

Alternative NAPA Plan:

Food and Climate Considerations in Ecuador

Climate Justice Seminar

University of Washington | Seattle

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I. Introduction and Setting

A. Food and Water Background

i. Historical Climate of Ecuador

Ecuador occupies a portion of equatorial South America that includes coastal lands, the Sierra of the Andes, and a region of the Amazon. In our studies of the impacts of climate change on food security we have focused on the high Andes, with reference to the overall food system, including the industrial agriculture of the coastal region when appropriate. The entire country has experienced a warming trend of ca. 0.1°C per decade, with the high Andes warming faster. The seasonal temperature cycle is smaller in magnitude than the diurnal temperature cycle, allowing many crops to be grown year round. Precipitation peaks in March in the coastal region and April in the Sierra (Annex IV).

ii. Crop Overview

Ecuador's geography and mountainous topography make for a prosperous and abundant agricultural sector. According to researcher Isabelle Anguelovski, the most vulnerable economic sector in Ecuador "is agricultural production, mostly due to severe flooding and droughts affecting banana, corn, soy, and rice plantations in the lower Andes, Amazon, and coastal region" (Anguelovski, 2009, 35). Agriculture accounts for 9.9% of Ecuador's GDP and 8.3% of the labor force. Principle export crops include, in order of importance, bananas, coffee, cocoa, rice, potatoes, manioc, plantains, and sugar cane. Primary subsistence crops include rice, potatoes, corn, legumes, rye, manioc, wheat, and barley.

More than one third of the Ecuadorian work force engages in some form of agriculture, including subsistence farming. The staple diet in Ecuador consists principally of rice, potatoes, and corn. With the exception of export crop production, most farming in Ecuador reflects Ecuador's consumption.

The rapid entry of the Andean region into the global economy over the past fifty years has dramatically altered Ecuador's agricultural landscape. In the Andes, formerly subsistence-only farmland is now a mosaic of agricultural systems, including both subsistence farming and large-scale crop production for national and increasingly international export. Most agricultural work in the Andes occurs through collective labor and sharecropping and most households have

their own small holdings of land. Nearly all Andean farmers engage in some form of crop irrigation, and most utilize fertilizers and pesticides in order to increase crop yields and decrease pests. Other common farming techniques include interplanting, crop rotation, and planting cover crops. The Ecuadorian Andes have a year-round growing season with most major plantings for potatoes and corn occurring in the winter months (October-December) and harvests in the spring (March-May).

iii. Key Environmental Stresses: Natural Variability in ENSO

The El Niño Southern Oscillation (ENSO) is a major source of natural variability in the climate of Ecuador. El Niño events occur irregularly, approximately once per decade. El Niño conditions in Ecuador consist of higher temperatures and increased precipitation, with a stronger response in the coastal regions, and notable anomalies in the Andes as well. Anomalously high precipitation associated with El Niño occurs primarily during the usual rainy months. A significant fraction of the variability in temperature and precipitation experienced in Ecuador is associated with ENSO. (Annex IV).

iv. Key Environmental Stresses: Temperature and Precipitation Impacts on Crops

One source of stress on crops is extremes in temperature and precipitation, whether associated with ENSO or not. Crop productivity is a function of a variety of environmental factors, including temperature, rainfall, and CO₂ concentration. Theoretically, an increase in temperature could increase production of a particular crop, but the portion of biomass produced that constitutes the edible component does not necessarily increase, so yields are harder to determine (Ritchie et al., 1998).

Many of the stresses from temperature and precipitation extremes are realized through secondary impacts, discussed in greater detail below. Frost and extreme high temperature events may not be captured in monthly or seasonal means that are studied to look at long-term climate trends. Additionally, these daily extremes are more difficult to project. Too much or too little precipitation can also cause damage to crops. Natural variability from El Niño events, as well as climate change projections, is associated with increased precipitation (Annex IV). Excess rain can cause problems with slope stability and erosion, as well as increase the susceptibility of crops to certain pests. Drought is also a problem in some provinces of the sierra and coast (Bermeo et al., 2000).

v. Key Environmental Stresses: Pests

Pests are a considerable challenge in Ecuador as evidenced by the extensive use of pesticides in the country (Annex I). Pesticide consumption has increased by over a factor of five for some compounds since 1990 (UN FAO, 2010) and farmers devote a substantial portion (25% in some cases) of production costs to pesticides. This change in pests and pesticides over the last several decades is owed in large part to the introduction of non-native crops that need pesticides to maintain high yields (Annex I).

Ecuador's wide range of altitudes provides pests with an array of microhabitats to survive in. For example, the introduction of potato moths to the Andes three decades ago has been devastating to some potato farmers (IRD, 2009). Each of the three species of moth flourishes within a specific temperature-altitude range, but research has shown that when overlap occurs crop damage may intensify (Dangles et al, 2008).

Research has shown that integrated pest management (IPM), which emphasizes decreased use of pesticides when they are not necessary, is cost effective and can be implemented effectively through farmer field schools (Mauceri et al., 2007). IPM also helps to reduce the costs and health and environmental effects associated with over-use of pesticides. Interplanting, crop rotation, and cover crops are helpful tools in pest management (Annex I).

vi. Key Environmental Stresses: Frost

Although temperatures in Ecuador are fairly constant throughout the year, diurnal temperature variation can be quite large and extend to freezing temperatures in high altitudes. Night radiative frost is a major stress factor for plants in the high altitude tropics of the Andes and the main mechanism for frost in the Andes (Villegas, 1991). Further, only 22% of the night frosts observed had an air temperature less than 0° C - demonstrating that radiative cooling can reduce the temperature below freezing even when the air temperature is not freezing. Even though Andean crops such as potatoes and quinoa are known for their tolerance to frost, frost can still be a limiting factor for crops in the highlands of Ecuador.

In temperate regions frost is typically a risk at the beginning and end of a growing season, but potatoes in Ecuador face the risk of frost throughout the growing season. Some studies have shown that increasing the frost resistance of potatoes by 1° C can nearly double the viable growing area and increase the yield by over 20% in some regions of the high Andes (Hijmans et al., 2003).

