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Unveiling Cacao Agroforestry Sustainability through the Socio-Ecological Systems Diagnostic Framework: The Case of Four Amazonian Rural Communities in Ecuador

Jilmar Castañeda-Ccori [1], Anne-Gaël Bilhaut [2], Armelle Mazé [3] and Juan Fernández-Manjarrés [1,*]

[1] Université Paris-Saclay, CNRS, AgroParisTech, Ecologie Systématique et Evolution, F-91405 Orsay, France; jilmarcas@gmail.com
[2] Institut Français d'Etudes Andines, Calle Alemania N° 32-188 y Guayanas, Quito 170519, Ecuador; agbilhaut@hotmail.com
[3] Université Paris-Saclay, INRAE, AgroParisTech, SAD-APT, 75005 Paris, France; armelle.maze@agroparistech.fr
* Correspondence: juan.fernandez@u-psud.fr

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Abstract: Cacao cultivation is rapidly increasing in Latin America under the influence of public policies and external markets. In Ecuador, the cultivated surface of high quality cacao trees has doubled in the last 50 years, creating great expectations in neighboring countries. Here, we investigated the social-ecological sustainability of cacao-based agroforestry systems in four rural Amazonian highlands communities in eastern Ecuador, close to the region where cacao was once domesticated. Kichwa- and Shuar-speaking groups were interviewed by adapting Ostrom's institutional diagnostic framework for social-ecological systems. Through a set of specifically created indicator variables, we identified key interactions and outcomes to understand the fragility and the sustainability of those communities. The studied communities were fairly young, with land rights secured less than 30 years ago in most cases. Per-family surfaces were very restricted (typically one hectare) and plots were divided between cash producing crops and their own home food. The small production per household goes through a precarious commercialization by both intermediaries and cooperatives, making the cacao bean production merely sufficient for pocket money. Ties with specialist producers in one community close to the capital has promoted the use of native cacao lines. Elsewhere, improved varieties of high productivity are planted along native trees being commercialized indistinctly. The continuity of these communities currently depend on a reorganization of their demography with parts of the population working elsewhere, as cacao bean production alone will continue to be insufficient, and will compete with their food self-sufficiency.

Keywords: amazon highlands; agroforestry; self-organization; social-ecological systems

1. Introduction

Latin American countries have a long history of providing commodities to northern countries, a situation that has shaped and continues to shape the social, economic, and land use choices of the region. The climates, soils, and natural vegetation of Latin American countries favor tree-based production in many areas that are too humid or too warm for conventional staple foods [1–3]. The demand for commodities has occurred in successive waves involving quinine, rubber, coffee, and cacao, among others, during the past three centuries [4].

Almost invariably, the commodities involved in these waves are produced in some type of agroforestry systems. Agroforestry—or the integration of trees in farms and agricultural landscapes to diversify and sustain production [5]—is one of the most important land uses in Latin America, and predates European colonization [3]. Indeed, agroforestry may cover more than 300 million hectares in the region, mostly but not exclusively involving shaded tree-crop systems of coffee and cacao [6]. Agroforestry is currently an ecosystem management approach highly promoted in the region by public policies [see for example [7] and references therein], making it a popular ecosystem management objective. Currently, one of the most sought-after commodities from agroforestry systems is the cacao bean, because of the ever-increasing market for chocolate and chocolate-derived products.

Cacao tree cultivation, in agroforestry and intensive form, has been increasing in Latin America almost exponentially the since the 1960s (Peru 2456%, Colombia 367%, 312% Bolivia, 202% Ecuador, and Brazil 145%, [8]). In particular, Ecuador is regarded as an example for the region, because despite being relatively small in size, it provides the international markets with high quality cacao beans, thanks to the presence of well-established varieties and adequate transformation and commercialization. Large properties with direct access to international markets are common on the coast, coexisting with small producers [9]. On the other hand, on the Amazon basin on the east of the country at middle elevations (300–900 m above the sea level), cacao is grown on a totally different pattern of land tenure, including small households [10] and communities typically inhabited by autochthonous people.

In Ecuador, "communities" are a sociological and political concept that encompasses different structures. Communes (or "comunas" in Spanish) are a legal entity that represents, among other things, one type of land ownership and management. In our context, we assimilate these communities to social-ecological systems (SESs), as they are groups of people organized within clear geographic boundaries to make use of the Amazonian forest in particular ways that can be considered a complex adaptive system.

Though communities are typically associated with indigenous populations and collective land ownership, this is not always the case. In fact, the Ecuadorian Constitution (articles 56 to 60 in the 2008 text) is quite broad in defining collective rights for different types of communities, including people of African descent. Since the new Constitution of 2008, many indigenous peoples have been granted access to land if they organize themselves to claim their "ancestral territories" [11]. Thanks to their constitutional rights, indigenous peoples can, in principle, claim ancestral lands as their own if they are able to demonstrate a minimum level of organization through a long and complex process to obtain collective property land that is tax-exempt. The land is granted to the communities with conditions, which limits the extent of their use. Communities are sometimes granted large tracts of forests on the condition that the urban area is restricted. This restriction on the extent of land surface used for agriculture, agroforestry, or cattle ranching has profound consequences on the available income possibilities for these communities, as we will explain later. Hereafter, we use the word "communities" to describe the places visited, bearing in mind that their local organization and demographic composition may vary from place to place.

Of the 11 recognized Amazonian indigenous nations in Ecuador, two of them, the Kichwa and Shuar speaking communities, are of particular interest for understanding the current role of cacao production as a driver of community self-organization. The Kichwa communities are internationally recognized as growers of award-winning chocolate bars, thanks to the work of private companies that have commercialized their products overseas. By contrast, the Shuar include descendants of the people who originally domesticated cacao trees [12] about 5000 BP and inhabit archeological areas where ancestral trees of the *Nacional* type are suspected to occur [13]. The Shuar are not currently recognized as high-quality producers.

