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# The Embedded Agroecology of Coffee Agroforestry: A Contextualized Review of Smallholder Farmers' Adoption and Resistance

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**Abstract:** Contemporary ecology and agronomy point to the many benefits of agroforestry crop systems for the provision of ecosystem services by regenerating native ecologies, and in many contexts, socio-economic benefits for coffee farmers, especially the contribution of nitrogen-fixing trees' litter to soil nutrition and water retention. However, the implementation of agroforestry in coffee cultivation is thus far incomplete and uptake has been uneven. In this paper, we examine the adoption and non-adoption of agroforestry coffee growing techniques as a reflection of the historical, social and cultural embeddedness of smallholder coffee cultivation. It is structured as a narrative literature review contextualized with the results of surveys of smallholder coffee farmers in Colombia, Malawi and Uganda regarding their perceptions of agroforestry coffee in their respective contexts. Findings suggest that coffee farmers' perceptions of agroforestry and the decision to implement or remove it are influenced by factors included in the notion of embeddedness, involving social relations, historical memory and formal and informal institutions, as well as practical capabilities. Intention and action are sometimes discordant due to the complex interactions of these institutional factors, and they often conflict with outside interveners' expectations based on epistemological differences. The study illuminates some of the main sources, manifestations and dimensions of the social embeddedness of agricultural practices which mediate the perception of current practices, the sacrifice implied by potential changes, the credibility of theories linking action with outcome and the desirability of expected outcomes.

**Keywords:** environment; agroforestry; circularity; regeneration; agroecology; nature-based solutions; political economy; embeddedness; coffee; agrifood chain



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## 1. Introduction

Contemporary ecology as well as agronomic research point to the many benefits of agroforestry (agroforestry is defined as "the deliberate combination of woody vegetation with crops and/or animal systems" [1]) systems for the provision of ecosystem services and, in many contexts, agroforesty brings socio-economic benefits for coffee farmers [2–6]. Agroforestry can provide multiple environmental benefits, such as improved soil health and fertility, the preservation of biodiversity and resilience to climate changes. Economic benefits are contingent upon several potential costs and opportunities as well as the productive potential of different growing systems. One important factor is the potential for the mechanization of cultivation, harvesting and processing, as well as the cost of mechanized production, including fuel, which is principally relevant in the Brazilian context given the topography and scale that is often conducive to mechanization [7,8]. The other important factor is the cost, availability and effect on productivity of synthetic soil conditioners compared to what is offered by shade trees in coffee agroforestry systems and the potential for

productivity reduction due to shade trees' presence. The provision of soil nutrients needed for coffee production, particularly nitrogen, is increasingly relevant to the economic and social viability of coffee growing as a livelihood strategy and lifestyle due to the rising average cost of fertilizer. In the period from January 1980 to December 2022, the fertilizer price index rose 3.6 times faster than the price of arabica coffee and 9.2 times faster than the price of robusta coffee (see Supplementary Materials Figure S1 and Table S1). In addition, agroforestry can provide growers with a range of non-timer forest products, which represent additional income [2–4,9–11]. Several studies have also shown that agroforestry systems can lead to higher yields and improved quality of coffee beans. Soto-Pinto et al. [12] find that in southern Mexico up to 48% shade cover is associated with higher crop yields than similar cultivation with no shade cover. Lara Estrada [13] documents the relatively higher physical and sensory quality of coffee grown under shade in Northern Nicaragua. Leijster et al. [14] find that coffee plantings under shade trees have a higher long-term crop yield and processing yield (of marketable coffee beans) than full-sun plantings.

However, the implementation of agroforestry in coffee cultivation is thus far incomplete and uptake has been uneven, despite the clear economic advantages as evidenced by the technical literature. This could be a source of frustration for those approaching agriculture from a technical perspective and interpreted as a failure to communicate or interpret, or as a failure of producers to act in their own best interest. On the other hand, uneven uptake may also be interpreted as evidence of a more complex context in which agricultural decisions are being made, involving social and institutional influences that contradict the technical profit rationale. This paper will explore the origins, dimensions and manifestations of this said context, or embeddedness, examining how embeddedness impacts on agricultural decisions, particularly the decision to practice agroforestry in coffee cultivation. Karl Polanyi proposed that economic activity, such as agricultural production and the decision whether or not to implement agroforestry, is embedded within a unique social and cultural context; the economic aspect is embedded within complex social relations. He wrote:

> *"man's economy, as a rule, is submerged in his social relationships. He does not act so as to safeguard his individual interest in the possession of material goods; he acts so as to safeguard his social standing, his social claims, his social assets. He values material goods only in so far as they serve this end."* [15] (p. 48).

Government and extra-government policies and institutions, both local and foreign, play a key role in promoting or hindering the adoption of agroforestry. Intervention programs that neglect to recognize the embedded nature of economic (such as agricultural) activity often serve to disconnect it from its local social, cultural, political and ecological context. These programs can fail due to the factors of embeddedness, or they can succeed, in the process traumatically disembedding economic activities and motives from their social contexts. Of a disembedded market economy, Polanyi wrote:

> *"It is governed by laws of its own, the so-called laws of supply and demand, and motivated by fear of hunger and hope of gain. Not blood-tie, legal compulsion, religious obligation, fealty or magic creates the sociological situations which make individuals partake in economic life but specifically economic institutions such as private enterprise and the wage system."* [16] (p. 60).

A compelling prospect offered, and corresponding with the remainder of this paper, by Ernesto Méndez et al. [17] suggests an agroecological approach that is "transdisciplinary, participatory, and action-oriented" and also engages with the political–economic embeddedness of the productive system. An agroecological approach, compatible with natural and human diversity (i.e., ways of knowing and being) while meeting the needs of greater humanity, must be holistic and inclusive, which requires looking beyond the "Western scientific paradigm". This requires "An appreciation for farmer-generated knowledge challenges conventional approaches to agricultural research and related policymaking that privileges Western epistemologies and knowledge production." [17] (p. 5).

This paper aims at contributing to the literature with an examination of the adoption and non-adoption of agroforestry coffee systems based on the historical social and cultural embeddedness of smallholder coffee cultivation, epistemological diversity, rationalities and interests of agents and stakeholders, and unmonetizable implications of on-farm decision making. The barriers to agroforestry are not simply tasks that need doing or blockages that need unblocking (i.e., culture that needs destroying), but are belief systems, ways of knowing and interacting with one's surroundings, interpretations of the motivations of interveners and incentive structures (based not only on rational profit maximization), and are tied to diverse sets of institutions, cognitive, state, cultural or otherwise.

Exploring the uneven uptake of agroforestry requires examining divergent rationalities. One rationality follows the Western positivist scientific paradigm and economistic resource allocation. From this standpoint, coffee agroforestry may check all of the boxes. Other rationalities, which are the focus in this paper, incorporate the infinitely diverse historically formed social and cultural contexts that mediate individuals' relationship with their surroundings and with the resource economy. In other words, the purpose is to recognize the embeddedness of coffee cultivation systems or agroecologies and the diversity of perspectives and orientations for the purpose not of showing outsiders how to more effectively alter them, but to encourage their appreciation and demonstrate the importance of the values and rationalities that uphold them [18].

The question that emerges from this tension, then, is the following: how is uptake of agroforestry practices dependent on the embeddedness (i.e., the unique local context) of smallholder coffee farmers? A better understanding of how farmers may interpret and act on different notions and strategies brought to them by outsiders and insiders to preserve and regenerate biodiversity and promote socio-economic prosperity should offer insights as to how support services could be offered most effectively and respectfully. The structure of this investigation is represented in Figure 1.

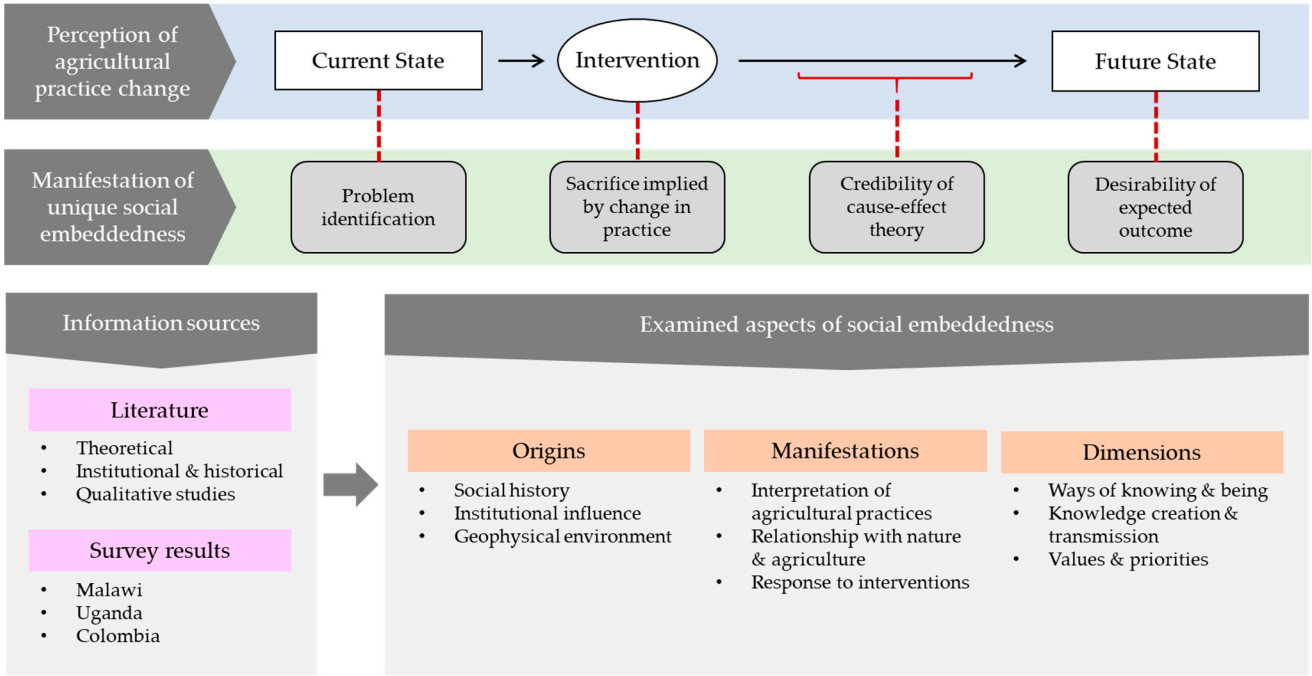


**Figure 1.** Exploring the social embeddedness of agricultural practices.

The term "smallholder" is defined in a variety of ways, in different contexts, based on several parameters. In terms of area, smallholdings are most often defined using a threshold of 2 or 10 hectares of operated land [19]. For the purpose of the present study, we will use the 10-hectare threshold and overlay this with two social criteria: firstly, that operating the farm is the primary vocation of the individual or family that controls the land, upon

which they depend for their sustenance [20], and secondly, that the farm is central to social and family life, as opposed to a strictly profit-driven endeavor. The production countries of focus in the original data collection, Uganda, Malawi and Colombia, are relevant for this study due to the importance of small-scale coffee production in each of them, as well as several contrasting aspects (see Table 1). Malawi and Uganda, in East Africa, are the setting of the participatory agroforestry program of focus. While Uganda is the sixth largest producer of coffee, contributing 4% of global production, Malawi produces just 0.0006%. Colombia is also a major producer of strictly mild arabica coffee in a very different historical and social context, also dominated by smallholders, and where agroforestry cultivation has declined significantly in recent decades in response to policies intended to increase yield and farmer income [21]. Brazil, the largest global coffee producer, was not chosen because most of its output does not come from smallholders and production in key regions is mechanically harvested and therefore not compatible with intercropped agroforestry techniques [22,23]. Vietnam, the second-largest production country, is a relatively new major coffee grower and productive systems were implemented abruptly according to government agricultural and relocation policies, largely by migrant farmers, and not as an expression of growers' culture or tradition [23–25].

