

Food forests: Their services and sustainability

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Abstract

Industrialized food systems use unsustainable practices leading to climate change, natural resource depletion, economic disparities across the value chain, and detrimental impacts on public health. In contrast, alternative food solutions such as food forests have the potential to provide healthy food, sufficient livelihoods, environmental services, and spaces for recreation, education, and community building. This study compiles evidence from more than 200 food forests worldwide, with

detailed insights on 14 exemplary food forests in Europe, North America, and South America, gained through site visits and interviews. We present and illustrate the main services that food forests provide and assess their sustainability. The findings indicate that the majority of food forests perform well on social-cultural and environmental criteria by building capacity, providing food, enhancing biodiversity, and regenerating soil, among others. However, for broader impact, food forests need to go beyond the provision of social-cultural and environmental services and enhance their economic viability. There is a need for specific trainings and other measures targeting this deficit. This study appraises the current state of food forests and provides an orientation for food entrepreneurs, public officials, and activists to better understand food forests' potential for advancing sustainable food systems.

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Keywords

Food Forests, Forest Gardens, Food Economy, Food Entrepreneurship, Case Studies, Sustainability Assessment

Introduction

Large-scale industrial food system are characterized by unsustainable development, including land degradation, water contamination, climate change, negative health impacts, and unfair distribution of economic benefits (Garnett, 2011; International Assessment of Agricultural Knowledge, Science and Technology for Development [IAASTD], 2009; Swinburn et al., 2011; Tilman & Clark, 2014). Alternative food solutions such as food forests address these challenges in various local contexts. Food forests are multifunctional biodiverse agroforestry systems using several (3 to 7) plant layers of different height (strata), including trees, shrubs, and groundcover. They have the potential to provide food, livelihoods, environmental services (habitat, heat mitigation, carbon storage), and spaces for recreation, education, and community building. Many food forests exist for self-sufficiency, with little formal organization and recognition. Yet, in this study, we focus on food forests with impacts on the wider food economy.

Mimicking nature in food production is still common in indigenous and traditional agricultural production systems, especially in the tropics, and dates back 4,000 years (Belcher et al., 2005; Kumar & Nair, 2004). In Europe, the concept of 'forest gardens' emerged in the 1980s in Great Britain (Hart, 1996; Sholto Douglas & Hart, 1984). At about the same time, the permaculture movement started in Australia, with 'food forests' being a major outcome (Mollison, 1979; 1981), and professionalization efforts at larger scale (Shepard, 2013). There is little distinction in research and practice between 'forest gardens' and 'food forests.' Both are defined as multi-strata ecosystems using mostly edible, perennial plants. Following definitions of what a 'forest' is (Chazdon et al., 2016; Food and Agriculture Organization of the United Nations [FAO], 2000), it seems reasonable to define the minimum size of a food forest as 1 acre (0.5ha) and at least 10% canopy cover to provide forest-like ecosystem services. However, in this study we do not apply this definition strictly and instead use the term 'food forest' as a synonym for both forest gardens and food forests, so as to not exclude interesting cases of smaller size. The practice of forest *farming*, i.e., growing edible or medicinal

plants in existing forests or forest management for the purpose of food production, is *not* included in this study.

Food forests adopt basic principles of *agroforestry* that improve water cycle and soil formation, store carbon, regulate the microclimate, increase biodiversity, and create livelihood opportunities (Jose, 2009; Toensmeier, 2017). In Brazil, 'syntropic farming' or 'successional agroforestry' developed as a biodiverse multistrata design and management approach (Götsch, 1992) with high yield and ecological restoration potential (Schulz et al., 1994; Young, 2017).

Unlike agroforestry at large, specific research on food forests is still at a nascent stage. Recent research compiled practical knowledge on different types of food forests (Bukowski & Munsell, 2018; Remiarz, 2017), their cultural transformation (Wartman et al., 2018), their nutritional benefits (Nytofte & Henriksen, 2019), and their ecological restoration potential (Park & Higgs, 2018). Common are single case studies and a focus on the social and ecological impacts of food forests (Hammarsten et al., 2019; Knuijt, 2020; Riolo, 2019; Schafer et al., 2019). Recent research also considers urban forestry, an internationally established planning and management practice for public spaces, as a potential scaling opportunity for (community) food forests (Koniijnendijk & Park; Vannozzi Brito & Borelli, 2020). Very few of these studies consider the economic dimension, which is necessary for a *comprehensive* sustainability solution (Schaltegger & Wagner, 2011).

A systematic knowledge base about food forests that comprehensively maps out the state of food forests is still missing. The present study intends to close this gap and open the field more widely by addressing the following research questions:

1. What are the general characteristics (location, size, age since its founding, services) of food forests?
2. How are food forests organized and managed?
3. To what extent are food forests *sustainable*, as measured against a broad set of criteria?

