

## **Assessing Socioeconomic Resilience of Rural Livelihood Systems in an Ecuadorian Agrosocioecosystem**

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### **Abstract**

Ecuador is the world's largest banana exporter. On the Ecuadorian coast an important part of the population lives as limited-resource farmers or landless commercial plantation workers. Much agriculture in Ecuador depends heavily on hand labor. However, many people are migrating away from the country due to economic crisis and other factors. This study presents an assessment of the current situation in a selected agrosocioecosystem, by studying its principal components, their socioeconomic resilience, and what economic output they provide. The study also assesses the benefits of remaining a small farmer, as an alternative to migration. There are a limited number of livelihood options in the study area. People can be small-scale farmers; town-dwelling, salaried plantation workers; live and work on plantations; or migrate. This lack of opportunity creates an unstable social situation. Four components or subsystems were studied: commercial banana plantations; town-dwelling plantation workers; small-scale farmers; and nature reserves. Analysis was undertaken using Ethnographic Linear Programming (ELP) that uses qualitative and quantitative data to estimate systems outcomes under several scenarios. Elicited data were used to construct models. Households were subjected to shocks, and those able to best respond were said to possess higher socioeconomic resilience. The study found that small-scale farmers are highly socioeconomically resilient to shocks. Town-dwelling plantation worker households possess little resilience. Transferring households from the town labor supply to small-scale farms improves economic output and adds resilience to the overall system. A rural worker survey revealed that small farms are perceived as the safest, most food secure place to live. The multifunctionality of small-scale farms, including their ability to add resilience to larger systems in which they are embedded is an additional outcome of the study.

**Key Words:** Ecuador, socioeconomic resilience, small-scale farms, banana plantations.

### **1. Introduction**

The objective of the study was to understand structure, linkages and resilience in a complex agrosocioecosystem. Three components were studied and modeled: the commercial banana production system; the plantation worker household livelihood system; and the small-scale farm livelihood system. The potential role of a local forest reserve in improving local livelihoods was also explored. The ultimate goal was to explore improved livelihoods for rural workers and the possibilities for improvement for the overall system. Each sub-system was modeled in order to understand how socioeconomic resilience might vary according to different living arrangements. Some plantation workers live on large plantations, others live in a local town and others live on small-scale farms. It was

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not known which of these living arrangements provides more socioeconomic resilience and thus more stability in the long run for the agrosocioecosystem, and better livelihoods for rural workers.

This study approaches sustainable rural livelihoods by seeking to measure resilience of rural worker households to major disturbances, commonly called shocks or stresses. The type of resilience is social and economic (hereafter socioeconomic resilience). Specific objectives were to assess resilience *vis-à-vis* economic crises; El Niño climate events, and sudden household composition changes. The working hypothesis was that while small-scale farm households are able to recover from stress and shocks, town-dwelling plantation worker households possess less ability to do so. This issue was explored using an ethnographic linear program models.

## 2. Theoretical Framework

Research was spawned by a local foundation that owns a remnant primary forest and had an interest in promoting social stability in the area. A systems approach was used in order to deal with the complexity at hand and to embrace economics, ecology, and institutional analysis to provide a deeper and more integrative understanding. People interact with nature in systems affected by economic, ecological, social, and evolutionary changes. Both gradual and episodic changes exist on the temporal scale, and local and global changes on the spatial scale (Holling and Gunderson 2002). The ability to recover from sudden change—and an attempt to measure it—is central to this study.

In Ecuador, as in much of the developing world, sustainable development deals with people between islands of wealth. A normative view of landscape envisions a mosaic of natural forest, sustainable agriculture, and human settlements. These elements are all contained within the study area. Food security is explicitly accounted for in models used to analyze the system under study. Food security analysis causes us to deal with the entire complex web of issues: ecological, sociological, economic, political, and others to begin the process of reorganizing socioeconomic-ecological systems (Vandermeer and Perfecto 1999).