**Table 1.** Top 10 coffee production countries 2010–2019.

| Production Country | Production Rank | World Share | Majority Agroforestry | Majority Smallholder | Coffee Share of Exports | Yield MT per ha | Yield 60 kg Bags per ha |
|---|---|---|---|---|---|---|---|
| Brazil | 1 | 30% | No | No | 3.0% | 0.77 | 12.8 |
| Vietnam | 2 | 22% | No | Yes | 1.5% | 1.77 | 29.5 |
| Colombia | 3 | 10% | No | Yes | 7.0% | 0.83 | 13.8 |
| Indonesia | 4 | 5% | No | Yes | 0.6% * | 0.5 | 8.3 |
| Honduras | 5 | 5% | Yes | Yes | 20.0% | 0.7 | 11.7 |
| Uganda | 6 | 4% | Yes | Yes | 25.0% | 0.64 | 10.7 |
| India | 7 | 4% | Yes *** | Yes ** | 0.2% * | 0.64 | 10.7 |
| Peru | 8 | 3% | Yes | Yes | 2.6% | 0.72 *** | 12.0 |
| Ethiopia | 9 | 3% | Yes | Yes | 25.0% | 0.71 | 11.8 |
| Guatemala | 10 | 3% | Yes | Yes | 6.2% | 0.9 | 15.0 |

Source: Author elaboration, data from IDH Sustainable Trade [22] (unless otherwise noted); * UN Comtrade [26], ** Coffee Board of India [27] and *** USDA [28,29].

This paper is structured as a narrative literature review, contextualized with the results of focus groups of coffee farmers in Malawi and Uganda and a series of interviews with farmers in Colombia. First, it details a variety of concepts related to the embeddedness of coffee agroecologies and their relevance to the prospect of agroforestry implementation, including examples from the relevant literature. Secondly, it presents the results of focus groups of smallholder coffee farmers in Malawi and Uganda, which were carried out as part of a program by the Slow Food Coffee Coalition (SFCC) in collaboration with the United National Food and Agriculture Organization (FAO), regarding their perceptions of the viability of agroforestry coffee in their context. Finally, interviews with a set of smallholder coffee farmers in Colombia add contextual richness and comparison.

The study finds that coffee farmers' perceptions of agroforestry and the decision to implement or remove it are influenced by factors included in the notion of embeddedness, including social relations, historical memory and formal and informal institutions, as well as practical capabilities. Intention and action are sometimes discordant due to the complex interactions of these institutional factors, and they often conflict with outside interveners' expectations based on their own economistic rationalities.

## 2. Materials and Methods

### *2.1. Literature Review Methods*

The literature review section draws from a wide range of materials from different periods and contexts, both theoretical and empirical, to explore the embeddedness of agri-

cultural practices or their placement within—and in dynamic association with—individuals' relationship with their surroundings and with the resource economy. It draws from diverse empirical research, in connection with theoretical social science content, to draw out the institutional components of embeddedness and connect them across contexts. The review includes country-specific studies of coffee production and producers in 15 countries which represented 79% of global production in 2019 (this figure was calculated from annual exports statistics obtained from the International Coffee Organization, available at https://www.ico.org/new_historical.asp, accessed on 9 February 2023). Nevertheless, the farmers sampled do not necessarily represent the social characteristics of all coffee producers in the respective countries. Indeed, our goal is not to generalize about characteristics or even patterns of traits of coffee farmers around the world, but rather to explore the scope of the diversity of their orientations, in what ways their outlooks deviate from the purely rational drive for profit, and how this diversity mediates decisions around farming practices.

The review explores the contrast between a purely economistic view of agriculture, completely divorced from its social context, and the diverse manifestations of the embeddedness of agriculture in agrarian societies the world over. This juxtaposition materializes in practice when technocratic interventions, such as to raise farmer income, assume disembeddedness and are frustrated when met with agriculture embedded in its social context.

The overarching mediating effects of embeddedness on a decision regarding agricultural practices can be visualized in terms of a return-on-investment equation, in which an investment is compared to the gain it is expected to generate based on a theory (see Figures 2 and 3). Applying such an equation to social life requires the perfectly disembedded economization of agriculture and profit-driven rationality in order to assign numeric values to the variables. Its application is therefore suggested in order to illustrate the absurdity of attempting to assign single numeric values to variables that represent subjective social concepts.

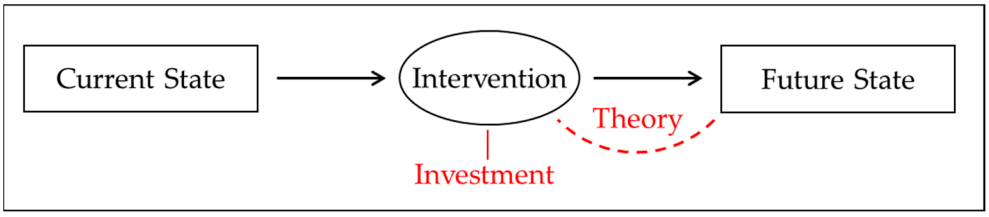


**Figure 2.** Logical consideration of changing farming practices.

$$\text{Benefit} = \frac{(\text{Future} - \text{Current})}{\text{Investment}}$$
$$\uparrow$$
$$\text{Theory}$$

**Figure 3.** Mathematical representation of Figure 2 based on return on investment equation.

Several key aspects of this equation are affected by the embedded nature of the decision maker. Which aspects of the current state should be modified or preserved, and the vision of an ideal future state, are expressions of values and rationality. The cost or sacrifice implied by the intervention, such as a change in the crop cultivated, the tools used or the activities performed, may affect the lifestyle and culturally important traditions of farmers and be more or less acceptable based on values and priorities. Furthermore, the likelihood of the intervention to achieve the projected future state is inevitably contingent upon a theory of cause and effect based on one's rationality or knowledge system, including experience and shared historical knowledge developed by the community over a period of time. Depending on the application, this theory could be deeply engrained in common sense for one group, while another may view it with suspicion. As an example, while low-cost changes to agricultural practices may clearly yield quantifiably superior financial results based on the most basic economic theory, implying a positive projected return on investment for a rural development planner, a different view of the changes suggested,

outcomes predicted and the theory connecting them for a farmer may imply a negative return on investment, clearly explaining non-adoption of the suggested practices. How the uncountable values of these variables are formed and compared and how they affect the decisions that farmers make is the goal of the following review.

The data included in this study are intended to further contextualize the literature component by facilitating additional connections in the diverging contexts of agroforestry coffee systems in Malawi, Uganda and Colombia, respectively. Different approaches are taken to include these perspectives.

### 2.2. Insights from Focus Groups under the Slow Food Coffee Coalition Agroforestry Program

Data on agroforestry perceptions in Malawi and Uganda were accessed through a documental review of focus group summaries prepared by the local staff of the Slow Food Coffee Coalition (SFCC). Details are provided as Supplementary Materials S1, Figure S2, Tables S4 and S7. Participants were smallholder coffee farmers and members of farmers' cooperatives that have engaged with SFCC to receive training on environmentally responsible coffee production and marketing.

Those in Malawi were located in the northern growing region and their cooperative organization was located in the city of Mzuzu. Those in Uganda were mostly located around the Mount Elgon region and their event took place in Mbale. Program participant testimonials were evaluated to gain an understanding of the perspective of farmers involved with the project in Malawi. This document, consisting of summaries and quotes of testimonials on the opportunities and challenges of coffee agroforestry, is from a gathering of participating farmers and program staff from Malawi and Uganda at the Terra Madre event organized by Slow Food in Turin, Italy on 26 September 2022. It includes highlighted input from three Malawian smallholder farmers affiliated with the program as well as the local program leader.

Insights from Uganda were accessed from this same document of meeting minutes as well as a synthesis document prepared by the local program leader based on focus groups titled "Marketing Constraints for Agroforestry Coffee in Uganda". Additionally, detailed information on smallholder perceptions of coffee agroforestry among program participants in Uganda was accessed via organized feedback reports from three training sessions conducted by Slow Food Uganda. These sessions included a total of 118 participants, 77 men and 41 women.

### 2.3. Colombia Smallholder Interviews

A series of in-person interviews were conducted by one of the authors with nine smallholder coffee farmers (between two and ten hectares cultivated) in Colombia between the 20th and 25th of January 2023 on their perceptions of coffee agroforestry and the adoption of agricultural practices. The guiding questionnaire is provided as Supplementary Material Table S5.

The interviews were conducted on the interviewees' farms, neighboring farms or in nearby towns, and coincided with farmer association gatherings, workshops or periodic farm visits. Subjects were selected based on their availability during meeting breaks and in some cases by introduction by other farmers or association staff. Interviews were all conducted in Spanish and recordings were subsequently transcribed and translated into English, and responses were coded where applicable.

All interviewees were members of farmers' associations involved in marketing members' coffee and providing training and technical assistance. In total, 78% of the interviewees had received some kind of agricultural training, ranging from association workshops to technical certificates from universities. Ages ranged from 32 to 66 years with a per-farm average of 46 years, compared to a national average of 52 years [30]. Three women and eight men participated in the 9 interviews; in two cases, married couples preferred to be interviewed together, averaging 37.5% female participation compared to the national total of 24.9% female farm leadership [30].

All of the interviewees were practicing agroforestry with the intention to continue, while nationally, only 37.2% of Colombian coffee is produced under agroforestry systems [31]. While the diversity of preferences regarding agroforestry and other agricultural practices is a topic requiring further study, several factors have been suggested as being associated with the higher rates of agroforestry preservation in Colombia.

