather a matter of choosing the right combination of strategies for the conditions at hand (Salafsky & Wollenberg, 2000). For example, in the case of Belize, where many different ethnic communities with different forest-use and agricultural practices are present adjacent to the projects, this requires of a multi-cultural approach in project design, mixed with a landscape approach that looks beyond the forests concerned (DeFries & Rosenzweig, 2010). The examples of continuous encroaching on to buffering project areas, or the fact that neighboring villages are often eager to secure land rights or access to more fertile lands, should be regarded by project developers as sufficient reasons to engage more significantly with their neighbors.
6. CONCLUSION

Mitigation and adaptation in the forestry sector can in theory be linked to the promotion of more climate-friendly rural development, the enhancement of mitigation, and increases in ecological resilience (Duguma et al., 2014; Guariguata et al., 2008; Locatelli et al., 2011; Matocha et al., 2012; Ravindranath, 2007; Reyers et al., 2009). However, the link in the projects examined in this article has proved elusive. Ecological adaptation has been somewhat, if unintentionally, enhanced through project activities in the three cases, but the social and agricultural adaptation aspects have been ignored. Only a few households across the sites have seen their livelihoods positively or negatively affected by project activities, and projects have been sometimes contested by neighboring communities because of property claims and food security concerns.

We have argued that the barriers that have been found to incorporate adaptation in certified carbon forestry projects are related, on the one hand, to the nature of the carbon markets and the provisions of the standards, which focus exclusively on the mitigation aspects and largely ignore the adaptation dimensions. On the other hand, the barriers to incorporating adaptation in project design and implementation are related to developers’ lack of resources and capacities to deal with both dimensions. Developers do not have the incentive to pursue a stronger link to adaptation, which could change if carbon standards made adaptation mandatory for projects. In line with other studies, we have shown that the projects suffer from weak additionality and lack rigorous enforcement, thus casting doubt on their actual contribution to mitigation. Consequently, the projects have mostly provided noncarbon benefits, such as biodiversity and watershed protection.

Overall, this research indicates that the current carbon market approach based on projects, standards, certifiers, developers, and auditors is unlikely to deliver both mitigation and adaptation, or at best only tangentially. Moving forward would require shifting the focus on to policy programs that support fair tenure regimes, promote sustainable resource management practices in agriculture and forestry, and effectively and legitimately restrict unsustainable resource use with the support of local communities. A focus on single projects and carbon trading seems to be diverting attention from the environmental, socio-economic, and cultural dynamics in which forest and rural people are involved. Therefore, international and national policy frameworks for climate change mitigation should refrain from providing continuous support for narrowly designed carbon projects and promote instead more holistic and territorial-based approaches focusing on the well-being of rural populations. We believe that the framework proposed in this article can effectively contribute to a more robust design and a more successful implementation of these approaches, which should in turn become the foundation for better forest and land use governance in Belize and beyond.

NOTES

1. There are roughly two groups of Mennonites in Belize: traditional/conservative (e.g., Upper and Lower Barton Creek near Bull Run, New Hope/Indian Church near Rio Bravo and Pine Hill near Boden creek), and progressive (e.g., Blue Creek near Rio Bravo). The groups mostly stay apart from one another and have very different lifestyles. For instance, the traditional/conservative groups do not allow the use of electricity or machinery, whereas the progressive groups use agricultural aircraft to spray their fields. They all speak German dialects and have migrated from the United States and Canada during the last fifty years. Large differences in openness and in involvement in the Belizean society exist between the two groups. Although they only account for 5% of the population, they have a huge impact on the Belizean economy and food supply, as their agricultural systems are very productive (Roessingh et al., 2009).

2. Larger trees are the most significant carbon sink in tropical forests (Brown & Lugo 1992; Brown 1997).

3. The principle of additionality has been adopted to avoid giving credits to projects that would have happened anyway. This ensures that projects reduce emissions more than would have occurred in the absence of the project. To prove additionality, proponents have to document that realistic alternative scenarios to the proposed project would be more economically attractive or that the project faces barriers which the implementation of the project will overcome (UNFCCC 2014).

4. Furthermore, climate change threatens coffee production in Central America more generally, as projected increases in temperature and changes in precipitation will most likely reduce crop suitability (Schroth et al., 2009; Laderach et al., 2011). And the leaf rust fungus epidemic that has devastated coffee crops in Central America (Cressey, 2013) also speaks against investing in coffee.

5. For instance, for a lawsuit over a scam when he bought the land (Supreme Court of Belize, 1999) or for a tense relationship with local NGOs and communities (De Vries et al., 2003).

6. According to Barnett and O’Neill (2010) is one type of maladaptation activities that increase emissions of greenhouse gases. Similarly, we could use the term “malmitigation” for an initiative that reduces greenhouse gas emissions but increases vulnerability.

REFERENCES


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