This research aligns with the approach of solution-oriented sustainability research that aims at developing evidence-supported solutions to sustainability problems (Miller et al., 2014; Wiek & Lang, 2016). We used a mixed-methodology approach to answer the research questions, combining literature and document review, interviews, and site visits (data collected in 2018). We reviewed more than 200 food forests and conducted in-depth case studies on a sample (14) of exemplary food forests in Europe, North America, and South America. The focus was on food forests that pursue social, environmental, *and* economic activities, going beyond self-sufficiency. The study might inform the work of food entrepreneurs, public officials, activists, and researchers interested in building upon current food forest practices from around the world. The insights on food forests' service diversity and sustainability can help realizing the full potential of food forests to advance sustainable food systems.

Research Design

First, we conducted a web-based search in English ("food forest," "forest garden") and German ("Waldgarten"), and did snowball sampling, and identified 209 food forests with activities that go beyond self-sufficiency. Networks and research initiatives in the U.S. and U.K. like the Agroforestry Research Trust and Bukowski (2015) provided larger lists of sites and contributed to 45% of the overall sample. For each food forest, we created a standardized profile with up to three main services and other relevant information, including location, size, etc. Not all relevant data were available for all food forests, e.g., size or age. For some cases with information gaps, we were able to estimate plot size through Google Maps measurements and photos of the site.

Second, we selected 14 exemplary food forests for in-depth case studies. Selection criteria included primarily age and main service (see Table 2, below) and secondarily location and access to primary data through site visits. We identified the main services by standardizing the most common activities carried out at each food forest such as generating

regular income through food-forest related workshops (main service: education), hosting regular community events (main service: community building), or selling food from on-site production (main service: food production). Environmental services, especially plant biodiversity, are inherent to food forests, hence, this was only tracked for explicit major services (e.g., flood protection). In addition to a wide spectrum of services, we covered in the sample of case studies different age groups to provide insights on the diverse practices of early pioneers and later adopters. We conducted semi-structured interviews and site visits that focused on the food forest's organization, management, and implementation process.

Third, each of the 14 exemplary food forest was assessed against a set of sustainability criteria (Table 1) identified from the literature on sustainability (Gibson, 2006), agroforestry and food forests (Jose, 2009; Park & Higgs, 2018), as well as expert interviews. Scorecards (see Table 3, below) indicate criteria fully (2), somewhat (1), or not (0) met.

Results

1. Food Forest Location, Size, Age, and Services

The food forests in the overall sample ($n=209$)¹ are located in 19 countries (Figure 1), predominately in the U.S. (86) and Europe (96). About 50% are in rural areas, 30% in large cities and metropolitan areas ($>0.5M$ inhabitants), and 20% in small to medium-sized cities (50,000-0.5M inhabitants). According to the available data ($n=129$), food forests are managed by nonprofit organizations (46%), conventional businesses (31%), social enterprises or cooperatives (7%), foundations or land trusts (3%), or public institutions like universities (2%).

According to the available data ($n=78$), the average food forest plot size is 4.7 acres (1.9 ha), with 50% of food forests being less than 1 acre (Figure 2).

While a few food forests started back in the 1970s (e.g., Langerhorst in Austria), many early adopters began in the 1990s (Figure 3). Starting in 2004, food forest start-ups steadily increased, with

¹ All data refer to the year 2018, if not indicated differently. Sample sizes vary due to data availability.

Table 1. Sustainability Criteria for Food Forests

	Criteria	Definition
Social-Cultural Criteria	Meaningful, safe employment and activities with social purpose	<ul style="list-style-type: none"> • Workplace with protective gear, diverse work activities, precautionary measures • Activities for community benefit, social justice, environmental regeneration
	Contribution to community wellbeing	<ul style="list-style-type: none"> • Affordable and healthy products and services, i.e., regional, seasonal, fresh food, and/or inclusive activities (e.g., for school kids, seniors, minority groups)
	Capacity building	<ul style="list-style-type: none"> • Learning activities for cognitive, normative, affective, and motoric development
Environmental Criteria	Water conservation and soil formation	<ul style="list-style-type: none"> • Measures for water conservation (e.g., drip irrigation, rainwater harvesting) and soil formation (e.g., chop-and-drop, mulching, Terra Preta)
	Cool microclimate	<ul style="list-style-type: none"> • Cooling and shading measures, e.g., dense, multi-strata design with high canopy cover and ground cover, surrounded by green infrastructure
	High biodiversity	<ul style="list-style-type: none"> • High species diversity and cultivation of rare varieties (flora), undisturbed areas for fauna, connection to green corridors
Economic Criteria	Economic viability	<ul style="list-style-type: none"> • Sustaining livelihoods of staff by providing fair wages (for at least one part-time position) and covering operating costs
	Formalized organization	<ul style="list-style-type: none"> • Reliability and foresight, for example, through having a site plan, tracking yields, bookkeeping, registered organization, related professional background
	Shared ownership and decision-making	<ul style="list-style-type: none"> • Institutionalized cooperative principles for shared and long-term ownership and decision-making, e.g. employee-owned business or foundation-based business

a peak of 19 food forests started in 2014.

