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Climate Change: How Costa Rican Smallholders Can Adapt and Be an Example for the World

Farmers have always had to deal with climate change. Currently, the effect of climate change on agriculture is relatively normal. However, the change farmers could face in the coming years could be truly unique due to the rate at which the change could occur. Considering existing information about climate change, preparation is certainly prudent.

Farmers need to take action to minimize climate change, as well as be prepared to adapt to climate change, if or when it happens. This paper focuses on the actions small-holder farmers in Costa Rica can take to sustainably adapt to climate change.

How Costa Rica deals with climate change is important because tropical regions that are seasonally dry are expected to be among the first areas to experience the most negative effects of climate change (Easterling 300). The ways Costa Rica and its small-holder farmers adapt can provide an example other nations of the world can learn from and thereby better help their own small-holder farmers implement effective solutions.

During the summer of 2010, I spent a month in Costa Rica. While there, I visited five agricultural operations: a typical small-holder farm in Paquara; a Quaker dairy operation in Monte Verde; a large coffee, sugar, and banana plantation also in Monte Verde; a cattle operation in Curu; and a large strawberry farm in Poaz. I also saw the diverse ways farmers in Costa Rica sell their products – large and small farmers markets, street vending, and grocery stores. I visited the University of Costa Rica, and talked to an entomologist. As well, I learned about the Costa Rican government during an extensive visit to their Congress. I have an interest in climate change and this experience in Costa Rica helped me to appreciate that climate change could affect real people and the challenges of finding solutions. Costa Rica is a land full of diversity. It is located on the isthmus between North and South America and has extensive shoreline along the Pacific and Atlantic Oceans. The Continental Divide forms the spine of the country. The population of Costa Rica is generally healthy. There is an infant mortality rate of 9.45/1000, and the average life expectancy is 74.61 years for men and 79.94 years for women (US Department State).

It has a total of seventeen unique ecosystems. Costa Rica currently has 26% of its land under environmental protection, which contains about 5% of the world's biodiversity (US Department State). Costa Rica utilizes its renewable resources, with 99% of its electricity coming from clean sources, mainly hydroelectric plants (US Department State). About 9.9% of Costa Rica's territory is arable (SICA 4). Much of the farming in Costa Rica is done by small-holder farmers. The size of an average small-holder farm is less than ten hectares, about 25 acres, on which a wide variety of crops are grown including corn, beans, potatoes, yucca, various fruits, and tobacco (Encyclopedia). The staple diet of an average small-holder family consists of rice and beans along with some meats, several fruits, and an array of vegetables. The size of small-holder families varies widely. Two prevalent agricultural practices are row cropping of vegetables and pasture grazing dairy cows on steep mountain tracts of cut forest.

Costa Rica has three main strengths that can help its small-holder farmers adapt to future climate change – resources, stable government and agencies, and extensive education system. Costa Rica is one of the wealthiest countries in Central America with a per capita income of \$6,900 in 2009 and an estimated GDP of \$38.27 billion. Agriculture is 6.5% of the GDP and exports bananas, pineapples, coffee, melons, ornamental plants, and sugar (US Department State).

The government of Costa Rica is stable and in good condition especially compared to its neighbors. Moreover, Costa Rica doesn't have an army and therefore has more resources for helping agriculture. The government has created several organizations to help the country adapt to climate change. The Ministry of Environment and Energy oversees Costa Rica's commitment to dealing with climate change, especially concerning the United Nations Framework Convention on Climate Change (SICA 3). The Ministry of Agriculture and Livestock is responsible for developing the agricultural sector of the country and adopting policies, plans, and programs to preserve natural resources and improve the environment of the country (SICA 3).

The general populace of Costa Rica is well educated. Education is compulsory for nine years with a 99% attendance rate for the first six, and a 71% rate for the last three. As a result, Costa Rica has a literacy rate of 96% (US Department State).

There are four main barriers limiting small-holder farmers' ability to adapt to climate change: lack of rewards, tradition, solutions not to scale, and complexity.

Currently, there is a lack of rewards for adapting. Right now, if farmers do adapt and plant a different crop, they probably will not have a market for the new crop because consumers will continue to buy the products they always have. For example, if a farmer plants a variety of drought-resistant wheat, there would probably be a limited market for that wheat because, currently, customers can easily get corn. Traditions that farmers have built up over years can make adapting difficult. For example, many farmers plant on set days of the year because that was when their ancestors planted. However, climate change could affect growing seasons and render such traditional dates irrelevant.

Scale is essential. Many solutions, such as better seeds, are not to the scale that small-holder farmers need. For example, it is impractical for small-holder farmers to buy fifty kilogram bags of seed intended for huge monoculture operations.

Adapting to climate change is complex because there is uncertainty, lack of information, and numerous decisions to make. Figure 1 organizes the challenges climate change presents to small-holder farmers and ways they can adapt. Often, adapting in one way can help meet several challenges.