Small-scale farmers are emphasized because their numbers continue to rise in developing countries, and because traditional farms have several known characteristics among which is the ability to survive a crisis. However, livelihoods encompass more than the farm. Commercial plantations are included in the analysis because the rural poor must have the means to purchase food they cannot grow. Food security depends as much on employment and incomes as it does on food production. Agriculture and natural resource development are crucial in both respects (Conway 1997).

Resilience is a key property of sustainability (Folke *et al.* 1998). Ecological resilience has been defined as the magnitude of disturbance that can be experienced before a system moves into a different state and a different set of controls (Holling 1973, 1986). Social resilience has been defined as the ability of human communities to withstand external shocks to their social infrastructure, such as environmental variability or social, economic, and political upheaval (Adger 2000, Conway and Chambers 1992).

Change and crisis are part of the dynamic development of complex coevolving social-ecological systems (Gunderson 1999). One of our principal theses is that small-scale polyculture agriculture may be an asset for sustainable development because those who engage in this activity may possess socioeconomic resilience and may confer some of this property to other levels of the systems hierarchy. Shocks and stresses are emphasized to differentiate from the normal small disturbing forces such as fluctuations in cycles in the surrounding environment (including physical, biological, social, and economic variables

that lie outside the agroecosystem under consideration). Shocks can be external, that is, exogenous, meaning issues that are beyond the farmers' control. Internal shocks are directly associated with farming system operations and decision-making. Resilience may be one of the best measures of sustainability. Sustainability is an emergent property of the interactions between communities of interest and of place that includes a healthy ecosystem, vital economies, and social equity (Flora 2001).

Greater resilience (to a point) can be built into farm systems. Sustainable agricultural systems will therefore display the characteristics of a resilient system (Folke et al. 1998, Carpenter and Gunderson 2001, Milestad et al. 2002). Berkes and Folke (1998) hypothesized that successful resource management systems will allow disturbances to enter on a scale that does not disrupt the structure and functional performance of the ecosystem and the services it provides. This capacity to absorb and adapt to change in an active way includes the following aspects: a) understanding cycles of natural and unpredictable events (Röling and Jiggins 1998); b) diverse and flexible on-farm and off-farm activities to stabilize the farm system (Ellis 2000); and c) stewardship and socioecological management (Milestad et al. 2002). In this study, systems resilience was explored by introducing shocks into linear program (LP) models and quantifying the outcomes. On-farm and off-farm activities are included. The study concludes with a plan for environmental management and ecosystems stewardship.

### 3. Study Context

Total Ecuadorian population in 1970 was 5,970,000. In that year the agricultural population was 3,201,000, which represented 53.6% of the total. In 2000—the most recent year for which data are available—total population of Ecuador was 13,184,000. The agricultural population for that same year was 3,480,000 (FAO 2002). In percentage terms the agricultural population has dropped. Yet, in absolute numbers, there are nearly 300,000 more people involved in agriculture today. Ecuador is an economically unstable country.

An area where a major Ecuadorian banana production and export company operates several important plantations was measured using a hand-held GPS unit in March 2002. Waypoints were taken at the extremes of the area's limits and the resulting polygon contained 13,308 ha. The study area in Los Ríos Province is located about lat. 0.5°S and long. 79°W. The principal infrastructure feature is the Quevedo-Santo Domingo highway, which bisects the study area north to south. Located in the northeast corner of this area is the Río Palenque (RP) Science Center and Nature Reserve.

Average altitude is 300m above sea level, with a mean annual temperature of 24.5°C. Most soils are of volcanic origin with high organic matter content. The fertile andisols are highly permeable and porous, with low water retention capacity. The drier season runs from June through November. The rainier period is from December through May. Two cropping cycles exist in the area. Soil moisture (and sunlight) in this part of Ecuador, especially during the summer dry season, is a function of cloud cover as well as rainfall (Núñez Torres 1998, Jones 1987).