Solanum tuberosum andigena (the most commonly grown potato taxon in the Andes) undergoes frost damage when the temperature drops below -2° C, but other Andean species have greater tolerances to frost. Similarly, quinoa can withstand -4° C for up to four hours (Jacobsen et al., 2003). Unfortunately many of the frost resistant species have elevated levels of glycoalkaloids, which makes the potatoes bitter and requires processing prior to consumption (Hijmans et al., 2003). Frost damage to crops in the sierra of Ecuador can be avoided by planting crops on soils with high thermal conductivity, planting on slopes, using smoke, greenhouses, and raised beds. With these interventions in mind, it is unclear how climate change will change the impacts of frost on crops.

vii. Key Environmental Stresses: Land Use

Another environmental stressor is degradation of the soil, with implications for agriculture as well as water resources. Erosion and desertification are cause for concern (Bermeo et al., 2000). Extreme precipitation events are associated with erosion, but neither process is solely the result of climate. Human land use practices have a large impact on slope stability and the maintenance of healthy ecosystems. In the Páramo, increased cultivation, grazing, and planting of non-native trees have negatively impacted the hydrologic system. Less ground water is stored in this high-altitude reservoir due to these activities. Ironically, trees planted for carbon-credit offsets also decrease freshwater availability due to climate change (Buytaert et al., 2006).

viii. Summary

Natural climate variability and existing stresses on agriculture in Ecuador provide a window into the types of concerns – from temperature and precipitation extremes, to pests and soil degradation – that may be exacerbated by climate change.

B. Glossary

APBS: Andean Price Band System

ATPA: Andean Trade Preferences Act

CIP: Centro Internacional de la Papa (International Potato Center)

Coast: Calculations used in this report defined the coast as the area west of 79° W longitude; more generally this is the area west of the highlands associated with the Andes mountains.

Diurnal: This refers to the variability over one day (24 hours).

El Niño: This is a phase in the El Niño Southern Oscillation Index (ENSO) with anomalously high sea surface temperatures in the Pacific (see NINO3.4 for more detail). El Niño events in Ecuador typically bring higher temperatures and more rain fall in the rainiest months.

ENAC: Empresa Nacional de Almacenamiento y Comercialización (National Board for Commercialization of Foodstuffs)

ENSO: El Niño Southern Oscillation refers to warming and cooling patterns over the tropical Pacific that impact climate globally. The El Niño phase occurs when sea surface temperatures in the tropical Pacific are enhanced, and La Niña occurs when sea surface temperatures in the tropical Pacific are suppressed.

FFS: Farmer Field School

GCMs: General circulation models (sometimes referred to as global climate models) are tools to explore the climate through computer simulations of Earth. GCMs are the basis of temperature and precipitation predictions used in this report.

INIAP: National Institute for Agricultural Research

IPCC: Intergovernmental Panel on Climate Change

IPM: Integrated Pest Management

NGO: Non-Governmental Organization

NINO3.4: This is an index used to characterize ENSO and is the average sea surface temperature in an area of the Pacific Ocean bounded by 5°N to 5°S and 170°W to 120°W.

Páramo: Ecosystem in the highlands of the Northern Andes, characterized by grasslands and lakes, storing water that supplies rivers originating from the region.

Radiative cooling: This is a type of cooling due to long-wave thermal energy emitted from the Earth's surface. This can be an important effect in clear-sky conditions at night when the sun is not warming the surface and the clear skies ensure that clouds do not reflect the heat back to the surface.

Sierra: Calculations used in this report defined the sierra as the area between 77.5° W and 79° W longitude; more generally this is the area encapsulating the Andes mountains and surrounding highlands.

II. Framework for Adaptation Program

A. Variables that affect the Agriculture Sector

i. Temperature

Large temperature gradients exist in Ecuador with temperature differences exceeding 10° C between the coast and the sierra of Ecuador. Further, diurnal variations are typically ca. 10° C with early morning temperatures reaching freezing in the Andes due to radiative cooling at high altitudes. Increases in temperature since 1990 are expected to be similar for all seasons and about +1.1° C by 2040 and +3.1° C by 2090 for the national average. Climate models predict larger temperature changes at higher altitudes and this is observed in the historical record, as well (Annex IV). These temperature changes may have important impacts on crops via frost action, assisting the spread of pests, and by drying the soil.

Period	Ecuador Average	Coast	Sierra
1900-1950	0.18°C decade ⁻¹	0.18°C decade ⁻¹	0.18°C decade ⁻¹
1950-2008	0.08°C decade ⁻¹	0.04°C decade ⁻¹	0.10°C decade ⁻¹
1900-2008	0.10°C decade ⁻¹	0.09°C decade ⁻¹	0.10°C decade ⁻¹
1990-2040	0.22°C decade ⁻¹ (projected)		
1990-2090	0.31°C decade ⁻¹ (projected)		

Table: Past and Future Temperature trends in Ecuador (Annex IV)

While it is unclear how the frequency of frost will change in Ecuador in the future, it is not a climate variable that can be dismissed; increases in average temperatures do not imply a decrease in incidences of frost (Annex IV). Furthermore, recent experimental work has demonstrated that summer freezing resistance is reduced in high elevation plants when the biota is exposed to increased mean temperatures (Sierra-Almeida and Cavieres, 2010). The study found that the point where 50% of plants are damaged due to frost increased by ca. 4 K when plants were exposed to warmer environments, indicating a decreased ability to survive frost events in a warmer world. Although the study did not focus on food crops, it pointed out that observed changes in the freezing point suggest that fundamental changes may be occurring during crystal formation (which could potentially extend to food crops).

If cloud cover changes are not homogeneous over all of Ecuador, it is probable that changes in frost frequency will be regionally specific. Even if a warmer climate brings about

decreased frost tolerance and increased frost events there are several potential adaptation avenues. Potential technologies to address frost have been proposed, including a bulk-breeding scheme for quinoa utilizing molecular-marker-assisted selection to pick out frost resistant varieties of quinoa (Trognitz, 2003). Large yield increases are projected for nominal increases in frost resistance and there are a number of farming practices that can mitigate frost on a household basis. All options should be explored, given the uncertainty of the sign of future frost trends and the potential for decreased frost tolerance in a warmer climate.

