Dissertation

Developing sustainable food forests

Key Features, Success Factors, and Transdisciplinary Partnerships

Submitted by

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Born November 18th, 1985 in Rostock, Germany

In fulfilment of the requirements for the degree

Doctor of Philosophy (Dr. Phil.)

to

The Faculty of Sustainability Science of

Leuphana University Lüneburg

Submitted on: October 14, 2021

Revised German abstract: May 2, 2022

Doctoral advisor and reviewer: Prof. Dr. Arnim Wiek

Doctoral advisor and reviewer: Prof. Dr. Daniel J. Lang

Reviewer: Prof. Dr. Matthias Barth

Included Research Articles

This cumulative dissertation includes the following four research articles. One of these is the version as published by the journals.

Albrecht, S. & Wiek, A. (2021). Food Forests – Their Services and Sustainability. *Journal of Agriculture, Food Systems and Community Development*. *10 (3), 91–105. DOI: 10.5304/jafscd.2021.103.014.*

Albrecht, S. & Wiek, A. (2021, in press). Implementing Sustainable Food Forests – Extracting Success Factors Through a Cross-Case Comparison. *Journal of Agriculture, Food Systems and Community Development*.

Wiek, A. & Albrecht, S. (2021, under minor revision). "Almost there" – on the importance of a comprehensive entrepreneurial ecosystem for developing sustainable urban food forest enterprises. *Urban Agriculture & Regional Food Systems.*

Albrecht, S., Wiek, A. & Friedel, A. (2021, submitted). Transdisciplinary Partnerships for Developing Sustainable Food Forests. *GAIA.*

Acknowledgements

My PhD project was part of the graduate program "Processes of Sustainability Transformation", a collaboration of the Robert Bosch Foundation and Leuphana University Lüneburg. I would like to acknowledge the Robert Bosch Foundation and the Graduate School of Leuphana University for their financial support in conducting this research for 3,5 years.

Firstly, I want to thank my supervisor Arnim Wiek for living a paradigm shift of collaborative mentorship that is beyond status-quo supervision. Engaging in complex, transdisciplinary and action-oriented projects requires senior guidance and engagement to navigate the many real-world challenges and be effective. Thank you for your focused commitment to food system sustainability, your pragmatic and solution-oriented yet rigorous and systematic research approach, and your interest and collaborative engagement in this research project. Your humor and diplomatic skills are ice-breaking, and a joy to work with and learn from.

Secondly, I like to thank my second collaborator Agnes Friedel. It is a pleasure to work with you - thank you for bringing your ecological expertise into our food forest work, navigating transdisciplinary teaching with me and continuing this journey despite initial failure. Beyond this PhD, food forests are emerging in Lüneburg – thank you, Matthias Barth, not only for initiating the graduate program but also providing the simple but crucial connection to our new project partner. And thank you, to all the dedicated Leuphana & ASU students!

Furthermore, I want to thank my project partners in Phoenix, Arizona – John, Darren, Amy, Sowan, Bruce, Maria, Brian and Alexis – for your persistent pioneer work on a sustainable food system in one of the most unsustainable cities worldwide. You are true champions! Thank you for your trust and commitment on this food forest journey, for living true to your values and engaging in unity with such diverse heads, hands and hearts.

I am also grateful for my support and exchange network of PhD colleagues, Charlotte, Maike, Sadhbh, Felix, Gustavo, Julius, Josefine, Karoline, Lisa, Stefan, and Hanna. Thank you Sadhbh for your thoughtful, theater-based interventions in my research projects. Maike, thank you, for all the fruitful conversations on transformations across spheres, and thank you, Hanna, for wonderful joint times in Arizona and boundless reflections on transdisciplinary research.

And finally, a big thank you to my family and friends. To my partner, Sebastian, for everyday delicious food and joining my path from off-grid adventures to up-tight avenues, expanding our comfort zone. To Maria, for your trusting support through an unconditional financial buffer that provided peace of mind and mobility to finish this research. To my neighbors Fritzi and Olli for providing your home as my office and yoga space. To Angela and Robert for providing a real home away from home in Arizona. To Maud, for your interest in documenting this research, the beautiful images and insightful reflections. Thank you for your perspective, care and/or English grammar support: McKenna, Johara, Angela, Nicole, Lisa, Julie, and Simone. Thank you, Andreas, Bärbel and Thomas for 35 years of support and homely garden times. And gratitude to my spiritual teachers, Pansh Nishan, Nirvair Khalsa, André and Luiza – I could not have done this without you as happy, holistic and healthy!

To Luna,

our dog companion,
who passed away just before finishing this work.

You were true medicine,
moving me away from the desk
into nature daily,
living joy daily
and showing me the wild side of life,
daily.

Abstract

The industrial food system is by far the largest greenhouse gas emitting sector. It causes significant damage to terrestrial, aerial and aquatic ecosystems, negative health impacts and an unfair distribution of economic benefits. The call for sustainability transformations is growing, entailing and promoting radical shifts in industrial food systems that lead to new patterns of interactions and balanced social, economic and ecological outcomes. While traditional research has focused on sustainability problems in the food system, it lacks evidence on solutions and desired future states; and more so, on how to practically move from the current to the desired state.