Agriculture and ancillary industries and services that support it overwhelmingly dominate the area. It is clearly an agricultural system. Relationships among plantation companies, workers and farmers make up a social network, albeit a rather loose one. It is also then a social system. It is a place where cultivation, manufacture, trade, salaries, supply, and demand link actors together; it is also an economic system. Finally, it is a complex interplay of living organisms, human beings, and the habitat that surrounds them. It is an ecosystem as well. Agriculture, socioeconomics, and ecology are interwoven in this *agrosocioecosystem* (ASES).

Nearly 400 (n=389) small-scale farms under 10 ha in size (mean = 3 ha) are located within the research polygon. Also located in the area are 513 medium-size farms between 11 and 99 ha in size (mean=12 ha), and 49 large properties over 100 ha in size (mean=110). The Parish, (an administrative unit below the canton or county level) of Patricia Pilar has a population of 6,241 (SIISE, 2002). The town of Patricia Pilar proper has around 4,500 inhabitants. Additionally, three hamlets and several crossroads settlements exist. Total farms in the area are 951. In summary, the population of the study area, although very mobile, is roughly 5,000 in small towns and hamlets; 3,000 on small and medium farms. Total population of the study area is approximately 1,800 households, or 9,000 people. Of these, some 3,000, or nearly 32%, are banana plantation workers. Just one company employs some 650 of these plantation employees. Some 2,000 additional banana plantation workers do not reside in the study area.

## 2. Methods

Field research was conducted from November 2000 to March 2002. A Sondeo, or multidisciplinary team appraisal (Hildebrand 1986) allowed for initial understanding of felt needs as well as the diversity and complexity of the research area. Focus groups were held to gain insight into livelihood options and strategies. Conversational, open-ended interviews were conducted in farmers' and workers' dwellings, fields, and at local markets. The researcher participated in everyday activities with farmers (n=32). Farmers provided valuable information needed to simulate the livelihood system in computer models. A perceptions survey was conducted with n=85 rural workers. The survey revealed stated preferences regarding safety and well-being in times of shocks and stress (Breuer and Hildebrand 2003, in review). Livelihood systems were modeled using Ethnographic Linear Programming (Breuer et al. 2003). Models were calibrated and validated on return visits to farms using participatory linear programming. Twelve of the original farms were re-visited for validation.

Ethnographic linear programming models link ethnographic information to a quantitative analysis tool. The strength of the ELP is that it can incorporate demographic, socioeconomic, ecological, climatic, production, and other data in one model. These models use information gathered directly from producers and workers using participatory methods. Model calibration with farmers was invaluable for understanding the system. Models were used to explore reaction to shocks, to look at the mechanics of linkages, and to test new technologies. ELPs are a rapid, low cost, effective tool for *ex ante* prediction and hypothesis exploration. Models may be scaled up to the community or landscape level simulating an entire agrosocioecosystem for predictive purposes. Since they are decision-making models, and heuristic in nature, they account for the human element in the system. Models were used to draw inferences rather than test hypotheses.

### 3.1. The Models

#### 3.1.1. Household Models

Household composition has been recognized by researchers as one of the most important variables in small-scale farm economies for many years. Thirty-two families were modeled for two of the living arrangements found in the study area—small-scale farms households and town-dwelling worker households. They were not analyzed on average but rather as individual units. Families grow in steps over the 10-year study period by younger children changing into a higher consumption and production category every 4 years. Sudden household changes, such as a relative coming to live with the family, a

new baby being born, the male adult leaving the household, etc., are introduced as shocks in the different scenarios.

Work availability and seasonality are built into the models. The latter is captured in the division of most activities into dry and rainy seasons. Selling activities are divided into monthly periods when crops are normally sold. The models assume that a limited amount of work is available overall in the local community, especially informal work, which, in the case of the town-dwelling workers, is the only source of income available to adult and adolescent females. Discretionary cash is carried over from one year to the next. While agroecosystems are networks that usually include feedback loops and learning processes, these are not contemplated in the models used in this study.