Like incidences of frost, the effects of climate change on the severity of pests and pathogens in Ecuador is not well known, but should be considered while building capacity for adapting to climate change. It has been pointed out that pests and pathogens should be incorporated into crop models for more realistic predictions of crop production (Gregory et al., 2009), but current knowledge of temperature effects on pests in the Andes suggests that there may be increases in the range and severity of certain pests.

The large number of thermal environments present in Ecuador may make the country susceptible to the introduction of pests, implying that more research is needed regarding pest distributions in the Andes under climate change scenarios (Dangles et al., 2008). Since temperature is an excellent predictor of pests such as *Symmetrischema tangolias* (potato tuber moth), upward range changes may occur under future climate scenarios (2008). Increasing the diversity of pests causes more crop damage than the sum of individual pests acting alone (Dangles et al., 2009). While these studies pertain only to potato crops in Ecuador, the results are striking enough to seriously consider, research, and plan for the impacts of pests within Ecuador.

ii. Precipitation

Most models predict an increase in precipitation in the future. Precipitation, however, is not as well predicted by General Circulation Models (GCMs) as temperature. When model reproductions of the end of the last century are compared with data, most are rather inaccurate. Based only on the IPCC models with the best skill at predicting the past, average annual precipitation is expected to substantially increase by an annual average of 9% over 1990 levels by 2040, and 35% by 2090. The magnitude of the projected shift in precipitation also varies with season (Annex IV).

iii. ENSO analogy

ENSO effects on temperature and precipitation have been considered a potentially useful analogy for the future climate in Ecuador, since El Niño years in Ecuador typically bring increased temperature and rainfall. This analogy holds quite strongly for temperature changes, but less strongly for precipitation. In summary (Annex IV):

- By 2040 the temperature change will approach that experienced during El Niño years. Temperature change will be larger than the temperature increase experienced for a one standard deviation ($+1\sigma$) increase in the ENSO state.
- By 2090 the temperature will be greater than the temperature experienced during large El Niño events such as the 1982-1983 El Niño and the 1997-1998 El Niño.
- Precipitation changes are not expected to be negligible, but are not as large as strong El Niño years.
- A relationship between ENSO and precipitation only exists in the rainy seasons March – May and November – December. During other months, the relationship between ENSO and precipitation anomalies is not significant.
- Even though precipitation changes are not of the same magnitude as strong El Niño years, the changes are still large relative to the natural variability for most months (an average shift of $+0.5\sigma$ by 2040).

This analogy between the current climatic effects of El Niño years and the future climate is a useful tool for exploring ways in which the food system may be challenged in the future. It is unclear how El Niño events will change with climate changes (both in frequency and magnitude), but preparation for El Niño events will help build capacity for many of the impacts of climate change. For example, even though precipitation changes in the future are not expected to be as large as strong El Niño events, the precipitation increases are expected to be ca. 15% in the rainiest months, which will require additional flooding infrastructure – the same infrastructure will help build resiliency to El Niño events.

The greatest resource of local knowledge to inform effective adaptation measures is the existing understanding of the impacts of past El Niño events. Pre-Hispanic Andean civilizations responded to ENSO events by relocating, or rebuilding and investing in flexible irrigation

infrastructure (Dillehay and Kolata, 2004). Natural variability, in the form of major El Niño events has exposed Ecuador to flooding, higher temperatures, and associated impacts on crops. During the major El Niño of 1997-1998, excess humidity and intense rains caused crop failures, loss of viability of seeds, and increased fungal infections in crops (Torres et al., 2001). Impacts also vary with altitude and depending on local land use practices and crop selection. The increase in pests led to an increase in the use of pesticides, without necessarily maintaining yields (Egusquiza et al., 2001). Crops that are more resilient to pests and temperature swings, as well as infrastructure to manage flooding and erosion, can mitigate the impacts of extreme climate events or long-term climate trends.

vi. Population

One factor involved with food security is population growth. As of 2004, 15% of Ecuador's population was undernourished (UN STATS, 2010). To continue to decrease the proportion of the population suffering from undernourishment, crop yields will need to grow as fast as population growth, unless more food imports are expected. Ecuador has projected that by 2030 the population will start to put pressure on the domestic food supply when food yield changes resulting from climate change are accounted for (Bermeo et al, 2000).

The population of Ecuador is expected to grow by 27% from 2010 to 2040 and crop yields are expected to decrease (per capita) for rice, corn, soybean, and potato (UN STATS; Bermeo et al, 2000). For this reason, food production must be analyzed in tandem with population growth since both are uncertain and neither can dictate appropriate policy alone.

B. Impact on Climate Justice

Increases in environmental stresses due to climate change have the potential to negatively impact food security in Ecuador. The extent to which the worst impacts are realized is a function of how much adaptability is built into the system combined with external factors discussed in the following sections.

C. Impact of Historical Agricultural Policies

The United States is Ecuador's principal trading partner with approximately 45% of Ecuador's exports going to the US. This close relationship with the US and Ecuador's orientation

toward the international market more generally has driven many of Ecuador's domestic agricultural policies. As a result, Ecuador's agricultural subsidies and price supports have focused on crops most readily accepted into international commodities markets. While government policies have encouraged crops like wheat, corn, bananas and rice, some traditional subsistence crops like quinoa and potatoes have been largely ignored by government programs.

A changing climate is likely to bring Ecuador's food system under pressure through increasing temperatures and increasing precipitation. Understanding the impact of Ecuador's current agricultural policies is essential to determining the best policy options for adapting to a changing climate.

The history of the interface between western cultures and indigenous Ecuadorians offers continued examples of indigenous peoples and their interests being harmed to the benefit of colonial or foreign interests. Scars from the system of haciendas instituted under the Spanish Colonial System remain, evidenced by the extreme imbalance of land ownership. The Spanish deeded ownership of vast tracts of land to influential colonists including the people living on and cultivating the land. Though there were land reforms beginning in the 1960's, imbalances remain. Small subsistence farmers, while accounting for 75% of the population in the Andean region, owned only 11% of the arable land by 1974 (Knapp, 1991). This imbalance has continued with the majority of the land in the country being cultivated in tracts of 50 hectares or more by 1989.

