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Agroecology from the ground up: a critical analysis of sustainable soil management in the highlands of Guatemala

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Abstract

A persistent problem in the dominant agricultural development model is the imposition of technologies without regard to local processes and cultures. Even with the recent shift towards sustainability and agroecology, initiatives continue to overlook local knowledge. In this article we provide analysis of agroecological soil management in the Maya-Achi territory of Guatemala. The Achí, subject to five decades of interventions and development, present an interesting case study for assessing the complementarities and tensions between traditional, generally preventative practices and external initiatives which tend to be curative. Our findings reveal a complex farming system that continues to rely on ancestral knowledge and practices, many of which display a high potential for sustainability and are deeply embedded in local culture. While some new practices have been incorporated into the traditional system, abandonment rates are high, and some extension methods have been paternalistic. The Achí are thirsty for new ideas to help them confront their current, unprecedented challenges. However, future collaborations should be built on existing local knowledge, which has contributed to the development of preventative and restorative practices still in use. Introduced technologies must coincide with local needs and socioecological context in a manner that encourages beneficial synergies, as well as horizontal learning/teaching processes.

Keywords Agroecology · Indigenous knowledge · Soil management · Guatemala · Agricultural development

Introduction

Indigenous knowledge and traditional farming systems are increasingly recognized as important and in some cases essential to agricultural development (IAASTD 2009; Anderson et al. 2019; IPBES 2018; Chambers 2021). This is especially evident in issues related to the conservation of agrobiodiversity, socioecological resilience, and climate change adaptation (Berkes et al. 1995; Barthel et al. 2013; Altieri and Nicholls 2005). At the same time, integrating Indigenous knowledge and worldviews into development plans and sustainability research remains problematic. A major obstacle has been the lack of meaningful engagement by development professionals with local knowledge systems.

According to Thrupp (1989), and others (Anderson et al. 2019; Mistry and Berardi 2016; Norgaard 1984; Chambers 1983; 2021; Bentley 1994; Pimbert 2015; Wakeford et al. 2016; Escobar 1995; Jacobi et al. 2016) ongoing exclusion of Indigenous perspectives is the result of deep-seated power imbalances between farmers and "experts," along with domination of agricultural development by external Western ideas

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and institutions. In Guatemala, where this investigation takes place, centuries of delegitimizing Indigenous livelihoods and "epistemic violence" (Elias 2020) has contributed to the loss of biocultural diversity, which includes local knowledge, crop varieties, beliefs and traditional food systems (Paracchini et al. 2020; IAASTD 2009). However, as some research has shown, Indigenous knowledge and practices are still very much alive in Guatemala, and may hold valuable clues for agroecological food production and resilience (Kline et al. 2020; Elias 2015; Morales and Perfecto 2000; Einbinder and Morales 2019).

An important step in reversing the trend of exclusion and biocultural loss is to identify local knowledge systems where they are active, accompanied by careful documentation that builds legitimacy while supporting local struggles for revitalization (Gadgil et al. 2021; Thrupp 1989; Sillitoe and Marzano 2009; Fernández-llamazares et al. 2021). According to Morales and Perfecto (2000, p. 50), research that validates Indigenous and local knowledge systems is essential, "both for empowerment of farmers and education of research and development workers." Inquiries into these systems also provide critical insight into the "feasible points of entry" (Chambers 2021, p. 355) for scientific knowledge and ideas into traditional systems, and the formation of beneficial synergies.

In this article, we present findings from an investigation into local soil management practices in the Maya-Achí territory of Guatemala, a unique region and farming population with regards to their ability and persistence to maintain critical elements of the traditional system amidst decades of intervention, violent conflict, and displacement. In the Achí territory, dozens of programs since the mid 1990s have introduced agroecological soil management techniques such as live barriers, worm composting systems, and green manures, while also educating the public on issues such as deforestation and unnecessary burning (Einbinder et al. 2019; Portillo 2015). Like elsewhere in the country, many programs have arrived without consultation into local needs, resulting in simplistic and ultimately ineffective interventions that may do more harm than good (Caballeros 2013; Hatse and Ceuster 2001; Einbinder and Morales 2019; Parraguez-Vergara et al. 2018). However, our experience working in the region has made us think that farmers are eager to receive new ideas and adopt some of them.

Bearing these factors in mind, we analyze the agroecological potential and complexity of local Achí soil management, by characterizing both ancestral[1] and newly introduced practices. Our main objective is to gain insight into ancestral knowledge, perceptions, and techniques, which have been largely ignored, while also examining the key differences and potential for complementation between external scientific and local knowledge systems. By providing in-depth analysis on local soil management, this research aims to contribute to ongoing efforts to highlight and validate Indigenous practices and knowledges, which include local movements to decolonize agricultural development (Einbinder and Morales 2019; Wight 2020). Another important goal of this research is to provide critical baseline information for future interventions led by external groups who do not fully recognize the extent of local knowledge nor understand how to approach it. Finally, we aim for this work to contribute to agroecological theory, which seeks to address the benefits and challenges for combining knowledges while highlighting the importance of undervalued traditional farming systems (Sinclair et al. 2019; Milgroom et al. 2016; Altieri and Nicholls 2005).

Following this introduction, we provide a theoretical section that approaches our framing of ancestral practices within agroecology, and decision on investigating soil management. We will then describe the geographic characteristics of the Achí territory, focusing on agrarian issues. This is followed by an explanation of our methods for carrying out and analyzing the field data. The next section covers our results, which provide a detailed description of the practices and perceptions we documented and how they compare with the agroecological literature. We close the essay with a discussion focused on characterizing ancestral and introduced practices and the identification of synergies, followed up by a conclusion that summarizes the article and its aims.

Theoretical framework

Our understanding of ancestral farming practices is as those passed down or inherited by family and community members. Often correlated with traditional or Indigenous crops and management, and local knowledge, ancestral practices are described as time-tested and adaptive, in a constant process of development, and complex in terms of their cultural significance (Wilken 1987; Brosius et al. 1986; Horst 1989). Agroecology, which has gained traction as a set of social, political, and agronomic principles for advancing transition to sustainable food systems (Gliessman 2018), is explicitly grounded in ancestral practices and wisdom, combined with "the latest insights from the science of ecology" (Pimbert 2015, p. 288). A key objective in agroecology and agroecological development is to initiate processes where local ancestral knowledge, which tends to be "deep but narrow," and external, scientific approaches, which are "broad but shallow" (Vandermeer and Perfecto 2013, p. 76) are united

[1] Indigenous farmers often use this word to describe crop varieties, practices, rituals, knowledge, etc. that have been passed down or "inherited" by family or community members, and developed locally, often with specific cultural relevance (see Wilson 1995; Isakson 2009).

to form new hybrid approaches. By means of horizontal methods and farmer-led innovation, the aim is for a co-creation of knowledge that is rooted in the particularities of local context and guided by ecological principles (Sinclair et al. 2019; Bell and Bellon 2018; Milgroom et al. 2016).

Since its introduction as part of the "farmer-first" approach (see Chambers 1983; Chambers et al. 1989), the concept of bridging knowledges has become a widely accepted method and goal among Non-Governmental Organizations (NGOs), international institutions and governments involved in rural development (World Bank 2004; Tengö et al. 2021; Schroeder and Gonzales 2019; IAASTD 2009). Yet, despite a few exemplary cases (see Brescia 2017; Méndez et al 2017; Jacobi et al. 2016; Milgroom et al. 2016), advancing theory and intentions into practice remains a challenge.