Coffee was traditionally grown in Colombia almost exclusively in agroforestry systems mimicking the native forest environment, but approximately 70% of growing areas were subsequently converted to full-sun systems between the years of 1970 and 2000 amid pressure from the National Coffee-growers' Federation (FNC) [21]. Because most of the coffee in Colombia is grown by smallholders, farming less than 5 hectares each [31], many small farms are included in the 70% representing full-sun systems. Nevertheless, it has been suggested that small farms have been less likely to adopt intensive input-dependent production systems than larger producers [21].

The areas where the interviews were conducted, southern Tolima and northwestern Huila, have been heavily affected by the different waves of the complex armed conflict plaguing the Colombia countryside throughout the 2010s. A common but unverified narrative in the Colombian countryside is that through the years of conflict, the FNC and agrochemical company extension agents promoting the switch to full-sun monoculture coffee tended to avoid more dangerous areas, limiting the adoption of such techniques in these areas. While this notion requires more thorough investigation, there is evidence of lower agricultural productivity in the areas of Colombia affected by armed conflict [32]. As an example of another possibility, in Planadas, Tolima, home to several interviewees, Navarrete-Cruz et al. recount that from the 1990s to the 2010s, when the FARC-EP controlled the area, deforestation was explicitly prohibited [33]. Because the Colombian conflict is complex, Lara-Rodríguez's "Brutality Composite Index" [34] can be useful to gauge the historical intensity of the conflict at the municipal level. It tracks a weighted mix of forced disappearances, massacres, targeted killings and a set of non-mortal acts from 2012 to 2020 using data from the Victims Department (*Unidad de Víctimas*) of the Colombian government (Lara-Rodríguez, J.S. Peace Made; Peace Built? Participation, Countryside and Politics in the 2010s Colombian Peace Process. Forthcoming, Universidade de Lisboa: Lisbon, 2022). Comparing an average sample brutality index weighted by the farm locations of the interview subjects to an overall coffee production brutality index weighted by coffee production share at the department (province) level, we find that the sample brutality index is 24% greater than that for the average Colombian coffee grower (see Supplementary Tables S2 and S3). The above-average incidence of brutality, believed to be associated with insulation from policy application and technology transfer, coincides with above-average agroforestry practice, conflicting with previous policy promoting deforestation and since-revised agroeconomic wisdom. Our recognition of this coincidence is not necessarily intended to suggest a broader connection between criminality or armed conflict and agroforestry, but rather a link between isolation or marginalization and the uneven influence of policy and spread of technology, leading to diversity of shared social memory which extends to agricultural practices. Such diversity may be connected to various factors resulting in the relative isolation and marginalization of segments of farmers, including armed conflict, ethnicity, language, topography and political affiliation, among many other factors that will be presented in the reviewed literature.

## 3. Results and Discussion

### *3.1. Literature Review*

#### 3.1.1. Opportunities of Coffee Agroforestry

The implementation of agroforestry practices in coffee cultivation systems is reported to have significant benefits for producers, the proximate environment and the planet, as agroforestry practices sequester carbon and mitigate the effects of climate change [35]. Agroforestry can generate ecosystem services that can be appreciated by the farmers themselves, both locally and globally [36]. It can support native biodiversity and provide

habitats for migratory bird species and other wildlife [7]. It can promote circularity by replacing synthetic fertilizers purchased off-farm with by-products such as tree litter and by replacing purchased food, for example with fruit and a source of animal feed [3]. In this way, it also supports the non-monetary bioeconomy, which is not subject to the same economic and geopolitical contingencies of today's intertwined global value chains.

#### 3.1.2. Ecosystem Service Provision via Coffee Agroforestry

Agroforestry can provide important ecosystem services that contribute to meeting the Sustainable Development Goals [5], which are relevant to humanity as a whole [37]. Traditional cultivation including shade trees has been shown to support greater species richness, an important indicator of biodiversity [7,10]. The conversion of coffee plots to agroforestry systems has also been shown to sequester atmospheric carbon [4,14,38]. Humanity's need for these services can be economized through payment for ecosystem services schemes (PES) such as the marketing of carbon offsets [39]. Nevertheless, recent research maintains that smallholder coffee farmers in the tropics can help themselves and meet their own needs through agroforestry practices, serendipitously also helping the rest of humanity [37], including concerned groups far away who consume the products that would-be agroforestry coffee farmers provide.

#### 3.1.3. Agricultural Benefits of Coffee Agroforestry

Agroforestry practices in coffee systems also have several important agricultural benefits, including pest mitigation, temperature and moisture regulation, nutrient provision, production stabilization and erosion prevention, among others [1,2,4,40–42]. In the East African and particularly the Malawian context, Akinnifesi et al. [43] have conducted a study on the impact of "fertilizer trees" on soil fertility, nutrient contribution and crop yields by comparing monocrop and agroforestry systems. They recorded significant nitrogen fixation in agroforestry systems (more than 60 kg per hectare per year) and a 75% reduction in mineral fertilizers, increased maize yields and higher farm profitability [43]. In the Colombian context, De Leijster et al. [14] found several evolving benefits of coffee agroforestry as shade trees matured, including coffee quality, timber volume, aboveground carbon stock, erosion control, reduced fertilizer requirements and insignificantly reduced coffee production.

#### 3.1.4. Socio-Economic Benefits of Coffee Agroforestry

In addition to the ecosystem services offered by many types of agroforestry systems, compared to monocultures and other production systems, the socio-economic benefits have been studied extensively and have been demonstrated in a wide range of contexts, including, and perhaps especially, coffee cultivation. While the environmental benefits of agroforestry are many, there are also social benefits, including food security, as highlighted by Jemal et al. [9] in a study focused on Ethiopian coffee agroforestry systems. This study finds that plant species richness and plant stories are correlated with food access security and dietary diversity in coffee farms. They find that coffee agroforestry is associated with food stability since some plants can serve as "emergency foods" if need be. Agroforestry is also associated with food sovereignty, since farmers can cultivate things demanded by the household as well as the market. They can grow what is expensive or difficult to buy as well as sell other things in order to buy what is less easily grown or more easily purchased, leading to more diverse diets. Finally, coffee agroforestry is associated with food access because easily marketable crops such as coffee allow for the purchase of food when on-farm food is not in season.

Intercropping in agroforestry systems also permits the diversification of income streams, reducing reliance on the often-volatile coffee market [2–4]. In this way, it can increase the total productivity per land unit and reduce the pressure on the remaining forested land for agricultural expansion [1]. A study by [44] also found that the adoption of agroforestry practices is associated with subjective notions of happiness and wellbeing,

which have been attributed to reduced vulnerability to environmental threats, such as landslides, droughts and floods, and economic shocks thanks to increased food security and income diversification.

Agroforestry coffee has economic benefits over full-sun systems as mentioned previously, providing additional outputs including firewood, fruits and medicinal plants [10]. The substitution of synthetic fertilizer also reduces farmers' production costs and break-even sales prices thanks to tree litter, especially from nitrogen-fixing species, and mulching banana and plantain leaves and stems [3,4,11]. This benefit is especially important in the South and East African context where, according to a study by Quinion et al. [6], soil nutrition is "the main constraint to agricultural productivity" in the region, "especially nitrogen and phosphorous." (p. 1). The agricultural benefits also have economic implications.

#### 3.1.5. Producers' Challenges

In addition to the opportunity that agroforestry coffee may hold, farmers also face difficulties that could be mitigated by implementing agroforestry systems. According to a report by the Voluntary Service Overseas [45], the board chair of a farmers' cooperative in Malawi identified environmental factors (described as "climate change and water shortages") that threaten the viability of smallholder coffee farming in Malawi. Institutional factors have also been presented to represent challenges for smallholder coffee farmers, including land tenure [45]. Reported labor shortages in coffee growing regions [46] are also likely due to demographic shifts, as reported in much of the rural world [40,47].

The situation is similar in Uganda, where farmers face serious challenges to successfully growing coffee, especially the adverse effects of climate change [48]. These include more extreme weather such as heavier and longer periods of rain, longer and more severe droughts, and less predictable patterns of rainfall which have come to characterize the climates of Ugandan coffee production regions [49]. SFCC staff reports based on participant feedback also indicate the emergence of new plant pathogens (referred to as diseases) which are attributed to climate change [49]. In addition to environmental challenges, [49] also cites nutrient depletion as a source of hardship and poverty among smallholder coffee farmers. While producer poverty is cited as a result of insufficient soil nutrition and pest management [49], it is likely also a cause, amounting to a positive feedback loop of low production and low income [49].

Adverse circumstances such as the environmental threats to coffee production described necessitate adaptation or departure, but this happens amid a complex social context, and decisions are made based on individual and community values, worldviews, priorities and rationalities. According to Bro [50], "adaptation occurs after an individual has undergone a cognitive process, which is influenced by a complex range of interacting factors such as individuals' beliefs, the social norms that shape their lives, their exposure and experience with environmental impacts, and their attitudes and cognitive preferences." (p. 2).

#### 3.1.6. Epistemological Embeddedness of Coffee Agroecology

A regrettably frequent topic of conversation among rural development practitioners of all stripes is the headaches of implementation with program beneficiaries. Generally compassionate implementers and researchers lament their struggles, tactfully implying farmers' stubbornness, shortsightedness and opportunism when they do not truly buy into the latest agronomic technology or "value added" upgrading strategy. We would contend that the common source of conflict is a misalignment of conceptual explanations of relevant phenomena. The technical and university-educated engineers, agronomists and business graduates likely take for granted the basic (traditionally Western) theoretical foundation that establishes the viability of their techniques, not to mention the purpose and desired outcomes, which may not match farmers' view of how the components of reality fit together. It is possible that neither party is aware that there are other ways to explain reality than the one they inherited and consider "logic" or "common sense". Different traditions,

experiences, perceptions and sensory histories, as well as those learned from others, help to create sets of models used to explain reality.

The historical process of developing models to explain reality, but that are not reality, and that we are all subject to in different contexts, leading to different ends, is eloquently outlined by Martínez-Dávila et al. [51]. They write that "this complex of relationships, as the generations pass, becomes a collective memory and then a social memory. That social memory in this historical moment is no longer concrete but abstract, imbued in the processes of identity-and although it is now abstract-it determines the behavior of social groups. The social and collective memory is reproduced in time (it is autopoietic) that generates a culture that translates into specific traditions and behaviors." (p.14). This basic recognition of epistemological diversity will guide this examination of agroforestry adoption in different contexts.

#### 3.1.7. Historical Epistemological Processes

Farm management decisions, embedded in local cultures and value systems, may be more complex and nuanced than simply economistic financial analysis, and are not haphazardly intuitive due to the lack of data or statistical tools. Meshesha et al. [52] propose three relevant theories of adoption of agricultural technologies which are useful for interpreting farmers' decision making processes: economic constraint theory, focusing on resource allocation for maximum economic benefit; diffusion innovation theory, considering knowledge transfer in local contexts; adopter perception theory, stressing the adopters' evaluation of potential benefits in addition to the communicated information.

