Pathways toward Climate Change Resilience in Monteverde, Costa Rica

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More than a lung cell for our planet, Monteverde is a living, dynamic, and changing ecosystem where ecosystem services emerge as a product of this living dynamic. In this ecosystem, strands of energy link together in a loving, constant, and harmonious dance that is embedded with a human community with increasing awareness, worried by the effects of climate change, which can already be felt in the local climate. Worried by the CO_2 emissions associated with the local use of fossil fuels, the decreases in hydrological processes, and the negative implications for biodiversity and, therefore, the local economy and production, self-motivated local leaders send a message of climate change adaptation to the world, by incorporating local technologies to avoid and reduce GHG emissions and at the same time generate alternative sources of energy for consumption. They have taken on the challenge of carbon neutrality by transparent processes in organizations through measuring, reporting, and verifying their information, while promoting the protection and regeneration of slopes with forest cover to leave a paradise for future generations and one that could be emulated by others. This change in awareness is an indicator that humans can change their ways of thinking, acting, and feeling and continue to do business in a living economy. . .

Edmundo Castro, Carbon Neutral Unit Director, EARTH University

PREFACE

Costa Rica, like other countries in the world, is facing a structural transformation of the economy. We face population growth, as well as an increase in the demand for energy as a result of economic growth. This situation exerts pressure on the use of resources.

If we manage this situation in a negligent and short-sighted manner, it will result in waste, contamination, traffic congestion, and the destruction of soils and forests. If we manage our resources poorly, the quality of life of the inhabitants will decrease severely. Adding to this, emissions of greenhouse gases will increase, with imminent risks for our climate. If the concentrations of greenhouse gases continue increasing, we will experience temperatures in the next 100 years that we have not seen on the planet in the last 10 million years.

The existing relationship between humans and the planet be transformed - it will lead to changes in rivers, sea level, hurricane patterns, deserts. Costa Rica already experiences extreme drought with loss of cattle, problems with water supply, sea level rise, and severe flooding in different regions. These changes will cause people to migrate in search of better conditions. If the need to migrate becomes worldwide, reaching millions of people, past lessons suggest that this can only mean severe and widespread conflict. And as Stern would say: *This simply does not have an off switch, a peace treaty cannot be made with the planet, the laws of physics can't be negotiated with. We are living it and could remain stuck here.*

As a product of this path of unsustainable development, the Monteverde Community Fund, with support from the Global Fund for Community Foundations, took a step forward and decided to create this white paper that introduces the Monteverde Commission for Resilience to Climate Change (CORCLIMA), an inter-institutional group that unites and aligns local actions for resilience to climate change in the Monteverde region, the Monteverde Climate Exchange (MCE), a dynamic online platform that will be used to broadcast local goals, monitor progress toward resilience, and connect people with the necessary financial and technical resources, as well as other concrete measures to mobilize people and resources.

The Monteverde Community, in the northwest of Costa Rica, is aware that economic transformation will happen either way, but shifting toward climate transformation is in its hands. They know that, although climate change presents important challenges, the local stakeholders value care for the environment and are committed to developing capacity in the areas of mitigation and adaptation.

The next two decades are decisive and will determine whether the next 100 years are the best or the worst. Because of this, collaboration exists between local organizations to respond to local calls for climate action that ensure greater community and ecosystem resilience in the region.

This white paper, aligned with Paul Watkiss's vision, deals with adaptation to climate change as a matter of resilient development, combining the challenges of adaptation and development in one strategy. In addition, it emphasizes integrating adaptation with local policies and development strategies, instead of thinking of adaptation actions as single, isolated interventions, each with their own reasoning, which is not always related to the set of national level policy guidelines.

This book is a tool to shift the economy toward one that has low emissions, which, with the Carbon Neutrality Country Program, gives us a huge opportunity, which we can either use or lose. By investing intelligently in our organizations, we will contribute to society with the construction of clean, quiet, safe, attractive, and productive cities.

Together we can have better growth, better climate, and a better planet by becoming agents of change. This way, we will be able to look future generations in the eye and tell them we understood the problems, recognized the risks and opportunities, and that, as a result of our actions, we contributed to the building of a better world.

Kathia Aguilar Martín, Dirección de Cambio Climático

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INTRODUCTION

I invite all of you to swallow an alarm clock because it really does make a difference what we're doing today.

These are the words of Costa Rican Christiana Figueres, describing the urgency with which we must act on climate change. After visiting Monteverde to show her daughters the Golden Toad that she had seen when she was younger and learning that it had gone extinct, she decided to dedicate her life to limiting climate change (McCarthy 2014). She went on to become the Executive Secretary of the United Nations Framework Convention on Climate Change and, in 2015, led world leaders at the COP21 Climate Conference to agree to contain the global temperature increase to 2°C, and to try to keep it to 1.5°C. Drastic reductions in greenhouse gas emissions are needed by 2020 if global temperature increases are going to be contained to 1.5°C (UNEP 2015). As temperatures increase, climate disruptions escalate and the challenge of adapting to these changes increases rapidly.

This reality presents a complex set of challenges that requires immediate action by everyone on Earth. The Monteverde Community Fund is collaborating with other local organizations to respond to local calls for climate action that ensure greater climate resilience for communities, economies, and ecosystems in the Monteverde region of Northwest Costa Rica (Figure 1). Though climate change presents significant challenges, local stakeholders in Monteverde have a strong ethos of environmental stewardship and are committed to developing capacity around mitigation and adaptation.

This paper provides an overview of the implications of climate change specific to the Monteverde region and outlines how local people and organizations can work together to achieve climate resilience on a regional scale through concerted, grass-roots efforts. The authors aim to enable and inspire local residents, business people, farmers, educators, students, public servants, visitors to Monteverde, leaders in the national climate movement, and others to act on climate change

This white paper introduces the Monteverde Commission for Resilience to Climate Change, the Monteverde Climate Exchange and other specific steps for mobilizing people and resources. The Monteverde Commission for Resilience to Climate Change (CORCLIMA by its Spanish acronym) is an inter-institutional group uniting and aligning local actions for climate resilience in the Monteverde region. The commission will link initiatives, sectors, and governance at different scales while incorporating a wide range of perspectives (Figure 2). The work of CORCLIMA will be shared on a dynamic on-line platform, the Monteverde Climate Exchange (MCE), which will transmit locally-defined goals, monitor progress toward resilience, and connect people with necessary financial and technical resources.

CLIMATE CHANGE & RESILIENCE

Climate change *is a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.*

— UN Framework Convention on Climate Change

Resilience *can be defined as the ability of a system – or in this case, a society or community – to absorb disturbances or experience changes and still conserve its essential structure, function and feedback loops.*

—Townsend and Masters 2015

Costa Rica: Total Population per Municipal District				
Municipalidad	District	Total	Men	Women
Puntarenas	Chomes	5,522	2,865	2,657
	Monteverde	4,155	2,022	2,133
	Manzanillo	2,811	1,471	1,340
	Pitahaya	2,211	1.140	1,071
	Acapulco	1,296	649	647
	Guacimal	923	488	435
	Arancibia	665	375	290
Montes de Oro	Miramar	8,298	4,038	4260
	La Unión	1,249	650	599
Abangares	Las Juntas	9,482	4,716	4,766
	Sierra	2,351	1,202	1,149
	San Juan	1,585	802	783
Total		40,548	20,418	20,130

Sourse: 2011 Census, INEC. Map produced by Randy Chinchilla, Monteverde Intitute (2016).

Figure 1. Our concept of the 'Monteverde region' incorporates the immediate municipal district, surrounding communities and the territory of the Bellbird Biological Corridor (outlined in black). The population of the district of Monteverde is 4,155, while the population of the districts (highlighted in distinct colors) represented in the Bellbird Biological Corridor is 40,548. Source: Randy Chinchilla (Monteverde Institute 2016).

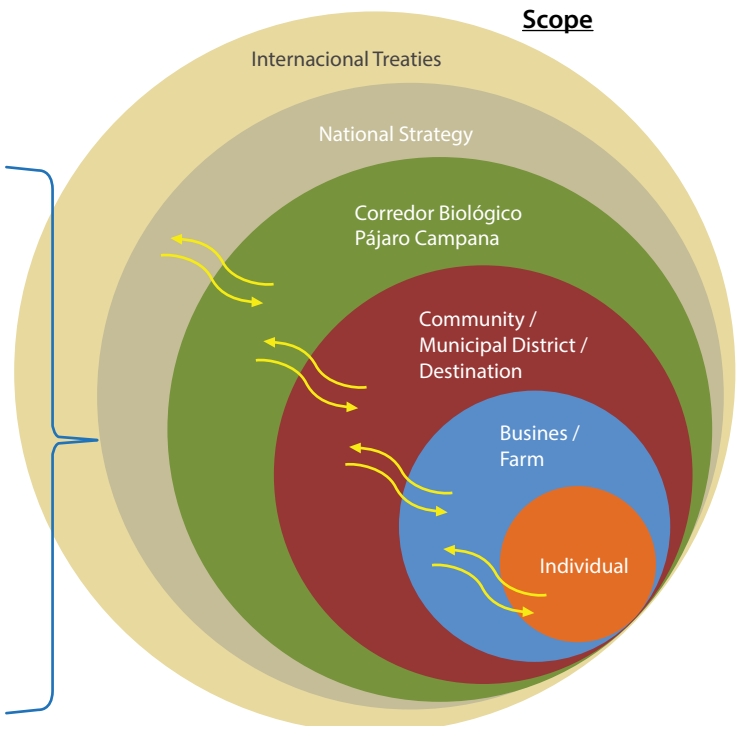

Figure 2. This figure illustrates our approach to building a local climate resilience strategy, which aims to link initiatives, sectors and governance at different scales while incorporating a wide range of perspectives.