From a research point of view, Ecuador offers the opportunity to examine in a reduced geographical scale, different types of cultivation strategies and the different approaches to production by different sectors of the population. In fact, cacao bean production has been a staple export since the 19th century. In this regard, Ecuador is seen as a reference, and even as a myth by neighboring countries that seek to

engage in successful export trade of fine quality cacao beans, mostly by Colombia where new cacao growers wish to emulate the 'fino de aroma' cacao from Ecuador (J.F.M., personal observation). In the latter country, cacao bean cultivation has been seen as key to providing alternative legal income for regions that have undergone decades of internal armed conflict and the cultivation of illegal crops. In consequence, hundreds, if not thousands, of families in Colombia are currently encouraged to plant cacao trees to produce beans for the national and international markets, an initiative that could benefit from the experience acquired in Ecuador.

In this study, we asked the central question: what are the inner workings of cacao-based agroforestry in the sustainability of upland Amazonian communities with different cultural backgrounds and different social contexts? To conduct our analysis, we used the Ostrom Institutional Analysis and Development (IAD) framework, which identifies the processes related to sustainability, the self-organization of people, and the role of different external drivers on the dynamics of SESs.

2. Materials and Methods

2.1. Study Sites

Napo Runa indigenous people. The Napo Runa, an Amazonian Kichwa-speaking group, has the largest population among the 11 Amazonian indigenous people recognized by the Ecuadorian government. They live in the eastern rainforest of the country's Amazon basin. This Kichwa population has essentially turned into agriculturalists, with sporadic hunting and fishing practices to meet their daily needs. The main farming activities are the planting and harvesting of *yuca* (manioc), banana, cacao, coffee, and *naranjilla* (*Solanum quitoense*). We selected two communities: "Pumayacu" and "Santa Rita", located in the northern Amazonian rainforest in the province of Napo (Figure 1, Table 1).

Table 1. Summary of political, physical and social characteristics of the study sites.

Language-Speaking Group	**Amazonian Kichwa**		**Shuar Chicham**	
Name of the Community	**Pumayacu**	**Santa Rita**	**Yawi el Cisne**	**Tuntiak**
Geographical region in Ecuador	Northern Amazon	Northern Amazon	Southern Amazon	Southern Amazon
Province	Napo	Napo	Morona Santiago	Zamora Chinchipe
Locality (canton)	Tena	Archidona	Gualaquiza	Centinela del Condor
Altitude above sea level	620 m	805 m	837 m	823 m
Population in 2017 (approximate)	150–200	748 (147 families)	43	600 (250 families)
Year of foundation	1991	1967	1997	1999
Surface of the collective community property	40 Ha	252 Ha	50 Ha	100 Ha
Surface of associated lands	1200 Ha	1400 Ha of primary forest	3120 Ha of Chumpias property	No additional lands
Main source of revenue	Cacao, fishing, mixed farming (crop, livestock), and recently charcoal as a complement	Cacao, heritage tourism (lodge, theme park)	Self-sufficient economy, marginal cacao, and land selling for mining	Fishing, livestock, artisanal mining, and charcoal production
Accessibility	5 h trip by public bus from Quito to Tena plus 45 min-walk	5 h trip by public bus from Quito to Tena, plus 30 min bus by unpaved road	15 h trip by public bus from Quito and 45 min in private 4 × 4 taxi	18 h away by public bus from Quito.
Telephone and internet	No	Yes	No	Yes

Shuar indigenous people. The Shuar people are settled in northern Peru and eastern Ecuador. They typically live in the headwaters and tributaries of the Marañon River, the tropical rainforest and savannahs of the Amazonian basin, and a few foothills of the Andes mountain range. They speak *shuar chicham*, and adopted Spanish as a second language [14] from the early 20th century, with the Salesian missions. They are well known for founding one of the first indigenous organizations in the world, the Shuar Federation, in 1962, and for developing a specific process of ethno-education through radio programs. The two Shuar communities visited were located in the southern Amazon provinces of Ecuador: "Yawi el Cisne" in Morona Santiago province and "Tuntiak" in Zamora Chinchipe province on the border with Peru (Table 1, Figure 1).