During this same time period Ecuadorian agricultural policy has become largely focused on crops produced for international trade. Again, at the urging of western powers such as the US, Ecuador has oriented its policies for the benefit of the foreign interests. Ecuador is the world's largest exporter of bananas and it is the country's largest export crop measured as a percentage of GDP. Domestic policies surrounding banana cultivation going back to the 1940s have favored large-scale operations effectively removing small producers from the banana market. Many of these bananas are now produced by large foreign corporations such as Dole or Chiquita, which effectively take profits out of Ecuador.

Modern Ecuadorian agricultural policy has continued to focus on international competitiveness while minimal attention is paid to the substantial population of small farmers in the Andean highlands. National policies played an immense role in Ecuadorian regional change beginning in the 1970s, in part facilitated by massive foreign exchange from petroleum exports.

These modern agricultural policies create a dichotomy between the modern farmers of Ecuador and those who follow historical practices. Over the past 40 years a pattern has emerged of policies that encourage modern export crop producers on large capital-intensive farms, which employ machinery and wage-labor. Policies including price supports, cheap consumer food programs that depress wages, and easy access to credit have benefited these producers (Lawson, 1988).

The traditional sector, by contrast, is characterized by small farms, low incomes, subsistence production, high tenancy, and illiteracy. While producing substantial portions of domestic food, this sector has been penalized by ineffective producer price protection, loan application procedures which screen out illiterate applicants, and cheap urban food. These circumstances have all led to a stagnation of domestic production (Lawson, 1988).

In general, modern food policies in Ecuador have two complimentary components: minimum commodity prices for producers and maximum food prices for consumers. The Empresa Nacional de Almacenamiento y Comercializacion (National Board for Commercialization of Foodstuffs, ENAC) implemented the first government policy following this approach by purchasing crops at official set prices and then selling them to Ecuadorian consumers at levels which covered their costs.

ENAC was eventually replaced through a series of events stemming from the passage of the Andean Trade Preferences Act passed by the US in 1991. ATPA coupled with the adoption of the US Dollar as the official currency in 2000 have dramatically increased trade between the US and Ecuador. Favorable trade policies for American producers allow heavily subsidized American wheat and corn to be sold into the Ecuadorian market undercutting domestic producers.

The Andean Price Band System (APBS) established in 1995 created price supports similar to those under ENAC, which were put in place to guard domestic growers. Commodities covered by APBS are generally grown by large-scale modern farming operations. From the US perspective there is concern that the APBS limits the US ability to export commodities into the Andean region. The price band has the effect of subsidizing domestic production of commodities subject to the price band. For Ecuadorian farmers, such subsidy protection may seem justified to counterbalance subsidies provided to the agricultural sectors of foreign competitors. However,

because the APBS does not cover all crops the dichotomy persists between modern farmers who benefit from government policies and those using historical techniques who are largely ignored.

Finally, during the mid-2000's, free trade agreement talks between the US and other Andean countries failed, in part, out of concerns about how such an agreement might impact Ecuadorian agricultural interests. While broad policy goals in Ecuador intend to protect and preserve indigenous agricultural practices, there has been limited policy progress towards meeting this goal.

D. New Laws Creating Potential Synergies With Climate Justice Objectives

Recent constitutional provisions and agricultural laws passed in Ecuador lay the groundwork for a new focus inward on the production of food resources for Ecuadorian populations. Specifically, the new Ecuadorian Food Sovereignty law prioritizes food production for domestic consumption. Food sovereignty is a policy approach that has gained traction in recent years in developing countries. In general, food sovereignty promotes the right of each country to determine its own food policy rather than the uniform approach that has been pushed by the World Trade Organization. Functionally, a food sovereignty policy allows a country to protect its own agricultural industries and food supplies so long as those policies do not harm the interests of other countries.

Non-governmental organizations have also undertaken smaller scale efforts to improve local agricultural economies to increase production of traditional staple crops. Looking forward, domestically focused agricultural policies must be balanced against the continuing drive towards competitive participation in international markets.

E. Implementation of Climate Change Responses and Potential Barriers

While past Ecuadorian food and agriculture policies have contributed to the country's economic growth, the realities of climate change will require the country to re-evaluate the ultimate objectives of these policies. Heavy reliance on imported staple crops has eroded Ecuador's domestic ability to feed its population. Glimpses of a changing climate, provided by El Niño events, reveal more instability in food supplies. All of these effects will be compounded by a continual increase in population throughout Ecuador. The first reaction by the Ecuadorian

government to these new circumstances must be to refocus policy goals on supplying crops for domestic consumption.

The first step towards achieving these goals may be to expand existing price support programs to the crops produced by Ecuador's small farmers and making it easier for them to take advantage of the same policies which have bolstered the business of Ecuador's major export crops. Because the current Andean Price Band System is international in scope this will at minimum require international diplomacy and policy coordination across the Andean region. While this can begin to level the playing field between the large modern producers and smaller producers using historical practices, additional steps must also be taken.

Because the small farmers who produce the bulk of food supplies for the Andean region of Ecuador come from rural communities, the next step of harnessing their resources to provide the country will be more complex. Small communities over vast mountainous terrain must be organized on a case-by-case basis. Past development efforts in the region have shown that homogenous development regimes imposed over large areas do not provide lasting benefits necessary to address climate change. This complex level of organization will require strong cooperation between the government of Ecuador and the international development community. Local communities must gain a strong understanding of what impacts climate change is likely to have on their way of life. This information must be conveyed in a way that does not predetermine what specific adaptation measures are implemented, but complements the existing understanding of the local populations. By empowering local communities to choose from a menu of adaptation options these communities will have a vested interest in the success of the adaptation measures they choose to implement.

Allowing communities to determine their methods of adaptation also creates additional pressure on the support structures that will aid the implementation. Government bodies and international aid groups best positioned to provide resources must adopt a decentralized structure that allows for localized adaptability. Many past development projects in Ecuador have lacked effectiveness and long-term viability because uniform approaches were imposed over wide areas without attention to specific local needs. Those that have been successful have focused on intensely local development efforts. While a new decentralized approach may require additional up-front resources, these should be offset by anticipated longer-term benefits and viability.