There are numerous factors that impact the lack of success in bridging knowledges and recognition of Indigenous or local perspectives. According to Maffi and Woodley (2008, p. 71), "The role of indigenous knowledge is sidelined because local people's objectives are ignored." Indeed, most agricultural interventions are designed far from where they are set, with objectives based on Western assumptions of progress and wellbeing (i.e., economic indicators and productivity). Programs are often created—and funded for—a perceived weakness in a distant population; a lack of capacities and resources which contribute to their impoverishment and environmental degradation. Development, transfer of scientific knowledge and introduction of practices are intended to fix the problem: to assist in building resilience, often with an underlying goal of advancement from "traditional" to "modern" (Thompson and Scoones 1994; Cook et al. 2021). Under this assumption of superior knowledge, there is little sense in expending time and resources to include Indigenous and local knowledge systems, which at any rate are complex, not easily quantifiable, and difficult to approach by Western-trained fieldworkers (Sillitoe 2006; Blaikie et al. 1997).

We tackle this problem through initial documentation and analysis of ancestral practices and knowledge in the Achí territory, with a specific focus on soil management. Aside from its increasing recognition as foundation for agroecology and sustainable food systems (FAO 2017; Lal et al. 2020), we chose soil management as a focal point for two main reasons. First, we recognize that soil management, centered on conservation and fertility, forms the basis of many if not most agricultural interventions in the region (Hellin et al. 2019; Hellin and López-Ridaura 2016; González-Esquivel et al. 2020; Copeland 2015; Portillo 2015). At the same time, soil management is also one of the principal activities in which Achí farmers continue to harbor locally developed or ancestral practices and knowledge (Wight 2020; Luna-Gonzales and Sørenson 2018; Escalón 2019; Einbinder and Morales 2020). As pointed out by Wilken (1987), in his analysis of Indigenous farming in the Guatemalan Department of Sololá, and supported by a growing number of sustainable agriculture researchers (Mountjoy and Gliessman 1988; Morales and Perfecto 2000; Perfecto et al. 2009; Moreno-Calles et al. 2016), ancestral soil management practices demonstrate a strong potential for sustainability and inclusion of agroecological principles. It is also believed that ancestral practices and knowledge contribute to Western science in its lack of understanding how to sustain soil quality over long periods of time (Pawluk et al. 1992; Heckman et al. 2009).

At the core of these practices is knowledge based on collective experience, experimentation, rituals, and keen observation and reverence for the environment, also known as Mother Earth, or *Qachuu Aloom* in the Achí language (Barthel et al. 2013; Berkes et al. 1995; Einbinder and Morales 2020). According to Sillitoe (1998, p. 189), "Indigenous knowledge may be more extensive and systematic than expected, and take account of complex interconnections which narrowly focused scientific disciplines may overlook, with unanticipated spinoffs." WinklerPrins and Barrera-Bassols (2004, p. 152) echo these sentiments, adding that: "Local soil knowledge forms part of broader local theories about nature, which constitute the bases for adaptive management systems." At the same time, it should be recognized that local knowledge systems—along with the individuals that utilize them—are dynamic, rather than static, and that inevitably "there will be knowledge "loss" as well as "gain" as local people experiment and adjust to new circumstances" (WinklerPrins and Barrera-Bassols 2004, p. 152).

Climate change, along with the negative externalities of industrial agriculture, namely soil erosion and greenhouse gas emissions, has led to a universal explosion of interest in soil health and stewardship, evidenced by the regenerative movement (Newton et al. 2020). Yet, despite the potential contributions of Indigenous and traditional farming knowledge and practices, they have received little attention. We aim for our documentary work with Achí farmers to demonstrate the value of these time-tested systems, arguing for their recognition and protection, and use as a foundation for any intervention.

Study site

The Achí territory is located in the highland and predominantly rural Department of Baja Verapaz, roughly 90 miles north of Guatemala City. The territory is characterized by a high Indigenous population (> 80%), rugged mountainous terrain, and relatively low (~ 1000 M) semi-arid valleys, which hold the larger market towns of Rabinal, Salama, and Cubulco (Segeplan 2010). Rabinal serves as the cultural, religious, and political head of the territory, and is where many important ceremonies and festivals are held, some of them predating the Spanish conquest (Hutcheson 2005).

As detailed in previous work (Einbinder et al. 2019; Einbinder and Morales 2020), the Achí have deep historical and cultural ties to agriculture, which remains the principal economic activity. Production is diverse, though traditionally centered on milpa: the iconic Mesoamerican trinity of corn, beans, and squash, often grown alongside edible greens such as chipilín (*Crotalaria longirostrata*) and macuy (*Solanum spp*). Other important crops include fruit trees (Rabinal was once renowned nationwide for its oranges), peanuts, melon, seasonal vegetables, tomatoes (grown conventionally in greenhouses) and coffee. Unlike in other regions where non-traditional export crops and large monoculture extensions have usurped the most fertile lands (Carte et al. 2019), the Achi territory remains unaffected by large-scale agricultural development, due to factors such as inadequate terrain and climate (Pellicer 2005; Segeplan 2010; Portillo 2015). Yet, this does not imply that Achi farmers have been excluded from external influences and "development," nor that access to resources—land particularly—is less of an issue than elsewhere (Steinberg and Taylor 2002).

As in other highland territories, agrochemicals arrived during the early 1970s accompanying programs set to modernize peasant production, which is labor intensive and would require land reform to be carried out sustainably (Carey 2009; Zilverburg et al. 2009). Key actors in the Achí territory included progressive religious organizations such as Catholic Action, who promoted synthetic fertilizers in a well-intentioned yet ultimately failed attempt to liberate Indigenous farmers from seasonal migration to industrial farms to work as day-laborers, often under intolerable conditions (Suazo 2009). These actions, which led to massive farmer participation in local cooperatives, ended abruptly in the early 1980s when the Guatemalan government turned genocidal in their tactics for controlling the Indigenous population (CEH 1999). Following the height of the violence, from the mid 1980s until the signing of the Peace Accords, in 1996, government programs such as those carried out by the General Directorate of Agricultural Services (DIGESA) began to incorporate alternative and/or organic practices, and included incentives for participation (see Copeland 2015).

Austerity in the late 1990s brought an end to government programs and the beginning of massive international NGO presence, along with the formation of local Indigenous farming associations. This latest phase of agricultural development is characterized by programs incorporating agroecological principles, for example transitioning away from agrochemical use through substitution of inputs and redesign, diversification, and reintroduction of ancestral crop varieties (Einbinder et al 2019; Portillo 2015; Luna-Gonzales and Sørenson 2018). Current agroecological extension work is complex, with a number of groups working independently, and significant methodological differences between local and external initiatives; the former emphasizing long-term accompaniment and structural changes to confront unsustainable habits and recover aspects of traditional livelihoods, while the latter focuses primarily on introduced techniques and crop varieties, and works generally under a limited timeframe.

Although it was beyond the scope of this study to analyze the direct impacts that development and violence has had on ancestral practices and knowledge, our experience working in the territory over the past ten years suggests that it is significant, and worth considering. Narratives of extreme loss of culture are commonplace, and often associated with the erosion of an entire livelihood centered on food production and related rituals. At the height of the violence simply planting milpa could be considered subversive, let alone carrying out ceremonies or gathering organic material in nearby forests to add to fields. These activities may have equated to being a guerrilla and subject to torture and/or assassination. In addition, massive displacements (and government-sponsored massacres) such as those in the Chixoy River Basin (CEH 1999) left thousands without access to land and other critical resources. These incidents coincided with programs that distributed chemical fertilizers, further rupturing the cycle of holistic soil management (see Carey 2009 for details throughout Guatemala).