Food forests offer a variety of services: they produce food (primary production, processing, nurseries), regulate and support the environment, and provide social-cultural services (community building, education, recreation). The majority of sampled food forests ($n=209$) focuses on education (40%), community building (32%), or food production (11%), often on larger sites (Figure 4). Few cases (<10%) prioritize self-sufficiency (while still offering other services), recreation, food processing, or environmental services, or serve as nurseries.

In summary, the sampled food forests are predominantly located in the U.S. and in Europe, with equal distribution across rural and urban areas. They are managed mostly by nonprofit organiza-

Figure 1. Geographical Distribution of Food Forest Sample ($n=209$)

Map created with Leaflet.

tions or run as conventional businesses. The number of annual food forest start-ups has been constant for many decades (<5), but has been increasing since the mid-2000s, with more than 10 start-ups in most years of the past decade. The majority of food forests focuses on providing educational or community-building services, with only about 10% of food forests prioritizing food production.

Figure 2. Distribution of Small, Medium, and Large Food Forests (n=78)

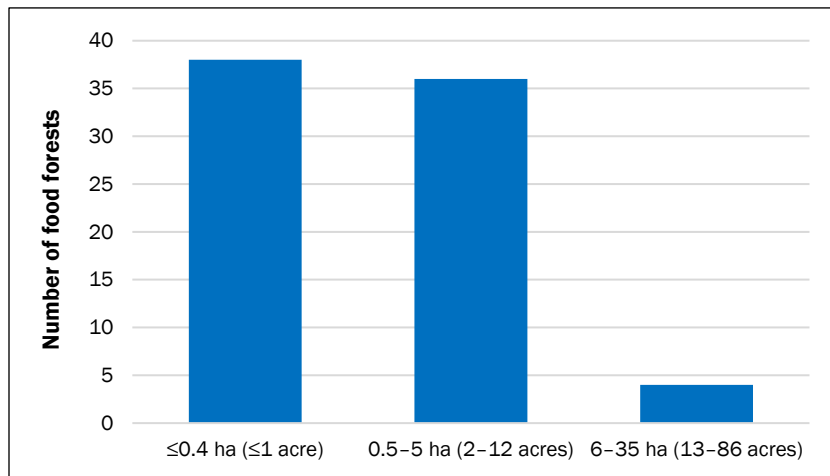


Figure 3. Number of Food Forest Started by Year, 1971–2017 (n=155)

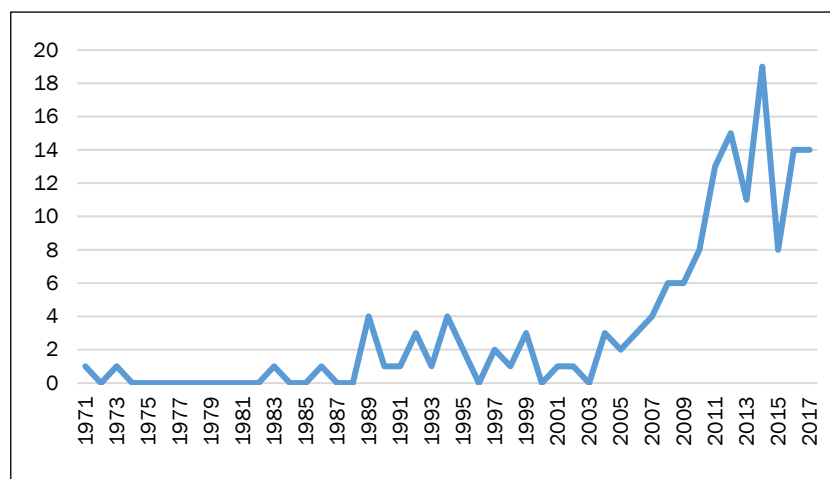
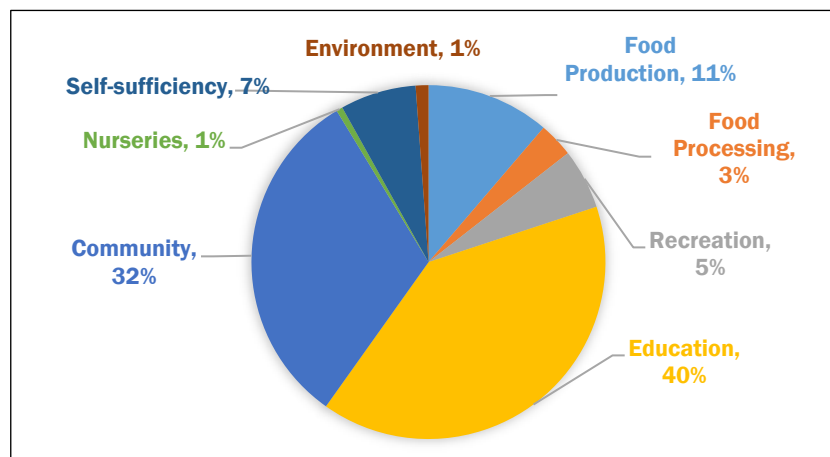


Figure 4. Main Services of Food Forests (n=209)



2. Exemplary Food Forests for Each Service

The exemplary food forests selected for in-depth analysis and showcasing ($n=14$; Table 2) represent all services mentioned above. Below, we provide descriptions of exemplary food forests for each service, detailing location, size, products and services, ownership, staff, and management.

