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The Practice of Co-Production through Biocultural Design: A Case Study among the Bribri People of Costa Rica and Panama

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Abstract: Research in co-production has given rise to a rich scientific literature in sustainability science. The processes by which co-production occurs are not well documented. Here, I present my work with the Bribri people to undertake a biocultural design project. Biocultural design is a process that begins with understanding participants' aspirations to support their livelihoods. The process is collaborative, imagining ideas and executing products and services by drawing upon the capabilities of the participant's biocultural heritage. In the Bribri territory, the biocultural heritage associated with cacao agroforestry systems is considered significant for Bribri livelihoods. Bribri people's aspirations to grow cacao go beyond increasing cacao yields and include the respect for cultural teachings and social relationships. The participants of this project designed cacao value-added products (e.g., cacao jam, cacao butter) and services (e.g., showcase farm) by identifying viable ways to execute their ideas. Biocultural design offers a guide to co-imagine and co-execute ideas to solve specific problems and contributes to the practice of co-production by offering an approach that recognizes the value of science, while respecting the knowledge, aspirations and values of other actors.

Keywords: co-production; biocultural design; Bribri people; biocultural heritage; cacao agroforestry systems

1. Introduction

In sustainability science, co-production refers to the interaction of different actors to solve specific problems [1]. Research on co-production has given rise to a rich literature focused on diagnosing problems with current scientific practice [2,3], identifying conditions for co-producing knowledge [4–6] and developing approaches to co-produce knowledge [7]. While the latter approaches outline some guidelines on how to conduct collaborative research (e.g., reflexivity, developing trust relationships, inclusiveness), the actual processes by which these activities are undertaken is not well documented [8]. Given the ultimate goal of “creating a new sustainability science that is more inclusive and more attentive to the process of co-production” [1] (p. 5), It is important to examine the methods in which collaboration is conducted. For example, we should explore how actors are identified, the ways in which problems are framed, and how we measure the success of any collaborative project.

Biocultural design is an emergent approach for supporting self-determination and sustainable economic development in indigenous communities. Biocultural design is an intentional and collaborative process in which people with different knowledge, skills, and experiences work together to design new products or services [9]. In a similar manner to the co-production literature, biocultural design emphasizes that the solution of specific problems, such as the identification of economic opportunities in indigenous communities, should be rooted in indigenous values, identities, and knowledge. Moreover, biocultural design offers an approach for co-generating

ideas and co-executing prototypes by building upon the adaptive potential of the stakeholder's biocultural heritage.

Biocultural heritage includes “the collective knowledge, practices, and innovations of indigenous or small-scale societies that have been passed down from generation to generation and that are linked to traditional resources and territories” [10] (p. 3). In the Bribri traditional lands located on the border of Costa Rica and Panama, cacao (*Theobroma cacao* L.) agroforestry systems are a type of managed and multi-strata ecosystem of significance for the creation, reproduction, and transmission of Bribri biocultural heritage [11]. Bribri biocultural heritage associated with cacao agroforestry systems have allowed Bribri people to satisfy part of their alimentary needs [12] and generate moderate-income in contexts of stability [13] and change [11,14].

Cacao agroforestry systems are also considered an important tool for biological conservation. Cacao agroforestry systems provide habitat for diverse species and are reservoirs of agrobiodiversity [15]. Deheuvels et al., for example, documented similar values of alpha diversity for small mammals, reptiles, and litter macro-invertebrates in Bribri cacao agroforestry systems and surrounding patches of natural forest [16]. Similarly, Rodriguez et al. documented four species of *Theobroma* and fifteen varieties of *Musa* in Bribri cacao agroforestry systems [17]. Bribri cacao agroforestry systems are a reservoir of plant and animal diversity [12,15].

Development and conservation initiatives have recognized the importance of cacao agroforestry systems for the protection of Bribri biocultural heritage and the conservation of biodiversity, leading to the implementation of external programs focused on increasing cacao yields. Despite these efforts, cacao agroforestry systems have spatially declined in Bribri territory as plantain monocultures gain prominence [18]. The abandonment of cacao agroforestry systems has been attributed to the impact of crop diseases in the cacao farms (e.g., frosty pod), market fluxes, and Bribri people's aspiration to have access to a constant flow of cash throughout the year [11,18].

This research project applies the biocultural design framework to identify new livelihood opportunities by drawing upon the capabilities of cacao agroforestry systems. I opted to follow the principles of the biocultural design framework because it offers an approach for co-generating ideas and co-executing prototypes by building upon the adaptive potential of the stakeholder's biocultural heritage [9]. Moreover, biocultural design centers its attention on the inclusion of human needs and aspirations to solve problems [19], and it uses ideas from the capability approach to prioritize and expand on the resources of the people participating in a design project [20].