While post-conflict development work was in theory aimed at improving the situation, leaders contend that their extension methods have been paternalistic, creating dependency among family farmers and provoking further displacement of practices and knowledge. Consistent with other narratives on modern development practices (see Bunch 1982, Escobar 1995; Thrupp 1989) "experts" are said to arrive with little consultation, hardly asking any questions of local people, and expecting great changes in little time (we recall one farmer stating: "they give you a hose and think that all your problems will be solved."). After a day in the field community leaders commented that we were the first outsiders to actually "sit down with us" and "ask about what we do." This is after three decades of consistent interventions by innumerable organizations.

It was precisely these comments, and many more, that sparked the need for an investigation that "asked questions" of local people, considering them experts in agriculture and sustainable land stewardship, with much to offer. In the following section we narrow in on the details of how we went about asking questions about local soil management within this context, as well as our methods for data analysis.

Methods

Our inquiry into soil management was facilitated by local sustainable agriculture leaders, along with the community organizations Qachuu Aloom (QA) and The Association of Committees for Community Production (ACPC), who shared an interest in examining traditional agricultural knowledge and practices, and their relationship to agroecology. With an aim to conduct participatory research (see Thompson and Scoones 2009), we consulted with these groups and leaders on all aspects of the study, for example: the most effective and culturally sensitive approach to collecting data, via interview guide and site visits, as well as choosing participants. During the months of January and February 2019, one author, Nathan Einbinder (N.E. from now on), visited and interviewed twenty-two farmers in the Achí territory, through the assistance of four local guides, all but one affiliated to QA or ACPC.

Participants were chosen by our local guides based on recommendations by N.E., which included demographics and geography. In general, we asked that participants be diverse in age, gender, and live in both highland and lowland areas, which are distinct from one other in terms of crops and ecology, as well as subtle cultural differences. Selection of participants was undoubtedly influenced by our guide's affiliation with agroecology and interest in revitalizing ancestral practices and knowledge. Therefore, it should not be assumed that the farmers involved in this study were representative of the average Achí farmer. For example, most participants were actively engaged with local agroecology groups and NGOs, which influenced the way they produced, e.g., lack of agrochemical use and increased biodiversity in growing sites, as well as concern for the environment and human health. On certain occasions our guides selected participants based on their "very traditional" styles of soil management, which allowed for an intimate view of ancestral practices and knowledge, yet also created bias. While some farmers lived in remote hamlets and were openly averse to external development programs, it is safe to assume that all participants had been impacted by interventions, meaning exposure to new technologies, practices, and different crop varieties. Why individuals decided to retain ancestral elements of farming surfaced in some of the visits, as described later.

Site visits typically lasted between two to three hours, though on some occasions took most of the day if group work was involved. Some visits were repeated, if new information was sought out. A typical visit began with a formal greeting, followed by introductions, which were often in Achí, and translated into Spanish by our guide. This was followed by questions about the farmer's background and life history. For older respondents the conversation occasionally led to stories about the violence, which were horrific, yet important in understanding local context. Some discussions were centered on both positive and negative experiences with extension/development workers and projects.

Following this initial conversation we visited all sites of cultivation, if possible, as well as areas in which amendments were produced; e.g. chicken coops and compost heaps. With an objective to capture local perspectives, utilizing what Markee (2012) denotes as an "emic" approach, we recorded techniques based on confirmation by the farmer, rather than our own observations. For example, if a practice was not mentioned to have implications regarding soil management (e.g., intercropping beans with corn), it was not added to the list of techniques utilized by that participant. On occasion we found it necessary to discuss certain techniques, such as polycropping, to ascertain whether the practice was perceived to have relevance to soil management. More often than not, these discussions were directed by our guides, in Achí, and translated back to N.E. in Spanish.

Upon reaching the area where milpa was cultivated, we made inquiries regarding soil quality—e.g., how is it known if soil is good or poor. This initial question responded to our aim to document local and ancestral knowledge and understand how this knowledge translated to specific practices. On several occasions N.E. participated in farming activities, such as cutting brush to prepare a bed for planting, harvesting, and building terraces. Useful details about practices, beliefs, and perspectives were often gathered in this informal setting, and captured in a field notebook. Closure and follow-up questions usually took place once again in a more formal setting in front of the participant's home.

Data analysis occurred once all fieldwork was complete. For one week in May 2019 N.E. returned to the Achí territory to spend time with our guides, and returned to several of the participants' homes, with a keen interest in observing activities related to the seasonal planting and preparation for milpa. After this visit N.E. maintained contact via telephone with the guides to clear up any doubts while reviewing and analyzing the data. Eventually a list was compiled of all the practices. Interviews were transcribed and coded, identifying themes such as "ancestral" and "introduced." Eventually, all practices were separated out based on their specific agricultural function, e.g. fertilization. Following this exercise we created a table of all practices, their function, and origin (see Table 1).

Confirming whether practices were ancestral or introduced involved discussions with our guides, and occasionally led to further discussions with local elders and experts. There were some inconsistencies between our sources about the origin of certain practices, as well as uncertainty due to the mixing of ancestral and introduced over time, and the finite details associated with each practice. For example,

Table 1 List of soil management practices of 21 participant/farmers, with reference to its origin (ancestral, introduced, or mixed). The number to the right of the practice indicates the number of participants who mentioned that they used this practice for the identified purpose

Erosion control/Soil conservation

1. Terraces (8) (**Mixed**)[a]
2. Weed control with hoe (9) [this is a practice believed to reinforce overall soil health; an opposite to herbicides] (**Ancestral)**
3. Minimum tillage (6) (**Mixed)**[b]
4. No till (1) **(Ancestral)**
5. Ditches (*zanja* or *acequias*) below crop rows, to catch soil/runoff (3) **(Introduced)**[c]
6. Contour lines (*curvas a nivel*) (6) **(Introduced)**
7. Live barriers (grass, izote) (7) used later for animal feed (2) **(Introduced)**
8. "Dead" barriers (rocks) (5) **(Ancestral)**
9. Trees (3) **(Ancestral)**
10. Living fence (1) **(Ancestral)**
11. Green manures (1) **(Introduced)**

Maintain humidity

1. Minimal weeding with hoe (4) **(Ancestral)**
2. Collect leaves from forest and incorporate into soil (1) **(Ancestral)**
3. Leave all crop residue and secondary plants (weeds/monte) until close to next planting (6 months), then cut and remove (2) **(Ancestral)**
4. Mulch (2) **(Ancestral)**
5. Nearby forest/trees (1) (**Ancestral)**
6. Agroforestry (1) **(Ancestral)**
7. Green manure (3) **(Introduced)**