### 3.1.2. *Small-Scale Farm Model*

Most input data used were gathered from farmers in the study area to take full advantage of local experiential knowledge and real-life, current, farmer-reported information. Production activities include maize, rice, a cacao-plantain agroforestry intercrop, passion fruit (*maracuyá = Passiflora edulis*), chili peppers, chickens, pigs, and selling male adult and teen labor off the farm. Constraints consisted of food requirements, land, labor, and capital available. A minimum of UDS 240 is required to begin the new season's planting. This money is given in the first year (assuming it is carried over from the previous year). Cash can also be borrowed in the informal market at a cost of 180% interest per year. The model runs for ten years.

### 3.1.3. *Town-dwelling Banana Plantation Worker Model*

Production activities are limited to salaried work on banana plantations available to adult and teen males only. Adult and teen females have access to informal work. A formula subtracts reproduction activities (child care, cooking, cleaning, etc.) from the total time available for obtaining income for adult females. Constraints consisted of food requirements, cash available for non-food costs (rent, water and gas, when applicable), school fees (when applicable), and miscellaneous. The model runs for ten years.

### 3.1.4. *Agrosocioecosystem Model*

The third model is a whole-agrosocioecosystem model. This LP incorporates the commercial banana component, the banana worker component, the small farm component, and the natural area component. In this large model, constructed as a matrix using a Microsoft Excel® spreadsheet, many activities occurring in the study area are incorporated. These include crop production and selling activities, total use of land, and hiring of temporary and permanent labor. Labor is of great importance because labor supply gaps are a problem for banana plantations.

Constraints include food necessary to feed all 9,000 persons (1,500 families) residing within the 13,300 ha study area; availability of two types of land (best and marginal); capital; family labor; and others. The objective function is the maximization of discretionary cash at year's end. The main activity in the study area is the commercial production of bananas. Overall maximum discretionary cash incorporates efficiency of both small-farm households and large banana haciendas.

## 4. Results

### 4.1. Results from Small-scale Farm Household and Town-dwelling Worker Household Models

Quasi data from model outcomes are semi-comparable. Each type of livelihood system is endowed with different resources and opportunities (or lack thereof). Small-farm households need to carry over more cash (\$240) than worker households (\$80) from one year to another. Keeping these differences in mind, small-scale farms are resilient to several types of shocks. Plantation worker households show little resilience to most shocks. When a household’s output (discretionary cash, the objective function) was 40% below the average across all scenarios, some households were not able to recover (i.e. move back into positive output). The criterion for describing a household of either type as “resilient” was when it did not drop below 0.4 of baseline under two or more scenarios. This threshold is the “threshold of resilience” in this study.

Any household that was not able to recover from two or more scenarios was considered not resilient, especially if the scenario produced two years in a row of negative outcomes. Thus, 23 of 32 sampled farm households were resilient over 15 scenarios (71.9%). Of the town-dwelling worker households, only 17 of 32 households were resilient under the same criteria (53.1%). In figures 1 and 2, 15 scenarios appear on the X-axis in the order in which they are listed in Appendix 1. The Y-axis is the total amount of accumulated discretionary cash at the end of the tenth year of simulation.

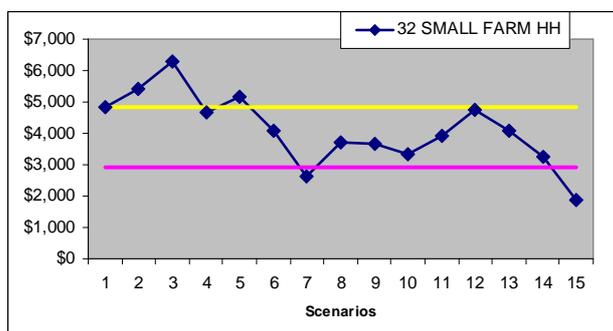


Figure 1. Average of 32 small-farm households: Discretionary Cash (blue), Baseline Discretionary Cash (yellow), and Threshold of Resilience (pink), under 15 Different Scenarios