Figure 1: Challenges and Ways Small-Holder Farmers Can Adapt

Challenges	Ways to Adapt
Increase in Temperature	Diversified Crops Suited to Environment Cover Crop
Increase in Floods	Diversified Crops Suited to Environment Cover Crop Natural Buffer Zones
Increase in Droughts	Diversified Crops Suited to Environment Cover Crop Natural Buffer Zones
More frequent and intense insect and disease infestations	Diversified Crops Suited to Environment Crop Rotation Natural Buffer Zones Integrated Livestock

Small-holder farmers' yields could decrease if climate change increases temperatures, causes more flooding, increases droughts, and causes more frequent and intense insect and disease infestations. The current effect of rising temperatures on agriculture is small, but predicted to grow rapidly. A drastic increase in temperature will directly slow the growth of plants. Soils will dry because of an increase in evaporation, caused by higher temperatures, and plant growth will be further inhibited (Gardener).

Models predict if a temperature increase of 1-2 °C and a precipitation variation of plus or minus 10-20% occurs, there will be a significant decrease in crop yields in Costa Rica (SICA 2). Those same models predicted that for some regions of the country temperatures could rise 3.8 °C by 2100. Already, a global average increase in temperature of about 2 °C is predicted to be unavoidable (Scialabba 158).

An increase in flooding due to climate change is likely to be another problem for small-holder farmers. A vulnerability study of Costa Rica's three most important river basins the Reventazon River, Grande de Terraba River, and the Grande de Tarcoles River revealed that with a temperature increase of 1-2 °C and a precipitation variation of plus or minus 15% on the Pacific side of Costa Rica and 10% on the Atlantic, will increase flooding which, in addition to severely damaging crops, will erode soil, further hurting small-holder farmers (SICA 5).

Droughts are expected to increase in some regions of the country if there is a temperature increase of 1-2 °C and a precipitation variation of plus or minus 15% on the Pacific side of the country and 10% on the Atlantic (SICA 5). Costa Rica is seasonally dry and an increase in droughts would be detrimental to the rain fed crops of small-holder farmers.

Insect and disease pressure on small-holder farmers could increase if the climate changes. Insects and disease are grouped together because many insects transport plant diseases. The expansion of warmer climates will make it possible for insects to spread further and for insects that caused minimal damage to become a larger problem (FAO). The pressures of changing insect and disease populations are being felt now. For example, the Quaker dairy farmers of Monte Verde raised dairy for years growing one type of grass in their pastures. Recently, an insect emerged that killed the variety of grass they grew by secreting a chemical that acted as an herbicide. This resulted in a decreased biomass in their pasture and a decrease in milk from their cows. The death of the grass also means that they had to incur the cost and labor of reseeding their pastures.

If the small-holder farmers of Costa Rica start to experience the negative effects of climate change, they will adapt to ensure their productivity. If their decision comes down to increasing their productivity or a practice to reduce climate change they will choose increasing productivity. For instance, if a farmer's crop is growing slowly, he will use fertilizer to ensure his yields rather than abstain because fertilizers release greenhouse gasses that contribute to climate change.

Their decision does not have to come down to this. Small-holder farmers can adapt to the challenges of climate change in a sustainable manner by using diversified crops better suited to their environment, cover cropping, implementing a crop rotation, creating natural buffer zones, and integrating livestock into production. These techniques are not new; nevertheless they can help small-holder farmers adapt to climate change. If climate change does not occur, small-holder farmers will still benefit from implementing these practices.

The most important adaptation small-holder farmers can make is growing diversified crops better suited to the environment. Growing diversified crops means growing multiple crops and even multiple varieties of a crop to avoid a total failure from an extreme weather event or sudden pest infestation. Growing crops better suited to the environment means choosing a variety of a crop that is better adapted to deal with the new weather and pests, as opposed to using seed saved from an existing crop (Scialabba 160).

Cover cropping is a great way for small-holder farmers to counter balance the negative effects of climate change. A cover crop is a crop planted in between two cash-crop plantings or underneath a cash crop for beneficial effects. Cover crops will counteract flooding and drought by increasing organic material in the soil, which will help hold or drain water as needed. The root systems of cover crops help prevent erosion caused by flooding. Cover crops also prevent evaporation of water, due to higher temperatures, by shading and covering the soil. Many cover crops increase the amount of nutrients in the system by absorbing excess nitrogen and carbon that the main crop did not use. If the cover crop did not use the

excess nutrients they would escape into the atmosphere. The nutrients are returned to the soil when the cover crop is plowed under (Scialabba 161).