Soil organic matter

1. Worm compost, from various raw sources, typically cow manure (9) **(Introduced)**
2. Incorporation of crop residues and monte and brush directly into soil after dried/composted (sometimes buried into holes) (8) **(Ancestral)**
3. Leave crop residue (after weeding) and brush/monte/weeds to make compost in-situ (mulch) (noted as left whole, or "*picado/chopeado*") (9) **(Ancestral)**
4. Collect leaves from nearby forest/trees and incorporate into soil (4); or compost (1) **(Ancestral) (Compost method- introduced)**
5. Cut and drag crop residue and monte into piles to decompose, then return to the soil in preparation for planting (5) **(Ancestral)**
6. Live fences (prune for organic material) of selective native trees (5) (**Ancestral)**
7. Above ground compost—dried brush, ash, zompopo, crop residue, green plants, pruned branches/leaves; cow waste; (sometimes covered in dirt) (many variations depending on availability of resources—e.g. coffee pulp, if available) (11) **(Mixed)**
8. Underground compost—brown and green leaves, rinds, any vegetable waste, ash, brosa, animal waste (dependent on availability) (6) **(Introduced)**
9. Chicken manure (2) **(Mixed)**
10. Agroforestry/forest patch (within plot) (leaves/mulch/OM) (5) **(Ancestral)**
11. Native worm compost (gallina ciega)—make compost heap in the ground, leaves, grass, herbs, cow waste; they come on their own (2) **(Ancestral)**
12. Compost pure coffee pulp (2); for native worm compost (1) **(Introduced)**
13. Acknowledgement of natural decomposers in soil ("escones") (1) **(Ancestral)**
14. Green manures (2) **(Undetermined)**
15. Multi-cropping (13) **(Ancestral)**
16. Crop rotation (7) **(Mixed)**
17. Feed crop residue to cow, use waste for compost (1) **(Introduced)**
18. Feed crop residue to cattle in plot, leaving waste for next planting (4) **(Ancestral)**

Fertilization

1. Chicken compost "*gallinaza*" (8) **(Introduced)**
2. Green manures: Mucuna (2); Canavalia (2); Frijol arroz (3); Gandúl (2); Frijol garbanzo (1); Dolico (1) **(Introduced)**[d]
3. Chemical fertilizer: Sulfato (1), 15–15-15 (4), Urea (1) **(Introduced)**
4. Chop corn stalks into a powder, use like fertilizer (1) **(Ancestral)**

Table 1 (continued)

5.“*Caldo nutritivo*” (mixture of plant ingredients, “madre de banana,” malanga (Xanthosoma sp.) root and leaves; make a “tea”, apply directly to the trunk of the plant) (1) **(Mixed)**
6. Foliar from macuy, “miel de café” (1) **(Introduced)**
7. Abono de zompopo (5) **(Ancestral)**
8. Foliar feed from worm compost tea (1) **(Introduced)**
9. Foliar made of cow excrement “tea” (1) **(Introduced)**
10. Legume rotation (1) **(Introduced)**
11. Compost “*ferti-maya*”—(Rapid compost fabricated in the middle of the rainy season when there is plenty of green organic matter, which is chopped up and left for 30 days to decompose. Applied directly to the plant as a fertilizer) (1) **(Mixed)**
12. *Zanja* (reutilize runoff/muck for its fertilizer) (2) **(Ancestral)**
13. Collect animal waste and dry it into a powder, place alongside crop (2) **(Ancestral)**
14. Bocashi method (2) **(Introduced)**
Preventative pest management—“disinfect soil”
1. Ashes (2) **(Ancestral)**
2. Lime (1) **(Ancestral)**
3. Manure with lime (1) **(Ancestral)**
4. Foliar made from macuy (1) **(Introduced)**

[a]Terraces have been in use for 500+ years in Mesoamerica. However, in the Achi area, some authorities claim that there is no physical evidence of terraces, nor did their parents/grandparents use them. What is certain is that external organizations focus heavily on their introduction

[b]Traditional methods of planting utilized low impact tillage. However, as a “technique,” this practice was introduced

[c]Terraces have been in use for 500+ years in Mesoamerica. However, in the Achi area, some authorities claim that there is no physical evidence of terraces, nor did their parents/grandparents use them. What is certain is that external organizations focus heavily on their introduction

[d]While all of these leguminous cover crops were indeed introduced from other parts of the world, their use, which span nearly 100 years in certain instances, has become “ancestral” due to the fact that it is passed down by elders, and has been given Achi names. There is also widespread belief that in the ancestral system native plants are used to enhance soil fertility, such as local beans in milpa production

it is widely acknowledged that using chicken manure is an ancestral practice, however, composting the manure before its application was an introduced technique. Therefore, we labeled these practices as “mixed”.

The final exercise of our analysis involved comparing the practices and knowledge with agroecological literature, as well as texts about regional traditional agriculture (for example, Wilken 1987). This served as the basis of our results section, as shown in the following section.

Results

Here, we present results from our fieldwork, as well as broader analysis and insight into the traditional soil management system and its agroecological features. Following an introductory segment describing farmers’ perceptions of soil quality, we delve into the practices catalogued during our site visits, which are organized based on three key functions: Incorporation of organic matter, Fertilization, and Soil Conservation.

> How do you know if the soil is good?
> *Sale hierbas… Si nace macuy, está bien. Y bledo y colix de buen tamaño.*
> The greens come out… If there is macuy, it is good. And bledo and colix of a good size. (Margarita Cojom Tum).
> *Es fértil cuando esta suave. Cuando está quemado, o no usa abono orgánico, se hace duro, o se raja.*
> It is fertile when it is soft. When it is burned, or when you don’t use organic compost, it gets hard, or it cracks. (Lisbeth Tun).
> *Un buen suelo tiene su colchón … La MAGA las llama malezas, pero nosotros digamos que forma el cuerpo de la tierra. Se convierte en la fertilidad del suelo.*
> A good soil has a cushion… The MAGA (Ministry of Agriculture) calls them weeds, but we say they form the body of the land. It becomes the fertility of the soil. (Cristóbal Osorio).

A first step into understanding local soil management in the Achí territory was to inquire with our participant farmers how they distinguished good and/or healthy soil. As shown above, responses varied. In the first statement, Ms. Tum, a fifty-year-old single mother from the community of Chuategua, identified the presence of semi wild edible greens as a key indicator. This was the most common response. The second quote, from a sixteen-year-old girl who had recently graduated from a local agroecology field school, highlights the importance of adding organic material to soften up the ground, rather than using herbicide (which "burns" the soil). The final reply, stated by local agroecological promoter, Cristóbal Osorio, also mentions structure as a key element, while emphasizing the importance of non-crop plant residues for attaining fertility.

Other responses include the prevalence of mushrooms, millipedes called "*esconés,"* and dark or black color.

These answers suggest a number of possible trends, including the use of local soil classification systems, as well as a high value placed on organic material and associated organisms. Something we find particularly intriguing is the apparent relationship between healthy soil and native edible plants, which remain an important aspect of the traditional diet, yet are also said to be in decline due to agrochemical use (herbicides especially) and rapid cultural changes (see Luna-Gonzales and Sørenson 2018, Álvarez 2020). Was it possible that local farmers intentionally manage soil specifically for these crops, or is their presence a byproduct of agricultural practices conducted for other purposes? Based on our preliminary data and inquiry, we suspect it to be a combination of the two. While several participants commented that by using certain natural inputs, such as chicken manure, it was possible to essentially "seed" a plot with these plants, other farmers (including local agroecological leaders) told us that by simply applying local composts or dried plant residues these plants emerge naturally, alongside other important native edibles such as *chipilín* (*Crotalaria longirostrata*), the renowned herb *apazote* (*Dysphania ambrosioides*) and a wild tomato relative known as *miltomate (Physalis spp.).* Other regional studies document similar relationships between farmers and semi-wild edible plants, also known as *quelites*, though in general literature on the topic is scant. In one study, from Honduras, Barrios and Trejo (2003) suggest that by using native plants as indicators of soil quality, traditional farmers demonstrate keen knowledge of ecological principles, such as natural succession, in which these herbs may occupy a specific niche. Similarly, Bye (1981), in Chihuahua, Mexico, concluded that the prevalence of species such as *Amaranthus,* also important in the Achí territory, may ultimately depend on the disturbances created by hand tillage—and furthermore suggested that farmers have developed practices over time with the intention to provoke these highly important secondary food crops. Finally, we turn to the seminal work of Chacon and Gliessman (1980), who documented the "non-weed" classification system inherent to traditional farmers in the state of Tabasco, illustrating their knowledge and use of wild plants that are undervalued by conventional agriculture.