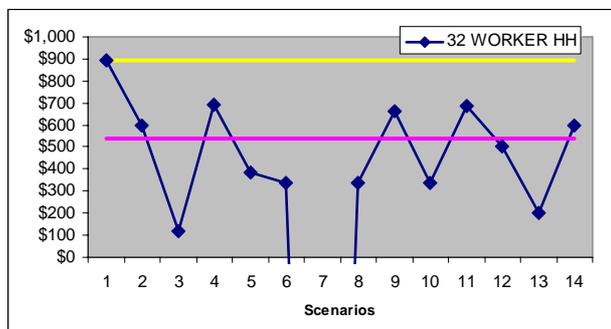


Figure 2. Average of 32 town-dwelling worker households: Discretionary Cash (blue), Baseline Discretionary Cash (yellow), and Threshold of Resilience (pink), under 14 Different Scenarios

## 4.2. Results from Agrosocioecosystem Model

One objective of this study was to understand the connections among small-scale farm households, town-dwelling worker households, and the overall agrosocioecosystem. Households were modeled first to measure their responses to shocks. Next, the coefficients were introduced into a larger matrix that also contained data on banana plantations and nature reserves. Twelve scenarios were modeled. The scenario that captures the dynamics of modifying numbers of small farm households and worker households is described here. One hundred households were transferred to small-scale farms in the proportion of one adult male and two teen males per household available for a full 296-day work year on the banana plantation. In the same scenario, this same number of workers was subtracted from the town supply of labor.

Total discretionary cash output of the entire agroecosystem was then calculated and compared with the baseline scenario. The transfer of 100 small-scale farm households from town to small farm in the model provided an overall economic outcome that was more than one third greater (36.78%, or \$15,477,325 vs. \$11,316,075) than the baseline, or current steady state of the modeled system.

Figure 3 shows estimates of socioeconomic resilience and economic output from the agrosocioecosystem as determined by running several scenarios in the LP models.

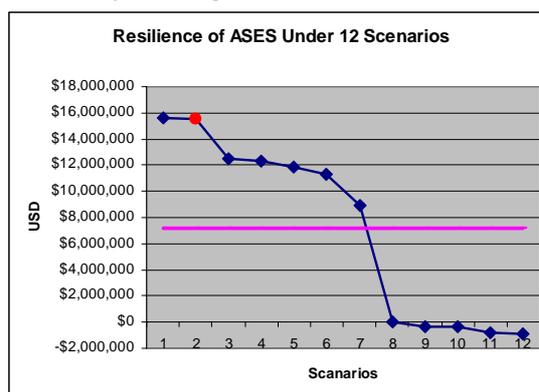


Figure 3. Resilience and economic output of the agrosocioecosystem

## 5. Conclusions and Discussion

### 5.1. Resilience of Small-scale Farms

Small-scale farmers are, in general, socioeconomically resilient to internal and external shocks. The results of a worker survey suggesting this were validated through modeling. Town-dwelling plantation workers show much less resilience to shocks. An important and perhaps often overlooked quality of small-scale farms is their ability to survive crises. This property may be especially important in landscapes that are dominated by productive though fragile monocultures such as banana. The concept of the multifunctionality of the small farm including livelihoods and environmental services, and as a provider of a measure of resilience in larger systems is clearly seen in the results of the study, although the precise factors responsible for this need to be further studied.

### 5.2. Agroecosystem Design

Results of this study lead us to infer that socioeconomic and environmental sustainability can build upon and mutually reinforce each other. A design that mitigates patchiness of nature reserves also serves to create new small-scale farms. Social and ecological sustainability are thus improved in one action. Land would be purchased first by banana companies, and later sold or leased to loyal trustworthy employees. Strips of land would connect “natural areas” on banana plantations to a local forest reserve. These strips, about 400m wide would consist of a central corridor, roughly 200m in width. Adjacent to the corridor, on both sides would be small-scale farms measuring approximately 200m x 100m (Figures 4 and 5).