CLIMATE CHANGE

AN OVERVIEW

The Intergovernmental Panel on Climate Change (IPCC) and other scientists have shown that human activity is a root cause of climate change (IPCC 2014a). The IPCC reports an increase in combined average warming of land and ocean surface temperature globally of 0.85°C from 1880 to 2012 (IPCC 2014a). Other indicators of changes in climate include increased ocean absorption of carbon dioxide, disrupted evaporation and precipitation patterns, rising sea levels, and decreasing ice coverage. These changes are interrelated. For example, global changes in the hydrologic cycle are linked to shifts in ocean surface salinity which, with surface temperature, indirectly influence the rate and concentration of evaporation and precipitation (IPCC 2014a).

The impacts of climate change on natural systems include:

- *Altered hydrological systems*
- *More frequent extreme weather events*
- *More wildfires*
- *Decreased biodiversity due to changes in habitats and ecosystems*

Impacts on human systems include:

- *Reduced agricultural productivity and predictability*
- *Exacerbated disease patterns*
- *Disrupted community livelihood*
- *Economic instability and increased poverty*

The upper Monteverde region is experiencing longer periods of dryness, higher annual precipitation, and more intense weather events. The increased dryness is due to variation in precipitation, rather than an overall decline. Due to increased sea surface and atmospheric temperatures, clouds are flowing higher over, rather than into, the Caribbean slope of the Cordillera de Tilarán and Monteverde. This causes a decline in dry-season mist and cloud moisture inputs into the forest (Pounds *et al.* 1999; Pounds *et al.* 2006; Foster 2001). Average annual precipitation between 1972 and 2012 increased from approximately 1.5 meters per year to 2.5 meters per year, but the number of dry days during the same period increased from an average of 28 to 82 days per year, an almost threefold increase ("40 Años" 2013). These climatic changes, including more pronounced dry seasons, droughts, and stronger rain and wind patterns, threaten regions like Monteverde (Foster 2001).

IMPACTS OF CLIMATE CHANGE ON THE MONTEVERDE REGION

The lower elevations of the Bellbird Biological Corridor are projected to experience extremely harsh changes: a 30% decrease in average annual rainfall by the end of the twenty-first century and a probable increase in temperature of more than 4°C (MINAET 2009).

GREENHOUSE GASES

The growth in greenhouse gas (GHG) emissions, which are the root cause of climate change, is heavily linked to the combustion of fossil fuels, population growth (IPCC 2014b), and increased consumption of material goods ("Consensus Statement" 2013). **The principal GHGs produced by humans are: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide(N_2O; Penman et al. 2006).** The primary sources of CO_2 emissions are combustion of fossil fuels, deforestation, other land use changes, and cement production. CH_4 emissions are primarily released by agricultural activities, fossil fuel extraction, and organic waste. And N_2O emissions result primarily from synthetic fertilizers (IPCC 2007). Figure 3 illustrates a rough estimate of the flow of greenhouse gases from specific sources in the Monteverde region. Figure 4 shows the growth of global emissions between 1970 and 2010.

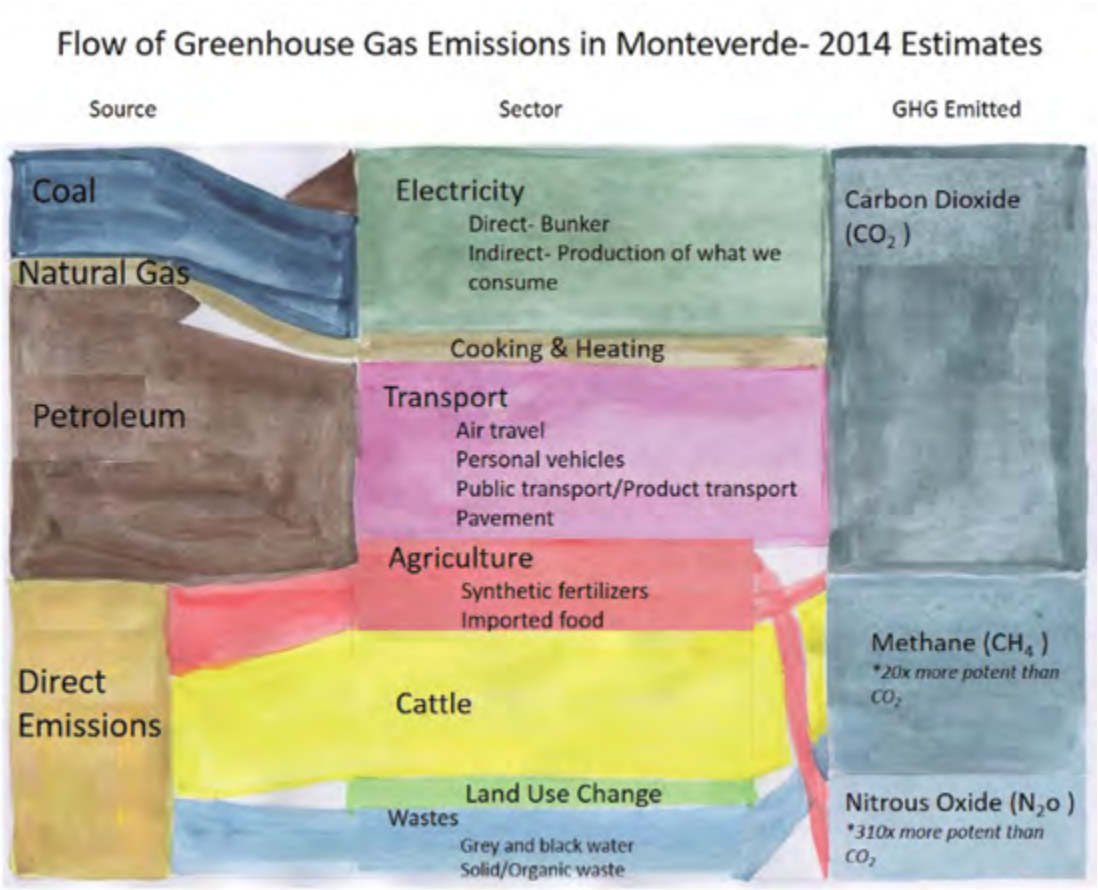

Figure 3. This flow chart shows a very rough estimate of the sources and activities that generate greenhouse gases in the Monteverde region. In reality, transportation probably produces the majority of emissions in the zone.

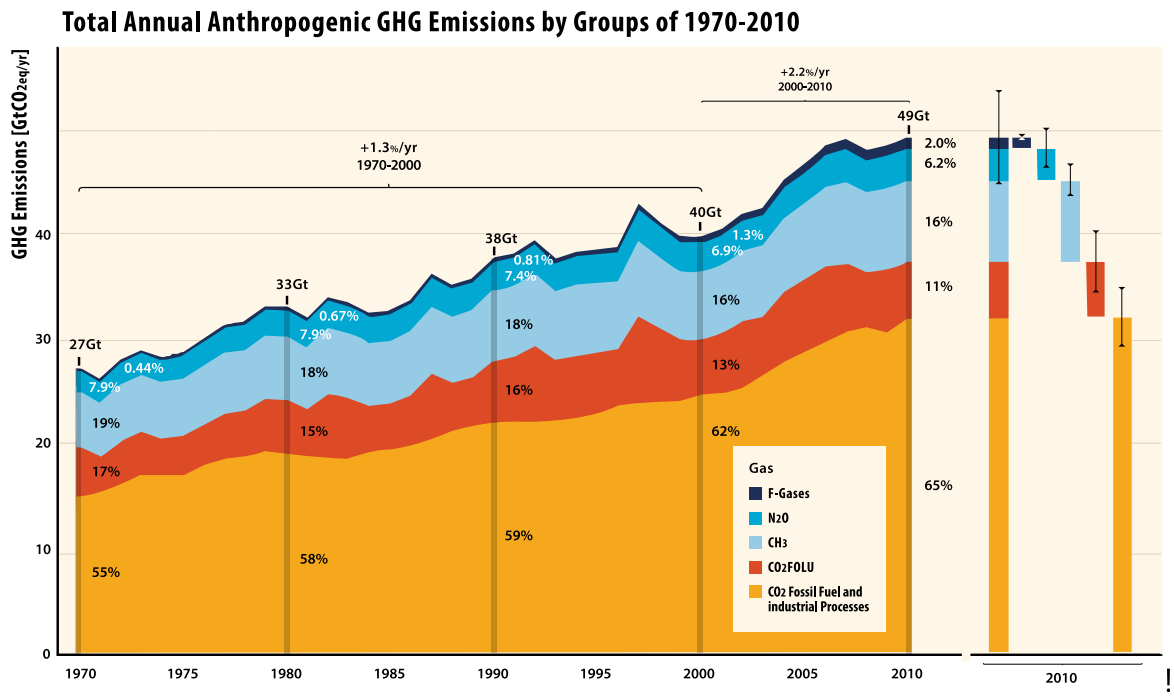

Figure 4. Total annual GHG emissions from human sources. The combustion of fossil fuels and other industrial processes account for approximately 78% of total emissions. Source: IPCC 2014b.