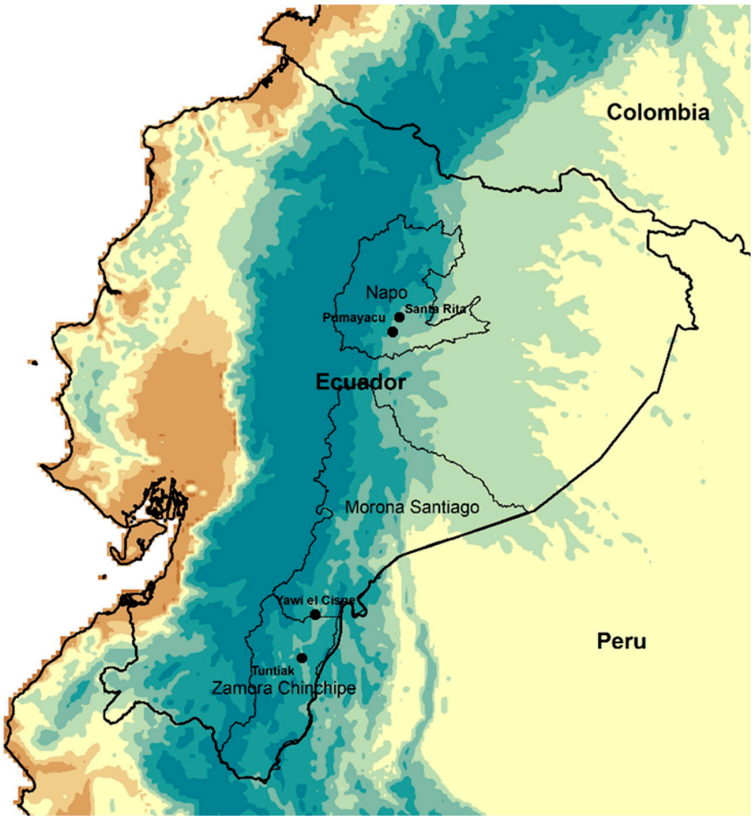


Figure 1. Study sites chosen for this study (black circles). The background colors of the map represent the altitude zones in this part of South America (brown < 50 m, light brown and sand 50 to 100 and 100 to 500 m, respectively; clear blue 500 to 1000 m; and darker blues 1000, 2000 to 3000, and upwards).

2.2. Data Collection and Survey Design

We used the Institutional Analysis and Development (IAD) framework developed by Elinor Ostrom for analyzing the sustainability of SESs [15,16], to design and organize data collection in the field. In this framework, eight types of umbrella categories (noted *S*, *RU*, *RS*, *GS*, *U*, *I*, *O* and *RE*), known as first-tier variables, are needed for the diagnostic (Table S1, first column). At one extreme Social, Economic and Political Settings variables (*S*) describe how current conditions impose boundaries to the economic activities in a given region, and limit the dynamics within the SES. In turn, the dynamics of the SESs are described through four interacting sub-systems: (i) Resource Units (*RU*), which, in our case, are the native and non-native cacao trees; (ii) Resource Systems (*RS*), describing how the harvested cacao seeds are sourced, transported, and commercialized; (iii) Governance System (*GS*), explicating how the access to the resource is regulated; and (iv) Users (*U*), describing the actors and their organization(s). As these four sub-systems interact, the Interactions (*I*), as well as their Outcomes

(*O*), need to be identified. Finally, as SESs belong to larger systems in their territories, a set of variables are defined to describe those interactions with Related Ecosystems (*RE*).

Each of these eight first tier variables has a pre-defined set of second-tier variables (Table S1, second column) that often need indicators specific to the study case. Hence, a set of 195 indicators (Table S1, third column) was developed, to construct the questions asked in the field. This set of indicators was used also as a checklist after the interviews, to ensure that enough information was gathered during the time spent with the actors. The full set of questions corresponding to the 195 indicators (in Spanish) can be requested directly from the first author.

The Ostrom approach relies on an institutional diagnosis looking initially at a large set of variables and afterwards, through an inductive process, the researcher focuses on variables that revealed conflicts between actors or specific challenges to the sustainability of the system. In general, but not always, these variables appear on the Interactions and Outcomes results. In our case, we decided to provide qualitative scores (very good, adequate, deficient, and completely lacking) of what was found in the field by consensus among the authors regarding the Interactions and Outcomes. These scores do not replace quantitative measures, which could have been done with other methods, but reflect an interpretative convergence [17] by the authors.

Interviews were conducted in an informal way avoiding any directive approaches and taking care to ask the questions in the most possible neutral way. When possible, the person conducting the interviews spent time with the local people, helping out in daily activities to build trust, while observing their activities. Voice and video recordings were accepted by most of the actors, allowing us to double check the field notes from the interviews if necessary.

Before visiting each community, arrangements were made with a local leader (the 'Presidente', in Spanish), which decided whom to visit and where to stay. The first community visited by the first two authors was Pumayacu. Previously, the second author had presented the goals of the study to the community and organized the one week stay. Without that initial contact, residents are reluctant to accept the presence of foreign people in their lands. In exchange for the interviews, a fee was arranged for housing and food, in a house designed by the president of the community. In each family household, both wife and husband work together in the production of food. Often, the interviews were done with a couple, but sometimes only the husband would remain, as he felt less shy with respect to the interview, and of having notes recorded on a digital recorder. In this first community, the age of the interviewed people was between 25 and 70 years old, as younger people were usually at school or working elsewhere. In this community, it was the children that showed the first author the cacao tree plantations, and are the ones in charge of gathering, selling, and being paid for the cacao in bulk.

About half of the interviews lasted between one and two hours when conducted at their homes, but the rest could last a complete working day, as the first author participated in their daily activities (fishing, charcoal production, husbandry, cacao cultivation training, etc.) These activities do not have a precise timing, but start very early in the morning and sometimes finish at dusk.

For the second visited community, Santa Rita, the first author contacted the president of the community directly by telephone. This community has more visitors because of the presence of external aid by the government, non-governmental organizations, and enterprises, so the members are more open for conversation. Likewise, the community leader indicated which families to contact and where to stay. Additionally, a modest fee for housing and food was requested.

In the case of the Tuntiak community, the organization of the visit proceeded through an agricultural technician working directly for the regional government, who has close ties with the people in this community. In contrast to the Kichwa speaking people, it is the women that are in charge of the food production, and of agricultural activities in general, hence, the interviews were carried out only with the women from each household. This was the only community where a hostel was used during the interviews. In contrast, for the Yawi El Cisne, a host family was designated by the community, and also a small fee for housing and food was requested. The decisions of who would be interviewed were taken collectively during the first contact with both Shuar communities. The interviews were

conducted between March and April of 2017 on the four target communities as well with some scholars at Universities in the capital of Ecuador, Quito. Table 2 presents a summary of the actors interviewed in the four communities, as well as in two neighboring areas.