While much more documentary work is needed to detail the reason or reasons Achí farmers look to the presence of these plants for determining soil quality, we view it as indicative of an approach to farming and fertility that takes into account the agroecosystem, rather than only the specific necessities of the crop, typical in "modern" conventional agriculture (see Perfecto et al. 2009; Alcorn 1989). In the following subsections we illustrate how this approach translates into specific practices that comprise local soil management, beginning with the issue of soil organic matter.

Incorporation of organic matter

Every farmer in this study employs multiple strategies to raise or maintain soil organic matter (SOM), which is perceived as a core element of soil health and long-term fertility. The bulk of these activities and practices, listed below, center on the collection and processing of dried and fresh plant material and animal wastes, which are then incorporated into vegetable, milpa, and agroforestry plots as mulch, composts, or buried in their raw form.

Diverse social and ecological conditions, along with variable access to resources, labor, and knowledge, result in an abundance of practices that build and/or conserve SOM. In general, farmers utilize the raw materials at hand: brush, crop residues, pulp from coffee fruit, branches and leaves from trees, animal wastes, kitchen waste, and *monte,* the regional term for "weeds." The ubiquitous "cleaning" of one's field, with a hoe and traditionally in a group, represents the first in a series of steps that return organic material and nutrients back to the soil in a "closed" process akin to traditional agriculture systems throughout the tropics (Perfecto et al. 2009, p. 64). In addition to what is grown on-plot, farmers utilize biomass from trees and shrubs planted as "living fences" along the perimeter, which also provide medicine and food. When access to forest is possible, leaf litter (especially from oak trees) is collected and utilized as mulch or buried into crop rows (*surcos*) (see Wilken 1987, p. 64 for similar observations and ecological explanation). Other plant materials used for SOM include non-native green manures such as canavalia (*Canavalia* spp.) and mucuna (*Mucuna pruriens)*, as well as leaves from on-plot trees in coffee agro-forests.

Roughly half the farmers in this study utilize animal manures for building SOM, as well as for crop fertilizer. Both cattle and chicken wastes are incorporated into topsoil directly or composted first. Cow manure is obtained by various means, depending on access and the ecological characteristics of the plot. Some farmers exchange forage (crop residues, specific grasses, or *monte*) grown on their land for the use of a neighbor's animal, for manure. A small number of individuals with greater access to resources—land, irrigation, and/or financial capital—own a cow or cows, which they may keep principally for the use of excrement. As pointed out by Magdoff and Weil (2004, p. 52): "Manure is often presumed to result in higher increases in SOM because it consists of relatively recalcitrant compounds, the most easily oxidized compounds in the original plant tissue having been broken down by the animal digestive system before excretion of the manure." While there is obviously a high value for animal manure, a number of the older farmers stated that it is not necessary for maintaining healthy soil, and that careful recycling of nutrients from plant material, along with other ancestral practices such as crop rotations, are sufficient for long-term fertility.

All of the participants in this study compost at least a portion of the organic material they collected, indicating knowledge of, and a high regard, for composted materials that are assumed to be higher in quality than non-composted mulch and free from pathogens (see Singh and Singh 2017). Practices range from piling *monte* and crop residues alongside *surcos* and fence lines, a noted ancestral method also used for retaining humidity and soil conservation, to more sophisticated techniques that include above and below ground compost heaps, called *aboneras,* where specific ingredients are added at different times. Brown and green materials are calculated depending how "hot" the farmer intends the mixture to be (Altieri and Nicholls 2005). Ash is utilized extensively for its "disinfecting" properties (see Wilken 1987, p. 48). Again, farmers utilize whatever raw materials they have at their disposal, which in turn influences the type of processing they choose. For example, if animal manure or coffee pulp is available, the farmer may be inclined to utilize red worm composting systems, or vermiculture, a popular introduced technique that produces humus-like material with "increased microbial and nutrient availability" (Arancon and Edwards 2005, p. 2). Some individuals simply dig a hole (or many holes) between the house and the plot where they dump all the "*basura*"—waste that includes chicken bedding, scraps of tortilla, fruit rinds, etc.—inviting native microorganisms and worms to carry out decomposition.

On two occasions we observed the use of a native white grub called the *gallina ciega* (*Phyllophaga* spp.), also a renowned "pest" (SESAN 2007). Both farmers claimed that they deliberately implanted the grub because of its composting abilities, yet were also aware of its tendency to destroy crops by eating the roots. "When there is enough organic material, *la gallina ciega* does not harm the plant," stated one of the farmers. Still curious, we asked local agricultural leader, Julian Vasquez, about the practice. "It may sound strange, but there are actually two types of the *gallina ciega*, the smaller one that eats roots, and the bigger one that eats any type of dung or piled up *monte,"* he told us. "If you were to do an experiment and take a sack of excrement, water it down and then place it in the sun, the grubs would appear in a matter of days. Later, you can harvest a very fine fertilizer… The *gallina ciega* is a gift from nature. There is no organization that works with the practice, because for them it is a *plaga* (pest)." (See Romero-López et al. (2010) for an additional study where *gallina ciega* is utilized for composting).

In general, the more labor-intensive composting practices were reported as infrequent or absent before the 1990s. A common narrative asserts that until the late 1960s/early 1970s the soil was largely fertile and did not need such intervention. The arrival of agrochemicals and a rupture in traditional practices, due to the violence, led to rapid soil degradation. International groups are said to have "brought the idea" of composting, often rewarding farmers with money or food in exchange for building *aboneras*, among other practices. The widespread adoption of composting is hypothesized to be a result of its proven effectiveness in terms of soil quality and crop output (particularly among individuals attempting to reduce dependency on chemical fertilizers), increasingly smaller plot sizes that require intensive intervention for continuous production, as well as the lack of full recovery of traditional knowledge and practices. We also consider the potential of newer agroecological techniques in accelerating processes of bioremediation for heavily damaged soils, something we examine later in this section.

Finally, we discuss the use of crop rotations and polycropping, also called multi or intercropping, two ancestral agroecological practices common throughout Mesoamerica (Altieri and Toledo 2011). In the Achí territory, polycropping is demonstrated in traditional *milpa* "*asociada"* (corn, beans, and squash, plus native greens), as well as in diversified agroforestry systems, kitchen gardens, and intensively farmed vegetable beds. Non-native perennials such as gandul (*Cajanas cajan),* an edible green manure also known as pigeon pea, and moringa (*Moringa oleifera*), a small tree with medicinal uses, are currently being incorporated as "alley-crops" (see Vandermeer 1998, p. 48–49) mainly through the work of NGOs. In certain exemplary plots, > 35 crops are grown simultaneously, with staggered harvest times and strategic placement based on microhabitat and other ecological characteristics. Crop rotations are also noted as common, occurring between *milpa* and peanuts, amaranth, and/or legumes, especially when irrigation is available (alternating dry and wet seasons).