In the next section, I present an overview of the study area where I implemented a biocultural design project. Then, I summarize the research methodology I used during the nine-months fieldwork in two Bribri communities. Subsequently, I present the results of the design journey through three phases: inspiration (documentation participant's aspirations and identification of areas of opportunity for collaborations), ideation (generation of ideas to create cacao added value products/services), and implementation (execution of prototypes). I conclude this paper by discussing the implications of using biocultural design for promoting cacao agroforestry systems as a viable livelihood strategy for the Bribri. I also discuss the contributions of biocultural design to the theory and practice of co-production in sustainability science.

2. Research Methodology

The Bribri are an Indigenous People living on the southeastern border between Costa Rica and Panama. It is estimated that 7772 Bribri live in the province of Limón, making them one of the most numerous indigenous groups in Costa Rica [21]. The Bribri practice agroforestry, which has persisted to date, despite the impact of several fungal diseases in their commercial lands [17].

I conducted this research in two Bribri communities located in the southeastern region of Costa Rica and the northeastern region of Panama (Figure 1). Yorkin (population: 232 in 2016) and Guabo (population: 57 in 2006) are situated alongside the Yorkin River (Rodriguez Valencia field notes, 26 July 2016). Although cultural tourism has grown into an important sector in recent decades in both

communities, the commercial production of cacao, banana, and plantain remains an essential economic activity for most parts of the community [14].

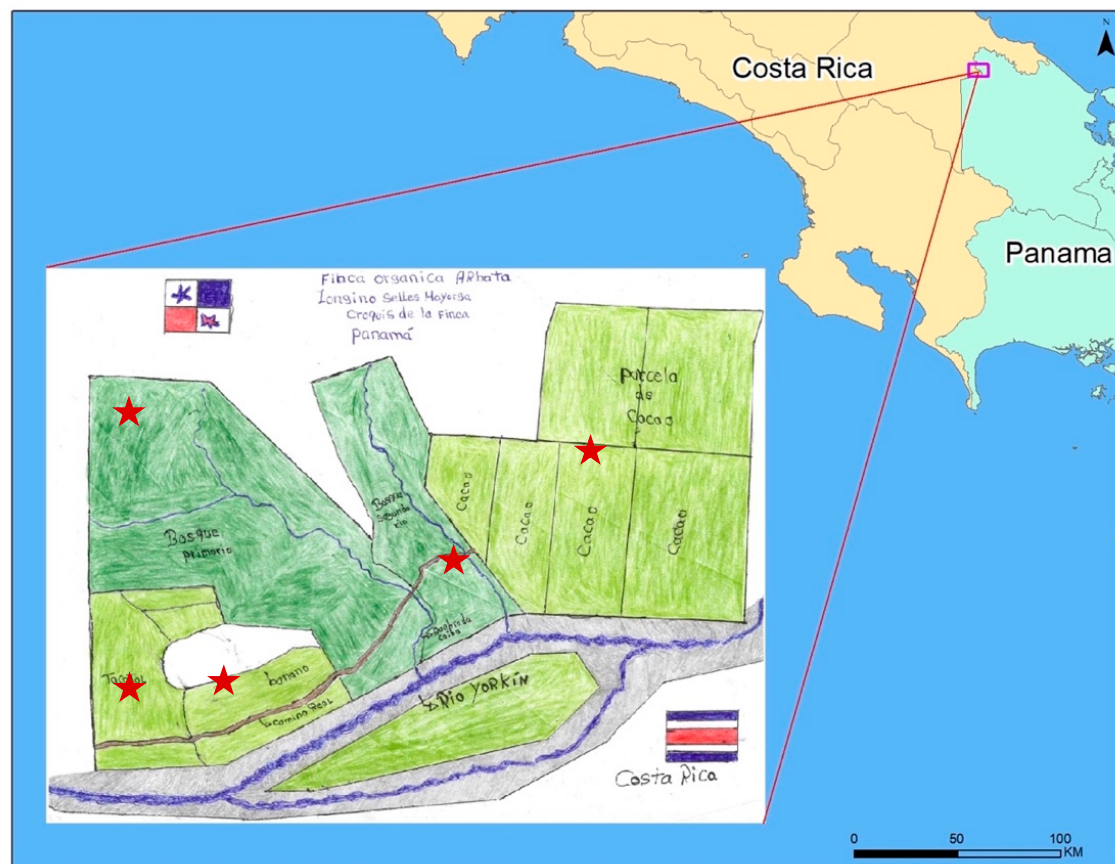


Figure 1. Approximate location of Yorkin (Costa Rica) and Guabo (Panama). The red stars indicate the estimated location of the trees that will be showcased on the land of one of the participants of a biocultural design project. Map elaborated by Longino Celles.