INTERNATIONAL AND NATIONAL POLITICAL FRAMEWORKS

The United Nations' Framework Convention on Climate Change (UNFCCC) is an international treaty that was established in 1992 to collaborate on limiting global temperature increases and adapting to existing climate change. The UNFCCC has 196 participating countries and is informed by the IPCC. At the 2015 Paris Climate Conference (COP21), leaders from 195 nations agreed to contain the global temperature rise to well under 2° centigrade, aiming to keep the increase under 1.5°. In order to meet this goal, global emissions must peak soon and then drop very quickly.

Prior to COP21, 188 countries submitted climate action plans called Intended Nationally Determined Contributions (INDCs), to dramatically slow the pace of GHG emissions. Costa Rica's INDC reaffirms the country's intent to become carbon neutral by 2021 (MINAET 2009; MINAE 2015). The Costa Rican Ministry of Environment and Energy (MINAE by its Spanish acronym) manages national climate change initiatives through the Directorate for Climate Change (DCC by its Spanish acronym) and is guided by the National Climate Change Strategy, which was created in 2009. This policy defines six strategies:

- Mitigation
- Adaptation
- A verifiable system of measuring changes
- Developing capacities and technologies
- Education and cultural change
- Financing

Of these, the principal ones are mitigation and adaptation.

MITIGATION

To date, **mitigation** has been the primary focus in climate policy worldwide. Mitigation includes reducing emissions of GHGs and capturing CO_2 from the atmosphere.

According to the Costa Rican National Climate Change Strategy, emissions are to be reduced according to the following sources.

- Energy
- Transportation
- Agriculture and Livestock
- Industry
- Solid Waste
- Tourism
- Water Supply
- Land Use

One of the most ambitious mitigation policy frameworks is that of carbon neutrality. This process measures total emissions within previously set boundaries (individual, institutional or geo-political), reduces those emissions through specific actions, and compensates the remaining emissions in order to reach net zero emissions (Equation 1).

MITIGATION AND GHG SINK:

Mitigation *is a human intervention to reduce the sources or enhance the sinks of greenhouse gases*

(IPCC 2014b).

GHG Sink *is any process, activity or mechanism that removes a greenhouse gas, or a precursor of a greenhouse gas, from the atmosphere*

(IPCC 2001).

Compensation can include removing carbon from the atmosphere oneself, paying another entity to do so, or paying to reduce emissions elsewhere. The principal way that CO_2 has been taken out of the atmosphere has been through reforestation. Soil and wetland restoration are other natural processes that can sequester carbon, but they are not generally used to compensate emissions.

Equation 1. The basic equation below illustrates how carbon neutrality is accounted for once limits are set.

$$\text{EMISSIONS} - \text{REDUCTIONS} - \text{COMPENSATION} = 0$$

Within the INDCs, mandatory and voluntary carbon neutrality schemes provide a framework for the accounting of emissions and the definition of reduction goals, thereby creating a basis for taking part in national or international carbon markets. Some mechanisms include Reduced Emissions from Deforestation and Forest Degradation (REDD and REDD+), Nationally Appropriate Mitigation Action (NAMA), and Low Emission Development Strategies (LEDS).

Reaching and maintaining carbon neutrality is a continual process that requires transparent accounting of emissions reductions and of carbon sequestration through specific actions. In Costa Rica, companies and organizations can seek carbon neutrality certification through the verification programs of two nationally recognized organizations: EARTH University and *Instituto de Normas Técnicas de Costa Rica* (INTECO). Voluntary carbon neutrality certification of private institutions is giving shape to a national carbon market as entities need to purchase carbon units from certified carbon sinks in order to compensate any net emissions. A need for compensation units, therefore, creates an incentive for landowners and businesses to account for and sell carbon sequestration units in the market, assuming the price of carbon exceeds the opportunity costs (MINAET 2009).

Currently, the only source of certified carbon credits available on the Domestic Carbon Market are 'Costa Rican Compensation Units' (*UCCs* by their Spanish acronym), which are available exclusively through the programs managed by the National Forestry Financing Fund (FONAFIFO by its Spanish acronym). Another option currently being explored in Costa Rica is Verified Emissions Reductions (VERs), voluntary markets that are used internationally to compensate emissions.

ADAPTATION

Even if global temperature changes are contained to 1.5 or 2 degrees centigrade, society will need to adapt to the effects of climate change that are already occurring. Understanding the points of vulnerability for a given community, ecosystem, or economy is a first step in developing resilience strategies.

The National Climate Change Strategy aims to reduce the vulnerability to climate change in the following sectors.

- Water
- Energy
- Agriculture and Livestock
- Fisheries and Coastal Zones Salud
- Health
- Infrastructure
- Biodiversity

Many adaptation measures also meet mitigation objectives. For example, reforestation projects along watersheds meet adaptation goals on maintaining water availability and preserving biodiversity, but also contribute to the mitigation goal of increasing GHG sinks. Since these two concepts are highly interrelated, it is important to identify multi-impact actions that create efficiencies for developing community resilience.

ADAPTATION:

*The UNFCCC defines **adaptation** as "changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change".*

*Adaptation lessens **vulnerability**, the predisposition to be adversely affected*

(IPCC 2001)

RESILIENCE

Mitigating and adapting to climate change create **resilience,** the ability of a social or ecological community to function despite major disruptions.

Local resilience requires multiple stakeholders in the community to focus simultaneously on mitigating emissions while adapting to climate change within a complex natural and socio-political landscape. Community leaders, financiers, public administrators, educators, business people, conservationists, farmers, and others must join together. Local resilience is continually developed over time via coordinated planning, action, learning, and adjustment. This process includes clear understanding of baseline conditions, possible actions, locally-defined priorities, and potential synergies.

SOCIAL READINESS FOR CLIMATE ACTION IN MONTEVERDE

Social readiness is the capacity of stakeholders to address their points of vulnerability. Using principles outlined by the Stockholm Resilience Centre (Simonsen *et al.* 2014; Biggs *et al.* 2015), the following conditions underscore Monteverde's strong social base on which to build greater resilience.

MAINTAIN DIVERSITY

Diverse groups of actors with different roles are critical in the resilience of social-ecological systems, as they provide overlapping functions with different strengths (Biggs *et al.* 2015).

Monteverde has a long history of valuing biological and social diversity. Nine Quaker families moved to Monteverde in 1951, started a cheese factory, and set aside 500 hectares of land as Bosque Eterno S.A. to preserve their watershed. Since this time, Costa Rican and international families have worked side by side to support their families, build community and protect their natural assets.

Expanding on the Bosque Eterno S.A., the Monteverde Cloud Forest Preserve was established in 1972. In 1986 a group of Costa Ricans, Quakers, and North American biologists living in Monteverde founded the Monteverde Conservation League (ACM by its Spanish acronym) "to conserve, preserve, and rehabilitate tropical ecosystems and their biodiversity." The ACM manages the Children's Eternal Rainforest, the largest private reserve in Costa Rica and perhaps Central America. Since then the Santa Elena Reserve, The University of Georgia Costa Rica, the Curi Cancha Wildlife Refuge, the Cloud Forest School, the Costa Rican Conservation Foundation (FCC by its Spanish acronym), the Monteverde Institute, and many others have expanded the regional complex of private reserves.

MANAGE CONNECTIVITY

Connected ecosystems recover more quickly (Simonsen *et al.* 2014; Biggs *et al.* 2015).

Local conservation organizations united in 2008 to create the Bellbird Biological Corridor (CBPC by its Spanish acronym) as part of the Costa Rican National Biological Corridor Program.

Figure 5. Monteverde community members discussing local GHG emissions during a learning exchange. Source: Selena Avendaño 2014.

This multi-stakeholder process aims to re-establish ecological connectivity through the protection and restoration of habitat between the cloud forests of Monteverde and the coastal mangrove forests along the Gulf of Nicoya. Ecological resilience is being built through habitat connectivity for migratory species and watershed protection. Similarly, economic resilience is resulting from new activities such as rural tourism projects, including the Pacific Slope Trail; and resilience in social and governance systems is strengthened through the collaborative efforts across families, community-based organizations, and government institutions. The CBPC provides a venue for developing adaptation strategies that add value to communities, especially in lower altitudes, which have higher ecosystem and species vulnerability to climate change (Piedrahíta López 2013) and fewer economic resources.