Table 2. Summary of actors interviewed during the field work. People or institutions not pertaining directly to the communities are marked as 'Other'.

Speaking Group	Province		Type of Organization	Type of Actor
Kichwa	Napo	Pumayacu	Community-based organization of cacao farmers and chocolate producers	Manager and legal representative (1)
			Amazonian Indigenous Community	Independent Small cocoa producers (3), commercial member of the local association (3), Small cocoa producers for the local association (2)
		Santa Rita	Amazonian Indigenous Community	Small cocoa producers (5)
		Other	Community-based Association	Manager and legal representative (1), Small cocoa producers (2)
			Independent producer	Small cocoa producer (1)
Shuar	Morona Santiago	Yawi el Cisne	Amazonian Indigenous Community	Small cocoa producers (6)
	Zamora-Chinchipe	Tuntiak	Amazonian Indigenous Community	Small cocoa producers (5)
		Other	Provincial government	Prefect of the province (1)
			Provincial municipality Government	Employee (1)
			Public enterprise for agricultural development	Agronomist (1)
			Federation of small organic agricultural	Manager, Tree nursery manager (1)
			Enterprise at the *Centinela del Condor* Municipality	Manager and legal representative (1)
			Private export enterprise at *El Pangui*	Manager and legal representative (1)

3. Results

3.1. Social, Economic and Political Settings (S)

One of the most striking results of our study is the fact that despite the visited communities are living in their own ancestral territories, their land ownership and self-decision-making capacities are quite recent. A review of the literature shows that, in the middle of last century, many indigenous communities in Ecuador settled in areas that were not necessarily their original settlement areas. These migrations, resulting from the colonization of their own territories after the agrarian reforms, obliged them to start afresh by incorporating new economic activities for which they had little or no experience into this process.

These rural movements were composed of indigenous organizations and marginalized communities from all regions in the country, but especially from the Amazon area. Collective organization and mobilization increased the pressure to secure land for indigenous peoples. Invasions, pressure from "colonos" landowners (colonos are people that claim de facto property of the land), and petitions were among the actions taken by community-based organizations to open forested land and enlarge their indigenous ancestral lands [18,19]. The protests scaled up until 1994, when the "Mobilización por la Vida" forced the Ecuadorian government to negotiate the requests of the

movement, represented by the "Confederacion de Nacionalidades Indigenas del Ecuador" (CONAIE, https://conaie.org/). A remarkable achievement of the movement was the constitutional recognition of the Amazonian indigenous communities' rights to their ancestral lands. Additionally, another triumph was a formal acceptance that communal farms are forms of productive organizations.

It is very likely that local ecological knowledge [20] regarding ecosystem management was lost during these migrations, thus, making these populations even more fragile, with respect to finding sustainable ways of living. Cacao trees were never kept in high densities neither during pre-Columbian times nor during post-colonization. These trees were grown as part of their family gardens, a sacred placed called ajas (pronounced ah-has) for the Shuar speaking people [21,22], and it was a plant kept mostly for medicinal properties, alongside several other species of shrubs and trees. A similar case occurs with the chakras of the Kichwa speaking people. High density cacao plantations to export beans began to flourish in many parts to the east of the Andes towards the Amazon basin from the 1990s, at the same time as when many rural movements arose in response to the abandonment of the central government, so any type of intensive cultivation is new for the four studied communities.

Interviews with the local actors in Pumayacu Napo Runa community revealed that land was claimed as ancestral territory quite recently, and the community was only created in 1991. Prior to this, the land was occupied and exploited by the religious Josephine mission. The Kichwa inhabitants of the area were exploited and underpaid by the mission (information extracted from interviews), until they decided to part ways. Rallies and protests led by one main family had spread out in the area by the end of the 1980s. After many clashes with the police, the religious mission gave up the land and abandoned the area. Since then, the descendants of these families have populated and worked in the community. Nowadays, the community leaders are taking steps to participate in the Socio Bosque (meaning "social forest" in Spanish) conservation program, a national Ecuadorian program that aims to pay for ecosystem services through forest conservation (http://sociobosque.ambiente.gob.ec/).

Nevertheless, the most extreme case of restricted communal land ownership that we observed was the Yawi El Cisne Shuar community. Interviews showed that the community was founded in 1997 by an extended single family that had previously lived in the nearest community a 30 min walk away. However, their agricultural lands were situated near the current location of the community. As a consequence, the patriarchs of this founding family and their eight children decided to move and create a community near their productive lands. The territory is collective, with Yawi being part of the 3120 hectares property known under the title of Chumpias. The community members are close relatives, and they have individual parcels and a division of land by inheritance. As a result, most of the members currently have between 1 and 4 hectares, which creates pressure over agricultural land. The community is surrounded by other communities, which are part of the global title mentioned earlier for the Shuar people. There were 43 permanent inhabitants at the time of the study, and all the households included one member of the patriarchal descendants. It is important to note that 27 other people from this community work elsewhere as school teachers in other Shuar communities, or are farm workers on the big plantations along the coast. The internal governance structure of the community is basic, being composed of the president and a few collaborators elected by family relationships.

Local leaders asserted that the government has recognized the communal ownership of the land by the members of the Yawi el Cisne, and it is guaranteed by its internal governance system. They cannot sell the land, but the inhabitants have formal individual rights for land tenure for agricultural and productive purposes. Additionally, their individual land possession is subject to intergenerational division by inheritance systems between the new members of the household, which means that less land is available for later generations. Currently, most of the households are still descendants of the founder family, and they have organized their internal governance structure by newer family ties. We observed that the members of the community referred to the founders and the oldest people of the community in a respectful manner. Each member has well-defined roles in the community and its internal governance structure.