In August 2014, I consulted representatives of five Bribri communities to explain the general purpose of my doctoral research; to understand how Bribri people use the biodiversity richness of their territory in making choices to respond to a dynamic environment. I conducted this research in the communities of Yorkin and Guabo because community representatives expressed their interest in being engaged in projects that will allow them to “revalorize their culture and conserve their natural resources” (Rodríguez Valencia field notes, 6 August 2014). This research was undertaken with the authorization of the Bribri local authority Asociación de Desarrollo Integral del Territorio Indígena Bribri (Development Association of the Indigenous Territory Bribri, Costa Rica) and obtained ethics approval from the Joint Faculty Research Ethics Board of the University of Manitoba (Protocol #J2015:093 HS 18831).

I started the field component of my research in September 2015. During the first three months of my fieldwork, I used the snowball technique to identify community members knowledgeable in the production of cacao. I identified 23 community residents knowledgeable in the production of cacao and I had informal conversations with them to document their interest of being engaged, or not, in designing cacao products and services. I did this because I believed biocultural design would allow me to fulfill my research purpose while respecting the principle of self-determination [22]. While often researchers only report on those who chose to be involved in a research project, keeping with the principle of self-determination it should be noted that:

- The majority of people I talked were not interested in designing cacao products and services ($N = 14$).

- Some community members were not part of this project because they were busy with other activities (e.g., working on their banana/plantain farms) ($N = 8$).
- A couple of people expected me to teach them “something new” ($N = 2$).
- Other community members were interested in different types of projects (e.g., people wanted to be part of projects unrelated to the production of cacao) ($N = 4$).

Nine community members chose to be engaged in the biocultural design project. These community members are recognized by their neighbors as knowledgeable and passionate about the production of cacao: “To be honest, she (one of the main participants) is one of the most knowledgeable women about cacao in this community” (Rodriguez Valencia field notes, 20 September 2015). Five members of the Morales family (three elders and two young people) and four members of the Celles family (two elders and two young people) were part of this project. The Morales family and I commenced working on the design project when they taught me how to make cacao jam and we talked about the possibility of using this idea to create a cacao value-added product. The Celles family and I commenced working on the design project when one of the family members requested my help to design a showcase farm. After this, the participants and I refined the original ideas and imagined other ways to generate alternative income by drawing upon the capabilities of their cacao agroforestry systems. We examined each one of the ideas generated through the lens of desirability (what makes sense to people), feasibility (what is functionally possible), and viability (what is likely to become part of a business model congruent with the Bribri knowledge and values) [23].

I used a case study research approach to explore the process of co-designing cacao value-added products and services with the participants of this project in depth. I collected detailed information about the biocultural design process by using three data collection procedures over a period of nine months: participant observation, un-structured interviews, and participation. Participant observation was undertaken from September to December 2015 to document local cacao production practices, involving mainly the transformation and commercialization of the cacao beans. During this period, I conducted un-structured interviews with the participants of this project to understand the local struggles to commercialize cacao, and the reasons for continuing growing cacao or wanting to re-connect with the practice. From April to August 2016, the participants and I executed some prototypes and reflected about the benefits of designing new cacao value-added products.

I documented the design process in my field notes. I transcribed and coded my field notes using key terms such as “inspiration phase”, “ideation phase”, “implementation phase”, “values”, “aspirations”, “knowledge”, etc. The use of the qualitative software NVivo facilitated the analysis of qualitative data. To check the validity of my interpretations, I held verification sessions with the participants in August 2016.

3. Results

3.1. Inspiration Phase

During my participant observation activities, Bribri colleagues taught me the everyday routines of harvesting, selling, and consuming cacao. In the Bribri territory, cacao is principally harvested from December to January and from June to August [24]. To harvest cacao, it is necessary to cut the mature pods with a machete. Then, the pods are collected in baskets and dumped in piles, where the cacao seeds are removed after the pods are cracked. The majority of the scooped seeds (known as wet beans) are sold to a local cooperative, who sells them to the international market as a high-quality input to make chocolate bars. The rest of the seeds are locally transformed into cacao mass.

Transforming cacao seeds into cacao mass is a time-consuming process. First, the scooped seeds are left in the sac for six days to be fermented. Following the fermentation, the cacao beans are dried, to subsequently be roasted, winnowed and ground. In Yorkin and Guabo, the cacao mass is either mixed with condensed milk to be sold as chocolate treats to the 1300 tourists that visit the communities

annually, or it is mixed with water to prepare chocolate beverages that are consumed locally on a daily basis.