Food Production Services

Primary Production. Food forests in this category produce herbs, vegetables, fruits, and nuts. They sell their produce through diverse channels from community supported agriculture (CSA), food box or u-pick schemes, and onsite and market sales (B2C) to cooperation with local food businesses (B2B).

Foodforest Ketelsbroek operates on 6 acres (2.4 ha) and markets its produce directly to three local businesses (gastronomy, catering service, and cider brewery) that participate in weekly harvestings. Two private owners have run the food forest in a nature-regulated approach since 2009. The design, inspired by agroforestry and food-forest pioneer Martin Crawford and farmers in Kenya, is partly “rational” in rows, partly “romantic” with high biodiversity (W. van Eck, personal communication, July 12, 2018). Input is very low, following the guideline “we must make ourselves become useless” (W. van Eck, personal communication, July 12, 2018), and consists mostly of harvesting and

minimal agro-ecological interventions. Produce derives mainly from tree layers (fruits, herbal plants, edible flowers) and provides for one part-time position. According to the farmer, yield increases slowly, but the land seems more profitable than the neighboring conventional farm. Consultation and workshops are the main income source (W. van Eck, personal communication, July 12, 2018). In 2017, 1,200 visitors received a guided tour.

Ökohof Waldgarten (Eco-Farm Food Forest) operates on 12 acres (5 ha) and was started in 2006 by a private owner planting chestnuts, soon thereafter also producing annual vegetables for market sales. The farm has run a community supported agriculture (CSA) operation since 2012 that currently delivers about 120 food boxes per week (20% fruits, 80% vegetables) to its 200 members. The site includes an older 5-acre (2 ha) dome food forest, and a 7.4-acre (3 ha) vegetable garden (*Demeter*-certified), which successively changes into an agroforestry system. The lead gardener-owner, three gardeners, two trainees (all full-time), and two part-time staff manage the farm. In the growing seasons, the CSA members participate in co-working days.

Den Food Bosch has operated on 2.5 acres (1 ha) since 2017, with an intricate food forest

design inspired by permaculture and syntropic farming to harvest on all layers. Produce is sold weekly on-site. Additional sales channels and processing options are currently under development. Den Food Bosch resulted from a student initiative, received public funding, and is steered by a foundation that contracts two managers who are responsible for generating their income. The local water authority owns the land.

Smaller food forests focusing on primary production are often part of a larger farm or network using direct-sales channels to restaurants or local markets. For example, the Rotterdam Forest Garden Network initiated 10 sites that produce food for market sales (in 2020, the network reorganized and sites are now managed by the Cooperative Ondergrond).

Processing. Food processing is rarely the main activity of food forests. It is more common as an educational activity or for catering to workshop participants. Ownership of the few food forests prioritizing processing is mostly private, the workforce is small (four employees, on average), and common distribution channels are on-site gastronomy or direct sales.

Fazenda Ouro Fino operates on 62 acres (25 ha) and processes high-value crops like açaí

Table 2. Overview of 14 Exemplary Food Forests (Two Main Services Indicated per Case)

		Young Cases (<5 years)	Established Cases (5–10 years)	Mature Cases (>10 years)
Food Production Services	Primary Production	W. C. L. (USA) Den Food Bosch (NL) The Secret Garden (NL)	Foodforest Ketelsbroek (NL) Voedselbos Kralingen (NL)	Ökohof Waldgarten (GER)
	Processing		Castle Garden (UK) Cafe Botanico (DE)	Fazenda Ouro Fino (BRA) Hotel Haferland (GER)
	Nursery		Mienbacher Waldgarten (GER)	
Social-Cultural Services	Community Building	Peace of Land (GER) The Secret Garden (NL)	Voedselbos Kralingen (NL)	
	Education	Peace of Land (GER) Keela Yoga Farm (PRT)	Castle Garden (UK) Cafe Botanico (GER) Mienbacher Waldgarten (GER)	Fazenda Ouro Fino (BRA) Essgarten (GER)
	Recreation	Keela Yoga Farm (PRT)		Essgarten (GER) Hotel Haferland (GER)
Environmental Services	Supportive		Foodforest Ketelsbroek (NL)	Ökohof Waldgarten (GER)
	Regulative	W. C. L. (USA)		

(puree) and cacao (fermenting) for sale at the local market and international distribution. The privately owned site produces a dozen food crops and offers educational trainings. As a neighbor and partner of agroforestry pioneer Ernst Götsch, the site contributes to the development of syntropic farming.

Café Botanico (0.5 ac; 0.2 ha) and Castle Garden (0.12 ac; 0.04 ha) process specialty crops that are sold at on-site cafés. While Café Botanico builds its dishes around the on-site food and limits its sales to yield availability, Castle Garden Café adds mostly preserves and teas from the site to a broader menu. Both businesses have high staff costs and are cross-financed by the owner(s) through a second job or a second business.