III. Evaluation of Key Adaptation Projects

Governmental and Non-Governmental organizations throughout Ecuador and the world have implemented adaptation policies and programs aimed at a strengthening and improving Ecuadorian agricultural systems.

A. Government Projects

i. Information Transfer: Farming Methods and Tools

Urban, rural, and peri-urban farmers in and around the capital city of Quito, Ecuador experience many challenges due to lack of municipal integration and recognition of agricultural needs. This region is also facing higher temperatures, droughts, and sporadic periods of heavy rainfall, which will increase pressure on agricultural systems (Anguelovski, 25).

Through a dedicated government office, AGRUPAR (Agricultura Urbana Participativa – participatory urban agriculture), Quito has begun supporting urban farmers to adapt to climate change. The program started in 2002 to help reduce poverty and contribute to food security in nearby urban, rural, and peri-urban areas (Cox, 2009). AGRUPAR was a continuation of a citywide consultation and pilot project, which was partially and initially funded by Canada's International Development Research Centre (IDRC). Additional funding came from the Urban Management Program of UN-HABITAT and IDR ("Agricultura Urbana Participativa"). The program provides technical assistance from advisors who visit community areas regularly to teach local residents organic farming methods and techniques to make their plots more efficient.

The program has since expanded to help residents to organize, produce, and sell food ("Agricultura Urbana Participativa"). As of July 2009, the following have been achieved under AGRUPAR's assistance: 100 Demonstration Gardens, 19 School gardens, 4 Gardens with NGOs, 130 greenhouses, 121 drip irrigation systems, 12,600 people trained on gardening/farming, and 60,000 beneficiaries of the program (Suarez, 2009).

Although AGRUPAR provides technical experience, the program is not integrated into larger municipal functions or planning. Furthermore, AGRUPAR only provides material support (seeds, compost, etc) for the first 9 months (Anguelovski, 25). In 2005, the municipality transferred AGRUPAR to Conquito, a municipal economic development agency (Guénette, 2006). Although the shift in business toward Conquito allowed some farmers to successfully

market their harvests, lack of formal marketing channels and absence of certification of organic products disincentivized the expansion of cultivation areas and ability to supply a constant volume of harvests for market (Rodríguez, 2009). Yet despite the shift toward income generation, at least 33 gardens will not become commercial enterprises (Guénette, 2006).

ii. Encouraging Domestic Crop Production

In the 1990s, the Peruvian government implemented a program called Programa Nacional de Apoyo Alimentario (PRONAA) which purchased domestically grown agricultural products directly from farmers and included the food items in national food programs. Although Peru implemented PRONAA in order to improve nutrition among children, pregnant women, and elderly women, the program has also served as a climate change adaptation strategy. By encouraging the production of nationally grown crops, including quinoa and other native grains, Peru has become one of the main buyers of its own native crops, which ultimately led to an increase in the cultivation of such crops (Hellin and Higman, 34). Many native grains are more resistant to climate change effects like drought and erosion (Annex I).

However PRONAA has faced resistance from Peruvians who tend to favor consumption of soy and wheat over quinoa and other native grains. In addition, PRONAA's success in stimulating production and consumption of quinoa competes with efforts of farmers who would rather produce quinoa for export. Organizations that wish to develop markets for the exportation of quinoa are unable to compete with PRONAA's higher purchasing price (Hellin and Higman, 35). Furthermore, future cuts in funding may threaten the long-term future of PRONAA, which would likely require alternative stimuli to encourage continued quinoa production (36).

iii. Improving Water Infrastructure

Reduced glacial melt and unpredictable precipitation rates will likely jeopardize Ecuador's existing water and irrigation infrastructure. Climate change adaptation programs must strengthen existing systems and develop further mechanisms to support water catchment and irrigation.

In the early 2000s, with the assistance and funding of USAID, Ecuador implemented the Northern Border Development Program (NBDP), which contributed \$21.6 million in funding to improve, among many things, water systems and sewer systems (\$9.1 million) and irrigation canals and reservoirs (\$500,000) (Bernstein, 7). By 2004, 39 water systems and five sewer

systems had been built or rehabilitated and contracts to build additional water systems and sewer systems were underway (10). Ecuador also constructed concrete irrigation canals to replace dirt canals, which reduce water loss and maintenance requirements (11).

To evaluate the program's effectiveness, USAID and Ecuador government representatives visited construction sites on a monthly basis to evaluate operational and administrative status of the water and sewer system improvements and provide additional assistance if needed (15). However improvements to irrigation canals received significantly less attention, possibly due to less allocated funding. Of the six irrigation canals improved, program leaders only visited two irrigation canals and one reservoir (17). Despite this, the projects appear to be sustainable since the farmers benefiting from the canals are already responsible for routine maintenance and operation work (18).

Although this program appeared successful, several of the non-water programs, including land titling, were not on schedule or unlikely to be completed. In addition, the final project report indicated the project evaluation double counted the overall number of NBDP beneficiaries (19). With the assistance and funding of USAID, along with cooperation from the Ecuadorian government, NBDP seems scalable to other areas of Ecuador in need of improved water and irrigation infrastructure.

B. Non-Governmental Organization (NGO) Projects

i. Information Transfer

Over the past thirty years, pesticide use in rural farming practices has become increasingly common. In Ecuador, pesticide application and related intoxications have resulted in societal, environmental, and health issues. Studies conducted in Ecuadorian communities have shown that in areas where the use of highly toxic pesticides is prevalent, women face reproductive health challenges and the societies as a whole have recorded higher than average rates of suicides, children born with disabilities, and instances of cancers and death.

Science shows that climate change may act to increase temperature, precipitation, and humidity. These sorts of climactic changes are favorable for pests and fungi. In the late 1980's, the Farmer Field Schools (FFS) concept was introduced by the United Nation's Food and Agriculture Organization (FAO) to promote Integrated Pest Management (IPM) in Southeast

Asia. Since then a number of governments and NGOs have adopted FFS as a tool for spreading best farming practices globally. The technique has been widely effective because it embraces local farmers' knowledge and practices and aims to incorporate community development into the transfer of information.