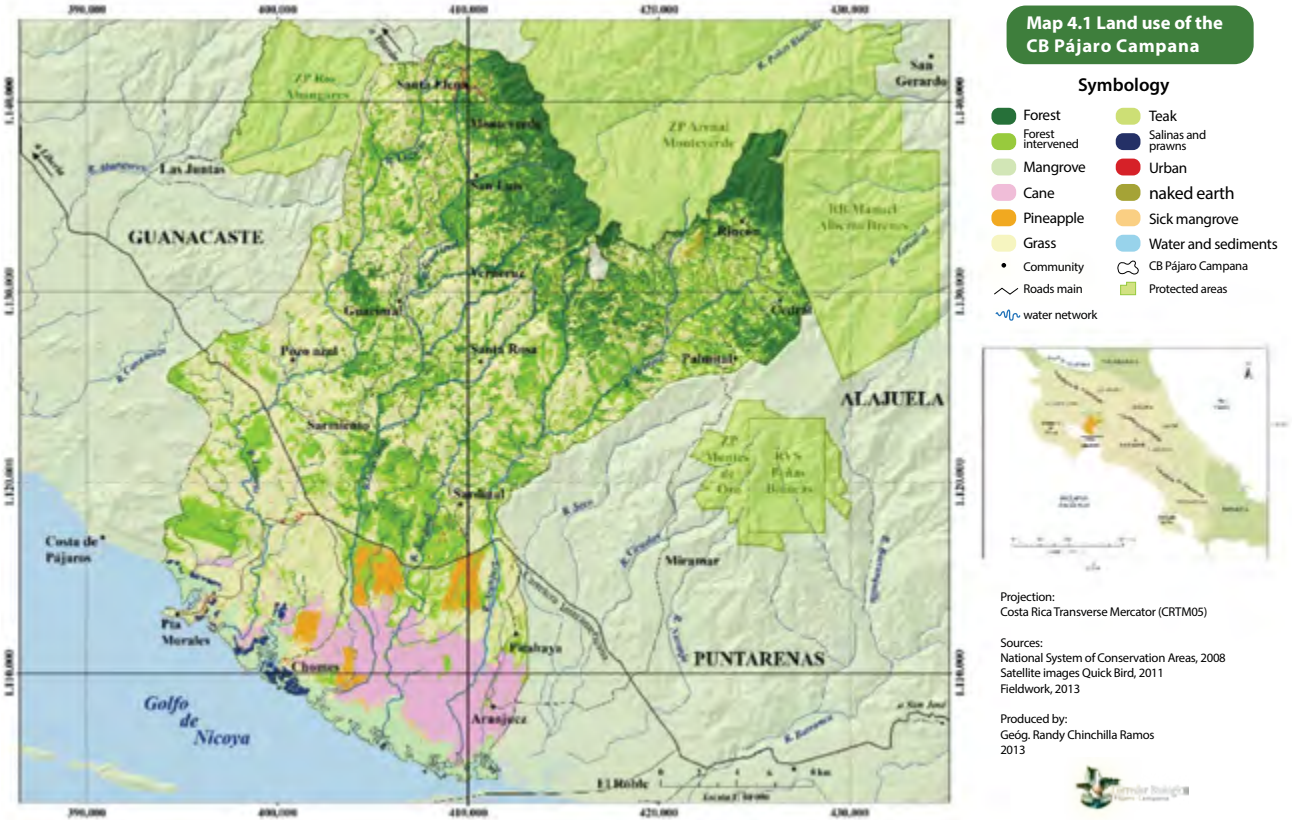

Figure 6. The impact region of the Bellbird Biological Corridor extends from the Pacific top of the continental divide in the highlands of the Cloud Forest, down the Pacific slope, and onto the coast of the Gulf of Nicoya. The dark green in the map represents primary forest, thus illustrating a heavily deforested landscape (approximately 55%).

Figure 7. The Monteverde climate movement emerged as a local response by local residents and organizations who seek climate-oriented policies and projects in the Monteverde region. A climate march with approximately 300 participants in September 2014 was one of the most visible events that gave impulse to local efforts. Source: Mauricio Valverde 2014.

BROADEN PARTICIPATION

Working as a group, where each participant is open to each other's ideas, is the basis for collective action (Simonsen *et al.* 2014; Biggs *et al.* 2015).

The Monteverde climate movement is a broad-based grassroots participatory effort initiated by the more than three hundred people who attended a climate march in downtown Santa Elena de Monteverde in September 2014. Several schools, hotels, and conservation organizations are currently working toward carbon neutrality and the Monteverde Cambio Climático Facebook page (with more than 1,250 "likes") is an active forum sharing news and events. The Monteverde Commission for Resilience to Climate Change (CORCLIMA) Monteverde Climate Commission welcomes anyone interested in working toward making the region climate resilient.

ENCOURAGE LEARNING

Socio-ecological systems are constantly changing which means people need to constantly gather new knowledge and adapt to new realities (Simonsen *et al.* 2014; Biggs *et al.* 2015).

Monteverde has a strong academic presence with a focus on environmental conservation and sustainability. Together, the environmental education programs of the Monteverde

Cloud Forest Preserve, the ACM, and the Santa Elena Reserve work with students in all the local public schools. The Cloud Forest School and the Monteverde Friends School both emphasize the stewardship of the earth and are currently working toward becoming carbon neutral. The Monteverde Institute advances sustainable living at the local and global level through education, applied research, and collaborative community programs. Several programs, including the Council on International Educational Exchange (CIEE), the Education Abroad Program of the University of California, the University of Georgia (UGA), and others, connect international university students with locals to do research on a growing number of projects related to climate change.

Figure 8. Monteverde participants in the EARTH University Organizational Carbon Neutrality Course. Source: Maricella Solis 2015.

Monteverde residents, community leaders and business owners are eager to learn about climate change and how to work toward climate resilience. In December 2014, 25 locals participated in a field trip visiting real life examples of mitigation in the region to "demystify climate action." In May 2015, forty-one people participated in a course on Organizational Carbon Neutrality given by Dr. Edmundo Castro of EARTH University, co-sponsored by the Monteverde Institute and the Monteverde Community Fund (Figure 8). Sixty participants in the current adult education group at the local Catholic Church are reading *Laudato Si*, Pope Francis's encyclical on climate change. The Monteverde Community Fund has featured in its events speakers from the DCC, FONAFIFO, and other national foundations working on climate change issues. Climate resilience was the key theme of the 2015 Monteverde Community Fund *Sustainability and Philanthropy Fair*. Each of these activities increases general awareness, deepens local knowledge of the varied aspects of climate change, and highlights tangible alternatives for action.

Residents are increasingly aware of which emissions need to be reduced and how. In 2011, members of the local climate movement gathered hundreds of ideas from local people to create a checklist for how to reduce emissions in the form of a poster, which is now well distributed in the zone. Many of these ideas are already in action, but others are still in process, individually, institutionally and collectively.

PROMOTE POLYCENTRIC GOVERNANCE

Networks where institutions collaborate to create and enforce policies have greater success in adapting to change (Simonsen *et al.* 2014; Biggs *et al.* 2015).

The Monteverde District, governed by the local municipal council, has eight permanent commissions and seven special commissions with community-wide participation, several of which relate to climate change: the Commission for the Management of Solid Waste (COMIRES by its Spanish acronym), the Commission for the Management of Water Resources (CEGIREH by its Spanish acronym), the Environmental Education Commission (CEAM by its Spanish acronym), the Library Commission, and the Sister Cities Commission. The municipal council's new five-year plan includes supporting the National Climate Change Strategy. Each of these commissions, as well as other local organizations, will be aligning their work with the National Climate Change Strategy. Together they will guide the development of "bottom-up" policies and incentives for systemic mitigation and adaptation.

On a regional level, local research often informs municipal and regional policies. The Monteverde Arenal Bio-region Initiative (MABI) was founded in 2014 to bring together researchers, educators, and conservationists in order to conserve the ecosystems of the region through shared problem-solving, data and resources. The group promotes collaborative work and shared information through an annual conference and a web-accessed database, the Monteverde Arenal Bioregion Database (MABD).

MITIGATION AND ADAPTATION NEEDED IN THE MONTEVERDE REGION

This section includes an overview of each of the sectors outlined in the National Climate Change Strategy, focusing on specific needs for mitigation and adaptation in the Monteverde region. Understanding the complexity of these systems will help lay the foundation for broad-based, collective actions. Throughout this section, actions that have multiple impacts are highlighted. These are just some of many possible activities that can both mitigate and adapt to climate change.

ENERGY

Over 90% of the electricity in Costa Rica is produced from hydroelectric, wind, or geothermal sources. Demand for energy is increasing. Drought is more and more frequent, reducing output from hydroelectric systems. Record high temperatures in some regions of the CBPC increase the use of air conditioning. To satisfy this demand without increasing emissions, the country will need to continue to increase the production of renewable energy, including solar. Nationally, there has been a movement toward locally generated energy that is tied into the commercial grid.

Figure 9. Solar panels installed on the roof of the Monteverde Friends School. Source: Katy VanDusen 2014.

In the district of Monteverde and the CBPC, the vast majority of households depend on the Costa Rican Electricity Institute (ICE by its Spanish acronym) to satisfy their electrical needs.

In Monteverde, a handful of families and organizations, including the Santa Elena Interactive Library and the Monteverde Friends School, have installed photovoltaic solar panels for generating electricity. More families have installed solar water heaters. In addition to increasing locally generated energy, it is important to reduce energy use by increasing efficiency. Reducing the number and brightness of street lights would reduce emissions and the negative impact on biodiversity (Anderson-Huxley 2015).