While many of these techniques have been practiced for centuries, others may be attributed to recent agricultural extension work emphasizing "diversification," particularly regarding introduced vegetable and coffee production, as well as "educating" farmers on the benefits of planting traditional *milpa* instead of only corn, in monoculture, as was once promoted during "Green Revolution" interventions (see Portillo 2015; Kline et al. 2020). Based on our conversations with farmers, polycultures and rotations are thought of not only in terms of greater yields, as may be the goal of development groups, but as a livelihood strategy that prioritizes a healthy and diverse agroecosystem, which includes enhancing SOM and the "life of the soil," as stated by one participant. This kind of systems approach is supported by agroecological literature that verifies how farming with multiple crops, especially perennials, leads to greater production of diverse sources of organic material, while increasing biodiversity far below the surface through complex root interactions (Bot and Benites 2005; Ehrmann and Ritz 2013). Magdoff and van Es (2000) explain how crop rotations not only replenish SOM but also improve its quality, as residues from various classes of plants impact the diversity of microorganisms, thus improving decomposition processes. Finally, we consider the way these two practices embody an essentially preventive approach to soil health (see Doran 2002), by conserving organic matter through increased coverage and soil stabilization (Magdoff and Weil 2004).

Fertilization

Chemical fertilizers have been promoted in the Achi territory by various groups since the early 1970s, and are widely used. Despite efforts by agroecology groups and sustainable agriculture programs to discourage the use of agrochemicals, our findings suggest that a majority of farmers (including in this study) continue to use small amounts of synthetic fertilizer, though application is generally limited to *milpa*. A principal reason is that *milpa* tends to be grown in larger extensions than vegetables and/or other crops. In addition, the nutritional demands of corn, particularly on steep and rocky slopes which may not be ideal in any case for these crops, require copious amounts of organic material and compost. This is especially true if one aims to compete with the potential yields achieved through the use of chemical fertilizers such as 15–15-15, a popular synthetic mixture with equal amounts NPK. Thus, while Achí farmers are ingenious at handling and processing organic material, the issue of resource access, cost of labor, land degradation, and physical limitations of the producer (many are elderly and no longer have the luxury of family labor), create a situation in which synthetic fertilizers are extremely attractive, if not considered necessary (see Zilverburg et al. 2009; Carey 2009, for similar observations at a national level).

That said, farmers in this study express concern over the use of chemical fertilizers, particularly in the way it "burns" the soil, an observation that runs parallel to other studies documenting the negative impacts of agrochemicals on organic matter and microorganisms (Kibblewhite et al. 2008), and pests (Morales et al. 2001). These farmers—and many others participating in agroecological programs (Einbinder et al. 2019)—express a preference and are in the process of transitioning to organic and locally produced amendments, which they claim to be "longer lasting" when compared to synthetic fertilizers, though not rapidly effective. *Gallinaza,* or chicken compost, is the most widely used organic input, and is believed to "strengthen damaged soils," by adding micronutrients that are often deficient, as well as "balancing the pH." Other studies verify the high demand for *gallinaza* in the region (Wilken 1987), along with its potential as a fertilizer and quality source of organic material (Magdoff and van Es 2000). Pareja (2005) shows *gallinaza* to be high in nitrogen and phosphorus, though dangerous if applied before adequately composted, due to high concentrations of macronutrients. In the Achí territory *gallinaza* is often incorporated into *aboneras,* and when used on its own is buried into *surcos* for a minimum of 8 days before planting, in order to not "burn the plant." This apparently gives adequate time to "ferment" and "cool down," according to one agroecological promoter. Farmers also purchase already composted chicken manure from local commercial producers, who use straw bedding to aid in the process (see Wilken 1987 for description of this traditional practice). In at least one local program, *gallinaza*, in combination with other soil conservation practices, is experimented with as a full replacement to chemical fertilizers (see Einbinder 2019). Although this may be viewed as a form of "input substitution" (see Rosset and Altieri 1997), local promoters claim it to be an integral step in agroecological transformation. According to Julian Vasquez, "In times past, there was no need for *gallinaza.* But now, with soils damaged from agrochemicals, it is necessary to recuperate. It is possible that after a few years he [one of 10 participants in his project] will not need to apply the *gallinaza*. The natural methods will be sufficient."

Other examples of organic amendments include native leaf-cutter ant (*Atta* spp.) excrement and nest residue (also referred to as "trash", indicating the bits of organic material brought back to the nest, which in turn encourages fungal growth), known as *abono de zompopo.* Wilken (1987) observed the use of *zompopo* in Guatemala and in Mexico as a localized and dissipating practice, due to widespread agrochemical adoption. However, many farmers in the Achí territory maintain a high regard for this resource, and continue its use for milpas and vegetable production. Also known as a pest, and a celebrated delicacy (in the month of May, "queen" *zompopos*, fly from their nests and are caught, fried, and eaten by many rural Guatemalans) *zompopo* nests are sought out and excavated, and used akin to chemical fertilizer. Small amounts (the material is likened to bran) are placed at the foot of each plant at critical moments during its growth and fruiting. Another interesting ancestral practice for generating fertilizer is through the use of *zanjas,* or small ditches, typically dug at the foot of a steep field where organic material and/or topsoil may wash down. Farmers let the matter and liquid accumulate into a "muck," which is then utilized for crops. Again, Wilken (1987) observes similar techniques throughout Mesoamerican farming systems, with noted beneficial results. In addition to these techniques we catalogued a small number of homemade concoctions and "teas," also known as bio-inputs, used as foliar feeds when plants are notably "weak" or "turning yellow." The method for producing these liquid fertilizers requires soaking either plant materials or animal waste in a bucket for a certain amount of time, usually 2–7 days.

The final subgroup in this category pertains to green manures. Green manures are multifunctional cover crops that fix nitrogen in the soil through root nodules while producing substantial amounts of high quality organic matter that may be tilled under or used as mulch (Holt-Gimenez 2006). Altieri and Nicholls (2005) provide examples in which green manures, and particularly mucuna, may double or triple yields, eliminating the need for synthetic fertilizers as well as herbicides, given its effect as a weed suppressor (see also Buckles et al. 1998 concerning a well recognized program in Honduras).

In the Achí territory we documented the use of "native" green manures; one called *frijol arroz (Vigna* spp.*)*, or *ch'u'* in Achí, and another called *frijol garbanzo* (species unknown), apparently Indigenous to the high mountains of the territory. Both mucuna and canavalia, two imported cover crops, are well known from previous sustainable agriculture programs, and highly regarded as effective fertilizers, as well as rich sources of organic material, and in some cases animal feed. However, the practice is rarely used. The main reason for this, according to conversations we had with farmers and leaders, relates to the lack of adequate land, and possibly knowledge in how to properly manage the resource. "Mucuna grows vigorously," said one farmer, "and topples the corn. If I could rotate mucuna with *milpa*, I would use it. But I do not have the space." Veteran farmer Cristobal Osorio, who worked for World Neighbors (see Bunch 1982) and other local NGOs, claims that with careful management you can grow mucuna and canavalia at the same time as maize, although "it requires being cut back at key moments," which involves extra labor and knowhow. Present agricultural extension work is focused mainly on pigeon pea, or gandul, a shrub (rather than an herbaceous cover crop) known for its drought tolerance, nitrogen fixing capabilities, and high protein content (Snapp et al. 2003). While interest appears high, long-term adoption remains uncertain, and may ultimately depends on how well the production fits into local needs, and if the edible bean can be integrated or successfully reintroduced into local diet.