The participants identified several problems in growing and commercializing cacao. Bribri people are still recovering from the impact of the frosty pod (*Moniliophthora roreri* Cif.), an outbreak of a pest that severely impacted the cacao farms starting in the late 1980s. Another challenge is the lack of profitability of selling cacao: “People come here and ask us to grow cacao. But what they do not understand is that sometimes we end up investing more money and labour than what we earn by selling the cacao seeds. This is not a good business for us.” (interview with Emilio, 27 October 2015). People also feel discontent with their relationship with the local buyer and with the implementation of projects in the area: “There are many problems but what I don’t like is that buyers are not formal. For example, sometimes they do not pay on time. I stopped believing in them because they told us they could not give us a better price for our cacao seeds. Later on, they paid us more only because the new company offered us a better price. Then they called us traitors because we were selling our seeds to the other company. Moreover, they want us to grow their sikua (Bribri word that means “from outside”) plants and not our criollo (Spanish word that means “local”) trees (Rodríguez Valencia field notes, 8 December 2015).

While most of the Bribri people have dealt with their discontent by switching to different livelihood activities (e.g., growing plantains, offering agro-tours), some of the participants continue growing cacao despite these constraints. “I will only abandon my cacao trees when I die, my parents raised me with cacao, and I cannot abandon my farm.” (Rodríguez Valencia field notes, 21 August 2015). These participants feel nostalgic and respectful for an earlier period when the production of cacao allowed their families to travel, get recognition, and sustain themselves (1950s–1980s). Other participants want to re-engage with the practice of growing cacao because they perceive an opportunity to diversify their livelihoods by showcasing the biodiversity of their farms: “My dad passed away and left this piece of land for me. I did not know what to do with this piece of land. Then, I had the opportunity to study community tourism. As part of my studies, I decided to design a showcase farm. In this way, I can do what I like to generate some extra cash. People visit me to learn about our culture and our plants. For example, I show the visitors how to make chocolate with the seeds I produce here.” (interview with Ballarino Oniel, 9 December 2015).

3.2. Ideation Phase

In the ideation phase, the participants and I generated some ideas to expand on the participants biocultural heritage to identify new value-added cacao products/services (Table 1). For example, we planned on creating a trail mix with the seeds of the trees located in the cacao agroforestry systems (e.g., *Anacardium occidentale* L., *Nephelium lappaceum* L., *Dipteryx oleifera* Benth., *Theobroma angustifolium* D.C.). However, we could not design this product because the fruits of these trees are seasonal, and we did not have access to the seeds at the same time. Another idea was to make chocolate bars. However, we did not know how to make chocolate bars, nor did we possess the technology (e.g., thermometers, refrigerators, tempering machines) and the optimal environmental conditions (e.g., humidity, temperature) to develop these products. I also proposed working on a collection of jellies made with the different varieties of plants located in the cacao agroforestry systems. This idea was functionally possible, but the participants were not interested in working on this product. They believed consumers would not be interested in buying small portions of each jam flavour.

Using ideation as an approach allowed participants to put forward any idea that came to mind and then undertake a structured preliminary reflection on its desirability, feasibility and viability. Through this process we were able to identify the main constraints of developing these ideas, such as the lack of (1) infrastructure equipment and technical resources, (2) constant availability of seeds, and (3) specialized knowledge to elaborate products such as chocolate bars. This first phase encourages participants to bring forward nascent ideas and then winnow them through a structured reflection, resulting in the most desirable, feasible and viable idea to be taken forward into the phase of implementation.

Table 1. Ideas generated during the ideation phase of the biocultural design project.