Another way small-holder farmers can adapt to climate change is implementing a crop rotation. The basic principal behind a crop rotation is to wait two or more years before planting the same family of crop in the same area. There are several benefits to a crop rotation. A crop rotation works to reduce insect and disease pressure by interrupting the life cycle of the insects and diseases. In a normal cycle, larvae emerge in the Spring and feed on the host crop, mature, and reproduce leaving offspring that overwinter to emerge the next Spring. Moving the host crop forces the pests to migrate to a different location. This leads to a higher mortality rate, less pressure from insects, and less disease transported to the host crop in the new location. Another benefit of a crop rotation is the absence of the crop in a location gives depleted nutrients time to regenerate before the crop returns.

Creating natural buffer zones is an important way for small-holder farmers to adapt to climate change. Natural buffer zones are parts of the natural environment left around the farm. Natural buffer zones help deal with floods and droughts by increasing water draining and holding capacity through organic matter. The root systems of the natural buffer zones prevent erosion caused by flooding. The natural buffer zones provide a wind break for more delicate crops, and also provide a habitat for predators that will eat harmful insects (Scialabba 160).

Integrating livestock into the production of crops is another way to adapt. Integration of livestock increases soil quality through manure application to fields (Scialabba 160). By releasing chickens or other fowl into fields to eat pests, insect pressure can be reduced. Two ways to integrate livestock are to enclose a small portion of the field and release poultry into the enclosure, or let grazing animals go through a crop field once the crop has been harvested.

Going from words to actions will involve, first and foremost, small-holder farmers, but they can not adapt to climate change alone. They will need the involvement of their communities, educational institutions, and local and federal governments.

Small-holder farmers need to do all they can to educate themselves now about their environment, alternative crops, and other techniques of growing so they are prepared. They also need to be willing to implement best practices, even if they are different.

The communities around small-holder farmers need to provide support. They can do this by being open to new products that grow better locally and support small-holder farmers who adopt sustainable practices by preferring them at market.

Educational institutions, such as the University of Costa Rica and international research organizations, need to support small-holder farmers by providing unbiased information and creating demonstration plots. The most important assistance educational institutions can give to small-holder farmers is unbiased information. Information promoted by special interests and private companies can be biased. With unbiased information, small-holder farmers can make better decisions about deciding what to plant, how to improve soil quality, and what new agricultural techniques to use. Small-holder farmers will be resistant to adapting techniques that they haven't seen implemented. Educational institutions can create demonstration plots where small-holder farmers can learn about and see alternative techniques in practice. Several locations would need to be created around the country in order to be accessible to as many small-holder farmers as possible. Once they have seen alternative techniques it will be easier for small-holder farmers to use them on their own farms.

There is much the government of Costa Rica can do to help small-holder farmers. It can help provide unbiased information, provide financial incentives for farmers who adapt sustainably, allow easier access to trans-genetic seeds, and improve weather forecasting.

The government of Costa Rica can improve access to unbiased information in several ways. In the future, the Ministry of Environment and Energy can publish documents containing data showing climate change in Costa Rica. This could help small-holder farmers realize the magnitude of climate change. Local branches of the Ministry of Agriculture and Livestock can provide small-holder farmers with unbiased information, such as what grows well in the new environment, is there a market for these crops, and what new techniques have been developed, then help the small-holder farmer make decisions.

The federal government can provide monetary incentives to encourage small-holder farmers to adapt to climate change. Once the local branch of the Ministry of Agriculture and Livestock determines what cash crops and cover crops will grow well in the new local climate, the federal government could provide a financial incentive to induce small-holder farmers in that area to purchase recommended seed.

Currently, small-holder farmers must go through an arduous process to use trans-genetic seeds. The use of trans-genetics is a controversial issue, but in the words of Bill Gates, “they [trans-genetics] can help address farmers’ challenges faster and more efficiently than conventional breeding alone” (Gates). Farmers in Costa Rica can plant trans-genetic seeds, but they must obtain permission from the Ministry of Agriculture and prove that there are no organic crops that could be affected (GAIN). The government needs to ease restrictions on trans-genetic seeds to make them available to small-holder farmers, so they can more quickly adapt to climate change

The government can use its resources to help the country develop better weather forecasting. The government can help build better forecasting infrastructure and train scientists how to use it. With better weather forecasts small-holder farmers will be able to make more informed decisions.

In conclusion, climate change could present challenges to small-holder farmers in Costa Rica in the form of increased temperature, an escalation in flooding, increased drought, and more frequent and intense insect and disease infestations. Five ways small-holder farmers there can adapt now that will help them deal with possible climate change are planting diverse crops better suited to the environment, cover cropping, implementing a crop rotation, creating natural buffer zones, and integrating livestock into production. The small-holder farmers of Costa Rica must take it upon themselves to adapt, but they will need the help of their community, educational institutions, and local and federal government. The other nations of the world should help and learn from Costa Rica in order to better help their own small-holder farmers.

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