Soil conservation

Concerns over soil loss and erosion in Guatemala has resulted in myriad programs that aim to extend soil conservation practices to smallholders, many of whom farm steep and naturally erodible slopes due to land scarcity and inequality (Holt-Giménez 2006; Hellin et al. 2019). Beginning in the 1990s, farmers in the Achí territory received trainings (*capacitaciones*) on how to build terraces and contour lines (*curvas a nivel*), were encouraged (and often compensated) to practice minimum tillage, as well as install live and dead barriers and plant cover crops. A number of these practices arrived and continue to arrive under the logic of Conservation Agriculture, an internationally recognized strategy whose principal tenet is to avoid disturbance through minimal intervention (e.g. tillage), consistent soil coverage, and rotations, "with the aim of emulating forest floor conditions" (Lampkin et al. 2015, p. 22).

Some of these techniques, for example rotations and the heavy use of mulch, are considered ancestral practices, yet may have been partially lost due to the adoption of agrochemicals, or were dismissed entirely by project leaders and agronomists (see Cotler and Cuevas 2019 for similar observations in Mexico). Other practices, such as terraces and the use of contour lines, by means of the renowned *campesino* tool "*Aparato A*", were newly introduced and promoted by external organizations following Hurricane Mitch in 1998, which devastated the region. While abandonment rates for these techniques are reported as high, as elsewhere (see Hellin and Lopez Ridaura 2016), many farmers—and particularly those living in the steep upper reaches of the territory—remain dedicated practitioners, claiming marked benefits in terms of yield and overall agroecosystem health. As a result, terraces are maintained and utilized by more than a third of the farmers in this study, with a range of milpa and vegetables planted typically in rotation. Similar to Wilken's (1987, p. 113) observations in Guatemala and in Mexico, terraces are constructed in order to achieve what he calls the "ultimate in slope management": completely flat surfaces on otherwise steep slopes, leading to better yields via increased water retention and minimal soil loss. However, upkeep and construction costs are high, due to labor, and often lead to neglect, demanding in some cases incentivization by organizations. The use of shallow contour lines (*curvas a nivel*)—at one point a symbol of the sustainable/low-input agriculture movement in Central America (Holt-Giménez 2006)—are also constructed in order to stabilize steep surfaces and manage irrigation in flatter areas.. Another important control measure is the use of barriers, which include rocks, piled up organic matter, rows of non-native vetiver grass (*Vetiveria* spp.), and native *izote* (*Yucca elephantipes*). These techniques, long promoted by organizations, are also recognized as ancestral methods currently in the process of revitalization. "These were activities we did as children," stated one elderly farmer, referring to the construction of dead barriers across milpa plots, to prevent erosion. "It was called *surún."*

For many if not most of the farmers in this study, soil conservation implies not only specific practices or control measures, yet is an outcome of management choices that prioritize agroecosystem health, with specific reference to organic material content, as well as traditional techniques for tilling and "cleaning" (weeding). The use of a hoe, or *azadón*, is a key symbolic and practical method for preserving or even improving soil structure, and reducing erosion. "When you clean a field with an *azadón*, there is humidity, and *hierbas* (edible native greens)," one farmer told us, claiming that he does not even use a pickaxe, because of the disturbance it causes. Another participant, eighty-eight-year-old Pedro Guamche, who has been farming the same sloping plot since he was a boy, explained that through the process of removing *monte* and "cleaning just below the plant, leaving the residue piled up as mulch," one might "ensure humidity and fertility… Every month [during the growing season] we clean the milpa, with an *azadón*; there is a ceremony for each part: *calzar, tapiscar*, and always with candles." In addition to the cultural significance, using an *azadon* is emblematic of the "good work" of their parents and grandparents, perceived as the opposite of machinery, herbicide, and burning. "Working with an *azadón* is five times slower than using *veneno*," or poison, another farmer told us. "But what comes easy, ends up more expensive… The soil gets ruined, and then must be recuperated."

While the tendency among agriculture experts has been to view these practices as archaic, or even backwards, we identify a system that demonstrates a high potential for reducing erosion and buffering drought—two key principles of "modern" soil conservation programs. As Hellin (2003) describes from his work with hillside farmers in neighboring Honduras, the logic of the traditional system is not to catch soil that will inevitably run downhill, due to topography and climate, but rather provide a substrate in which roots can penetrate and succeed in finding adequate nutrients, facilitated by high microbial activity. Consequently, the soil becomes resistant to erosion or rapid drying. Achí farmers build their protective "cushions" through intensive SOM management, and practice conservation through minimal or zero tillage, depending on plot characteristics and local ecology. Specific examples include a method reminiscent of shifting cultivation (see Pérez-García and Castillo 2016), which occurs in semi-forested plots where farmers direct seed using a dibble stick amidst fallen leaves and branches, and a heavy mulch layer. Other forms include building *surcos* after the removal of dried brush, which involves considerable disturbance to the upper soil horizon, though is generally shallow, given the nature and limitations of the *azadón*. Minimal weeding during the growth cycle, as well as leaving fresh mulch, as implied by Mr. Guamche, is deemed essential for drought resistance. On more than one occasion we were able to witness firsthand the effectiveness of leaving *monte* in place, as far as humidity retention during critically dry periods.

These observations run parallel to agroecological literature claiming that "[t]illed soils are usually drier, warmer, and more susceptible to erosion than their untilled counterparts" (Magdoff and Weil 2004, p. 56), and that reducing tillage permits "increased water infiltration" (p. 49). In addition, Bot and Benites (2005, p. 2) state that intensive and frequent tilling not only has a drying effect but impedes the critical formation of humus—the optimal state of SOM due to its water retention capacity and ability to "hold nutrients in a plant available form"—by negatively impacting microbial activity and the horizontal movement of beneficial organisms such as earthworms. Finally, Lampkin et al. (2015, p. 22) assert that minimum disturbance "allows for the development of mycorrhizal associations, which is normally curtailed through soil tillage and intensive application of agrochemicals." This last statement is particularly relevant, as potent herbicides (Paraquat) are increasingly used by farmers (though none in this study) as a time and labor-saving alternative to cleaning by hoe, or leaving *monte* largely intact. Yet, as described by Einbinder (2019) these techniques demonstrate notable and ultimately positive impacts on crops and soil ecology during drought.

Discussion

Throughout the previous section we examined the diverse soil management practices employed by Achi farmers. In our discussion section, we argue that these practices should be viewed in a systematic way that recognizes their history and complexity. By providing a characterization of introduced and ancestral practices we argue the different logics in which they operate: curative and preventative. We conclude by identifying where synergies are taking shape, and some ideas about how better knowledge dialogue might occur.

The ancestral practices recorded in this study are characterized by their complexity in terms of ecological function and emphasis on prevention and long-term processes. We also take note of explicit connections to local livelihoods and worldviews, which include a reverence for non-human life, and knowledge in how to integrate biodiversity into agricultural production. Examples of preventative ancestral soil management techniques include polycropping and low-impact tillage, which play an important and complex role in maintaining soil structure and reducing erosion. Also to consider is the entire ancestral process of recycling organic material to build SOM. As indicated by veteran soil scientists Magdoff and Weil (2004, p. 45): "Improving SOM management is, in essence, a preventative approach to agroecosystem health." Agroecologists Altieri and Nicholls (2005, p. 37) further support this theory by illustrating how practices that increase organic matter, and biodiversity—also an ancestral trait—will effectively "strengthen the immune system" of the agroecosystem, resulting not only in better maintained soil health yet also resilience to harmful insects and diseases (see also Morales and Perfecto 2000; Howard 1943).