Desirable Ideas ^a	Feasible Ideas ^b and Challenges to Overcome	Strategies Used to Solve the Challenges	Viable Ideas ^c
Trail mix made with seeds of the trees located in cacao agroforestry systems	This idea was not feasible because the availability of seeds was seasonal, and we did not have access to the necessary infrastructure to store the seeds for long periods.		
Chocolate bars	This idea was not feasible because we did not have the knowledge and infrastructure (e.g., thermometers, refrigerator, tempering machines) to transform the cacao mass into chocolate bars.		
Fried plantains	This idea was feasible. However, we did not work on it as we were focused on the elaboration of other products.		
Chocolate beverages with the seeds of different <i>Theobroma</i> species	This idea was feasible because we have access to the seeds of the trees and the participants had the knowledge to elaborate the beverages. However, we could not further develop the products because we did not have access to enough seeds.	We grew the seeds in a nursery. Then, we made a plan to transfer the plants in different landscape patches to mitigate the impact of fungal diseases in the trees.	This idea has to potential of being viable. However, it requires more time to become part of a business model.
Showcase farm intercropping cacao/banana in the same area	The idea was feasible. However, we changed our original design after learning about the white cacao and the cacao Bribri cultural narrative. For the development of this idea, we faced the following challenges: (1) It took us a long time to find the seeds of the trees we needed. (2) Once we got the seeds, we needed to figure out the best way to grow them to avoid the incidence of the monilia.	The participants consulted neighbors and relatives to get the location of the trees. I contacted other researchers to learn the scientific and Bribri names of the trees.	The idea has the potential of being viable. However, it requires more time and reflection to become part of a business model.
Cacao jam	The idea of creating cacao jam was feasible. However, we faced the following challenges: (1) The fermentation process was interrupted, and the participants could not sell the seeds to the local cooperative. (2) The participants could not remember how to extract the butter (3) We did not have containers to package the product. (4) We did not know how to sell this product to the tourists visiting the community.	(1) We used the fermented seeds to develop a second product: cacao butter. (2) The participants consulted neighbors for the traditional method to extract cacao butter. (3) The participants and I bought glass containers to package the product. (4) We shared the ideas of the project with some community visitors, and they demanded the product. The participants shared our products with other community members, and they traded for other products (e.g., wood, sugar, rice)	This idea was viable because the participants: - Had access to the cacao seeds and to the knowledge to prepare cacao jam. - Had access to other sources of knowledge, which allowed them to remember how to extract cacao butter. - Had the freedom to select the containers and final design for their product - Decided the price of the product and agreed on how to trade the product for other merchandises with neighbors

^a Desirability: what makes sense to people. ^b Feasibility: what is functionally possible. ^c Viability: what is likely to become part of a business model that is congruent with the Bribri knowledge and values.

3.3. Implementation Phase

3.3.1. Developing and Implementing Products with the Morales Family

The Morales family and I decided to work on the elaboration of cacao jam in April 2016 (Figure 2). The cacao jam is made by using a part of the cacao that is not typically used in the community: the white mucilage that surrounds the cacao beans. To make cacao jam it is necessary to boil the white mucilage that surrounds the cacao beans with sugar and with a local type of cinnamon (plant not identified). The result is a sugary product with a fruity flavour. With this idea, the participants were able to generate a product that added value to the commercialization of cacao. However, there were two main problems. First, the participants were not able to sell the leftover cacao seeds from the jam because the fermentation process was interrupted. Second, the participants did not have packaging for the product.



Figure 2. Elaboration of cacao jam. (a) Extraction of cacao seeds from the fresh pod; (b) boiling the cacao pulp, water, sugar and cinnamon; (c) cacao jam.

Eventually, one of the participants realized we could use the leftover cacao beans from the jam to extract cacao butter and create a second product. Cacao butter is used in Bribri communities for medicinal and ritual purposes; “Well, my mom used to extract cacao butter. She used it to heal our skin when we were sunburned” (Rodriguez Valencia field notes, May 2016). “The Bribri use cacao butter to purify the soul of people when they are born and when they die. These are very sacred processes . . . ” (interview with Noemi Rojas, 5 May 2016).

We decided to work on this idea; however, the participants could not remember how to extract the butter from the cacao seeds. To solve this problem, I looked on the internet for some methods to extract cacao butter. The methods I found were expensive as they required the use of complex machines. The participants visited their neighbors and asked them for advice. Then, we tested the technique they learned, and we created a second product (Figure 3).



Figure 3. Extraction of cacao butter. (a) Rodriguez Valencia grinding cacao beans to obtain cacao mass; (b) cacao mass boiling; (c) participant pouring cacao butter into a container

After extracting the cacao butter from the seeds, I realized there was a remnant of cacao mass and I proposed to use it to elaborate chocolate candies by adding condensed milk and other spices (e.g., cinnamon, ginger). By using this remnant, I thought we could add more value to the same amount

of cacao that was used to make the jam and the butter. The participants disagreed with my idea and decided to use the cacao mass for their own consumption and for sharing it with their neighbors.

By mid-July 2016, we had mastered the elaboration of cacao jam and the cacao butter. However, we did not know how to package the product. Two of the participants and I travelled to the town of Limon in Costa Rica to find containers. On our way to Limon, we stopped for a cup of hot chocolate in the touristic town of Puerto Viejo. When one of the participants realized a cup of hot chocolate cost the same as one kilo of raw cacao seeds, she mentioned: “This is enough, they need to respect my cacao trees! How come they are not paying me more for my cacao seeds?” (Rodríguez Valencia field notes, 25 May 2016). After this situation, this participant became very active in the rest of the project.