In 1999, the FFS methodology was brought to the Andean region in response to tremendous pest problems and pesticide abuse in the potato-farming industry. The FAO's Global IPM Facility (GIF) and the International Potato Center (CIP) jointly financed a three-month course that trained 33 FFS facilitators in Ecuador, Bolivia and Peru. From this initial outlay of resources, each country took a different approach to the implementation of FFS. Each country used different organizations and funding mechanisms, but utilized the same basic principles.

In Ecuador, CIP and the National Institute for Agricultural Research (INIAP) built on what the FAO had started with the goals of improving farmers' understanding of agro-ecosystems and strengthening local decision-making and technological capacities in order to increase the productivity and sustainability of the agricultural industry. The CIP and INIAP focus was on the potato because it is a food security crop in the Andean highlands that has significant soil fertility needs and is often subject to pest and fungi problems. A pilot project was conducted in the province of Carchi and the successes were substantial. Farmers within the province reduced their pesticide usage by 75% and saw an increase in productivity of up to 40%. This outcome resulted in the acceptance of FFS as a best farming practice throughout the Ecuadorian Andes. As expected, the FFS programs spread to potato producing provinces through a network of local institutions.

FAO funding for FFS initiatives in South America ended in 2003. This was compounded by the existing neglect of rural development issues by Ecuadorian government policies. The government increasingly placed the responsibility of rural development on NGOs. However, even with the aggressive steps towards adopting a multi-organizational, collaborative funding approach, donor agencies decreased financing for agricultural development, and NGOs were unable to bear the weight of the on-going development needs of rural communities. In the absence of lasting public or private support, a number of examples of self-financing mechanisms to fund FFS at the community level were developed. These situations were often initiated by farmers who had experienced the benefits of the FFS programs themselves. However, without a steady flow of funding it is becoming increasingly difficult to train facilitators and promote FFS.

The challenges faced by FFS are not unlike other very promising community-based approaches to rural development and natural resource management.

During that same period a lack of government funding for INIAP developed into a situation where the institute had to go outside the government for funding and it turned to CropLife, the pesticide industry collective. This relationship created a questionable situation between public and private motives. Together, these organizations introduced programs that focused on the “Safe Use of Pesticides,” which was aimed at teaching women and children about the correct way to use pesticides. NGOs have put pressure on INIAP by requesting that the institute reevaluate its funding sources and the ways that CropLife funding may have changed the nature of the INIAP’s mission. CropLife member companies have occasionally shown interest in funding FFS, but overall interest has faded with FFS’s advocacy for reducing rural farmer reliance on pesticides and the elimination of highly toxic products. Some NGOs have argued that INIAP uses FFS methodology in their “Safe Use of Pesticides” programs, a complete contradiction to the original intention of the FFS initiative.

Ecuadorian FFS programs have explored a number of different funding avenues over the years. One method was to develop ties to their respective markets, particularly the food processing industry. Groups of farmers in Ecuador established production contracts within the agrifood industry, such as FritoLay and Kentucky Fried Chicken (KFC), which provide fairer prices and enable farmers to avoid the unpredictability of national markets. However, this method is becoming less and less frequent because farmers have difficulty meeting quality standards. In 2007, FritoLay had six contracts with potato farmers in the region; this was down from 30 contracts in 1995. The number of KFC contracts saw a similar pattern of decline. More work is needed to further develop such market opportunities for FFS and to coordinate production among groups in order to meet quality and volume demands throughout the year.

CIP, INIAP and the Ministry of Agriculture have been trying to develop and institutionalize an extension approach to information transfer. The premise is that the extension approach will be based on participatory research methodologies and establish an effective mechanism of communication between the local institutional actors and scientists working on agro-ecosystem best practices. The strategy is twofold; the *first* part involves increasing agricultural knowledge in rural communities and the *second* part involves supporting the local process of technological development with participatory research groups such as those used by

the International Center for Tropical Agriculture (CIAT). The participatory research groups include FFS graduates, research institutions and universities. Consequently, the present challenges for the FFS movement are to establish collaborative networks that will complement these extension programs and establish steady lines of finance and technical support mechanisms to sustain a FFS movement.

ii. Leveraging Expertise

Historically, extreme weather events have been particularly harmful to rural communities in Ecuador. The prevalence of droughts and floods has jeopardized the livelihoods of many of the poorest populations that have the least ability to cope with disaster events. Water resource management will be increasingly important as precipitation trends change and glacier melt becomes progressively more severe. Flooding events and prolonged erosion can affect structural stability of infrastructure, particularly the vulnerable infrastructure that serves poor populations. Increased glacial melt could threaten long-term water resources for major cities like Cotapaxi.

Climate change adaptation projects are expected to be a large part of international climate change agreements. At the 2009 Conference of the Parties (COP) in Copenhagen, many developed countries agreed to contribute to a global climate fund that would provide money to developing nations for mitigation and adaptation projects. The fund is expected to distribute \$100 billion per year from 2020 onwards. Ecuador is a good candidate for climate financing, but whether or not funding will reach rural communities is debatable.

One avenue that rural communities could choose to increase their chances of government support for adaptation projects is to provide a high level proposal with the help of professional organizations or NGO assistance. International organizations such as Engineers Without Borders (EWB) and the American Society of Civil Engineers' (ASCE) International Program aim to combine knowledge, capabilities, technical and organizational skills, with the needs of impoverished populations. EWB is a non-profit organization that works with developing communities around the world to provide solutions to quality of life challenges.