The banana companies would spearhead this transformation with several objectives in mind. First, a constant supply of workers would ensure that labor gaps would be less of a problem. Overall worker stability and resilience could be enhanced in the area possibly preventing out migration. Formerly disengaged workers would become stakeholders in environmental matters in their home area.

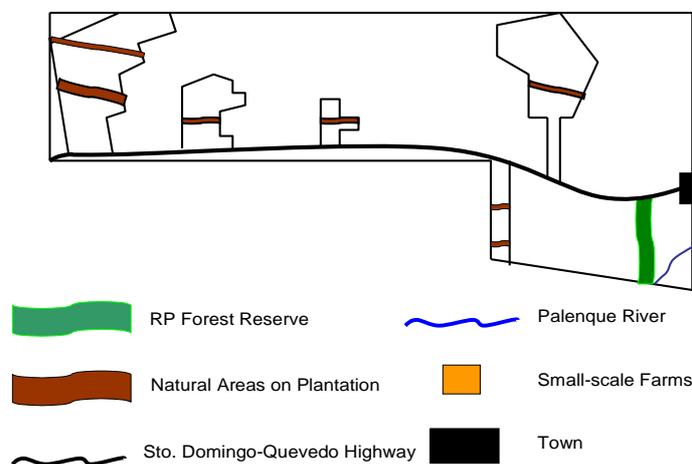


Figure 4. Banana plantations including natural areas, and a forest reserve as currently exists

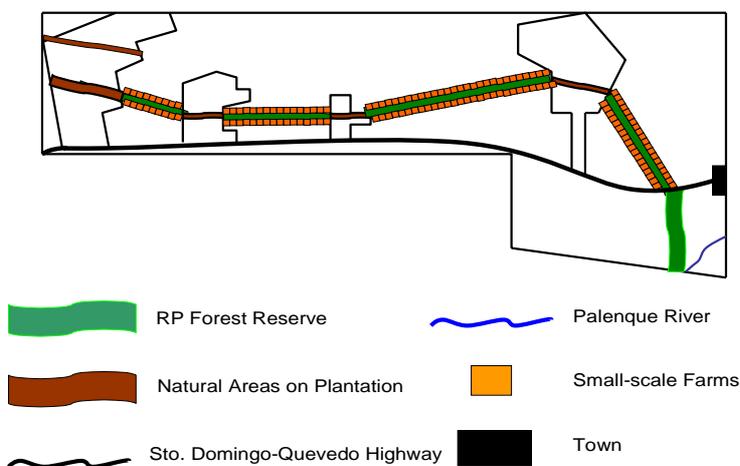


Figure 5. Corridors lined with small-scale farms between natural areas on banana plantations.

Banana monoculture is particularly susceptible to disease. An important benefit would come from the agroecological balance such areas would provide surrounding plantations. As habitat for predatory insects and pollinators, agroecological resilience may be enhanced. Erosion control, improved water and nutrient cycling, and carbon sequestration are other environmental services that would be provided by these corridors.

## **6. Limitations of the Study and Future Research**

This paper compares modeled outcomes from entities that are only just comparable, small farms and plantation employees. However, simply comparing farms with farms, for example smaller farms with larger ones, would have denied a basic reality in the study area. The deficiencies incurred by comparing only slightly comparable units is made up for by the inclusion of the plantation worker, because it is this sector that is most vulnerable, liable to emigrate and create social unrest. The possibility of making some of the landless landed, is a worthwhile research endeavor. Model outputs were limited by their design and construction.