To improve the appearance of the jam, we decorated the glass contained with the leaf of a non-commercial type of plantain (*Musa textilis* L.) (Figure 4). The cacao butter was packed in the container without any other aesthetic component (Figure 4).



Figure 4. Cacao value-added products: (a) cacao jam; (b) cacao butter.

The Morales family and I did not know how to sell the products we designed. On July 2016, I had breakfast with some tourists, and I told them I spent the last evening making cacao jam. The tourists were curious about the product and subsequently visited the Morales family to try the jam. The Morales family used this opportunity to show the visitors the jars of cacao butter. The tourists expressed their satisfaction and bought all the containers we prepared; “Mariana, you should have seen the tourists, they were fighting for our products!” (Rodríguez Valencia field notes, 9 July 2016). The participants and I prepared more products and other community members traded the products for other merchandise (e.g., firewood, rice).

At this point, one of the participants was very excited about the project as she realized she had significantly increased the value of one kg of cacao. Instead of earning USD \$1.00 by selling one kilogram of wet beans to the cooperative, she was earning USD \$58.00 by selling the cacao jam and butter. The participant calculated the amount of money she could earn by spending more time making the products. An elder stopped her and said, “we were able to make an alternative little business, and that is good. However, you need to remember that you will not have the capacity for making a big amount of product. Also, what are you going to make with all the cacao that we have in the farm? It is better to use the cacao not only for jam, but for our consumption, and to sell to the cooperative” (Rodríguez Valencia field notes, 9 July 2016).

I visited the Morales family for the last time on 7 August 2016. We had dinner together and talked about the benefits of working on the products. The participants were satisfied with creating products that reflected their knowledge and practices. They were also pleased about the economic potential of being able to generate a regular cash income by selling the cacao products during the low season and continue selling cacao seeds to the local cooperative during the high season. This strategy was allowing them to diversify their livelihood portfolio and, at the same time, become more independent from the local cacao buyers. Finally, they realized our products were only a few of the multiple ideas that could be developed. In this regard, they developed other products after I finished my fieldwork. The participants have been selling and trading some of these products (e.g., coconut oil)

since August 2016. Other products, such as the hats made with *Musa* leaves are in the development phase (interview with Saulin Morales, 15 March 2020).

3.3.2. Developing and Implementing Products with the Celles Family

One Celles family member and I decided to work on the development of a showcase farm by undertaking a botanical inventory of his cacao plot. The participant's original idea was to design a farm to showcase the botanical richness of the area, as well as to offer tours to university students to present information about the local strategies to grow organic cacao: "Everything started one year ago (2015) when I was invited to a workshop organized by the university of Costa Rica. The workshop was held at the farm of a producer that had all sort of plants in the same plot. After this workshop, I thought it would be a good idea to do something similar with my farm. In this way, I could continue growing plantain, banana, and cacao at the same time. I got very excited with this idea and now it is my goal to work on it in the following years" (interview with Longino Celles, 13 July 2016). While working on the botanical inventory, the participant told me it would be important to include in his farm a "cacao criollo tree". The cacao criollo, he told me, was the original cacao in the area, a tree resistant to the frosty pod disease.

We visited the participant's uncle in a nearby community to learn more about the criollo cacao. The elder was confused when we asked him about this cacao variety. The only cacao criollo he knew was the one his parents obtained from the United Fruit Company, an American corporation that produced bananas in Latin America in the early and mid-20th century. Then, he asked us if we were looking for the "cacao blanco" (white cacao in English). The elder told us that the white cacao was a tree that existed in the forested areas surrounding the community. This tree looked very similar to the cacao trees located on the farms, but the beans were white, instead of violet. During this visit, the elder showed us a tree with small cacao-like pods. The tree he showed us was a wild variety of the genus *Theobroma*. After this visit, the participant's uncle became part of this project and his role was to guide us to understand the diversity and location of wild varieties of cacao in the area.

In the subsequent months, the main participant of this project and I searched for the white cacao tree. Following the advice of the Celles' family members we searched for the tree in abandoned farms and forested areas. While doing this, we found other wild varieties of cacao, locally known as the cacao sisters (Figure S1). The participant's relatives told us that, in the past, people used the seeds of the cacao's wild relatives to make chocolate beverages. However, the Bribri people cut down these trees because they believed they were responsible for spreading frosty pod in the cacao farms.