In the case of the Santa Rita community, a complete lack of access to land ownership did not trigger self-organization but rather a growing population of children without education facilities in proximity. According to the people interviewed, the community was officially founded in 1967 (the oldest case studied here), although the area has always been populated by Kichwa Napo Runa people but without any communal structure. The number of children during the 1960s increased in the area, and they had to walk about 7 km through the forest to reach the nearest school. Therefore, with the support of a Catholic priest, some inhabitants of the area decided to create a school, an event that triggered the land rights claim process. The community has 252.2 hectares, with the land considered to be an ancestral territory surrounded by primary forest and other communities. Nowadays, it has the same property rights governance as the other Kichwa community, because the government has recognized the communal ownership of the land, which is guaranteed by its internal governance system with defined rules. They cannot sell the land, but the inhabitants have formal individual rights in land tenure for agricultural and productive purposes. Additionally, their individual land possession is subject to intergenerational division by heritance, which decreases the land available for future generations. Most of the interviewees have between 3 to 7 hectares of agricultural land.

The Tuntiak Shuar community was created 18 years ago in a territory that was previously held by the Ecuadorian army; it is the largest community visited in this study with more than 800 people. In the early 2000s, some Shuar families were looking for a place to settle down, so the army and the Shuar population agreed to share the territory. The land is also considered to be "ancestral territory". They therefore have communal property rights over the land, as well as individual property rights with intergenerational heritage, as in the three former communities. However, according to its internal governance structure, no single person is directly responsible for land sharing or cacao production activities (see the next section).

3.2. Resource Units (RU), Resource Systems (RS) and Users (S)

The most outstanding finding of our survey (our own observation) is that trees belonging to native *Nacional* or *Criollo* are only found in areas with strong links to niche markets, like the Santa Rita community, and are not necessarily abundant in more remote areas of the Amazon provinces of Ecuador (Table 3).

> *" . . . here, we didn't have that many trees of cacao before, but when the coffee market prices reached 1 cent the pound, we said that's it, and we cut all the trees . . . then we had people coming here telling us to plant cacao trees . . . "*. cacao producer in Santa Rita (our own translation)

In stark contrast, all the other visited communities exhibit a mixture of trees including the highly productive clone CCN-51, which was distributed by the government (information provided by locals), probably a result of the large public policy of the reactivation of *fino de aroma* varieties that was started in 2012 (https://www.agricultura.gob.ec/magap-impulsa-proyecto-de-reactivacion-del-cacao-fino-y-de-aroma/) and had a target of offering help for 100 thousand families. The second most striking finding, unrelated to cacao production but related to the overall land use, is the presence of associated lands (Table 1), which can represent between three and 60 times the urban and exploitation area granted to each community. Only one of the visited communities lacks additional lands (Tuntiak in Zamora Chinchipe), but it theoretically has the option of being granted forested areas to manage outside the community through the *Socio Bosque* program.

In all the visited communities, cacao bean production is not the main activity, but a source of supplementary income, as the main activity is agricultural subsistence, a common response by all the interviewed people. Surplus banana plantain, manioc, and miscellaneous fruits are sold in the local markets. The most salient result in terms of the marketing of cacao by these communities is that organic produce is not necessarily the most profitable commodity (Table 4). In fact, all types confounded of dried beans could be sold in 2017 to intermediaries at prices up to USD 0.60 (note that Ecuador uses the US dollar as currency), but as low as USD 0.30 if sold to unscrupulous intermediaries. Organic

dried beans are sold at intermediate prices (USD 0.45). The opportunity cost of accessing the more stable prices of organic cacao (more work on the trees, strict selection of pods, careful fermentation, and drying) means that the "on the pulp" or on-the-spot selling of cacao beans to an intermediary is an attractive option, as standards are much lower, and the production is less time-consuming.

Table 3. Cacao resource units (*RU*) characteristics in the four communities.

Language-Speaking Group	**Amazonian Kichwa**		**Shuar Chicham**	
Name of the Community	**Pumayacu**	**Santa Rita**	**Yawi el Cisne**	**Tuntiak**
Governmental program known as "fino de aroma" reactivation project (2012)	Yes	Yes, with additional funding from the FAO and local government	No	Yes for the plant provisions, but alternative programs exist with the provincial government
Date of cacao development	15 years	More than 15 years	Not known by the interviewed people	Not known by the interviewed people
Cacao producer's collective association	Yes (community-based cooperative)	Yes, community-based cooperative	None, but one person started a *Criollo* nursery at the time of the interview	incipient cooperation of few families
Cacao varieties	Mainly *Nacional* intermixed with CCN51, *Criollo*s, mountain, and other native varieties	Mainly *Nacional*, with some *Criollo*s and native varieties	Mainly old "ancestral" *Criollo*s, a few *Nacional* and CCN51	Mainly *Nacional*, with a high presence of native varieties. A few CCN51 in community plantations
Plantation type	1–3 ha, 300–600 trees maximum	3–7 ha, 600 trees	1–4 ha with heterogeneous plantations	High-density *Nacional* with 800–1000 trees; use of natural fertilizers, disease control, and technical assistance
Technical assistance	Local cooperative	Local cooperative	None	Agronomist paid by the provincial government
Production issues	Disease on cacao pods observed, but no management	Well-managed cacao plantations	Disease on cacao pods observed, but no management	Basic management of disease on cacao pods

Table 4. Cacao resource system (*RS*) characteristics in the four communities.