Referring to Ajzen's theory of planned behavior, the authors of [53] interpret the farm operator's decision whether or not to plant trees and outline important factors, which are not necessarily associated with an empirical cost–benefit analysis. They state that:

> *"the effectiveness of tree planting programs and activities will be largely determined by the degree to which we understand and address the factors which encourage or discourage farmers to plant trees. It is essential to comprehend how farmers perceive the benefits and challenges associated with tree planting in order to explain the current extent of tree planting in Malawi and scale up these efforts in the future. To accomplish this, it is important to understand the decision-making process of farmers who plant trees on their land. In addition to the beliefs farmers hold with regards to the possible positive and negative outcomes of tree planting activities, their decisions are also influenced by the opinions and behaviour of relevant others in their surroundings as well as the practical possibilities they have to plant trees."* [53] (p. 2).

As such, showing farmers why planting trees will help them may be effective, but understanding how much different factors matter to them and the beliefs they hold, reasonable to outsiders or otherwise, is essential to understanding farmer decisions and avoiding frustrations common in intervention projects where epistemologies and value systems intersect.

Farmers' perceptions of the benefits of tree planting, such as the costs, implications, resource requirements, tradeoffs and any other considerations, may be guided by rationalities other than the "economistic and reductionistic ways of thinking" [54] (p. 13). Escobar [54] further specifies that "Development has relied exclusively on one knowledge system, namely, the Western one. The dominance of this knowledge system has dictated the marginalization and disqualification of non-Western knowledge systems." (p. 13).

#### 3.1.8. Farmers' Relationships with Land

Contrary to many recent and ongoing rural development programs, small farms cannot always be considered businesses in a strict sense, and thus cannot be managed in strictly profit-rational manners. Smallholder farms are not only sources of livelihood but sources and settings of all aspects of life, economic and non-economic [54]. Therefore, converting them into agribusinesses means converting lifestyles and family life into production and human capital. Similarly, "the Zapotec people of San Lorenzo (Mexico) do not put fertilizer on their coffee bushes because 'it makes the Earth capricious and she does not want to

give anything afterwards without being fed that way'" [10] (p. 12) (citing unpublished responses gathered by P. Beaucage). Escobar [54] cites Andean indigenous peoples' similar view of chemical fertilizers, which they believe to damage the land and interfere with humans' relationship of reciprocity with it.

Paige West's [55] exploration of the context of coffee production in Papua New Guinea includes an observation of the indigenous Gimi people and their relationship with the forest. She describes that, "for Gimi, since everything is the physical incarnation of their ancestors' life force, everything is a 'gift' from the forest", and that for them, "people and forests will always be and always have been—in a constant transactive relationship, making and remaking each other over time." [55] (p. 116). A strictly agronomic and productivity-oriented approach to forest and land management would surely conflict with this way of understanding forests. In relation to cultivated crops, she describes that "For Gimi, sweet potatoes and other cultigens are part of Gimi past, present, and future. Coffee, on the other hand coffee is not part of this cycle of transaction; it is only present and future Coffee production, like Christianity, waged labor, and community consumption, refocuses Gimi toward individuality instead of collectivity and this transformation is one of the hallmarks of modernity." [55] (p. 128).

There is a common theme of relationships of reciprocity with nature, a hallmark of pre-industrial societies, according to Polanyi [15], and in contrast with an extractive resource-based view of nature. Given these relationships with land and nature that transcend those of a productive asset, it would surely be considered off-putting to treat the land as such, changing its makeup and implementing chemical-dependent monocultures to maximize marketable production without concern for other aspects. Likewise, were such economistic productive systems to exist, it may be equally offensive to consider marketing the cost of degradation via a payment for ecosystem service (PES), implying the will to degrade the land if farmers do not pay to conserve it.

#### 3.1.9. Non-Economic Rationalities

It is essential to highlight one particular point of divergence between the contemporary "Western" rationality and others: the level of economization of existence. While the neoliberal mentality that guides many rural development interventions may consider this an inevitable and universally desirable process [54,56–58], an economistic approach to all (or any) aspects of one's existence may not be unanimously desired. Failure to adopt such a mindset may be the result of conscious objection and not the inability to grasp it. Escobar [54] bluntly explains that "Since the mid-1960's, economists studying small farmers had not ceased to emphasize that the same backward peasants they had discounted in previous decades would behave like good and decent capitalist farmers if they were provided with the necessary conditions for doing so . . . the failure of peasants to behave as theory predicted was construed as the peasants' inability to respond adequately to the programs' inputs." (p. 157–158).

This perspective is also manifested in West's [55] examination of highland coffee growers in Papua New Guinea, where she describes the emergence of a "subsistence export industry" in which "people invested enough labor to take a profit that would meet their day-to-day monetary needs, with little to no desire on the part of the majority of rural landholders to amass capital and reinvest it in the industry, other industries, or large goods and services." (pp. 94–95).

## 4. Historical Embeddedness

### *4.1. Legacy of Past Intervention*

From the establishment of cash crop agriculture, colonial or otherwise, there have been different interventions and waves of "modernization" that have changed cultures and behaviors and formed part of the collective social memory, disembedding economic processes from social relations. This conglomerate of past influences can display a level of path dependence as previous interventions are not automatically deleted from the social

memory and replaced by the newest concepts [59]. Arturo Escobar [54] highlights the disruptive nature of economistic intervention, stating that the introduction of capitalist regimes to agrarian societies "undermine the reproduction of socially valued forms of identity", while subsequent development interventions into agrarian communities "destroy elements necessary for cultural affirmation." (p. 170–171).

E. Bradford Burn [60] likewise appreciates the traumatizing effect of the introduction of export-oriented agriculture into pre-industrial agrarian communities, replacing self-contained food systems, and their subsequent modernization, changing cultures and ultimately leading to a disintegration of rural societies. "Local communities became part of a larger, more distant, more impersonal, and more pervasive economic system to which the folk sacrificed their land, labor, and life styles but from which they received scant or no benefits." [60] (p. 12).

Moreover, agricultural modernization efforts have established practices that are damaging to ecosystems, including causing the loss of biodiversity [10]. In the case of Burundi, coffee was introduced by foreign-occupying authorities in full-sun monoculture systems through what [11] describes as a coercive process, which generally continues a century onward. Nevertheless, according to this study's survey of farmers, the agronomic and economic benefits of coffee agroforestry are widely accepted and interest in implementation by members of cooperatives is substantial [11].

Long after the colonial establishment of coffee in agroforestry systems, many of these systems were coercively converted into chemical-dependent full-sun systems involving incentives, penalties and persuasion based on an implanted economistic rationality; these practices were then absorbed into the collective social memory and behaviors [3,7,37,61]. These interventions, welcomed or not, changed cultures and worldviews and naturally displayed a property of path dependence, not easily undone by subsequent contradictory interventions [62]. Additionally, two studies of farmers cite a certain resilience of agricultural practices due to network effects, specifically, a resistance to new practices due to social pressure from peers and the appreciation of the intergenerational legacy of certain farming practices [59,62].

Despite the history of agricultural modernization interventions associated with increased environmental degradation, subsequent efforts to convince rural people to conserve ecosystems instead have attempted to "'teach' rural people how to take part in the modern world so that they will not have to rely on their biophysical surroundings for their livelihoods and therefore will not destroy 'nature.' . . . Ironically, in contemporary conservation, western ways of seeing and being in the environment are implied to be both the problem and the solution." [55] (p. 60).

One of the main reported benefits of agroforestry coffee is the diversification of production, thereby diversifying environmentally vulnerable income streams and sources of family sustenance by hedging against seasonal and periodic hunger [1]. However, these benefits directly conflict with notions of specialization and professionalization of smallholder agriculture that have been widely promoted throughout the Global South by domestic and foreign policymakers and implemented through aid and extension programs [57,58,63,64]; these programs are based on the concept of rational economistic logic, whereby the producer focuses all available resources on the one activity where he or she enjoys the maximum comparative advantage. Following such interventions, which implant the concept that increased profits are accessible in exchange for ecologically destructive practices [65], it is only reasonable that there would develop a perception of a tradeoff between profits and conservation, leading to resistance to conservation efforts in profit-driven but barely profitable agricultural operations.

### *4.2. Institutional Embeddedness and Agency*

#### 4.2.1. Transnational Companies

In the post-structural-adjustment rural Global South, transnational companies' access to vast quantities of low-cost raw materials has paired well with policy prescriptions

to intensify and expand cash crop agriculture, liberalize trade, finance and investment, promote export specialization over diversified local consumption crops and promote smallholder farmer integration into global value chains as a path to prosperity [56,64,66]. This has put raw-material-producing countries of the Global South in constant competition with one another to offer the most attractive opportunities for accumulation by foreign companies, unfortunately putting coffee farmers and others into a global race-to-the-bottom [55,66]. Export specialization policies dictated from abroad have also come at the expense of local food production, causing food prices to rise, and requiring farmers to produce more coffee (or another cash crop) in order to subsist, further increasing their dependency on concentrated buyers [56]. When there is a tradeoff between short-term productivity and environmental conservation, common scenarios of declining terms of trade for producers clearly favor agricultural intensification [67–69].

Foreign commercial interests in smallholder farmers of the Global South coalesced with the Green Revolution extension programs to intensify agriculture, whereby agrochemical and seed providers desired new markets for their products and transnational trading firms wanted increased volumes of commodities and low prices [54]. Both were feasible and even considered desirable by some, according to the neoliberal playbook, as farmers would produce, earn and spend more, production countries would import more foreign exchange, and consumption countries would control internal consumer prices [24,58,70,71].

#### 4.2.2. Multilateral Organizations

Producer countries' need for increased foreign exchange imports, which often necessitated export specialization and agricultural intensification, has typically been attributed in part to foreign debt service involving the IMF and World Bank, and tied to structural adjustment programs of economic liberalization [56,58,67,70]. Multilateral agencies that provide some form of credit to coffee-producing country governments have a vested interest in those states' access to foreign exchange and economic growth to be able to make loan payments, favoring investment in export sectors [67].

As part of these programs, government extension and planning based on national and community interests were often cut back and replaced by "market-based", privatized solutions, frequently provided by foreign transnational buyers and foreign aid agencies [72–74]. These groups are likely beholden to the interests of coffee value chain stakeholders in addition to or aside from those of the program beneficiaries: the smallholder producers themselves [57,75].

As these changes in land use and techniques have shifted the output mix of countries, supplies of internationally traded commodities have increased and local consumption products have decreased. This has led to increases in the cost of food in areas where export-oriented agriculture has replaced food production, affecting producers' cost of living [56]. On the other hand, it has caused an oversupply of coffee (and other commodities) which has resulted in declining terms of trade for those involved in coffee exports, creating desperate situations for the millions of smallholder producers around the world as well as macroeconomic difficulties at the national level, both of which have resulted in increased dependency on foreign trading partners [68,76–78].