TRANSPORTATION

Nationally, the greatest source of CO_2 emissions is from transportation (MINAET 2009). This amount is growing as the number of private vehicles in Costa Rica grows by 5% each year (Cordero 2015). These same trends are occurring in Monteverde. In 1980, Monteverde had one round-trip bus to Puntarenas a day and a handful of cars. Most people moved on foot, horseback, motorcycle, or in one of the trucks that delivered milk to the cheese factory. Now Monteverde has improved bus service to Puntarenas, Tilarán, and San José, but public transportation within the region is limited. Most of the population is now dependent on personal vehicles, thus increasing emissions. Data collected at the Monteverde Friends School from January to May 2016 indicated that over 95% of the emissions from school activities come from transportation of students and staff (Turner 2016; Bollin 2016; MFS Carbon Neutrality Committee pers. comm. 2016).

Figure 10. Electric vehicles in Monteverde. Source: Rodrigo Alvarado 2015.

Possible ways of improving local transportation while lowering emissions include the following:

- Continuing to install sidewalks
- Encouraging the use of bicycles by installing bike racks
- Providing incentives for low emission, hybrid, and electrical vehicles, including electric golf carts and electric bicycles
- Sharing rides
- Buying locally produced items when possible
- Local collective transportation, such as small buses or colectivos

The largest transportation footprint in Monteverde is indirect: the air travel of local residents and of more than 250,000 tourists that visit Monteverde each year. While reducing this footprint may be a major challenge, these visitors also offer an opportunity for both education and compensation.

multi-impact action

Colectivos (collective small bus transportation)

- In much of Latin America, colectivos are a common, convenient form of transportation within a region
- Emissions are lower when people share transport
- The cost per person is lower
- Total income for the bus owner is higher
- Fewer vehicles reduce traffic congestion

AGRICULTURE AND LIVESTOCK

Dairy farming is an important activity in Monteverde, supplying an estimated 5% of total dairy products nationally (MAG 2014). In this sector, mitigation goals call for measures to reduce GHG emissions and adaptation requires measures to maintain productivity levels (Smith *et al.* 2008; Nardone *et al.* 2010). All types of manure produce CH_4 and chemical nitrogen fertilizers produce N_2O. In Costa Rica, agriculture and livestock production rank second in total GHG emissions after transportation, and first in emissions of CH_4 and N_2O (MINAET 2009).

While a clear assessment and forecast of the implications of climate change on agricultural productivity in the region are not available, predictions of unreliable precipitation patterns and observed changes in water availability and temperature begin to point to areas of vulnerability (Gay et al. 2006). Along with changes in primary economic activity, food security has decreased at the local level, which calls for a resilience strategy that brings opportunities that benefit local food production and distribution capabilities (Himmelgreen *et al.* 2006; Himmelgreen *et al.* 2012). Such a strategy could have a three-fold effect: decreasing dependence on less nutritious processed foods, creating economic efficiencies for individual small farmers and decreasing transport-related GHG emissions.

Coffee production in the Monteverde region contributes to the livelihood of local families and is also a selling point in tourism. Changes in precipitation and temperature are altering local flowering and production of coffee plants (Gay *et al.* 2006; Peters and Carroll 2012). Observations of bee pollination and production patterns on local coffee farms suggest that flowering and initial fruit set rates decrease in years of unusual rainfall (Peters and Carroll 2012). Another point of vulnerability is the increased incidence of fungi, such as coffee leaf rust, which has impacted coffee production in coffee growing areas, including Monteverde. Adaptation by seeking rust-resistant varieties of coffee requires technical and financial resources that exceed the capacity of small farmers (Fox *et al.* 2015). Additional adaptation opportunities include shade-grown coffee systems for water retention and diversifying economic activities (Peters and Carroll 2012; Fox *et al.* 2015).

As a climate strategy is developed, opportunities for integrating silvo-pastoral practices regionally should be strongly sought to create a nexus with conservation objectives (Townsend and Masters 2015). Agroforestry and silvicultural practices provide a host of ecological services that in turn improve the livelihoods of rural agricultural communities (Harvey et al. 2005). National and local policies affecting the agricultural sector can provide incentives for landowners in the region to improve practices, such as the use of live fences, windbreaks, and isolated trees, in order to increase pasture and coffee-plant health, as well as enhance ecological functions, serving natural resource conservation and biodiversity purposes (Harvey *et al.* 2004; Harvey *et al.* 2005).

Under the national strategy towards carbon neutrality, Costa Rica is partaking in the Nationally Appropriate Mitigation Action (NAMA) scheme for the coffee and cattle farming sectors. Both initiatives are aimed at reducing GHG emissions in coffee and cattle farming practices while increasing carbon sequestration capabilities within farms. Joining the country's carbon market, the strategy opens opportunities for farms in the coffee and cattle sectors to sell UCCs, or Costa Rican compensation units. NAMA coffee aims to reduce 15% from agricultural emissions by increasing tree coverage on farms, reducing nitrogen use

Figure 11. Local coffee production. Photo by Mauricio Valverde.

in fertilizers, increasing energy efficiency in processing, and reducing methane and carbon emissions from waste-water and pulp treatment processes (Nieters *et al.* 2015). Similarly, the NAMA cattle farming strategy aims to capture approximately 4 million tons of CO_2 by 2030 through a variety of practices such as an increase of agro-forestry systems and improved pasture management practices, among others (MAG 2014). Under these strategies, farmers can benefit from the national Payment for Ecosystem Services scheme; for example, coffee farms with 70% forest cover can expect annual payments of $70/ha/yr.

Biodigesters have been installed on over a dozen farms in the Monteverde region, reducing CH_4 emissions from animal and organic wastes. Many dairy farmers have recently switched to irrigating their pastures with manure mixed with water as a way to reduce the use of chemical fertilizers. Most coffee farmers now use solar drying systems and compost their organic waste.

multi-impact action

Agroforestry

Planting trees with other farm activities mitigates climate change by:

- Taking carbon out of the atmosphere

And reduces vulnerability by:

- Providing windbreaks and reducing soil erosion
- Enhancing infiltration of rainwater and slowing runoff
- Providing food, live fences, shade for coffee, and lumber
- Creating habitat for wildlife
- Beautifying landscapes

INDUSTRY

Monteverde's main industry that processes raw materials is cheese-making. *Productores de Monteverde* was founded by the original Quaker settlers in 1954 and was the principal economic activity in the zone until the growth of tourism in the 1990's. The cheese factory is now owned by Sigma Alimentos S.A., a multinational company based in Mexico. Their environmental management plan includes the following measures:

- Reducing the environmental impact of transportation
- Reducing water use and improving water treatment
- Energy efficiency
- Reducing and effectively manage solid waste
- Improving packaging (Sigma Alimentos 2014)

Local Sigma employees at *Productores de Monteverde* are committed to learning more about and acting on climate change. In addition to working toward these goals at the factory, staff is working to improve the management of their pig farm and lagoons, which were built in the 1990s to process whey and treat wastewater. Monitoring and reducing CH_4 emissions from this farm is a high priority.

multi-impact action

Biodigesters

Used to capture CH_4 from decaying organic waste such as manure, pulp, or kitchen waste. They reduce emissions by:

- Converting CH_4 to CO_2 when the gas produced is burned. CH_4 is 22 times more potent than CO_2 as a GHG
- Producing organic fertilizer which returns carbon to the soil and can be substituted for chemical fertilizers that emit NO_2

They serve as an adaptation action by:

- Purifying waste water to meet the standards of the Ministry of Health
- Provide gas for cooking, heating or electricity production

Figure 12. Productores de Monteverde, now owned by Sigma Alimentos, is the principal industry in Monteverde. Source: Katy VanDusen.

SOLID WASTE

Most solid waste in Monteverde is transported to Tecnoambiente, a regional landfill near Miramar, where it is buried under a cap of cement. Solid waste sent to landfills produces methane when organic material decomposes anaerobically. At Tecnoambiente, the CH_4 is vented and converted to CO_2 by burning it without using it for any purpose. Most of this CH_4 is produced by food waste. Approximately 40% of solid waste generated in the district of Monteverde is food waste (Welch 2013). Separating organic waste and recyclable materials can significantly reduce the amount of trash being transported to the landfill. Organic waste collected separately from other trash can be made into compost by farmers, fed to pigs, or processed in biodigesters on a household or community scale.

Septic tanks are another source of CH_4. Biodigesters can also be used to process this waste and lower emissions. The UGA campus in San Luis processes all their waste water in a biodigester that produces gas for cooking in their kitchen. The Hotel Belmar has also installed a biodigester to process sewage.

Figure 13. Biodigesters (left) at the UGA campus in San Luis provide methane gas for cooking and keeping food warm in their dining facilities (right).

The Commission on the Integrated Management of Solid Waste (COMIRES) has been very effective at promoting recycling in the district and is beginning to investigate how to process organic waste.

TOURISM

In the tourism sector, efforts to create carbon neutral destinations are an important element of the *Davos Declaration on Climate Change and Tourism,* as 5% of global GHG emissions are linked to tourism (Gössling 2009). Most of this is through air travel.

Tourism now dominates the economy of Monteverde. The first eco-tourism enterprises began to emerge in the late 1970's and the number of visitors reached over 100,000 per year at the turn of the century (LaVal 2004). Monteverde has since become an important destination for ecotourism and illustrates the high value that is placed on tropical forests in the tourism sector (Menkhaus and Lober 1996). It is now estimated that more than 250,000 tourists visit Monteverde each year.