Language-Speaking Group	**Amazonian Kichwa**		**Shuar Chicham**	
Name of the Community	**Pumayacu**	**Santa Rita**	**Yawi el Cisne**	**Tuntiak**
Plantation location in the communities	15–60 min walk	Close to the community	Close to the community	Close to the community
Technical guidelines for harvesting	Defined by local cooperative: beans collected and dried for one night before being collected by truck	Specific requirements of cooperative 1: 3–5 days in advance without opening under the trees, then pod opening and bean harvesting. Cooperative 2 is less rigid	No specific guidelines, local know-how practices	No specific guidelines, local know-how practices
Purchase planning	Every 2 weeks for 4–5 months by local cooperative	Close coordination with cooperative 1 and local cooperative 2	None	None
Post-harvesting facilities	Association facilities	In association with cooperative 1	None	None
Cacao marketing	Fresh beans with pulp (USD 0.45): local cooperative (80%) and intermediaries (20%). "Dried bad cacao" all types confounded: sold to intermediaries (USD 0.20–0.60)	Fresh beans with pulp sold to cooperatives 1 (USD 0.35) and 2 (USD 0.45) for organic beans only. Market for dried beans all types confounded (30 min bus with prices of USD 0.35–0.60)	Dried beans sold to intermediaries in marketplaces (40 min walk, 20 min by bus). Trading prices unknown but probably not different from other places	Dried beans sold to intermediaries; no price difference for organic beans (USD 0.55)

3.3. Governance System (GS) of Amazonian Shaded Cacao Agroforestry

Our study found that the governance system of native cacao trees is quite weak or non-existent and that it depends more on external markets that actively search a stable production of *Criollo* or *Nacional*, like in Santa Rita. For the other communities, we could not detect any pattern of local protection or promotion of their spontaneous trees. Growers are aware that different species exist, like *Theobroma bicolor* and *T. grandiflorum* among others, and that even the closely related *Herrania* species, from which chocolate can also be made, may have some interest for commercialization in the future, but they prefer to focus on their current rudimentary markets. Locals seem to be willing to accept improved varieties like CCN51, distributed by the central government with the hopes that some marketing scheme will follow. However, lots of skepticism was perceived during the interviews:

> *" . . . in my opinion, the cacao policies are just cheap policies from the central government . . . but how else are we going to earn 60 or 70 dollars to pay for basic needs?"* Independent cacao producer in Pumayacu

As for the prices, all interviewed people acknowledged they did not have any control on the price of cacao beans, whatever their quality. In fact, one of the sources of conflict found was not directly related to land ownership, as one would expect, but related to what represents an acceptable price to be paid for by the cooperatives or the intermediaries (Table 5).

> *" . . . each time they lower the price of the cacao beans by the pound they say it is because the international market prices have dropped . . . ".* Independent cacao producer in Santa Rita

The second source of conflict that could affect the native cacao as a resource, and ecologically sustainable agroforestry, is the emergence of alternate activities, like charcoal production (Pumayaco community), the opening of forests for cattle ranching, or selling tracts of land for little controlled mining operations (Shuar speaking people, Table 5). The geographical position of the Shuar speaking territories farther away from the capital city or from regional capitals allow land clearing and mining activities to be performed with little supervision. These activities affect not only cacao production, but possibly too the availability of lands for growing crops for their own basic needs.

> *" . . . we cannot live from cacao alone, it is seasonal . . . , we rely on charcoal production in our own parcels . . . ".* Woman and husband from the same household in Pumayacu

Table 5. Conflicts issues affecting the governance system (*GS*) of the studied communities.

Language-Speaking Group	**Amazonian Kichwa**		**Shuar Chicham**	
Name of the Community	**Pumayacu**	**Santa Rita**	**Yawi el Cisne**	**Tuntiak**
Main sources of disputes or debates	Cacao prices	Cacao prices. Disagreement about how to manage cacao trees and harvest	Cacao prices. Disputes about land selling for mining, clearing for cattle ranching, or cutting trees for charcoal production	Cacao prices. Disputes about land selling for mining, clearing for cattle ranching, or cutting trees for charcoal production
Alternative sources of revenue to cacao	Increasing charcoal production, because a 50 kg bag is worth $7–8 at the nearest market	A few people employed in cacao-related ecotourism	Land selling for mining activities	Agriculture and livestock supported by the local prefecture; artisanal mining

3.4. Interactions (I) and Outcomes (O)

We observed that the visited communities can be considered to have clear physical boundaries, external and internal, where the interactions of actors between them, and between the actors and

the ecosystem, have been clearly defined with the creation of each community. Urban/housing areas, per family plots and adjacent forest reserves have all clear boundaries that seem to be respected. The current generation of inhabitants are aware that they can only leave as inheritance a fraction of what they could secure during the creation of the communities and that the next generation will need to rely on jobs elsewhere to establish their own family, for which they need an education:

> *" . . . our heritage is more on giving the means for studying than in giving lands to our children . . . I have six children and seven hectares, . . . after they finish high school, I will give each one, one hectare to build their own house, that is all what I can offer . . . ".* Associated producer to the cooperative in Santa Rita

Outcomes seem more positive for communities close to the capital city and with the large involvement of the public and private sector (Figure 2).

A clear outcome has also emerged, as the less organized communities use more of the clonal varieties distributed by the Ecuadorian government, because of their higher yield and robustness against diseases compared to the communities that work closely with companies using organic cacao beans for national and international markets. Paradoxically, the areas of the Shuar communities that are in the direction of the archeological sites showing the early domestication and use of cacao [23] seem to be more fragile regarding their disorganized mixing of clonal and local varieties. Isolated communities struggle to make a living, so they have little choice but to accept any kind of external aid from the national or regional government.