#### 4.2.3. Producer Country Governments

Including for the reasons mentioned above, the governments of coffee-producing countries have often shared an interest in expanding coffee production, despite the fact that the means and results may not be advantageous to producers and their communities [58,63]. Some of these governments have directly and indirectly encouraged full-sun coffee cultivation. In Kenya, for example, synthetic fertilizers were heavily subsidized by the state in order to increase agricultural productivity, incentivizing technified, chemical-dependent production systems. When fertilizer subsidy programs were eliminated following structural adjustment programs, soil health and productivity suffered [79].

A survey of coffee famers in Puerto Rico found that, despite financial incentives for tree planting by the federal government and general recognition of the benefits of shade farming, sun farming still prevailed due to a widely utilized state government subsidy of synthetic fertilizer which respondents understand to require eliminating shade cover over coffee plots. In this scenario, resistance to a shade implementation program had more to do with skepticism of political continuity and the top-down nature of the implementation procedure, such as the government's selection of tree species which producers consider misguided [80]. This example clearly shows the impact of institutions on farmer behavior, in this case, contradictory institutional pressures based on diverging interests within the state.

#### 4.2.4. Consumer Country Governments

The governments of coffee-consuming countries of the Global North also have reason to favor increased output in production countries and control of the production process by downstream firms. Abundant and low-cost commodities support their citizens' cost of living and consumption of other goods [24]. Low-cost inputs for their national companies (though thoroughly transnational) support profits which would theoretically be taxed, as well as potential wages at downstream nodes of the chain. Governments can also feel pressure from large companies and sector lobbies pushing for policies that favor sector profits [55]. Food aid programs from donor counties that are also coffee consumers, such as the EU countries and the United States, have also contributed to the displacement of food farmers in recipient areas and accelerated the conversion of land use from food crops to exportable cash crops by capitalist farmers [54].

#### 4.2.5. The Aid Complex

Development and aid programs from foreign governments, corporate social responsibility, national government support and diverse donor and civil society projects with a variety of goals have been an intervening presence in agrarian communities of the Global South for decades, and they have had profound impacts on smallholder communities, values, cultures, habits and landscapes [74,81,82]. This aid complex (to designate the construct) is the tip of the spear, where the interests of multilaterals, producer- and consumer-country governments and transnational traders converge and materialize to intervene in agrarian livelihood and culture.

Escobar [54] frames the need for "development" assistance as based on the recognition of underdevelopment, which is based on differences between subjects of intervention and observing outsiders. Members of the intervening group, considering themselves benchmarks of development, view social and material differences between themselves and others as deficiencies, "conceiving of social life as a technical problem". The effect of development aid, and perhaps more importantly the realization that one is underdeveloped and somehow inferior, is the alienation and the disintegration of culture and community. Escobar writes that "many in the Third World began to think of themselves as inferior, underdeveloped, and ignorant and to doubt the value of their own culture, deciding instead to pledge allegiance to the banners of reason and progress" [54] (p. 62).

Such efforts have been shown to be highly effective at changing farmer perceptions of and their relationships to their surroundings, as well as their aspirations and behaviors, and even value systems and religions [10,55,60]. Escobar [54] describes how Colombian farmers included in extension programs come to reject their own cultures and land management techniques as inferior, tending "to become ardent advocates of development. These farmers, moreover, begin to interpret their lives before the program as filled with ignorance and apathy." (p. 61).

Aid interventions have also led to behaviors not encouraged by programs and in some cases contradictory to ecological conservation goals. In fact, incentives for the adoption of sustainable practices effectively incentivize opposing practices in order to obtain incentives, and disincentivize permanent adoption [83], in accordance with the pragmatic, economistic rationalities discussed above. In fact, where incentives and subsidies exist or have existed

in the past for transitioning to agroforestry as part of intervention programs, farmers may logically conclude that implementing or maintaining agroforestry without external support carries an opportunity cost. This could be likened to purchasing a product at full price when there could be a sale in the near future. Kiptot et al. [79] document such a phenomenon in a study of agroforestry adoption in Kenya, labeling those who engage in this behavior as "pseudo-adopters". "The pseudo-adopters are farmers who tried improved tree fallows with different objectives. These included: (a) getting free inputs from the projects, (b) as a means of participating in tours and seminars which often involved payment of allowances, (c) as a means to access credit, (d) as a means to access the seed market and (e) to gain prestige" [79] (p. 514).

### *4.3. Resistance to Agroforestry*

Despite the many opportunities associated with agroforestry, adoption remains incomplete and uneven. The reasons for this are complex and related in diverse ways to the embeddedness of coffee agroecologies. By applying the lens of the historical and social contexts which have led to the current form of coffee cultivation and beliefs of producers about different practices given their needs and constraints, we can better interpret adoption and non-adoption of agroforestry in different scenarios.

#### 4.3.1. Practical Resistance to Agroforestry

Producer resistance to agroforestry implementation may have to do with practical considerations. Do et al. [84] have cited a lack of short-term compensation and the complexity of and uncertainty around the potential benefits of tree planting for coffee production which dissuade some farmers from investing in it. "Farmers often find it difficult to make predictions about long-term returns on investments in agroforestry systems, due to system complexity and long planning horizons." (p. 1). It is implied that this uncertainty would prevail in contexts where shaded coffee systems have not existed for at least a generation. Producers may also perceive an opportunity cost of tree planting, possibly related to the earlier promotion of full-sun intensive systems based on income potential. In a study of the adoption of agroforestry in coffee farms in Puerto Rico, farmers reported skepticism of the economic viability of shade farming despite comprehending its benefits [80]. Regardless of measurable accuracy and overall economic benefits, in some contexts there is a perception that full-sun coffee systems are inherently more productive, and thus, more profitable [85]. Another practical consideration in the decision to adopt agroforestry practices is land tenure. This includes permission to change land use (such as planting trees) or the confidence that access to the land will be maintained for long enough to enjoy the delayed benefits of an investment in the implementation of agroforestry [86].

#### 4.3.2. Resistance to the Means

Aside from farmer support of agroforestry and ecological conservation in general, resistance to adoption may be related to the presentation, means of implementation or institutional implications of adoption, particularly of participation in programs aimed at promoting such practices. Escobar [54] proposes that farmer resistance to intervention into agricultural practices, regardless of their ecological implications, may be directed more against the rationalization and economization of lifestyle and culture as underlying motives for intervention than against the practices themselves. He specifies that for farmers, there is often "more at stake" (p. 95) than simply supporting or rejecting sugar cane or agroforestry; rather, farmers resist capitalist relations of production that conflict with social values. Where trust between communities and interveners has been eroded by unpleasant past experiences or poor outcomes, enthusiasm for subsequent interventions may be lacking regardless of the specifics.

Paige West, in her exploration of coffee production in Papua New Guinea, evaluates the emergence of third-party certification programs designed to mitigate the marginalizing outcomes of smallholder participation in the coffee commodity chain. While relief from

scarcity created by status quo participation in the coffee economy was desired, it was offered by the aid complex in the form of "schemes which impose fully formed prescriptive regimes of governmentality at odds in many ways with Melanesian ways of seeing and being in the world." [55] (p. 1).

Despite agreement on the merits of the desired outcomes of programs, farmers may not accept the means of attaining them. For example, in a study of agroforestry adoption by coffee farmers in Puerto Rico, it was found that program buy-in was lacking despite agreement around the virtues of agroforestry because producers were not involved in planning the implementation and disagreed with some of the methodologies [80].

Resistance to agroforestry coffee systems can also be related to the rationalization of the need for it. One such narrative involves shifting the blame for environmental degradation, often a result of past external interventions in coffee lands, onto farmers who have overseen it. Farmers who experienced the disruptive and destructive development processes "are now admonished for their 'irrationality' and their lack of environmental consciousness" and considered backward once again based on updated criteria [54] (p. 195). Conservation efforts that contradict damaging agricultural practices may still represent top-down planning or *environmental managerialism* that considers nature as resources, disregarding the historically formed cultures between inhabitants and their surroundings (including the impact of past interventions) [54]. In such cases, nature is still fetishized and incorporated as capital, not in order to monetize its degradation, but rather its preservation, still without accounting for how its management will affect its social and cultural context. This could be considered a double capitalization or redisembedding of nature as a fictitious commodity, first as a productive or monetizable asset, and then as a degradable asset. Nature can then be remonetized, requiring a credible threat to destroy it.

Diverse cognitive institutions related to the prospect of agroforestry coffee systems may also exist with origins in different historical social and cultural experiences. For example, a study conducted in the Democratic Republic of Congo revealed a perception shared especially among women that agroforestry brings birds which damage crops, and that participating in agroforestry requires physical "hardiness" that men tend to possess [86]. In another study of landscape preferences of rural and urban residents of Veracruz, Mexico, respondents favored cultivated land, including monocultures, over native forests, based on ecological grounds [87]. This demonstrates significant dissonance between this sample's perception and that of contemporary ecology. It was also mentioned that people preferred the type of landscape that they have known since their childhood, perceiving it to be ecologically sound [87]. This points to the possibility of significant resistance to the implementation of agroforestry based on conflicting views of ecology and the impact of agricultural practices.

### *4.4. Capabilities*

#### 4.4.1. Access to Resources

Information and training are mentioned by several studies as an impediment to agroforestry expansion, and this is consistent with reports from SFCC program staff and stakeholder surveys. Quinion et al. [6] highlight labor availability as well as a lack of training in agroforestry management as challenges. Meijer et al. [53] echo this sentiment, citing a "lack of extension and training" as a key barrier to agroforestry according to their survey of farmers in Malawi (p. 7).

In addition to a lack of training about the management of agroforestry, a study of the obstacles to implementation in Malawi by [88] finds that traditional local knowledge, including of managing indigenous tree species, has been undermined by external "modernization" efforts. They emphasize that "this knowledge and its value have for many years been undermined and not promoted. It has often been replaced by formal agricultural and forestry extension" [88] (p. 25). This being the case, it would seem there is a countercurrent against agroforestry and biodiversity to contend with. Do and Mulia [89] find in their study of tree planting in Vietnam that the availability of quality genetic material for tree seedlings,

which is even more scarce for indigenous species, pushes farmers toward available exotic species, often with low productivity and low-quality output, limiting farmer income from the activity. Graham et al. find a similar inclination toward exotic species due to availability in the Mount Elgon region of Uganda [90].