Nursery. Nursery services are informally present at many sites either for a small income or to propagate plants for other sites. Some use them formally to generate an income, although mostly on a very small scale; for example, Mienbacher Waldgarten (3.7ac; 1.5ha) sells plants and seeds online. Several professional nurseries connected to food forests exist; for example, the Balkan Ecology Project in Bulgaria offers polyculture plants, exotic varieties, and multilayer packages (Remiarz, 2017), and Forest Agriculture Enterprises in the U.S. offers wholesale.

Social-Cultural Services

Community Building. Community-oriented food forests are usually located in urban areas, often on public land, and are managed through a core (member) group with support from volunteers. A prominent example is the Beacon Food Forest (7ac, 2.8ha) in Seattle, Washington, U.S. (Bukowski & Munsell, 2018). At Peace of Land (0.1ac; 0.04ha), core members from across the city meet for weekly gardening activities and offer educational workshops to educate both their core group as well as others who are interested. At The Secret Garden (0.1ac; 0.04ha), one trained volunteer maintains the site for a retirement home and a school.

Education, Consultation, Research. Educational food forests are located in urban and rural areas. They offer tours, workshops, courses, and

programs from day- to year-long, about permaculture, food forestry, and related specialty topics (e.g., grafting). Educational offerings often help with the setup of a food forest through volunteer labor and provide a source of income. Mienbacher Waldgarten has specialized in self-sufficiency education since 2010. One full-time manager and other trainers use the food forest and its seminar house. The site also contributes to the food self-sufficiency of the manager's family and the property owners' families. Some food forests generate revenue by consulting on the design and management of food forests, including permaculture, regenerative agroforestry, holistic management, and syntropic farming. Only a few food forests engage in substantial research in collaboration with research organizations and universities; examples include Bec Hellouin in France, collaborating with Agro-ParisTech, the French National Agronomy Research Institute, and the Free University of Brussels (Dendoncker et al., 2017; Morel et al., 2016).

Recreation. Some food forests offer aesthetic and recreational value through their multilayered design, cool microclimate, high biodiversity, medicinal plants, and fresh food, as well as opportunities for foraging, relaxation, and discovery. Aesthetics and ecological benefits may require guidance, e.g., through signage about wildlife or insect-friendly practices. The food forest of Hotel Haferland (0.5 ac; 0.2 ha) has a seating area for relaxation, enjoyment, and contemplation. A hotel janitor manages the site, and the restaurant's chefs harvest from it. The professional design requires little maintenance. The site is too small for significant food production but offers aesthetical value. Another example is Keela Yoga Farm (2% of 46 ac; 19 ha) that offers yoga retreats combined with a tour of the food forest.

Environmental Services

Supportive. Many interviewees expressed concerns about the degraded soil and biodiversity loss associated with conventional agriculture and pointed to the regeneration of nature (and human health) as a major motivation for implementing their food forest. Foodforest Ketelsbroek limits

access for visitors to reduce disturbance. The manager also regenerates soil in a slow, *laissez-faire* approach with a naturally occurring groundcover. Fazenda Ouro Fino does “chop-and-drop” management to increase biomass, soil building, and early yields. While Fazenda Ouro Fino manages around 20 species/ha, Foodforest Ketelsbroek manages around 200 species/ha. Plant biodiversity is often high in social-culturally focused food forests. Essgarten (6 ac; 2.5 ha) offers habitat to around 1,200 species.

Regulative. Keela Yoga Farm, for example, manages its food forest with chicken and sheep for fire protection. In semi-arid Arizona, U.S., the new food forest of W. C. L. (2.5 ac; 1 ha) aims at cooling the microclimate while producing food.

3. Sustainability of Food Forests

Assessing each food forest by social, environmental, and economic criteria indicates their sustainability and highlights areas for improvement (Table 3). Scores indicate that criteria are fully (2), somewhat (1), or not (0) met.

Overall, the assessment shows that food forests perform well on social-cultural and environmental criteria by offering benefits such as educational attainment, community happiness, high biodiversity, healthy soil, and resourceful water management. However, economical practices and structures tend to be unsustainable. Ownership and decision-making are often in private hands or instable due to insecure tenures. Few have business and financing plans. Young (<5 years old) food forests tend to receive a lower score due to being less developed ecologically and economically. Most food forests perform higher in the areas related to their main services.

In Table 3, we provide general insights on each assessment criterion across all 14 cases.

Social-Cultural Criteria A – Meaningful, Safe Employment and Activities with Social Purpose

All food forests in this study (14 of 14) offer work activities with meaningful outputs like ecological regeneration, quality food production, and nature-based education. Food foresters are motivated by regenerating the land and people’s health. They

enjoy the diversity of tasks and often develop strong emotional connections to the food forest. However, many food foresters experience high stress levels at times, due to the diverse activities, lack of qualified staff, or financial insecurity during initialization.