3.5. Related Ecosystems

From the information gathered in this study, only three of the four studied communities have access to external tracts of land. As the access is relatively restricted, the communities can only benefit indirectly if there is a program like '*Socio Bosque*', which can give funds to the community if they engage in a sustainable use of the resource. It is still too early to know, in our opinion, if communities with adjacent lands would be more sustainable than those without, as income and crops for their own food are not grown in the adjacent areas. In addition, there is a demographic growth and any external aid for forest management with the community would need to be shared between more people. A clear opportunity exists if the adjacent lands (old and new) will be considered as repositories of native cacao trees, as their management and conservation could be funded externally by the commerce of high specialty cacao beans.

First-tier variable	*Second-tier variables*	*Third-tier variables (specific to this study)*	*Kichwa Puyamaco*	*Kichwa Santa Rita*	*Shuar Tuntiak*	*Shuar Yawi El Cisne*
Interactions	**I.1** Harvesting	I.1a - *Nacional* organic cocoa productivity				
	I.2 Information sharing	I.2b - Fluidity of information over cocoa market situation				
		I.2a - Fluidity in cocoa production process between actors and stakeholders				
	I.3 Deliberation processes	I.3a - Collective deliberation process (assemblies) for cocoa production issues				
	I.4 Conflicts	I.4a - Conflicts between certified and non-certified producers			N/A	N/A
	I.5 Investment activities	I.5a - Investment activities to improve cocoa production, post-harvest process, and/or international certification				
	I.6 Lobbying activities	I.6a - Influence of users over final cocoa price				
	I.7 Self-organizing activities	I.7a - Internal rules for collective management in cocoa production, search for markets, and/or certification process				
	I.8 Networking activities	I.8a - Cooperation and partnerships with external actors for cocoa production (NGOs, local and central government, etc.)				
	I.9 Monitoring activities	I.9a - Collective agreements to control cocoa production quality				
	I.10 Evaluative activities	I.10a - Assessment of compliance with certification guidelines			N/A	N/A
Outcomes	**O.1** Social performance	O.1a - Vulnerability to external economic impacts				
		0.1b – Vulnerability of food self sufficiency				
		0.1c – Mobility of younger generations				
	O.2 Ecological performance	O.2a - Vulnerability to environmental pressures				
		0.2b – Conservation of local cacao tree varieties				
	O.3 Externalities to other social ecological systems	O.3a - Emergence of other activities that can create pressure over other SESs				

Figure 2. Summary of outcomes (*O*) resulting from local interactions (*I*). The scale is qualitative, and colors represent conditions as assessed by the authors from the interviews: very good (dark green), adequate (green), deficient (yellow), and completely lacking (red). The white cells with N/A represent instances where the variable is not applicable.

4. Discussion

Our results show that agroforestry centered on cacao is an activity that is constrained by the community's food security needs, even in communities where apparent signs of success stories can be shown to external observers. In simple terms, it does not produce enough and constant revenue for the farmers to rely on them as their main source of income. As evidenced with the Kichwa and Shuar communities, alternative activities, like producing charcoal and mining are attracting more inhabitants because of their urgent need for revenue sources. Moreover, the level of self-organization observed was not dependent on the size of the community (large communities were loosely organized), but rather on the external connections that allowed for more organized interactions in the communities.

Communities have a weak tolerance to accept the opportunity costs imposed by organic markets. A frequent response in our study was that if the buyer of organic cacao did not show up for whatever reason, the alternative was to sell in bulk their dried beans on the local market, or if cash was needed urgently, to sell them not dried but still with the pulp on them that is even less profitable. The presence of local associations or small niche companies that seek to provide fair prices to family producers only slightly changes the amount of income earned from selling beans. In this regard, despite all the good intentions of associations and buyers of organic beans willing to pay a premium, there is simply not enough production per family to encourage an activity that goes beyond extra spending money. In general, the lack of accessibility to pre-processing facilities to export cacao paste (also called cacao liquor) instead of raw beans, impedes producers from escaping a poverty trap along the cacao value chain [24,25]. The inability to directly access export markets, because cacao beans pass through at least two levels of re-sale within the country [26], keeps small cacao bean producers at the base of an asymmetrical value chain for which more work does not necessarily represent higher revenue [27]. Not even temporary positive price fluctuations favor the small producers, as they rush to sell their produce at the expense of quality standards [28]. Unfortunately, all these processes described by the literature were observed in one way or another in the four communities.

In Santa Rita, almost all our qualitative indicators were considered positive, as there is clear evidence of discussion and governance regarding the amount and extent of organic cacao using non-clonal varieties (*Nacional* and *Criollo*), with clear objective-driven production for the local companies that purchase their produce. However, we would not conclude that the somewhat sophisticated level of self-organization around the production of cacao beans and the promotion of chocolate culture means that this community has reached economic sustainability. A recent evaluation of their territorial management goals [29] clearly suggests that the cacao bean industry is not yet the main source of revenue, and that activities like eco-tourism and chocolate promotion provide only a few local people with wages, so it has therefore not replaced basic agricultural activities. More importantly, this community like others has undergone a rapid population growth, which has led to the emigration of young people to look for jobs in other areas of the country and not necessarily in the agriculture sector. Still, being close to the capital city of Quito offers the younger generation with more study opportunities and possibilities of future jobs outside of the agricultural sector.

A second factor possibly influencing the degree of local interactions (self-organization) is the age of the community (Santa Rita is at least 50 years old, while the others have existed for barely 20 years), but Santa Rita's proximity to a main national road linking the site to the capital easily confounds what is the result of self-organization and what is the result of external inputs. Five decades have allowed the communities to interact with external actors, and test the different ways of securing income, including through the chocolate industry, for the past 15 years. More isolated communities are associated with simpler social structures and more fragile production means, an observation that is especially evident in the southern Shuar communities.