#### 4.4.2. Economic Challenges

Economic frustrations can also represent impediments to the intended agroforestry adoption. Potentially tied with the reported challenges of labor availability is the question of the economic capacity to dedicate scarce labor to tasks beyond those required for immediate sustenance, such as tree planting and maintenance. The reported lack of seeds and seedlings [6,53] may also be associated with the availability of funds to invest in tree planting. Thangata et al. [91] found additionally that agroforestry adoption is associated with the availability of land and labor needed in order to do it, suggesting that it is desired and implemented by those who are able, while lack of resources is the real limitation. The farmer survey conducted by Meijer et al. [53] additionally reports that poverty is one of the most commonly reported barriers to agroforestry, and that while it is considered important, meeting short-term needs is generally ranked as a higher priority. They state that "many farmers considered household needs such as buying food and agricultural inputs, as well as children's education, as more urgent than investing their scarce resources in tree planting." [53] (p. 1).

Regarding the marketing of agroforestry products, economic challenges include the time lag to perceive economic benefits [6]. Sibale et al. [88] also cite the need in Malawi for certification from the Bureau of Standards to market some tree-derived products such as medicines and fruit juices, as well as the lack of quality standards and measurement protocols for products such as neem and moringa which lead to consumer mistrust.

While there are no reports of negative connotations of agroforestry in the studies on Malawi, there are several reports of land availability as a barrier to implementation [6,53], implying a tradeoff between trees and other crops, in which non-tree crops are favored. If consistent with the reported general interest in implementing agroforestry, this prioritization would be associated with short-term sustenance needs and not a lack of interest in tree planting. In a context of scarcity and instability, as is experienced by many smallholder coffee farmers, short-term solvency and survival often outweigh long-term viability [92]. Increased coffee production and reduced production costs may favor some farmers on a short-term individual basis, while potentially jeopardizing their collective long-term economic sovereignty and solvency. Another study of smallholder coffee farmers in Nicaragua found that the most resource-scarce and least food-secure households are those least likely to take measures to mitigate climate risk, such as planting shade trees, due, ironically, to their necessarily risk-averse outlooks which the study relates to socio-economic conditions [50,93] and not a psychological disposition.

Economic shocks and immediate financial need can necessitate deforestation of shaded coffee plots for the one-time income generated from timber sales. In a study of deforestation of coffee plots in Oaxaca, Mexico, an association was made between low prices for coffee and higher deforestation rates [94]. The inverse would point to simply raising coffee purchase prices in order to preserve forests and associated ecosystem services. The authors of this study also found associations between higher rates of deforestation and the lower profitability of coffee farming, higher profitability of chemical-dependent farming based on the cost of accessing fertilizers and lower access to social services.

Economic challenges faced by coffee producers can have complex effects regarding tree cover of their land. According to three extensionists in southern Mexico, a voluntary recovery of pre-modernization agroforestry practices has taken place due to the failure of modernized systems (L. Velázquez, A. Luna, D. Flores, personal communication, 11 January 2023). They cited the increasing incidence of disease and diminishing productivity of hybrid sun-tolerant varieties that farmers had been encouraged to adopt [3,23]. They also noted increased urgency in attaining the soil nutrition benefits of shade-grown systems

due to macroeconomic shifts, namely, the reported three-fold increase in synthetic fertilizer prices and a similar increase in labor costs corresponding to an earlier increase in the global coffee price which has since reversed (L. Velázquez, A. Luna, D. Flores, personal communication, 11 January 2023). While some economic pressure may promote a return to shaded coffee systems, the financial unviability of coffee production has been shown to lead to deforestation as farmers unable to subsist on the income from coffee transition to other land uses not as conducive to agroforestry [85]. It was found that when coffee farmers are forced to abandon their land, it often falls into the hands of others interested in logging and/or cattle grazing in full-sun systems [85,94].

### *4.5. Participatory and Socially Inclusive Efforts*

Alternative to the top-down, managerial and economistically rationalized interventions that have been disruptive to agrarian cultures and rejected by participants is the notion of participatory efforts that come from within communities, rather than being applied to them hoping that one conforms to the other. Likewise, programs and policies likely to be widely accepted function within existing social networks, "locally trusted channels through which agricultural information can be delivered to other farmers", rather than attempting to replace them [83]. Local social networks are how information is received, analyzed and operationalized, and may or may not have a socket for outsiders to enter via their workshops and leaflets. A study by Buyinza et al. [83] found that "adoption behaviour of smallholder farmers is mainly shaped by existing community social norms and beliefs that tend to promote knowledge exchange, as opposed to the conventional knowledge transfer extension approaches. Norms are therefore an inherent part of social systems and can create distinct farming practices, habits and standards within a social group".

A study by Meyfroidt [95] of smallholder agriculture in northern Vietnam documented community recognition of the impact of forest degradation and subsequent political mobilization to attempt to rectify the situation. Following widespread deforestation from the 1970s to 1990s, rural people recognized several negative effects of forest degradation, including vulnerability to flooding and reduced water availability, leading to community programs to recover some lost forest area. While all the communities interviewed regarded deforestation negatively, commitment to the means of recovering the forests varied. These recognitions and the corresponding action are attributed to deliberate ecological knowledge dissemination and social learning processes. Land management, zoning and agricultural policies and institutions also corresponded to patterns and community perceptions of deforestation and reforestation, such as the prohibition of raw wood exports [95]. An interesting point to note is that the negative feedback loop in which community members sensed the effects of deforestation and acted against it occurred within the community itself and, as far as the study describes, was not part of an outside intervention.

### *4.6. Malawi and Uganda Focus Groups*

The following is a synthesis of key insights from a documental review of minutes and reports from focus groups of smallholder coffee farmers which are members of cooperatives engaged with the Slow Food Coffee Coalition (SFCC). Their testimonies were recorded by the local SFCC staff while convened locally in the majority of cases, as well as one discussion that took place at Slow Food's annual gathering. Participants' testimony is compared with the reviewed literature in order to contextualize it.

### *4.7. Uganda*

#### 4.7.1. Conflicting Interventions

While agroforestry could likely aid in mitigating the adverse effects of and adapting to a changing climate, the SFCC program staff report that a thorn in the side of efforts to promote measures that improve health and resilience is the manipulation of smallholder farmers by distributors of chemical agricultural inputs. They report that, in addition to the environmental hazards and economic disadvantages, a loss of traditional ecological

knowledge is also occurring due to this destructive influence. The program staff are then motivated to counter agrochemical distributors' persuasion efforts with contradictory efforts. This conflict of messages is consistent with one interview from Colombia reporting similar pressure from input sellers. It also coincides with several reports from the reviewed literature of efforts to influence smallholder farmer behavior in service of the interests of others which sometimes conflict with farmers' own wellbeing [71,72,77,81].

#### 4.7.2. Coffee Agroforestry Is Viewed Favorably, but the Means Are Unclear

According to the SFCC staff and farmer organization leadership, there is strong interest from farmers in agroforestry and many are already practicing it in some way. The program staff explain that the intention is to balance the external benefits of indigenous tree species with farmers' desire and need to promote productive species by promoting indigenous fruit trees. Focus groups also suggest that agroforestry training would be welcomed and is needed by program participants, specifically on how to establish and manage agroforestry systems accounting for different geographical variables, implying a desire to understand the ecological dynamics in order to optimize agroforestry practices around farmer priorities. The reviewed literature indicates that these diverse priorities, capabilities and needs could be considered via participatory program design and planning, ensuring that the means as well as the outcomes are amenable to farmers [80,86].

#### 4.7.3. Non-Economization of Ecosystem Services

Producer testimonials indicated that an increase in sale prices was expected for coffee from agroforestry systems. In fact, one producer expressed that a barrier to agroforestry implementation is mistrust between farmers and buyers. The mistrust they refer to is the buyers' potential unwillingness to compensate farmers for adopting agroforestry practices, demonstrating an assumption that this individual act would be economized, and they should be able to monetize it. It seems feasible that this unwillingness to offer a higher price could simply amount to buyers' indifference due to a lack of economic incentive to reward agroforestry coffee, regardless of trust between the parties. The SFCC report states that "it is very difficult for buy(ers) to offer (a) fair price for coffee produced in an agroforestry system . . . farmers do not feel comfortable to give their extra energy to produce coffee sustainabl(y) to be (sold) to the same buyers who will not appreciate it". This perspective indicates that producers' view of their interactions with nature is already quite economized, likely following experiences with certification programs. It also implies that producer motivation to grow coffee under agroforestry practices may be contingent upon price premiums, at whatever level they consider to be fair.

### *4.8. Malawi*

The Malawi focus group concentrated even more heavily on economic difficulties as well as the lack of cooperative capacity to provide desired services and market the members' coffee in a satisfactory way. A focus group of producers from the Phoka Coffee Cooperative convened to discuss challenges producers face revolved around insufficient farm profits by specifying potential causes and possible but unfulfilled means to address the problem. Francis Maclear Kachali, a farmer in the group, stated that "variation of the marketing (in term of price) is the big challenge". He also specified separately the need for a "fair price", which could have many potential meanings but likely implies a price that offers him a level of profitability sufficient to provide an acceptable standard of living to him and his dependents. The expressed desire to "add value" implies plans to address the issue of household income by transforming the product and accessing different markets, also requiring infrastructure and other resources and making certain assumptions about a market. This preoccupation with sources of income is consistent with other studies focusing on coffee production in Malawi, which cite the need for several key resources in order for agroforestry to be implemented, despite existing interest, including strong

and well-provisioned farmer organizations, marketing channels for output and desired information [6,46,53,96].

There was no mention of agroforestry as an independent aspiration of coffee producers surveyed by the project in either Malawi or Uganda, nor were constraints to the implementation of agroforestry reported as problematic for farmers. If agroforestry is not considered an objective or aspiration (though it still may be), it must be considered a means or a tool available for achieving another objective which producers do desire, whether explicit or implicit.

It is clear that when a minimum level of economic viability and family sustenance cannot be achieved, it is irrelevant to discuss matters such as agroforestry, unless a clear line can be drawn between it and the most pressing issues. Consistent with other situations analyzed, there is little capacity to invest resources in (or even talk about) programs related to long-term stability and sustainability until basic family needs are met [50,85,92,94].

In the contexts of both Malawi and Uganda, questions about challenges and aspirations are largely answered in the form of purchasable things which farmers do not have, also implying an economistic view of future possibilities. These expressions of desire for capital goods imply that they would be necessary or helpful in carrying out processes that would lead to outcomes that alleviate unspoken underlying problems. Responses of this type may also be stimulated by the impact of previous interactions with the "aid complex" and an assumption that such meetings are followed by material or monetary contributions.

While interest in the proposed topics of the focus groups was not entirely consistent, responses did not indicate significant epistemological or cultural dissonance. This could be attributed to the fact that they were not oriented around externally planned interventions or goals; rather, they were simply exploratory. Furthermore, it was, in all likelihood, made clear that SFCC is not an aid agency and has no mandate to intervene in communities but rather endeavors to facilitate farmer organizations' planning of their own programs and participatory creation and operation.

### *4.9. Colombia Interviews*

In order to further contextualize the literature reviewed and to enable comparison with the perspectives offered from smallholder farmers in Malawi and Uganda, structured interviews were conducted with nine smallholder coffee farmers in the Huila and Tolima regions of Colombia about their experience and perceptions with agroforestry coffee systems.