Given the importance of the ecological health of the fauna and flora of the cloud forest for tourism, this sector, and by extension the local economy, is vulnerable to changes in climate as the natural conditions that characterize Monteverde as a cloud forest destination dissolve. As clouds rise, the forest may no longer be a cloud forest, and iconic species such as the Resplendent quetzal or the Three-wattled bellbird may disappear as the Golden toad and the Monteverde harlequin frog already have. The protection of the natural ecosystems is imperative for economic resilience. In addition, it would be wise to diversify options for tourists without risking losing the concept of the Cloud Forest.

Figure 14: Ecotoursim dominates the local economy. This sector produces emissions, mostly through transportation, and is vulnerable to the changing climate's effect on water availability, disease vectors and biodiversity. Source: Mauricio Valverde.

Fear of increased vectors that transmit tropical diseases such as Zika and Dengue has already caused tourists to choose alternate destinations other than Costa Rica. Controlling the vectors that spread disease and dispelling fears with honest communication should help.

Other vulnerabilities that affect tourism include unreliable water supply and quality, cancelations due to extreme climatic events, and electricity and internet outages (Cooperación Alemana para el Desarrollo 2016). These are discussed in the sections on water and infrastructure.

A visit to Monteverde motivated Christiana Figueres to act on climate change. It has the potential to motivate many others to act as well. The presence of visitors from around the world is an opportunity for education and for generating income for local mitigation projects. Some naturalist guides already discuss the impacts of climate change with their clients. Some of these visitors may even deny the existence of climate change. Visiting Monteverde may be a chance to open the hearts of these people to the reality of climate change and inspire everyone to do what they can to reduce and mitigate their emissions. People who work in tourism can explain ways that Monteverde is addressing climate change, how visitors can reduce emissions, and how they can offset their travel footprint in the Monteverde region.

WATER SUPPLY

Water supply is essential for both mitigation and adaptation within all sectors. For forests to capture carbon from the atmosphere, trees need adequate water to grow. Drought conditions also increase the risk of forest fires, which in turn release more carbon.

multi-impact action

Installing Dry Toilets

- Cuts water consumed by individuals by more than half
- Reduces CH_4 emissions
- Restores soil

They can be pleasant and sweet-smelling if done right!

Though Monteverde has experienced an increase in average annual precipitation, it is uncertain how consistent the groundwater supply will be with changes in precipitation and infiltration patterns, or how adequate the supply will be in the face of growing demand from population and economic growth.

While local water associations continue to invest in infrastructure for capturing, storing, and distributing water, these strategies may not satisfy the demand in the long term unless measures are taken soon. Riparian eco-systems downstream are already impacted by the amount of water that is diverted for potable water and irrigation. Toward the end of dry season, the Guacimal River is reduced to a rivulet when it reaches the mangroves and the Gulf of Nicoya. Improved data collection is essential to accurately monitor the supply of and demand for water.

In 2016, CEGIREH initiated a baseline study of cultural, social and environmental factors related to wastewater management in the Monteverde District. The data gathered will influence the 2012-2017 Strategic Plan of Integrated Management of Municipal Wastewater in the Monteverde District (CEGIREH 2015). Incentives and mechanisms to use water more efficiently, capture rainwater, and reuse waste water need to be implemented and explored. Installing water-free urinals and toilets that use a small amount of water or none at all would save water that until now has literally been flushed down the toilet.

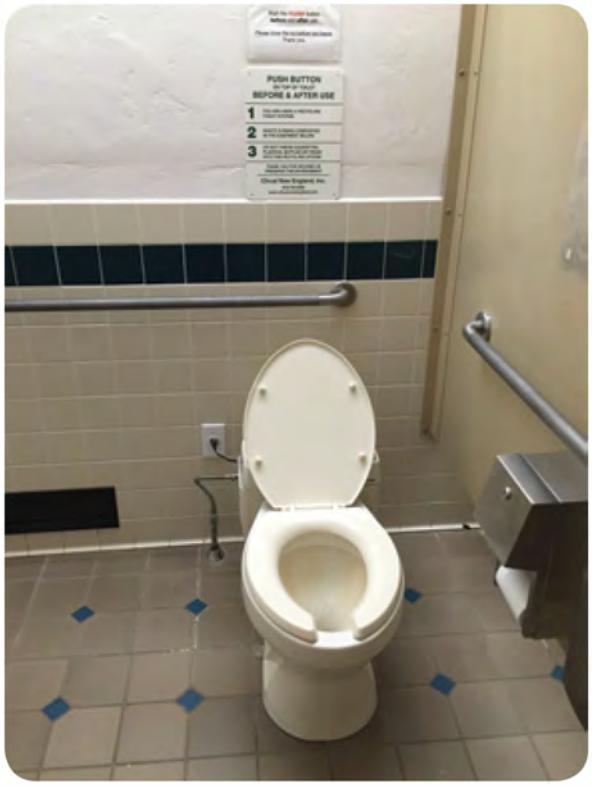

Figure 15. This composting toilet uses a little soap and no water. Source: Katy VanDusen.

LAND USE

As the global population grows, the amount of arable land per person in the world has been shrinking and that land is increasingly degraded by erosion, contamination, salinity and desertification. In order to increase the amount of land in production, forests are being cut down globally at a rate of approximately 30,000 square kilometers per year (FAO 2012). After the combustion of fossil fuels, deforestation is the primary source of emissions of CO_2

multi-impact action

Reforesting Aquifer Recharge Areas

- Sequesters carbon
- Protects freshwater springs
- Connects forest to support biodiversity
- Beautifies the landscape

In Costa Rica, major deforestation occurred in the first part of the last century. Although regional conservation efforts reversed this trend along the Atlantic slopes of the Monteverde-Arenal Bioregion, approximately 55% of the 66,400 hectares that encompass the CBPC is deforested (Chinchilla 2013). Much of this deforested land, especially on degraded hills and along streams and rivers, has the potential to be reforested and serve as a carbon sink. The area currently in forest also needs protection. Primary forests function as important carbon reserves and may continue to sequester carbon (Stephenson et al. 2014).

Conservation organizations, communities, businesses, and many farmers and land owners are committed to restoring forests in the region, especially for water conservation. Since 2006, the FCC has distributed more than 180,000 trees of 93 native species. More recently, they have worked with other local partners in San Luis and Guacimal in order to establish tree nurseries with species native to lower elevations. In total, the FCC has worked with over 150 residents from Monteverde to Guacimal (Hamilton pers. comm. 2016). The CBPC is working closely with rural aqueduct associations (ASADAs) in order to direct reforestation efforts toward degraded aquifer recharge areas.

Figure 16. Deb Hamilton explains the carbon sequestration of trees planted by FCC. Source: Selena Avendaño 2014.

Growing trees and regenerating forests requires resources for protection from weeds, wind, fire, livestock, and poachers. Ongoing support is needed for tree nurseries. A cost-benefit analysis of some species shows that for some trees, weed removal three times per year within the first year is adequate, assuming that survival and regrowth are minimally affected by surrounding vegetation (Hamilton *et al.* 2015). Fencing is required to prevent livestock from eating and trampling small trees.

multi-impact action

Local Fire Brigades

- Prevent CO_2 emissions due to fire
- Minimize soil degradation
- Help preserve aquifers
- Save infrastructure
- Create community
- Protect the habitat of the flora and fauna

The needs of landowners that are reforesting have the potential to be met by the growing demand from carbon neutral organizations for certified UCCs and from conscientious travelers and philanthropists interested in non-certified compensation. In developing opportunities for payments for environmental services, aligning market-based mechanisms with local conservation values will be necessary for success. Although forests have regrown in the CBPC during the last few decades, this has been more due to farm abandonment and agricultural intensification than because of market-based mechanisms. Many landowners do not have an adequate understanding of or trust in FONAFIFO and UCCs. On the other hand, many praise the former *Bosques en Fincas* program of the ACM for raising their environmental awareness (Allen 2016).

Large scale agriculture is intensifying in the lower part of the CBPC. Major crops include pineapple, sugar cane and cotton. Agricultural land, whether in large or small scale production, needs good stewardship. Soil rich in organic matter, which in turn is rich in carbon, is more productive. Adding organic material to soil improves its structure and fertility while potentially removing carbon from the atmosphere. In contrast, when vegetation and soil are burned, carbon is released. Fire is becoming a common threat to farmland and regenerating forest as temperatures and drought increase. Preventing and controlling fires are essential.

Figure 17. Fire brigades in Guanacaste create firebreaks to prevent the spread of forest fires. Source: Felix Huertas Salazar.

FISHERIES AND COASTAL ZONES

In the lowest part of the CBPC there is a substantial need for the reforestation and protection of mangrove forests and for implementing responsible fishing practices. Mangroves are a highly endangered ecosystem that provides habitat for mollusks, breeding grounds and nurseries for fish, carbon sequestration and storm surge protection. Many of the small coastal communities within the CBPC have fishers' associations that are motivated to lead this effort. In addition, many of the fishers in the associations are working to produce and harvest seafood sustainably. The CBPC has begun to support these fishers by helping them to market sustainable seafood to local restaurants in Monteverde.