Social-Cultural Criteria B – Contributing to Community Wellbeing

Almost all food forests (13 of 14) offer affordable food products or educational services. For example, Mienbacher Waldgarten provides food education in a rural neighborhood to adults and children, donates food surplus, and is engaged in setting up a community garden in the nearby town. Young food forests attract specific user communities and struggle with wider uptake. For example, the Rotterdam Forest Garden Network aims at connecting a school and a retirement home at The Secret Garden. With little activity from the partners, a volunteer maintains the site for the retirement home. The site acts as an investment for plant propagation, food sales, and display.

Social-Cultural Criteria C – Capacity Building

Almost all food forests (13 of 14) offer various learning activities on food production and ecology to guests, students, and co-workers. Offerings depend on the land management approach (nature- vs. human-regulated). The depth and quality of the offerings depend on the length of stay, expertise of the trainer, and content focus; for example, tours facilitate basic understanding of food forests, while workshops facilitate experiential learning and skill development. Structured educational programs vary significantly in duration, ranging from the more common 1 to 2 weeks (e.g., Mienbacher Waldgarten) or, less often, 1 month (Keela Yoga Farm) to, exceptionally, 2 years (Fazenda Ouro Fino).

Environmental D – Water Conservation and Soil Formation

Mulching is a common management practice at all food forests to build soil and conserve water. Several food forests irrigate lightly, and some integrate rainwater harvesting. Only one site with major annual vegetable production has high irrigation needs

Table 3. Overview of Sustainability Assessment of 14 Food Forests by Social-Cultural, Environmental, and Economic Criteria

Food forests are listed in alphabetical order, scores indicate that criteria are Fully (2), Somewhat (1), or Not (0) Met

Food Forest Cases	Social-Cultural criteria			Environmental criteria			Economic criteria			Average Score
	A. Meaningful, Safe Employment	B. Contribution to Community Wellbeing	C. Capacity Building	D. Water Conservation and Soil Formation	E. Cool Micro-climate	F. High Biodiversity	G. Economic Viability	H. Formalized Organization	I. Shared Ownership and Decision-Making	
Castle Climbing	2 – Four part-time staff, shared responsibility	2 – Educating especially the climbing community	2 – Educational, experiential events	2 – Substantial rainwater harvesting and composting	0 – Micro-site	1 – Micro-site	1 – Subsidized by climbing center	2 – Yield report, automated volunteer system	2 – Employee-owned company	1.6
Den Food Bosch	1 – Two managers, high stress (start-up)	2 – Regional, affordable food supply, test site	2 – Research, volunteering, tours, consultation	2 – Mulch, chop and drop, biomass plants	1 – Young site, high layer diversity	2 – High species diversity, rare varieties, green corridors	0 – Micro-income for two full-time managers	2 – Foundation, evidence-based site plan, yield record	1 – Foundation board, land leased	1.4
Essgarten	2 – Balance to main job, investment for pension	2 – Affordable food and education	2 – Short holistic education, events	1 – On-site well and lake, no special soil management	2 – Mature site	2 – Over 1,200 species	2 – Diversified income	2 – Registered gastronomy business	0 – Private ownership and decision-making	1.7
Fazenda Ouro Fino	2 – Family, diverse activities (mature)	2 – Diverse products and education	2 – Short and long-term holistic education	2 – Low irrigation, chop and drop, biomass plants	2 – Large mature site	2 – High species diversity, rare flora and fauna	2 – Sustained family livelihood, diversified income	1 – Registered agricultural business, no economic analysis	1 – Family business, informal democratic principles	1.8
Hotel Haferland	1 – Partly seasonal contracts	0 – Exclusive experience for hotel guests	0 – No tours (lack of staff)	1 – Water sprinkler irrigation, composting	1 – Mature, small site	2 – High species diversity, rare varieties	1 – Contributes to hotel marketing	1 – Hotel business, no yield records	0 – Private ownership and decision making	0.8
Keela Yoga Farm	1 – Two owners, diverse activities, high stress (start-up)	2 – In-depth affordable education, local bartering	2 – Long-term, hands-on education, volunteering	2 – Sparsely used pipe and flood irrigation, (pond, well)	0 – Small part developed, very arid	2 – High species diversity, rare varieties	1 – Yoga retreat and work abroad income	2 – Registered agricultural business, documented site plan	0 – Private ownership and decision making	1.3
Foodforest Ketelsbroek	2 – Two owners, low stress and work input, high local demand	2 – Regional food supply (B2B), school garden	2 – Tours, seminars, research, co-harvesting	2 – Connection to waterways, pond, slow natural regeneration	2 – Mature site	2 – High species diversity, rare varieties, undisturbed areas	2 – One full-time position, low input and cost	1 – Registered agricultural business, rough yield figures	0 – Private ownership and decision making	1.7
Mienbacher Waldgarten	2 – One manager, diverse activities	2 – Gifts surplus food, community-engaged	2 – Self-sufficiency education with external experts	1 – High irrigation in dry years (well), partly low humus	2 – Mature site	2 – High species diversity, rare varieties, undisturbed areas	2 – Seminars finance 1 manager and co-educators	2 – Registered business, documenting activities	0 – Private ownership (1 year lease by manager)	1.7