It must be reiterated that, while the interview responses are an informative contextualization of the literature and help to explain the orientation of a specific segment of coffee farmers in noteworthy areas of Colombia, they are not intended to be used to generalize about Colombian coffee farmers more broadly. Such generalization would be inappropriate based on the anomalous characteristics of the sapmple with respect to national averages, particularly in the sample's acceptance of traditional agroforestry techniques, farmer organization membership and location in isolated areas long affected by armed conflict.

#### 4.9.1. Favorability of Shade Trees

All of the farmers interviewed recognized that the shade trees within and around their coffee plots provide ecological services, many commenting on this opportunity favorably, showing pride in offering this service to others (Figure 4). Despite taking pride in caring for the environment, respondent two also lamented that outsiders such as customers and NGOs hold coffee farmers responsible for the environment without offering any compensation to share in the burden.

While most respondents felt that agroforestry systems have economic advantages over full-sun systems, many also recognized that productivity can suffer. All of those who disagreed that agroforestry is economically advantageous, completely or partially, also recognized that there are economic benefits, including soil nutrition and protection against the effects of adverse weather such as droughts. This contradiction shows a focus on top-line income and shorter-term cash-flow over profitability. It is also consistent with the long-standing FNC policy of promoting full-sun systems for maximum productivity and farmer

income [21]. As suggested by [37,61,80,97], some resistance to previously discouraged behaviors despite the recognition of their advantages could represent a level of path dependence of previous interventions that remain present in social memory as cognitive institutions. Given the previously mentioned gradual but significant increase in fertilizer price versus coffee price (see Supplementary Materials Figure S1 and Table S1), the net difference between coffee yield and fertilizer expense has likely changed significantly since chemical-dependent intensification was first promoted in the 1970s.

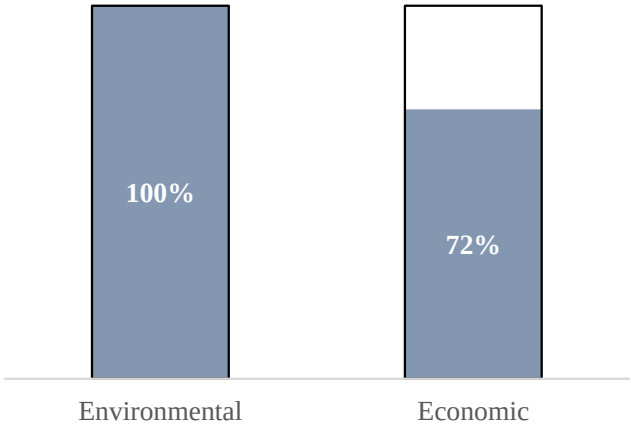


**Figure 4.** Frequency of perception about the favorability of shade trees in coffee plots by Colombian smallholders when asked "Do you view agroforestry coffee systems as economically and/or environmentally favorable to exposed coffee systems?".

Our data from Malawi and Uganda suggest that basic subsistence needs take priority over agroforestry and other environmental concerns and practices with non-immediate economic returns, coinciding with the reviewed studies from Malawi, Ethiopia and Nicaragua [6,50,53,91,93]. This does not appear to be the case for the Colombian farmers interviewed, who recognized environmental benefits despite the economic hardships most of them cited. This could be related to their possible relative financial security, to the fact that all who were interviewed were born into coffee growing, with most inheriting agroforestry practices from their ancestors and communities, and/or to the fact that native trees grow in the surrounding forests and their seeds are easily attainable. Respondent two, when asked why he chose to plant the trees he has, responded that most of them germinated spontaneously.

#### 4.9.2. Advantages of Agroforestry

When asked about the relative advantages and disadvantages of agroforestry coffee systems as opposed to exposed systems and the reason for planting the tree species present, the most common answers were the fertilization of coffee trees and protection from the adverse effects of drought on coffee crops (Figure 5). The soil nutrition benefit of certain shade trees is widely recognized in the scientific literature [6,14,43], but its recognition on the farm requires a level of analytical sophistication to recognize the positive effects of natural fertilization by shade trees if not otherwise applying fertilizer, or the ability to reduce fertilizer application without sacrificing productivity if it is normally applied. These answers may reflect the long experience of the farmers interviewed with the systems and/or shared social memory due to the lagged fertilization effect of tree litter after the planting of trees; the answers likely also reflect the occasional benefit of drought protection. The differences in experience with agroforestry coffee systems may be able to explain the differences in recognition of benefits between the Colombian data and those from Malawi and Uganda. While Table 2 indicates that the number of total unique tree species reported on coffee farms was greater in Colombia than in Uganda (34% versus 22%), it is perhaps more telling that 89% of farmers interviewed in Colombia had at least one nitrogen-fixing species present. Unfortunately, these data are not available for the Uganda sample.

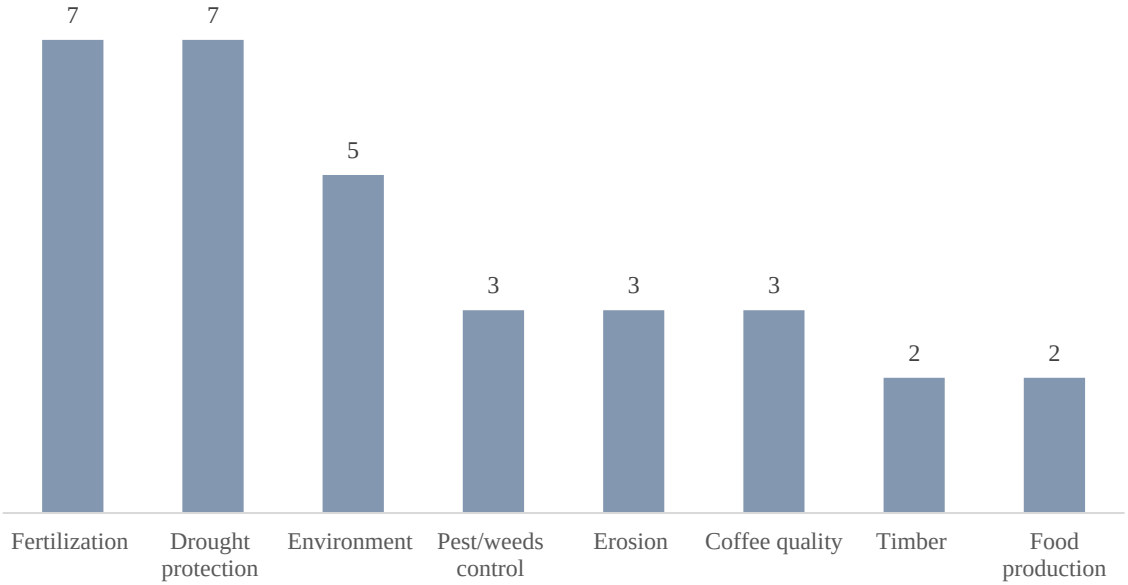


**Figure 5.** Frequency of perceptions of the benefits of shade trees in coffee plots by Colombian smallholder coffee farmers when asked "What are the advantages or benefits and disadvantages of coffee agroforestry systems compared to exposed systems?" and "Why did you choose the tree species present on your farm?".

**Table 2.** Categories of unique tree species reported on single farms.

| Tree Presence | Uganda | Colombia |
|---|---|---|
| Native | 42% | 71% |
| Nitrogen-fixing | 22% | 34% |
| Edible-Fruit-Producing | 50% | 26% |

Interview question: "Which tree species are present on your farm?" The result is a list of unique tree species present on farms, which were counted and classified according to these three categories. The percentages listed are the frequencies of unique species within the categories that are featured on a given farm (See Supplementary Materials Figure S2, Tables S6 and S7 for species frequencies and categorization).

Another factor confounding the recognition of the soil benefits of agroforestry coffee systems is the variability and distortion of fertilizer prices. From a profitability standpoint, the relevance of the soil nutrition benefits of agroforestry coffee systems relative to exposed monoculture systems is also relative to synthetic fertilizer prices, based on global markets, exchange rates, import policies and distortions such as subsidy and donation programs. As we saw in studies from Kenya [79] and Puerto Rico [80], fertilizer subsidy programs can disincentivize the adoption of coffee agroforestry. On the other hand, rising fertilizer costs relative to the sale price of coffee (see Supplementary Materials Figure S1 and Table S1) have put pressure on farmers to reduce fertilizer use, as cited in the context of southern Mexico (L. Velázquez, A. Luna, D. Flores, personal communication, 11 January 2023).

Aside from the financial benefits of replacing synthetic fertilizer with natural tree litter, the effect of non-economistic cognitive institutions on farming practices has also been suggested [54,55,59,62], particularly regarding the path dependency of practices based on prior interventions associated with chemical-intensive technification of smallholder agriculture explicitly noted in Kenyan and Colombian coffee contexts [21,98]. Alternatively, non-economistic priorities may also promote the maintenance of traditional agroforestry systems [54,55] despite Colombian interviewees' justification of the practices by citing practical reasons, which they may have expressed because they assume they will be comprehensible to the interviewer, a community outsider. Respondent two, in fact, commented on a cultural affinity for shade trees in the area, citing that "shade grown coffee is part of

coffee culture in Tolima (department of Colombia)". This orientation supports the notion that smallholder farming cannot be viewed like any capitalist investment of capital and labor, but is tied to the lifestyle of the farming family and situated within their social networks [54,83].

Gauging the drought protection benefit of coffee agroforestry requires a broad time orientation. It requires an adaptive historical outlook, either from one's own experience, a collective social memory from family or the community, or a trust in others' warnings of the impact of drought on unshaded coffee. It also requires a long-term vision and willingness to sacrifice short-term productivity for long-term risk mitigation, in the case of those farmers who reported that shade trees negatively affect productivity. Respondent one commented that "economically, in times of tremendous summer ("summer" refers to periods of intense sun and drought, not the astronomical season which is not relevant for this farm located at a latitude of 3° north), shade favors the coffee plot in that it isn't damaged by the sun". Despite recognizing the benefits of coffee agroforestry, including fertilization, erosion prevention and drought protection, interview respondents five and six from Paicol, Tolima, Colombia disagreed that coffee agroforestry is relatively economically favorable. They reported that it is partially and not economically favorable, respectively, all things considered, citing that given frequent rains in the past year, the shade over their fields had inhibited coffee flowering. The relative importance of drought protection likely weakens in the collective social memory as the span between destructive droughts increases. Respondent five commented that the economic benefit of shade trees is relative to the weather. While 44% of respondents cited reduced production as a disadvantage of agroforestry, only 28% reported that it was, on the whole, economically disadvantageous, despite all respondents' intention to continue practicing it regardless.