To grasp the broader importance of ancestral practices, it is helpful to contemplate them as a system, and ideology, rather than independent technologies. Consider, for example, the *agricultura cero* (zero agriculture) method articulated by farmer Pedro Guamche and practiced by a handful of other mainly older participants. The concept involves the development of a permanent production site that, over time, requires "little intervention." Management is perceived as "complementary to natural processes," and consists of returning all organic matter back to the soil at precise moments in the growth and climatic cycles, as well as seasonal fallowing that maintains soil coverage and encourages underground biodiversity. Seeds are meticulously saved and reused; external inputs and amendments are limited. Knowledge, labor, and sufficient organic material are the key components—yet never far behind are the accompanying ceremonies and rituals. Activities, such as cleaning last year's brush (*botando guamil*), are marked by customary foods and beverages shared between neighbors and family members, as well as specific prayers "asking permission, and giving thanks" to Mother Earth. As stated by Guamche:

At the moment of the planting, I call out to the animals and birds: 'we are planting the food! Leave some for us!' This is a commitment. A custom of the *abuelos* (elders or ancestors)… Some people call me a *brujo* (witch), especially the youth. They think that farming is just a job; that it's only for the economy. But it is so much more. It's spirituality. It's a vital connection with nature.

With respect to techniques introduced over the past fifty years, we identify a tendency towards resolving problems, rather than preventing them. Examples of "curative" or "therapeutic"[2] introduced soil management practices include many erosion control techniques, as well as fertilization methods. While often "agroecological" in the sense that they utilize resources in a way that is environmentally benign or even restorative, these practices—along with the projects in which they arrive—tend to follow technical approaches that overlook long-term processes and the rich web of knowledge characteristic of traditional agricultural systems. Seeking "changes overnight," as one leader put it, organizations arrive with limited time and background knowledge, promoting and often incentivizing new crops and techniques, such as the Bocashi composting method, which, although highly regarded, is typically abandoned once the "*proyecto"* is completed. Similar observations include that of non-native green manures, once viewed as a "panacea" to declining soil fertility, yet increasingly disused (see Neill and Lee 2001). The problem, as pointed out in a related study by Hellin and López Ridaura (2016, p. 203), is not the techniques per se, which are undeniably effective, rather in how they do not "complement farmers' agro-ecological and socio-economic realities."

Despite the paternalism and inadequate extension methods which has resulted in high abandonment rates, along with resentment among local farmers, we acknowledge that newly introduced practices and crop varieties have made a large impact regionally and play an increasingly important role in local agroecological development. Aside from a small number of resistant farmers, most participants had at one time used and/or incorporated new soil management techniques, and many are eager to learn more. While displacement of ancestral practices and knowledge is a concern (see Einbinder and Morales 2019), we agree with Aldasoro (2012, p. 330) in that adoption of new techniques should not be assumed as "the death of the Indigenous cultures," nor "imply a passive response" by farmers. Processes of appropriation and adaptation are complex and have long played a role in the development and continuation of traditional agriculture. In our case we identify the potential for synergies between ancestral and newly introduced techniques, especially among farmers empowered to carry out their own experiments, as well as those seeking new ideas to confront problems such as recurring drought and severely degraded land. In one exemplary case, farmer Cristobal Osorio experimented with an array of new technologies (green manures, contour lines, and various methods for composting animal manures) to recuperate a plot deemed "infertile" after years of overgrazing and agrochemical use. "It was a ten-year process," he proclaimed, building soil structure and planting trees and shrubs, such as non-native gandul. Now, aside from maintaining the green manures, he has returned to ancestral practices in a way resembling Guamche's *agricultura cero*. As stated by Osorio:

My system is permanent. What does that mean? It means I do not have to put anything on the plant [fertilizer]. In the beginning I had to. But not anymore. Now I just prepare the *surcos,* [use] minimum tillage, and bring in the *organica* from the fence line.

We observed other examples in which techniques, such as terracing, are used in conjunction with native mulches and legume rotations. Practices such as composting with red worms are noted as increasingly assimilated into local farming systems as they fit into the ancestral worldview of "working with nature," as stated by one promoter. Finally, we mention the experimental designs taking shape in the community of Xesiguan, where imported agroforestry techniques, including coffee production, are combined with diversified milpa in areas where strictly "traditional" methods are no longer perceived to be viable, due to the risk of deforestation and unavoidable erosion on steep slopes (see

[2] See Kirschenmann (2003) for broader discussion on the topic of "therapeutic intervention".

Escalón 2019). With the goal to maintain or even intensify agricultural productivity along with reforesting the entire Xesiguan Watershed, promotors from the group ACPC effectively "pick and choose" techniques and crop varieties offered by external development groups. Yet, at the root of the project are ancestral values, wisdom, and commitment to working with Mother Nature, as well as maintaining local control, even if it means turning down potential funds by external groups and institutions (Einbinder and Morales 2020).

We assume that many more combinations of local and external practices and knowledge exist throughout the territory and are optimistic for the development of more beneficial synergies. Yet we also recognize the critical importance of greater farmer participation and control, as evidenced in the case of Xesiguan, as well as situations in which co-creation of knowledge is facilitated (see Jacobi et al. 2016, Mier y Terán et al. 2018). This will require continued restructuring of extension methods into those that emphasize horizontal exchange and take into account the immense value of locally developed practices, as demonstrated here. Ancestral practices should serve as a foundation when considering introductions, and extension agents and external program officers must attempt to engage with all aspects of the complex ancestral system. Peer to peer learning/teaching opportunities as outlined by Bunch (1982), Holt-Gimenez (1996), and Utter et al. (2021), which encourage experimentation and empowerment of farmers, would offer a strong step forward. Finally, project design and implementation should be carried out by local organizations and run by local people who inevitably understand the context and needs better than external groups.

Conclusion

In this study we present an analysis of agroecological soil management practices currently used by family farmers in the Achí territory. After half a century of external interventions that include the promotion of Green Revolution and organic techniques, as well as processes of exclusion and "epistemic violence" (Elias 2020), our study reveals that local practices continue to form part of a system that brings together ancestral knowledge, customs, and beliefs. Our research suggests a deep interconnectedness between practices and livelihoods, reinforcing the idea that techniques cannot be separated from worldviews as well as daily routines (Rist et al. 2011).

In addition, our work supports a process of validation and revalorization of traditional farming methods, with respect to their agroecological features and potential. We argue that sustainable practices are intricately connected to intact systems of local knowledge, which guides resource use; as well as the continued reverence for Mother Earth, a stated ancestral principle and key component in local perspectives of wellbeing, known as *utziil k'asleem* (Einbinder and Morales 2020). These observations run parallel to theories surrounding the connection between biocultural diversity and sustainability (Maffi 2007), and the vital importance for conserving—and learning from—"priority biocultural regions" (Boege 2008) or areas of "biocultural refugia" (Barthel et al. 2013), which, according to our observations, include the Achí territory.

Similarly, we consider the dynamism of Achí soil management with regards to the integration of new technologies, recognizing that "knowledge systems have always cross-fertilized and benefitted from each other and have rarely developed in isolation" (Tengö et al. 2014, p. 580). As expressed by numerous Achí leaders and farmers, novel tools and ideas will be necessary for traditional farming to continue given the weight of multiple crises, from land and water shortages to the latest difficulties caused by the global pandemic and economic fallout. Complex synergies that build on existing ancestral knowledge and experience, resulting in new contemporary knowledge that can be implemented by local farmers through horizontal methods, would offer a vehicle for bringing agroecology to scale.

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