The Ecuadorian community of Susudel was selected by EWB for a water resource feasibility study. The feasibility study developed alternatives for improvements to irrigation storage and delivery systems in the Rio Leon basin. EWB representatives collaborated with local community leaders, the regional mayor, and government officials in Cuenca to ensure that their work was being done with as much input from all stakeholders involved. The EWB team

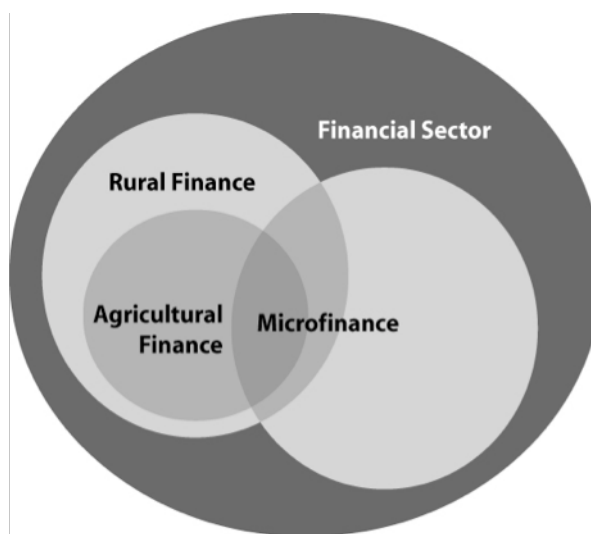
completed a feasibility analysis as well as a plan for recommended projects that the community could carry out.

The advantages to implementing a project such as this are that these organizations possess the professional skills to carry out the necessary studies or designs, but they do not require financial compensation. These organizations use local labor, materials, and maintenance schemes for any projects that are recommended. The major hurdle to this approach is the limited capacity of these organizations to reach all communities in need.

iii. Microfinancing and Agriculture

The agricultural sector is a central component of rural development in the Ecuadorian highlands. Much of the population relies on farming to make a living and/or feed their family. Lending and borrowing are key aspects of economic development, which can be offered to farmers through microfinancing. Microfinance institutions provide banking related services such as credit, savings and insurance to low-income clients that typically do not qualify for such services under the stipulations of other financial institutions. As a result of insufficient collateral for credit approval, there is a lack of funding opportunities available to farmers, typically serving as a barrier to increased productivity.

In Ecuador, the most established microfinancing institution is Banco Solidario, a commercial bank based out of Quito. Banco Solidario was the first Latin American financial institution motivated by a social mission and established with 100% private capital. In 2008, Banco Solidario boasted a total of 147,000 serviced microfinance clients and had an active loan portfolio of over \$236 million USD.



Source: *Microcredit and Agriculture: How to Make it Work*

Banco Solidario is different from many other microfinancing institutions because it developed a number of services that are targeted towards rural farmers. In September 2001, Banco Solidario and ACCION International, a global leader in economic development, began implementing a rural lending program. The program included adjusting Banco Solidario's individual working capital loan product to better meet rural client demands. These modifications

included tailoring loans for clients' seasonal income patterns and considering household payment capacity. Once the concept proved itself on the individual loan product market, ACCION and Banco Solidario began developing rural group loan products. By the end of 2003, the rural lending program was reaching nearly 4,000 individual and group borrowers with a portfolio of nearly \$5.4 million.

Banco Solidario's strategy has been to move gradually into rural areas and to provide a wide range of rural loan products from which clients can choose. The program provides its customers with credit for increasing inputs and labor costs, among other things. They also allow borrowers to invest in machinery, equipment, tools, and vehicles, as well as personal home upgrades.

IV. Key Considerations for Adaptation Activities

Criteria for prioritizing adaptation activities in Ecuador include food security, project feasibility, sustainability, local empowerment, accessibility, and synergy with existing and future development efforts.

A. Food Security

The 1996 World Food Summit defined food security to exist “when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life,” (“Food Security”). To achieve food security, adaptation programs in Ecuador must ensure sufficient amounts of food are available on a consistent basis (food availability), people have sufficient resources to obtain nutritious food (food access), and people have adequate water and sanitation to prepare and consume food (food use).

B. Project Feasibility

Successful adaptation strategies require adequate funding, both initially and in the long-term. Initial funding must cover all start-up costs and short-term implementation. If initial funding is only available for a brief period of time, or may be threatened by market variability or economic shortfalls, a long-term funding plan must be in place. The ease in which a strategy can be implemented determines whether a project’s funding will last long enough for the project to successfully begin.

C. Sustainability

Sustainability in this context does not refer to the long-term sustainability of a particular project; rather sustainability refers to a coping strategy’s ability to advance the Republic of Ecuador without depleting resources – economic, cultural, and environmental. Sustainability is a long-term ideal, which is appropriate for the inherently long-term problem of climate change. Although short-term sacrifices are made for short-term capital gain, long-term costs must be considered. Examples of sustainability include advancing long-term projects that keep ecologic systems intact (i.e. reducing pesticide consumption), maintain trading equality (i.e. maintaining

market protections so that resources are not eroded from the nation without proper compensation), or protect social customs and norms (i.e. recognizing indigenous rights).

D. Local Empowerment

Local empowerment refers to the ability of an activity to encourage a community to take action and make decisions that are in their best interest. It is imperative that projects are designed and implemented with emphasis on local decision-making. When a community collectively decides to begin a project they become invested in the outcome of the project. A sense of ownership and acknowledgement of the collective value of an activity acts to strengthen community ties and further development objectives.

E. Accessibility

Accessibility is vital for all coping strategies. The accessibility ideal is that targeted groups will be able to participate in projects aimed to mitigate or adapt to climate impacts. In a nation as diverse as Ecuador, accessibility ensures that: project information is communicated to people of all languages and that language is not a barrier to participation; people will be able to access resources, especially those in remote and rural areas and those who do not have information technology infrastructure; people will be able to participate in projects regardless of color, class, creed, or disability.

F. Synergy with Existing and Future Development Efforts

Preparation for climate impacts should not be made in isolation of other developmental considerations. Climate is just one complexity that will exacerbate existing infrastructures (that may already be taxed). When opportunities exist, there can be synergistic or, at least, mutually beneficial partnerships that can address problems from the root. When these opportunities exist, they should be fully explored. In instances in which immediate needs must be addressed before climate difficulties, adaptations should be constructed in a way that considers the long-term impacts of climate.

V. List of Coping Strategies

A. Government Program for Domestic Marketing of Andean Crops

This adaptation strategy contributes significantly to food security. By encouraging national production of native crops like quinoa, Peru's PRONAA program strengthened local agricultural systems and improved access to nutritious crops, which contributed to food availability and access. Although the project was easily funded using government resources, implementation was difficult due to lack of compliance with the program and lack of interest in consuming native crops like quinoa (Hellin and Higman, 35). Long term funding is also in jeopardy in the event of a shortfall in government resources, which would hinder the strategy's longevity.