#### 4.9.3. Tree Species Selection

It is also of note that timber and food production were the two least-mentioned benefits of shade trees in Colombia (Figure 5). This may reflect the relative levels of coffee specialization in the respective locations, the need for additional income sources and/or the available markets for these products in addition to farm and family use.

Specialization in export crops has been cited as a component of structural adjustment packages supported by foreign aid and producing country states, including in Latin America [56–58,64,66]. While the frequency of the reported relative benefits of coffee agroforestry is not available for Uganda, it is clear from the more frequent presence of edible fruit trees (almost double that recorded in the Colombia sample) and less frequent presence of native tree species that there is a preference for trees capable of generating non-coffee income or offsetting the costs of non-fertilizer purchases.

#### 4.9.4. Sources of Knowledge

The most commonly reported sources of knowledge that farmers interviewed in Colombia considered credible was some combination of tradition, observation and experience, reported in 67% of interviews, and their own farmers' organization was reported in 33% of interviews (Figure 6). This is consistent with the notion of embeddedness of agricultural practices, including agroforestry, within the social context. It coincides with the literature and studies reviewed that recognize the importance of non-empirical knowledge formation [53,54], knowledge transmission within social networks [83,95] and a reliance on the collective historical experience of kinship networks and communities [51,52] in shaping decisions around agricultural practices. It is also noteworthy that most of the farmers in this sample had also had some form of agricultural training, and most recognized many of the benefits of agroforestry as highlighted by the agronomic literature [1,2,4,9,40,43], displaying an openness to knowledge created outside their social networks, but still relying on them as a base. This conflicts with Escobar's [54] account of Afro-Colombian farmers in the Pacific region who tended to disparage traditional practices after receiving training on modern agricultural techniques.


**Figure 6.** Sources of information regarding agricultural practices that interviewed farmers view as credible. Percentage of all Colombian smallholder coffee farmers who answered with this option when asked "Which are the most trustworthy sources of information about agricultural practices and technologies?"; "SENA" refers to the Colombian national education service; "FNC" refers to the National Coffee-growers' Federation of Colombia; "Farmer group" refers to the group of which the informant is a member, in all cases an association in the sample.

The SENA (National Learning Service) was the second most mentioned credible sources of agricultural knowledge. This could be due to the entity's localized practical training programs as well as due to buy-in from both farmers organizations that all interviewees belonged to. This value may also be artificially high due to sampling bias because the founder and leader of one of the two farmers' associations, also a local farmer, was formerly an instructor there and most of the current organization members were her students.

Further supporting the prioritization of intra-community knowledge transfer and reliance on the collective social memory over external sources is the fact that no interviewees mentioned NGOs, foreign aid programs, input sellers or coffee buyers as credible sources of knowledge about agricultural practices, despite all of these groups' investment in training and knowledge transfer directed at smallholder coffee farmers. For these producers, confident in their traditional, and in some cases recovered, agroforestry practice, past interventions to intensify production that have resulted in unsatisfactory outcomes in their regions and elsewhere [72,74,77,81] may have contributed to their aversion to such influences whose recommendations have been internalized in other Colombia coffee farming communities [14,21].

A ubiquitous influence over coffee farming practices since the 1930s is the National Coffee Growers' Federation of Colombia (FNC) [21]. It was mentioned as a credible source of knowledge 22% of the time. However, 75% of the interviewees willing to name an untrustworthy source indicated the FNC. Respondents who cited the FNC as a credible source recognized the value of much, but not all, of their work, citing a good national reputation for quality as positive and the continued promotion of economically and environmentally unsustainable practices as the main negative factor. Respondent two stated that "Coffee farmers don't believe the committee (the local branch of the FNC). They have made us commit many errors. One, planting 10,000 coffee trees per hectare" (an extremely intensive full-sun growing system). He also commented that they promote the planting of *Cordia alliodora* trees in coffee plots which he feels do not combine well with coffee and fears that growers who heed the recommendation will become disenchanted with coffee agroforestry more generally. Respondent six mistrusted the FNC's agronomic outreach efforts because "they set policies that are inconsistent. They have an interest in farmers producing as much coffee as possible and buying fertilizer from them". Respondent three attributed the fact that the majority of Colombian coffee is grown in sun-exposed monoculture to

"the coffee growing culture that the FNC has imposed on us". She also stated that her father grew coffee this way for most of her life, but after several crop failures attributed to weather conditions, she was able to convince him to implement agroforestry as a means of protection from adverse weather. The embeddedness in the collective social memory of this familiar narrative of obeying pressure from an outside entity which produces irreversible changes, followed by failure, may help to explain farmers' weariness of recommendations of novel agricultural practices, despite the empirical and political support for them, without personal or community verification.

## 5. Conclusions

What can be noticed from the extensive literature on agroforestry and agroecological embeddedness, as well as our sources of contextualizing data, is that agroforestry as such is not the main point of contention. Agroforestry is simply the manifestation of knowledge creation in one context and attempts to apply it in another, with rationale and means that are sometimes incompatible, and in contexts where institutions, cultures and capabilities sometimes do not fit. It is clear that the process and effects of agroforestry overwhelmingly coincide with the interests and desires of the farmers involved in the study. Nevertheless, in order for producers to enjoy the benefits of agroforestry systems and for their environments (as well as all of our environments) to benefit from the positive externalities, they must decide to implement agroforestry out of genuine desire and not out of coercion or due to a compensatory incentive structure. Such brute force attempts to engineer social and institutional contexts will inevitably be disruptive and unsustainable. Program design, including implementation, desired results and theories that make success possible in the specific context, must come from within communities in order to avoid the *conflicts of embeddedness* described in the examples, where outsiders make incorrect assumptions based on their own worldviews. Rather than seeking to overcome barriers to changing others, external and internal planners and executors may rethink their roles, from leaders and developers to aides and advocates, handing over control of the process, and with it, the outcome. In order to end unsuccessful and destructive agricultural planning, the measurement of the performance of many of the people involved must also change to overcome the focus on income-related metrics of success, valuing structural and open-ended outcomes instead.

This analysis, starting with an economistic return-on-investment equation and exploring the uncountable nature of the relevant social variables, has not resulted in an expanded equation using creative measurement techniques to quantify social behavior. On the contrary, the literature and study results confirm, in a variety of situations, that it is inappropriate to try to apply such rigid and linear logic to infinitely unique, complex and dynamic social situations. It would be unreasonable and disrespectful to offer a fetishizing conclusion such as *farmers in East Africa need to be paid to adopt agroforestry, while those in the Northern Andes only need to have control over the process*. The alternative, then, is to avoid the temptation to attempt to simplify and codify where this cannot be achieved reasonably and to appreciate instead the endless diversity that social history continually produces.

### *Summary of Conclusions*

To summarize the findings of the literature review and survey results (see Table 3), we refer back to Figure 2 which describes how interventions achieve outcomes based on theories of cause and effect. Having reviewed a wide range of complications of this relationship due to the embeddedness of agricultural practices in their social context, we attempt to partially classify some of them in terms of the aspect of embeddedness from which they arise as well as the area of the return-on-investment equation they affect. It must be noted that this table is merely a summary of the literature reviewed here and the limited surveys collected and does not intend to summarize the embeddedness of coffee farming practices in general, which, as we attempt to illustrate, is infinitely diverse, nuanced and unquantifiable by nature.

**Table 3.** Manifestations of embeddedness and point of decision-making dissonance matrix.

| Manifestation of Embeddedness | Point of Potential Dissonance | | |
|---|---|---|---|
| | **Theory** | **Intervention** | **Problem & Outcome** |
| Epistemological Dissonance | Different expected benefits<br>Interpretation of cause-effect relationship<br>Sufficiency of context-relevant evidence and experience<br>Credible knowledge transmitted through social networks | View that obedience of or collaboration with outsiders contributes to the loss of sovereignty<br>Perceptions of unintended consequences | Resistance to economic rationalization of nature as a resource<br>Outsiders' diagnosis of differences as problems: imposed underdevelopment<br>Prominence of individualistic desires |
| Values & Priorities | Moral environmental prioritization<br>Focus on reciprocity over accumulation<br>Lifestyle or routine change may not be worth the projected outcome | Social harmony, prioritization of community-wide beliefs and practices<br>Social cost of increased integration with monetary economy<br>Social factors such as status may outweigh the desire for a projected outcome<br>Program governance structures incompatible with community organization (e.g. third-party certifications) | Different desirability of projected outcomes<br>Individuality vs. collectivity; importance of externalities caused<br>Importance of preserving traditional practices and aesthetics<br>Perceived non-economic tradeoffs |
| Institutional & Historical Factors | Failed past interventions may undermine credibility of proposed theories<br>History of prior interventions oppose adoption of conflicting/updated theories<br>Private interests promote opposing theories, e.g. agrochemical sellers<br>Lack of confidence in own ability to achieve projected outcome via intervention<br>Suspicion of conflict of interest | Development program support that incentivizes "pseudo-adoption"<br>Outsider demand for performance implies value, requiring compensation<br>Land tenure: permission, expectation of continued access<br>Resource constraints: inability to execute despite buy-in<br>Disruption of status-quo & current distribution of power | Implanted view of inferiority, rejection of local knowledge, mistrust of community, and individualization<br>Resource scarcity & prioritization (relative scale of problems)<br>Limited access to basic social services<br>Outcome attractiveness influenced by institutions (e.g. subsidies, market access, permissions) |

Based on the results of the study and consistent with the agroecological paradigm, we propose that a more respectful and effective approach to envisioning and creating successful programs would be centered around farmer-created knowledge in contrast with top-down planning. Participatory program design involves generating initiatives based on farmer and community objectives, from within the context of local cultures and epistemologies, and collaborative planning based on acceptable methods and considering unique capacities. While local self-determination may prove more acceptable to those involved than programs planned by disengaged outsiders, we must also be aware of inequality, power asymmetry and the reproduction of structures of accumulation within communities [17,54].

The literature reviewed and data discussed in this article point to the conclusion that agricultural practice and the adoption of agricultural techniques are embedded within producers' social context and informed by their collective social memory. While their acceptance of empirical evidence and external sources of knowledge vary based on their worldview, means, unique history and previous exposure, many are weary of novel fixes, having been disillusioned in the past. Limited buy-in by farmers despite evidence from outsiders offering advice that agroforestry is beneficial may not be due to an inability to understand the technology or an opportunistic and short-term outlook, as are often diagnosed by onlookers. It may be that propositions are less compelling due to different

sets of priorities. It may have to do with the degree and nature of social embeddedness of the farm and family in their community context and the fact that smallholder family farming is much more than a profit-seeking allocation of resources; rather, it is a lifestyle and an intergenerational relationship with land and nature. What could be seen through an economistic lens as an inability to plan for long-term profitability may be a much more comprehensive orientation encompassing many generations, past and future, and the ability of the land to provide for life above it and vice versa, in an eternal reciprocal fashion that transcends 10, 20 or 100-year profit projections.

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