Food Forest Cases	Social-Cultural criteria			Environmental criteria			Economic criteria			Average Score
	A. Meaningful, Safe Employment	B. Contribution to Community Wellbeing	C. Capacity Building	D. Water Conservation and Soil Formation	E. Cool Micro-climate	F. High Biodiversity	G. Economic Viability	H. Formalized Organization	I. Shared Ownership and Decision-Making	
Ökohof Waldgarten	2 – CSA for more than 120 households, partly stressful	2 – Regional food at solidarity pricing	2 – Experiential co-working, farm updates and events, politically active farmer	0 – High irrigation and fertilizer needs for annuals (80% of land)	1 – Partly cool in tree-canopy dense area	1 – Mostly classic varieties, propagates rare vegetables varieties	2 – Sustains the livelihood of at least 8 people	2 – Registered agricultural business, informal, self-organized CSA	1 – Private ownership (farmer), yearly plenary meetings	1.4
Peace of Land	2 – Mostly volunteers, community-oriented, high self-learning motivation	2 – Affordable workshops	2 – Diverse experiential and cognitive inputs, social events, volunteering	1 – Poor urban soil, mulch, regular irrigating	0 – Young micro-site	1 – Micro-site	1 – Start-up funding incl. staff, insecure long-term funding	1 – Trusteeship of permaculture institute (lease taker)	1 – High tenure insecurity (yearly lease); low-hierarchy organization (sociocracy)	1.2
Permakulturgarten Botanico	1 – Staff partly aware of or interested in sustainability	2 – Local food (urban core)	2 – Tours, food experience	2 – Low irrigation, dense ground cover, compost from busy café	1 – Small site, green oasis in urban center	2 – High diversity in ground cover	0 – Fluctuating customers, high staff cost, subsidized by owner	2 – Registered restaurant business, comprehensive calculations	0 – Private ownership and decision-making, tenure insecurity	1.4
Voedselbos Kralingen	1 – Occasional volunteers	1 – Display site, some complaints about messy look	1 – Volunteering, occasional tours or events, few signs	2 – No watering, slow natural regeneration	1 – Small site, dense canopy	2 – High species diversity	1 – Low income, low costs	2 – Network, formal agreement with local government	1 – Informal decision-making along pragmatic principles	1.3
The Secret Garden	2 – One trained volunteer, maintains elderly home garden	1 – Aesthetic, failed to connect school and elderly home	2 – Trained volunteer, education and co-working offers	2 – No irrigation, mulching	0 – Micro-site	1 – Micro-site	2 – Low costs, income investment	1 – Network, informal agreements	0 – No lease, informal decision-making	1.2
W. C. L.	1 – One owner with strong vision, high stress (“survivalist”)	1 – Community vision	1 – Educates WWOOFers, silence in nature to reconnect to self	2 – Mulching, earthwork for passive rainwater harvesting	0 – Small part developed, very arid	1 – Very small part developed	0 – No income, very low cost	0 – Informal, no site or business plan—trial and error approach	0 – Private ownership and decision-making	0.7
Average	1.5	1.6	2	1.8	1	1.6	1.2	1.5	0.5	

and observes soil degradation. Syntropic sites like Den Food Bosch use strata and succession-based management for efficient water storage and biomass production.

Environmental E – Cool Micro-Climate

The majority of food forests (10 of 14) are very small or too young to yield significant cooling effects. Ten food forests are large, mature sites or connect to other green infrastructure. Due to dense canopy covers, they contribute to cooler microclimates.

Environmental F – High Biodiversity

The majority of food forests (9 of 14) shows a very high plant species diversity. In addition to traditional species, most food forests include diverse rare and specialty crops, often from other regions with similar climatic conditions. Climate change resilience and curiosity about specialty foods motivates these plant choices. Some food forests support high genetic diversity and have areas reserved for wildlife only.

Economic G – Economic Viability

The weak point of many food forests (8 of 14) is economic viability. While many food forests develop site plans, very few use financing plans and business plans due to a lack of experience or interest, or resistance to conventional business practices. For example, Ökohof Waldgarten, while envisioned as a food forest business, was implemented without a business plan or training (e.g., planted seeds for chestnut trees that do not carry edible fruits), and now generates most of its income from annual vegetables.

For many, idealism acts like an alternative currency: a natural lifestyle and resistance to conventional food production compensate for economic burdens. Common income sources are fees (tours, workshops and consultation) and grants, especially for young sites. Small food forests with on-site gastronomy primarily provide an aesthetic service, and their owners subsidize them. Large and mature food forests are economically viable with diversified income sources or a few high-selling products or services (e.g., Essgarten, Foodforest Ketelsbroek, and Fazenda Ouro Fino).