The Celles family and I solicited the counsel from other Bribri people, and non-Bribri people, to learn the names of the trees we found, as well as the cultural importance of the cacao sisters. From Alí García (a Bribri researcher working at the National University of Costa Rica), as well as from W. Phillips-Mora (a researcher from the International Cacao Collection of the Tropical Agricultural Research and Higher Education Center, CATIE), we realized that we had located the following wild varieties of cacao: (1) Solo' (*Theobroma angustifolium* D.C.), (2) Skuálöm (*Theobroma bicolor* Bonpl.), (3) Wèrö (*Theobroma simiarum* Donn. Sm.), and (4) Chuwál (*Theobroma bernoullii* Pitier).

From our conversations with an awá (Bribri medicinal man) and a tsuru'óköm (Bribri women in charge of purifying people with cacao), we learned that the wild varieties of cacao were part of a Bribri narrative that guides the behaviour of the Bribri with other humans, and non-humans [25]. According to the awá, these trees represent the failed attempts of Sibö (a Bribri cultural hero) to create cacao, the perfect plant. In the Bribri worldview, Bribri people are considered by Sibö as cacao trees [26]. The participants and I concluded that by including these trees in the showcase farm, we had the potential of honoring the Bribri worldview and its history.

From our conversations with W. Phillips-Mora, we learned that it would be very unlikely to find a criollo cacao in the area because this type of agricultural race is not very resistant to the frosty pod. Although we did not find the criollo cacao, we realized there are some cacao trees in the area that have

some traits of the criollo genetic material. These traits include the presence of white coca beans and a non-bitter flavor.

Once we harvested the seeds of the cacao sisters, we decided to work on other design ideas. For example, we elaborated beverages with the seeds we harvested. The beverages we elaborated were not as bitter as the beverages made with cacao. We could not continue working on this idea because we were constrained by the low quantity of seeds we harvested. Our second idea was to grow the seeds in a nursery to design a farm showcasing the wild varieties of cacao.

During August 2016, the main participant of this project and I noticed that some of the *Theobroma* species found were not infected by the frosty pod fungus. We hypothesized that these plants were not infected because they were located far away from the infected cacao farms or, they were located in higher altitudes, where the temperature was lower. With these hypotheses in mind, we discussed a plan to grow the seeds obtained in the main participant's farm (Figure 1). We used a participatory mapping technique to record the approximate location of the seeds he needed to plant. This technique helped us to have a long conversation on how to potentially manage the incidence of the monilia fungus on a landscape level.

In an interview with the main participant of this project on 13 July 2016. He told me what he imagined his showcase farm would look like in the future; "My showcase farm will be an important place to conserve all the types of cacao that we had found and that my people were forgetting. Now I am very curious about these trees. I hope that in the future people come to learn about these trees, and I am not only thinking about outsiders but also about our kids. They need to learn about our culture and our history" (interview with Longino Celles, 13 July 2016).

The Celles family and I generated a few ideas to attract tourists to the showcase farm. Some of the ideas included to; (1) search for other plants of cultural importance to enrich the farm (e.g., *Crescentia* sp., *Pouteria* sp.), (2) make an alliance with the tourism associations that already existed in the area, (3) request funding from governmental agencies to continue the project, and (4) make alliances with development organizations to be trained in receiving tourists. I had the opportunity to visit the community in May 2017 and learned that the Celles family had requested funding from the Panamanian government to develop the showcase farm. I have not been in touch with the Celles family since. However, I heard from a member of the Morales family that the trees the participant planted have not produced cacao pods yet (interview with Saulin Morales, 15 March 2020).

4. Discussion

I described my experience in co-designing products/services with community members of Yorkin and Guabo. I described how this project emerged, who was involved, what conversations emerged between the participants and how decisions were made. In contrast to co-production practice, which puts an emphasis on documenting the unintended consequences of scientific progress, biocultural design contributes to the co-production theory by offering a solution-oriented approach to co-imagine and co-execute ideas to specific problems. This approach, which consists of developing the most desirable, feasible and viable ideas that emerge from interactions with community members and outside actors, not only takes into consideration the participants' knowledge about resources and practices, but also their needs, aspirations, and values.

Biocultural design contributes to coproduction practice by offering an approach that recognizes the value of science, while also respecting the values of other actors. In the case described in this paper, the participants received private value in the form of cash flow by selling the cacao value-added products to tourists. Consumers (e.g., tourists and neighbors) received value in the form of having access to valuable products. Sustainability science, in general, will hopefully see its value in the form of new knowledge that has the potential to support the implementation of initiatives that take into consideration Bribri needs, aspirations and values. Contrary to the idea that the "products" of a coproduction process are exclusively public goods "consumed" by society as a collective (i.e., knowledge,

practices, institutional arrangements), the products that result from a co-production process entail diverse outcomes which result in and may constitute one or more private or public values [27].