HEALTH

Although the degree and extent are still uncertain, climate variability is expected to increase the incidence of diseases such as asthma, flu and diarrhea, as well as increase exposure to disease vectors such as rodents and mosquitoes (Githeko *et al.* 2000; Kovats *et al.* 2001; Retana *et al.* 2008). According to the Santa Elena Public Clinic, lower altitudes have epidemiological profiles marked by transmittable diseases such as dengue fever and chikungunya (Córdoba Vargas 2015). Dengue fever returned to Costa Rica in 1993 and has since expanded nation-wide (Cantero and Fonseca 2007; Retana *et al.* 2008). The *Aedes aegypti* mosquito, carrier of the dengue virus, is common in the lower elevations of the CBPC but has not historically been found in the higher altitudes of the Monteverde region. To date, all local diagnoses of these diseases indicate they were contracted while patients travelled in lower altitudes (Córdoba Vargas 2015). The lowlands of the Central District of Puntarenas, to which the CBPC belongs, are reported to have the second highest incidence of dengue fever in the country (Retana *et al.* 2008). As temperatures rise, the range of *A. aegypti* is expanding and the incidence of the diseases it transmits is expected to spread to higher altitudes.

Figure 18. *Aedes aegypti* mosquito. Source: www.vector.caltech.edu.

Other diseases that are being affected by increasing temperatures include the Zika virus, also spread by *A. aegypti*, and the vector-borne Chagas disease (Moreno 2006). In addition, a doctor in the Santa Elena Public Clinic links higher rates of diarrhea in dryer years to improper storage and handling of water (Córdoba Vargas 2015). When water is in short supply, people often store it in open, large receptacles that are not clean and in which mosquitos breed.

The main adaptive measure for health is educating people to:

- Store water properly
- Eliminate standing water where mosquitos can breed
- Use mosquito nets on beds, and
- Use proper hygiene

Table 1: Groups of diseases associated with climate change prioritized by the Costa Rican National Meteorological Institute (IMN by its Spanish acronym) and the Ministry of Health. This was before the appearance of Zika in Costa Rica. Source: Retana et al. 2008

Disease group	*Disease*
Vector-transmitted	Dengue Malaria
Cardiorespiratory	Asthma Cardiopathy
Gastrointestinal	Diarrhea
Parasitic	Abdominal angiostrongilosis

INFRASTRUCTURE

Sustainably designed infrastructure can reduce dependency on fossil fuels and vulnerability to climate change. Buildings designed to use natural lighting and stay cool and dry without air conditioning use less energy. As cement production emits about five percent of global GHGs (UNFCCC) and this amount has been increasing (Levin 2013), it is better to minimize its use. Roads that facilitate pedestrians, bikes and collective transportation encourage transportation with lower emissions.

Climate change predictions forecast more unpredictable and pronounced dry and wet periods, in addition to stronger storm systems (Gay *et al.* 2006). Public infrastructure such as roads, buildings, water systems, telephone, internet and electrical lines are vulnerable to these extreme weather events. The lower elevations are especially susceptible to flooding while the higher elevations are predisposed to landslides. All new

construction needs to anticipate the likelihood of these events and prepare accordingly.

multi-impact action

Building with Wood from Sustainably-grown Native Trees

- Stores carbon
- Tends to be cooler than cement, reducing the need for air conditioning
- Supports sustainable forestry and habitat for flora and fauna

BIODIVERSITY

Changes in climate conditions threaten to alter ecosystem dynamics at different elevation ranges, threatening a loss of biodiversity, including some flagship species of great ecological and economic value such as the Resplendent quetzal and the Three-wattled bellbird. A cloud forest ecosystem as found in Monteverde is comparable to that of an archipelago, given that the altitudinal isolation helps drive unique high levels of speciation, endemism, and climate sensitivity (Foster 2001). Increased competition for resources between species due to climate-induced migrations, changing habitat conditions, and a higher incidence of pathogens are some of the symptoms of the factors driving biodiversity loss (Pounds *et al.* 1999; Pounds *et al.* 2006; Foster 2001). For example, epiphytes, which play a key role in water and nutrient cycles, are hypersensitive to humidity, and hence are among the most vulnerable in cloud forest ecosystems (Foster 2001; Richardson *et al.* 2000; Masters *et al.* 2005).

Many studies show changes in species distribution and biodiversity loss in Monteverde. Observed changes in the distribution of bird species and the extinctions of lizards, frogs, and toads in Monteverde have been linked to lower mist frequencies and increased temperatures resulting from regional climate shifts since the 1980s (Pounds *et al.* 1999; Pounds *et al.* 2005). For example, bird species from lower pre-montane forests on the Caribbean and Pacific slopes, such as Golden-crowned warblers (*Basileuterus culicivorus*), Lesser greenlets (*Hylophilus decurtatus*), and Keel-billed toucans (*Ramphastos sulfuratus*), have been observed to progressively nest higher in montane forests (Pounds et al. 1999). Highland species, such as the Sooty-capped chlorospingus (*Chlorospingus piliatus*), the Yellow-thighed finch (*Pselliophorus tibialis*), and the Fiery-throated hummingbird (*Panterpe insignis*) have diminished in number (Moreno 2015).

Figure 19. The recent, widespread amphibian extinctions in seemingly undisturbed highland forests may attest to how profound and unpredictable the outcome can be when climate change alters ecological interactions (Pounds *et al.* 1999). This photo of *Bufo periglenes* in amplexus was taken in Monteverde in 1982. It has not been seen since 1989 and has been declared extinct. Source: Frank Joyce.

Similarly, bat species richness in Monteverde has increased, in part due to climate change (LaVal 2004). Rainfall sensitive populations of lizards, such as the Cloud-forest anole (*Norops tropidolepis*) and the Montane anole *(N. altae*), apparently disappeared suddenly in the late 1980s (Pounds *et al.* 1999). Frog and toad losses in Monteverde include the extinction of the Monteverde harlequin frog (*Atelopus sp.*) and the Golden toad (*Bufo periglenes*) in the late 1980s as well as episodic extinctions of others following years with extreme climatic conditions (Pounds *et al.* 1999; Pounds *et al.* 2006). The climate-linked epidemic hypothesis begins to explain this extinction by pointing to an increase in fungus and other diseases after unusually warm years (Pounds *et al.* 1999; Pounds *et al.* 2006).

As conservationists continue to try to preserve and understand the great biodiversity in Monteverde, it is not enough to set aside the land. The different forms of life in conserved areas are affected by much larger forces. People who can influence those larger forces, from local residents to national policy-makers to multinational corporations, need to understand the impact that their actions have on climate change and, in turn, the many life forms in Monteverde and on this planet.

WORKING TOGETHER TOWARD CLIMATE RESILIENCE

The MCF proposes a five-fold strategy in order to cultivate capacity and collaboration around climate resilience.

1. Create a network of leaders that promote synergies, efficiencies and innovation for climate resilience

2. Monitor GHG emissions and sequestration, as well as indicators of adaptation on a regional scale

3. Identify, prioritize and implement actions that maximize impact with efficient use of resources

4. Develop local resource mobilization strategies that can be sustained over time and leveraged

5. Create an on-line platform for sharing information, resources and inspiration

Figure 20. Monteverde community members working in participatory planning groups. Source: Monteverde Community Fund.

CORCLIMA: THE MONTEVERDE COMMISSION FOR RESILIENCE TO CLIMATE CHANGE

Established in 2016, the Monteverde Commission for Resilience to Climate Change is uniting and aligning the efforts of local organizations, businesses and individuals to make the Monteverde region climate resilient. All of the organizations and businesses already mentioned in this paper are invited to participate and most are already committed. The commission has a core committee with representatives from the Monteverde Community Fund and the Municipality of Monteverde that is coordinating a network of sub-committees. Using the framework outlined by the National Climate Change Strategy, there will be a sub-committee to focus on each of the following themes:

- Energy / electricity - mitigation and adaptation
- Transportation - mitigation and adaptation
- Agriculture and livestock- mitigation and adaptation
- Industry - mitigation and adaptation
- Solid waste - mitigation and adaptation
- Tourism - mitigation and adaptationn
- Water - mitigation and adaptation
- Land Use - mitigation and adaptation
- Health - adaptation
- Infrastructure - mitigation and adaptation
- Biodiversity - adaptation
- Fisheries and coastal zone – adaptation

Each group will measure baseline information, prioritize actions and plan for their implementation.

In addition, the following sub-committees will support the groups above:

- Monitoring
- Education and Awareness
- Communications
- Financing

The approach towards resilience needs to be sustainable to avoid burnout. Whenever possible, each group will work within existing committees and organizations that are already focused on their sector, to avoid duplicating efforts. Each sub-committee serves as a mutual support group that fortifies existing efforts and generates efficient responses to the specific challenges of climate change that affect their sector most.

MEASURING THE BASELINE AND MONITORING PROGRESS

Monitoring emissions, mitigation and adaptation over time is essential to measure progress. The first step is to gather baseline data on appropriate indicators. Each sub-committee will initially do this for the district of Monteverde. Over time the effort will expand to the rest of the corridor.