Economic H – Formalized Organization

Almost all food forests (13 of 14) are run through a registered association or a business. Few practitioners, however, track yields and do full bookkeeping. Younger food forests design a site plan. Design and management techniques differ, building on British forest gardening, Australian permaculture, Swiss-Brazilian syntropic farming, farming practices from Kenya, and Indigenous food systems in Brazil. Apart from Permaculture Design Certificate and Permaculture Teacher Certificate for general design principles, there is no certified food forest education. Accordingly, food foresters have diverse educational backgrounds, often in creative or social professions. The managers of four food forests—all focused on food services—have professional backgrounds in agriculture, forestry, or landscape architecture.

Economic I – Shared Ownership and Decision-Making

The majority of food forests (9 of 14) are in private ownership. Often, one person manages the site and has exclusive decision-making power. A few food forests, like Den Food Bosch or Castle Garden, formed a foundation or employee-owned business with a board for collective decision-making. About half of the food forests face lease insecurity, with short-term leases on private or public land.

Discussion

Services of Food Forests

Food forests are often part of multifunctional spaces and organizational hybrids with diverse services, products, and other income sources. Apart from producing food, all of them offer social-cultural and/or environmental services. The large majority of the food forests in the full sample ($n=209$) are small and focus on education and community building (70%), while only a few pursue food production on a substantive level (11%). Still fewer cases (<5%) prioritize food processing or serving as a nursery. The focus on social-cultural services reflects the community gardening trend (Bukowski & Munsell, 2018) and the social-cultural background of many food forest initiators. For developing food forests as food businesses, practi-

tioners often have insufficient farming or market gardening experience, specialty crop knowledge, and entrepreneurial training. Guidance on efficient design and management techniques like syntropic farming or restoration agriculture was not widely available (in English) until recently (Giezen, 2018; Shepard, 2013). To harness the food production potential of food forests and contribute to wider food system change, specific training and research on food forests should to be offered and conducted more broadly.

Sustainability of Food Forests

Food forests contribute to a diverse food system with perennial crops and experiential educational and recreational offerings around food and ecology. Many perform well on social-ecological criteria but display weaknesses on economic criteria. As 30% of the food forests studied in-depth are young (<5 years), their economic viability may still be developing. They could learn from mature food forests that diversified their product range or focused on a few main products or services. Weak economic viability—common in many permaculture farms—may also be overcome by monetarizing the value of ecosystem services and receiving adequate compensation (Fiebrig et al., 2020). However, such compensation policies to date focus on agro-industrial sites; this poses a structural barrier to the economic viability of agro-ecological solutions such as food forests (Fernandez et al., 2013; Smith et al., 2012).

Generally, the pursuit of cooperative ownership models may address several sustainability challenges, such as work overload, high land prices, limited start-up funds, and late return on investment. Initiated collectively, a group (and community) could invest into setup and management, share specialty knowledge, value individual net benefits, and promote self-governing practices (Bukowski & Munsell, 2018; Poteete et al., 2010). Collective ownership models such as cooperatives, land trusts, or foundations may also help accessing larger land parcels to increase food production potential. Generally, for wider agroforestry uptake, a “cognitive unlocking process” might help with adopting holistic agro-ecological practices rather than following the dominant reductionist paradigm

towards agriculture (Louah et al., 2017). This calls again for specific training and research to be offered in vocational schools, colleges, and universities. Interestingly, for all sustainability gaps identified at individual food forests, we found solutions at other sites—which points to an even larger cooperation potential.

Study Limitations


The presented findings cannot simply be extended to all food forests worldwide due to a number of factors. First, while the overall pool of 209 food forests analyzed is large (the most extensive pool analyzed to date), it is somewhat biased. First, the pool (and subsequently the sample of 14 exemplary food forests) draws mostly on sites in Europe, North America, and South America. This regional bias is due to the search language (English), the general search engines used (DuckDuckGo, Google), and the researchers consulted (inventories). For example, few Australian and New Zealand food forests came up in the general online search, although the permaculture movement that contributed to food forest designs started there (Mollison, 1979, 1981) and country-specific online searches yielded a number of sites. Additionally, a search in Portuguese and Spanish yielded some potentially relevant cases. Finally, some renowned food forests did not respond to our interview request.

Beyond the sampling, the study displays other limitations. There were some relevant data gaps for many food forests due to a lack of data collection capacity or due to nondisclosure of data. In addition, the presented assessment offers initial results for a moderately sized sample ($n=14$) with a broad criteria set, which could be further specified for in-depth research. For a full assessment, longer monitoring periods of outputs and outcomes at each site are necessary (Park & Higgs, 2018). And for higher validity, more cases would need to be studied in detail and included in comparative studies.

Conclusions

Food forests differ in what main services they offer and how sustainable they are. For the main services, there is a focus on social-cultural services (education, community building) and less on food

production. Food forests often perform well on social-cultural and environmental criteria, while displaying weaknesses in economic ones, especially regarding economic viability and sustainable business model innovation. Yet, best practices can be found across the cases, e.g., for inclusive ownership through cooperative, land trust, and foundation models. Advances in specific food forest education (farming, business practices) and the transfer of best practices across food forests are necessary to harness the full potential of this multifunctional

sustainability solution. While this study offers a broad exploratory overview, there are several limitations calling for additional research to validate these findings and allow for wider applicability. 

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