Although government programs like PRONAA and Ecuador's AGRUPAR have involved and empowered many local communities and farmers, such efforts are sometimes at odds with non-governmental efforts to develop crops for national or international export, and although they initially target small-scale farmers, efforts eventually shift toward more large-scale production.

B. Making Local Crops Competitive with Imports for Domestic Consumption (Price Guarantees for Indigenous Andean Crops)

Price supports provided through the Andean Price Band System have provided stability for long-term growth in Ecuador's export crops. Expanding these price supports to crops like potato and quinoa grown through traditional farming practices in the high Andes will empower the local communities to compete with the more modern farming operations. Enabling these local communities to be more competitive in providing domestic food supplies should also increase overall domestic crop production providing better food security for the people of Ecuador. Price supports to traditional crops grown on smaller rural farms directly addresses the criteria of accessibility by providing access to government support that these farmers could not otherwise receive.

C. Facilitating Access to Government Support Policies and Programs

In the past, numerous barriers have prevented many indigenous small farmers from accessing government support programs. High tenancy, as opposed to farm ownership, limits access to credit. Illiteracy has been used to screen out otherwise qualified loan applicants. The lack of producer price supports for crops like potatoes and quinoa disadvantages small farmers who grow the bulk of those commodities. When instituting any policies aimed at climate adaptation, close attention must be paid to the ability that vulnerable populations will have to access the benefits of these policies. Simply removing existing barriers is not sufficient. Any new policies must find ways to reach out to vulnerable communities, educating the population about what government support programs are available, and facilitating access to those programs.

D. Water Infrastructure for Irrigation and Flood Control

The improvement of water infrastructure aids food security by facilitating irrigation of crops so that production can keep up with the increased demands of population growth. Systems to handle excess quantities of water prevent losses due to flooding, and store water for agricultural and other purposes in less rainy seasons. Depending on the scale of the project, funding can be an obstacle. Large-scale projects often displace or simply fail to benefit small-scale farmers. Some large-scale projects, like dams, have ecological consequences as well, and the local groups most impacted can be disenfranchised from decision-making. Ecuador suffers from the legacy of the hacienda system in modern day allocation of water rights (Annex II). There are examples of communities organizing to address water distribution in a local consensus-based framework, to maximize accessibility for everyone in the community (Boelens et al., 2002).

E. Information Transfer on Agricultural Management Practices

As discussed in Section III, the Farmer Field School (FFS) methodology of information transfer has been a successful way to disseminate agricultural management practices. Local farmer knowledge and practices have long been overlooked by a society that encourages a top-down approach to information transfer. This approach embraced a network of field experiments and adult teaching techniques to encourage the implementation of efficient and safe farming.

These types of programs often receive little or no government support because the Ecuadorian government focuses much of its attention on large scale agriculture. Thus, financial sustainability has proven to be a significant challenge for these programs. Another major consideration is geographical distance between rural farming communities. Often network development between rural communities proves to be a challenge for the transfer of information.

F. Information Transfer on Climate Change Effects

Dissemination of knowledge about the changes in climate that can be expected gives farmers the opportunity to mobilize local knowledge about how to adapt. Local people are best positioned to observe changes as they occur and assess the impact on their crops. Timely communication of the impacts that begin to be felt is also necessary to help mobilize outside resources. Improved technical monitoring of climate variables works in the interests of improving model predictions of future climate impacts, and of documenting climate impacts for climate justice related claims. Instrumentation to monitor glaciers and meteorological conditions, however, can be expensive to install and maintain, and requires technical training to operate. Thus, funding and empowerment of local communities to carry out this work themselves is a challenge.

G. International Technology Transfer

Effects of climate change are likely to permanently perturb local climates of Ecuador in ways that have been unseen for hundreds or thousands of years. Even the most resilient crops may have diminished yields or may need to be planted in new locations. In many cases, technology will exist to help adapt to and mitigate the effects of climate change, albeit on an international scale. International research and research tools will need to be employed to understand the magnitude and impacts of climate change and potential avenues for adaptation. In some cases, for-profit companies may develop technology and infrastructure (such as seeds, sustainable pest management applications, renewable energy sources) that will need to be employed in Ecuador. Ecuador should consider the importance of international technology transfer when negotiating international agreements. Ecuador should work toward being eligible

for aid and reparations in the form of technical assistance, which should then be distributed national via Coping Strategy E.

VI. NAPA Preparation Process

Beginning from our earliest research stages, the Food and Water Group sought to create a clear and meaningful dialogue among our group members. Because our group would come to rely heavily on analysis of both scientific data and policy, this dialogue could not be merely a summarization of our research. As we progressed through initial research phases, each group member contextualized how their own research fit into the larger project as it took shape.

Functionally we accomplished these objectives by each writing semi-weekly summaries of our research accompanied by our own commentary on how the research developed our understanding of our project. We circulated these summaries among our group members prior to class each Wednesday. We could then use class time to meet and discuss how different elements of our research connected and interacted. This also allowed us to educate one another on the elements of our project, which fell outside our area of academic expertise. By engaging the academic attributes of our collective disciplines on the project as a whole we were ultimately able to craft a more thorough and integrated analysis of climate change impacts to Ecuador's food supplies.

After the initial research and project definition phase, we shared a comprehensive understanding of group goals making it easier to delegate tasks to create the final NAPA document. During the spring quarter we began assigning elements of the NAPA outline to different group members as primary drafters. In some cases certain elements were drafted jointly. After compiling the distinct elements into a single document, each group member conducted an independent review to ensure that all NAPA components clearly conveyed the findings in a way that was effective from their disciplinary perspective.

VII. Annex Documents

- A. Annex I: Ecuadorian Agriculture: Subsistence Farming in the Andes and Beyond
- B. Annex II: Ecuadorian Agricultural Policies
- C. Annex III: Agriculture and Aquaculture in Ecuador: An Overview of these Export Sectors
- D. Annex IV: Climate and Climate Change in Ecuador: An Overview

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