In Costa Rica, measuring emissions is done on a national scale by the National Meteorological Institute. While the NCCS states that emissions and mitigation can be measured on a regional scale, to our knowledge it has not yet been done in Costa Rica. The DCC promotes carbon neutrality at a business or organizational level. The 25 local organizations that participated in EARTH University's Organizational Carbon Neutrality course in May 2015 learned how to account for emissions, reductions and compensations through verifiable sinks. While several organizations are in the process of becoming certified, others are measuring their emissions, implementing reductions and finding ways to compensate them without seeking an official certification. Carbon neutrality certification can be extremely time-consuming and expensive and, while many organizations are committed to reducing and compensating emissions, most organizations and individuals cannot afford the process.

Monitoring progress on a regional scale will be much more efficient and provide much more information. By publicizing the information, it also has the potential to motivate the general local population to mitigate emissions and take adaptive measures. The information can also inform policy-makers about which actions will have the greatest impact in the region.

Figure 21. Monteverdeans discuss how to monitor emissions and vulnerabilities at the initial meeting of CORCLIMA. Source: Noelia Solano Guindon.

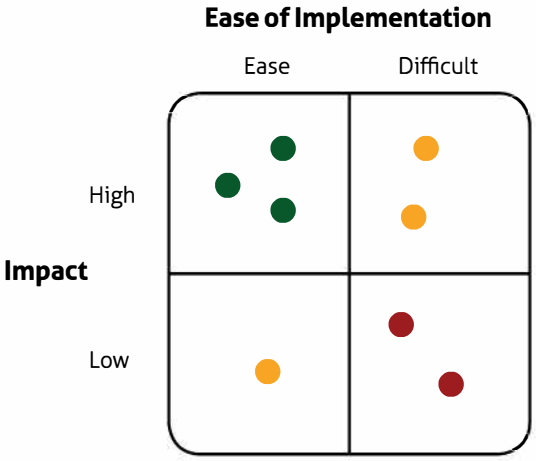

Figure 22. Contingency table comparing degree of impact of climate actions with the degree of ease of implementing them. Actions in green are high impact, high ease and should be given higher priority. Actions that have low impact and are difficult to implement should have low priority.

IDENTIFYING AND IMPLEMENTING PRIORITIES

Once the CORCLIMA sub-committees have baseline information on emissions, mitigation and vulnerabilities, they can use that information to establish priorities for action. Other information that needs to be gathered for establishing priorities relates to the degree of difficulty of implementing particular actions:

- Information about relevant national policies and programs
- The degree of risk and urgency for action
- The cost of alternative actions
- Available resources
- Motivation of local actors to participate

For each of the highest priorities, the sub-groups will establish a work plan that includes clear actions, timelines and responsible parties. The sub-groups on monitoring, communication, education and financing will provide additional support. Regularly monitoring progress will allow sub-groups to re-evaluate priorities and revise and adjust action plans.

RESOURCE MOBILIZATION STRATEGIES

A critical tool for catalyzing action plans into real actions is often access to financial capital, whether that be in the form of grants or loans. Presently, millions of dollars are being poured into international and national climate change programs, however, accessing these resources is often difficult for small communities due to unsuitable matches in timing, thematic focus, maturity of the local initiative, geographic location, scale, internal capacities of proponents, and available counterpart funding.

The Monteverde Community Fund (MCF) offers small grants that provide financial resources for local organizations to develop projects that contribute to sustainability in the region (see more at: www.monteverdefund.org/sgp). Examples of projects that have been funded to date include protection of the aquifer around the largest spring in the Santa Elena aqueduct system, capturing rainwater at the Cloud Forest School, installing solar panels on the Santa Elena Interactive Public Library, and a baseline study of waste water by CEGIREH. Through the MCF's annual 'Donor Circle' and Travelers' Philanthropy programs, local and visiting donors continually replenish these funds.

Monteverde is well positioned to facilitate investments in mitigation and adaptation throughout the Bellbird Biological Corridor. Accountability, transparency and alignment of local values are essential for ensuring success with any mechanism. Locals need to be able to develop projects in their own way, at their own scale. Their knowledge and abilities need to evolve as new challenges emerge.
Ways that the Monteverde Community Fund and other institutions may mobilize locally-pooled resources that support climate action include:

- Facilitating formal carbon offsets through FONAFIFO and the international carbon market and informal carbon offsets from philanthropic sources
- Growing 'donor circles' or groups of individuals and businesses who give annually to a specific cause,
- Creating 'second-tier banks' to invest resources on behalf of a larger donor organization,
- Establishing endowment funds or other means to generate flexible financial resources on an annual basis,
- Making available revolving loans, subsidies, or credit programs for renewable energy, low emission transportation and other mitigation projects,
- Providing grants, loans, or financial incentives for water conservation, watershed protection projects, and other adaptation projects, and
- Leveraging local capital to attract additional investments from donor institutions or governmental entities.

Figure 23. Explore Monteverde, the official site of the Monteverde Chamber of Tourism, is developing a way for visitors to support local mitigation initiatives.

THE MONTEVERDE CLIMATE EXCHANGE

The Monteverde Commission for Resilience to Climate Change needs a platform that generates greater identity, opportunities and action, while enabling the broadcast of its continued progress. We propose a community administered website, the *Monteverde Climate Exchange*, to satisfy this need. This virtual platform will serve to:

- Publicize action plans
- Disseminate new information on local challenges, possible solutions and available resources
- Facilitate connections between potential collaborators
- Mobilize financial resources
- Monitor and publicize progress in each sector
- Provide a visible model to other regions in Costa Rica and the world of how to achieve climate resilience.

ARE YOU READY TO ACT?

Each of us must continue to incorporate climate change literacy into our collection of knowledge and ideas, regardless of our interests, profession, affiliation or location. The world is already facing the tangible and growing impacts of climate change. Are we preparing for these changes? Are we ready to do our part in drastically reducing emissions fast? Are we ready to create systemic changes that will facilitate rapid mitigation and adaptation? Will Monteverde succeed in becoming climate resilient and serve as an example to the rest of the world?

That depends on how we respond together.

Organizations and businesses, are you ready to make the changes within your institution and collaborate more to make systemic changes that will create a climate resilient future here?

Residents of Monteverde, are you ready to make necessary changes in your home and join forces with your neighbors to make your community resilient?

Visitors to the region, are you willing to compensate for your travel footprint by contributing to reducing emissions and sequestering carbon in the Monteverde region? Do you have wisdom to share from your experiences elsewhere? Are you ready to drastically reduce emissions in your own community?

The Monteverde Community Fund is committed to empowering participants in the local climate change movement through our grant programs, supporting local organizations in the mobilization of resources, and through the 'Monteverde Climate Exchange.'

Christiana Figueres invited us to "swallow an alarm clock." She says we have until 2020 to begin drastically reducing global emissions. Let's do our part. And let's be ready as we are impacted by climate change.

Please contact the Monteverde Commission for Resilience to Climate Change (ClimaticaMonteverde@gmail.com), if you would like to be more involved in making Monteverde climate resilient, or the Monteverde Community Fund (info@monteverdefund.org) to see how you can support these efforts.

Figure 24. Save the planet, graphic art by Mauricio Valverde Arce, for The XV International Conference on Climate Change, in Copenhagen, Denmark, 7-18 of December, 2009. The artwork was solicited by the Costa Rican organization Preserve Planet.

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GLOSSARY

Adaptation	changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change
Carbon neutrality	a process where Emissions - Reductions - Compensation = zero
Carbon reservoir	a place in nature, such as forests or soil, where carbon is stored
GHG Sink:	Greenhouse Gas Sink: Any process, activity or mechanism that removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas or aerosol from the atmosphere
Mitigation	a human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC 2014b).
Resilience	the ability of a system to absorb disturbances or experience changes and still conserve its essential structure, function and feedback loops.
Social Readiness	the capacity of stakeholders to address their points of vulnerability.
Vulnerability	the predisposition to be adversely affected.

ACRONYMS AND ABREVIATIONS

ACM	Asociación Conservacionista Monteverde; Monteverde Conservation League
CBPC	Corredor Biológico Pájaro Campana; Bellbird Biological Corridor
CORCLIMA	Monteverde Commission for Resilience to Climate Change
CO_2	carbon dioxide
CH_4	metano
DCC	Dirección de Cambio Climático (Office on Climate Change)
FCC	Fundación Conservacionista Costarricense; Costa Rica Conservation Foundation
FONAFIFO	Fondo Nacional de Financiamiento Forestal - National Forest Financing Fund
GHG	Greenhouse gas
IMN	Instituto Meteorológico Nacional - National Meteorological Institute

INDC	Intended Nationally Determined Contribution
INTECO	Instituto de Normas Técnicas de Costa Rica
IPCC	Intergovernmental Panel on Climate Change
LED	Low Emission Development
MABD	Monteverde Arenal Bioregion Database
MABI	Monteverde Arenal Bioregion Initiative
MCE	Monteverde Climate Exchange
MCF	Monteverde Community Fund
MCL	Monteverde Conservation League
MINAE	Spanish acronym for the Ministry of Environment and Energy
MVI	Monteverde Institute
NAMA	Nationally Appropriate Mitigation Action
NCCS	National Climate Change Strategy
N_2O	Nitrous Oxide
REDD	Reduced Emissions from Deforestation and forest Degradation
SINAC	Spanish acronym for National System of Conservation Areas
UCC	Spanish acronym for Costa Rican Compensation Units
UGA	University of Georgia
UNFCCC	United Nations Framework Convention on Climate Change
UCC	Universidad de Georgia
VER	Verified Emissions Reduction

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