The study is based on research conducted in a specific 13,300 ha study area located in northern Los Ríos Province. Many factors are known to contribute to greater resilience in small-scale farm systems. Attributes of small-scale farm livelihoods that allow for resilience are diversity, complexity, indigenous knowledge, ecological adaptation, and a host of others. In this study, we have not attempted to identify what factors are specifically responsible for resilience of the resource-limited farmer. Research in this area is a logical next step. More information is needed on the effects of changing dynamics of household composition, migration, remittances, and gender. Accessibility to infrastructure and amenities, as well as physical safety in the countryside needs research to complement any scheme of maintaining or increasing the current population in the countryside.

New technologies such as bamboo, medicinal plant, and papaya production for latex and fruit should be undertaken as subjects for research. Newly available climatic information, such as improved forecasts of El Niño climate events should be explored.

Studies need to be undertaken on the current biodiversity situation. A study of edge effects, patchiness, and connectivity is also needed to support agroecosystems design and management. Environmental services including Beta diversity, carbon sequestration, improved nutrient cycling, and erosion reduction need to be better understood.

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## Appendix A.

**Table 1. Scenarios for three models used in analyzing socioeconomic resilience**

<b>Small-farm household</b>	
Scenario 1	This “baseline” or steady state of 32 farm families.
Scenario 2	The adult male (father) of the household is removed through emigration or death.
Scenario 3	The adult male being absent and teen males are removed from the household composition.
Scenario 4	An additional consuming and non-producing person (baby or relative) is added to the household, thus affecting the consumer to producer ratio.
Scenario 5	New dependent added to the household in absence of the adult male.
Scenario 6	The cost of living rises 30%.
Scenario 7	The cost of living rises 100%.
Scenario 8	Small-scale farmers are unable to obtain cash generating off-farm work.
Scenario 9	Farmers cannot sell their produce in the year 4 (El Niño).
Scenario 10	Farmers cannot sell their produce in the fourth and eighth years (El Niño).
Scenario 11	Produce cannot be sold in years 4 and 8. Principal adult male missing.
Scenario 12	Small-scale farm households cannot hire labor.
Scenario 13	Crash in the market for passion fruit pulp – no sales.
Scenario 14	No passion fruit or chicken sales.
Scenario 15	Late rains. All crops yield 30% below average.
<b>Town-dwelling Worker household</b>	
Scenarios 1-7	Identical to scenarios used in small-scale farm household model
Scenario 8	Daily wage reduced from USD 4.00/day to USD \$3.00/day.
Scenario 9	No plantation work available. Unlimited informal work is available in the area.
Scenario 10	No plantation work available. Informal work limited to 10 days per person per month.
Scenario 11	Two El Niño years in a row. No banana work available in years 4 and 5 of the model.
Scenario 12	Two El Niño years, no banana work every 3 <sup>rd</sup> year.
Scenario 13	No work available in the informal sector.
Scenario 14	No plantation work available in years 4 and 8. No adult male.
<b>ASES</b>	
Scenario 1	Medicinal plants and bamboo adopted and grown by for small-scale farmers.
Scenario 2	100 families are subtracted from the town labor supply and transferred to small farms within the study area. Off-farm work for the new farm adult males and teen males is limited exclusively to banana plantations.
Scenario 3	100 households are added to the town labor supply, while a similar amount is subtracted from area small-scale farms.
Scenario 4	Plantation workers who usually leave the area on a temporary basis (labor gaps) to plant and harvest during certain periods, are constrained from leaving the area.
Scenario 5	10% of workers leave during labor gaps (ordinarily 25%).
Scenario 6	Baseline: 25% of workers temporarily leave the ASES and create labor supply gaps.
Scenario 7	Banana yields are reduced 30% during very intense El Niño climate events.
Scenario 8	Only environmentally certified bananas can be exported.
Scenario 9	Fifty percent of the worker population migrates during the rainy season.
Scenario 10	50% permanent out-migration (as opposed to temporary absenteeism).
Scenario 11	75% of the worker population permanently out- migrates. The entire system, which depends heavily on hand-labor, becomes infeasible under these circumstances.
Scenario 12	No bananas are produced in the study area. Although the total economic output of the region suffers a severe decline, food for local consumption is still produced.

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