While increasing cacao yields have received the most attention in the Bribri territory, the participants expressed interest in pursuing additional goals such as diversifying their livelihoods and living up to cultural ideals (e.g., honoring Bribri worldview). The latter acknowledges that the participants' aspirations go beyond the instrumental objective of maximizing short term economic inputs. The conversion of resources into new functions, defined by Sen as things that a person values doing or being, is influenced by personal, social and environmental factors [28]. Assumptions of growth and development are not automatically correlated to increased capabilities or functions [19]. Unlike the dominant development approaches that centres on economic value, for the Bribri it is but one facet that must be considered, balanced and weighed off against other dimensions of value such as cultural teachings and social relationships.

Biocultural design provides a strength-based approach that allows creativity to emerge out of the capabilities found within biocultural heritage to implement changes in livelihoods. In this project, these capabilities were informed by a set of resources that the participants commanded to perform different functions. These resources included:

- Access and availability of materials (e.g., diversity of *Theobroma* and other plant species)
- Specialized place-based knowledge (e.g., location and use of biological resources, Bribri cultural narratives)
- Placed-based practices (e.g., techniques to transform plants into dishes and medicines)
- Strategic alliances with key actors to gain access sources knowledge (e.g., neighbors, researchers, Bribri traditional authorities) and access to markets (e.g., touristic operation)
- Strong attachment to biological resources tied to the Bribri identity (e.g., cacao)

Biocultural design moves away from the identification of a one size fits all approach to solutions and focuses on the creation of new possibilities. In this project, the participants and I imagined and put into practice a different way to address their problems and open new opportunities; instead of focusing on a narrow approach to maximizing economic returns through yield, we created an alternative system based on the idea of creating cacao added value products, as well as generating direct links between producers and consumers (e.g., tourists). This process opened up a new relationship between producers and consumers, a relationship in which Bribri people are not only producers, but also entrepreneurs. In this regard, the participants continued designing new products (e.g., coconut oil, hats with palm leaves) to further diversify their livelihoods without major economic and technological investments.

The implementation and development of this project indicates that biocultural design “is an approach that requires time to realize the benefits” [20]. In this case, the execution of the showcase farm, as well as the elaboration of beverages with wild relatives of cacao, have the potential of becoming viable ideas. However, the implementation of these ideas will require more time and more resources if they are to be generated and controlled by the Bribri as opposed to the more conventional and colonial outcomes, such as international cacao supply chains, which emerge from and are controlled by people outside of the community.

In reflecting upon the implementation and development of this biocultural design project and others' reviews of this work, ideas emerged that could have enriched the project in several ways. For example, I could have tried to replicate the elaboration of cacao value-added products in other communities. This does not mean that this particular case, with its specific context, could have been reproduced. This means that I could have researched the participants' wishes to establish collaborations with other Bribri people to develop products further. Moreover, I could have conducted a marketing study before the development of this project to inform the participants about the availability of markets for their products. This strategy, perhaps, could have motivated more people to participate. Additionally, I could have provided the participants with information to develop marketing strategies to reach other consumers. Although the use of these ideas and strategies should be incorporated

into the practice of biocultural design to enrich its practice, I believe that the role of a researcher in a biocultural design project goes beyond researching and sharing information with stakeholders to (1) ensure the development of the design process while balancing power inequalities between the participants (e.g., researchers, stakeholders, consumers), and (2) build capabilities through biocultural heritage so that participants feel more confident in developing their ideas and new possibilities.

5. Conclusions

This research focused on the practice of co-production in two Bribri communities. To be more specific, I used a biocultural design approach to co-design cacao value-added products and services with Bribri community members by drawing upon the capabilities of their cacao agroforestry systems. The participants of this project, including myself, strategized, planned, and found ways to move forward our ideas to design products and services by recognizing that some products are not desirable, feasible or viable. Ultimately, we understood that at times action had to be taken to improve situations and often key resources such as biological materials, place-based knowledge, and place-based practices need to be used in an innovative way. When needed, we complemented our capabilities by turning to others who could provide guidance, alternative ideas, information, and resources. The results of this case study confirm previous findings that recognize the importance of; (1) developing trust relationships with stakeholders [6], (2) including different types of knowledge [7] and reflecting about the process of co-producing knowledge [1]. At the same time, the findings of this study provide new information on the practice of co-production by offering a guide to co-imagine and co-execute ideas to solve specific problems. Further research in biocultural design is necessary for consolidating and replicating similar projects to support sustainable economic development in other indigenous communities.

Supplementary Materials: The following are available online at <http://www.mdpi.com/2071-1050/12/17/7120/s1>, Figure S1: Cacao sisters.

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