With the information gathered, we hypothesize that if the above pattern holds for the many indigenous communities that have recently become established, the emerging land use created by granting ancestral territory will create a series of difficulties because of: (a) small but densely populated urban centers of up to 800 people; (b) patches of land for agroforestry used in ways that depend on

the amount of external help (i.e., organic with *Nacional* trees in shade zones or mixtures of non-shade and shade zones for different varieties); and (c) a forested area not used for any kind of agroforestry. On account of this land use, the zones that can be used for agroforestry or subsistence agriculture are limited by the contract with the government, which may induce migration out of these communities after a period of time, as has already been observed, even in well-developed communities like Santa Rita [29]. "Fair trade" initiatives may also not offer a stable market environment, as fierce competition between labels may induce a relaxation of standards that directly impacts the revenue and working conditions of farmers [30]. In general, it has been observed that the creation of these niche markets is possible, requiring the presence of strong cooperatives [31], as well as a long, difficult, and continuous learning process [32]. In our study cases, cooperatives were present mostly in the Kichwa communities, but they act in a similar mode as a private company, raising a mitigated interest in the members of the communities.

It is unknown whether the Shuar and Kichwa peoples would turn to monocultures out of exasperation with the difficulties associated with organic cacao and its low profitability in the fair trade value chains. In analyzing 50 households in coastal Ecuador where both native cacao agroforestry and intensive improved varieties co-exist [33], it was observed that, if sources of revenue are scant, the additional effort in time required by organic farming is unaffordable for households, a situation that is perfectly understood by intermediaries and works to their advantage. A second study on coastal Ecuador with 188 households showed that without access to specialty markets with a differentiated value chain, it is very difficult for families struggling for increased income to maintain organic production [9]. In fact, a decade-long analysis in Ecuador has shown that, despite the presence of new markets, many farmers switch to monocultures of improved cacao varieties on account of their greater productivity, because their prices are similar to the sought-after *Nacional*, *Arriba*, or *Criollo* varieties [34].

The possibility of maintaining food and medicinal plants in the same plot may prevent households from implementing monoculture practices. This may well be the case of the Shuar and Kichwa people, who value forested areas as sources of food, fibers, and medicinal plants, through their traditional way of gardening—the chakra system for the Kichwa and *aja* for the Shuar—being the women's responsibilities. Thus, certification requirements of "organic farming" and shade farming are common grounds for continuing to use the forested areas, as diverse and multifunctional vegetation not needing external inputs for nutrients or plague control [35]. However, innovative structures need to be created for allowing economic growth not based on monocultures, as happens in coastal Ecuador.

Can the effects of the limits on the communal lands be solved with current policy tools? A bolder approach to helping these communities would incorporate not only payments for the forest conservation of adjacent lands but also for maintaining the different wild cacao trees present in their own community lands (*Theobroma* spp., *Herrania* spp.). The produce of these very valuable trees could then be commercialized at a premium price, allowing the local people to skip unscrupulous intermediaries. From the different programs set up to pay for ecosystem services in the country, the literature reports that the Ecuadorian *Socio Bosque* program has proved to be successful in other parts of the country [36]. The interesting aspect of this program is that it is not centered on the actual lands used by a community for agricultural purposes, but on adjacent lands. Currently, only one community benefits of economic help for the management of the forests, but all the communities could benefit from an extended program covering an adjacent forest, in addition to their high diversity biodiversity agroforestry systems.

5. Conclusions

It can be argued that, no matter what "miracle" tree species is proposed in these tropical areas to provide income to rural communities, as many public policies do in the region [37], two basic problems will always haunt these strategies. First of all, land tenure in Latin America, even if granted in a very unique way in Ecuador, does not give enough space for growing communities to rely on agriculture alone. Second, as raw producers at the start of the value chain, the margins of commodities will always

be low for the communities if they remain fragile and preyed upon by intermediaries that profit from their lack of organization.

Land tenure restrictions, like in most Latin American countries, continues to be the main factor that favors or prevents the self-organization of communities [38]. In the particular case of eastern Amazonian Ecuador, we observe the dynamics of a very recent process, which tests the abilities of these rapidly growing communities to earn enough income within the granted lands [29]. Unfortunately, for native cacao beans to become a game changer, a very sophisticated commercialization scheme needs to reach these communities, which is not yet the case, as several layers separate them from the international markets.

Countries like neighboring Colombia and Peru can learn from the outcomes of these communities and their interaction with the cacao market. There is a clear risk of losing very valuable and unique genetic resources if only a handful of improved varieties are used to start widespread programs of cacao production. Wild and semi-wild cacao trees grow in many Latin American countries, and peasants and indigenous peoples may, in the long run, lose access to niche markets, if everyone produces undifferentiated cacao trees from breeding programs. Additionally, it is clear that some degree of association is needed, so that households can negotiate the price of the cacao beans in a given region, avoiding the tyranny of intermediaries or companies holding a local monopoly. Under current conditions, the economic sustainability of households seems very difficult to achieve if centered only on a single resource if available surfaces remain restricted, both for Amazonian Ecuador and neighboring countries.

Future programs in the Amazon promoting the development of niche markets should bear in mind that household agriculture is mostly managed by women in Shuar and Kichwa speaking communities. While Kichwa women are active members of cooperative and boards, Shuar women have weak participation in the producer's organizations, and the commercial aspects are still largely handled by men. Hence, conflicts may arise if this added complexity of the agroforestry production and cacao bean market in Shuar communities is not taken into account by organizations seeking to promote these kinds of niche products.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/12/15/5934/s1, **Table S1**: List of variables used to characterize the four studied communities.

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