Food forests present a promising solution to address multiple sustainability challenges adaptable to local contexts. As biodiverse multi-strata agroforestry systems, they can provide several ecological, socio-cultural and economic services. They sequester carbon, limit soil erosion and regulate the micro-climate; they offer the opportunity for education on healthy diets and ecology, and they produce food and can create livelihood opportunities. However, despite their obvious benefits and a trend in uptake, food forests are still a niche concept rarely known in mainstream culture. To date, research has focused on their ecological and social services; we lack an understanding of food forests as a *comprehensive* sustainability solution, including their economic dimension, and knowledge on how to develop them.

Addressing these gaps, this qualitative research used a solution- and process-oriented methodology guided by transformational sustainability research. In a comparative case study approach, it created an inventory of 209 food forests, followed by interviews and site visits of 14 sites to understand their characteristics and assess their sustainability (Article 1). More in-depth, it analyzed the implementation path of seven food forest for success factors, barriers and coping strategies (Article 2). Based on these insights, two experimental case studies were initiated to develop sustainable food forests with practice partners, one based in Phoenix, Arizona, U.S. and one in Lüneburg, Germany. Two studies analyzed the cases' outputs and processes highlighting success factors and challenges, including the role of a sustainable entrepreneurial ecosystem (Article 3, Phoenix case) and key features of productive partnerships to understand why one case succeeded and the other failed (Article 4).

Findings include key features of existing and sustainable food forests as well as success factors on how to develop them; namely acquiring a complementary skill set that includes specialty farming and entrepreneurial know-how, securing sufficient start-up funds and long-term land access as well as overcoming regulatory restrictions. Supporting institutions are especially needed to integrate and professionalize the planning stage and provide know-how on alternative business practices. Key features of productive partnerships include an entrepreneurial attitude, access to support functions, long-term orientation and commitment to food system sustainability. The synthesis provides a detailed, ideal-typical implementation pathway to develop sustainable food forests and relevant supportive actors.

This study provides researchers, food entrepreneurs, public officials, and activists with insights on how to develop and advance food forests as a sustainability solution.

Zusammenfassung

Das industrielle Ernährungssystem ist bei Weitem der Sektor mit den höchsten Treibhausgasemissionen. Es führt zu erheblichen Schäden in Ökosystemen in Böden, Luft und Gewässern, negativen Gesundheitsauswirkungen und einer unfairen Verteilung ökonomischer Leistungen. Der Ruf nach einer Nachhaltigkeitstransformation wächst, verbunden mit radikalen Veränderungen im industriellen Ernährungssystem, die zu neuen Mustern von Interaktionen sowie ausgewogenen sozialen, ökonomischen und ökologischen Ergebnissen führen. Während traditionelle Forschung auf Nachhaltigkeitsprobleme im Ernährungssystem fokussiert, fehlen Nachweise zu Lösungen und wünschenswerten Zukunftsweisen; und mehr noch, Pfade wie wir praktisch vom derzeitigen zu einem wünschenswerten Zustand kommen.

Waldgärten zeigen Lösungsoptionen um vielfältige Nachhaltigkeitsherausforderungen, angepasst an den lokalen Kontext, zu adressieren. Als biodiverse, mehrschichtige Agroforstsysteme können sie verschiedene ökologische, sozio-kulturelle und ökonomische Dienste leisten. Sie binden Kohlenstoff, begrenzen Bodenerosion und regulieren das Mikroklima; sie schaffen Bildungsmöglichkeiten zu gesunder Ernährung und Ökologie und sie produzieren Lebensmittel und können Lebensunterhalte sichern. Trotz ihrer offensichtlichen Vorteile und einem zunehmenden Trend sind Waldgärten jedoch ein Nischenkonzept, das im Mainstream kaum bekannt ist. Bisher betrachtet die Forschung ihre sozial-ökologischen Dienste; uns fehlt jedoch ein Verständnis von Waldgärten als *ganzheitliche* Nachhaltigkeitslösung, die die ökonomische Dimension miteinbezieht sowie Wissen dazu, wie wir sie entwickeln können.

Um diese Lücken zu adressieren, nutzte diese qualitative Forschung geleitet von *Transformational Sustainability Research* eine Lösungs- und Prozess-orientierte Methodologie. In einem vergleichenden Fallstudienansatz schaffte sie ein Inventar mit 209 Waldgärten, gefolgt von Interviews und Ortsbesichtigungen von 14 Flächen um ihre Charakteristiken zu verstehen und ihre Nachhaltigkeit einzuschätzen (Artikel 1). Vertieft analysierte sie den Umsetzungspfad von sieben Waldgärten auf ihre Erfolgsfaktoren, Barrieren und Bewältigungsstrategien (Artikel 2). Darauf basierend initiierte sie zwei experimentelle Fallstudien um nachhaltige Waldgärten mit PraxispartnerInnen umzusetzen – in Phoenix, Arizona, USA und in Lüneburg, Deutschland. Zwei Studien untersuchen die Ergebnisse und Prozesse in den Fallstudien und unterstreichen Erfolgsfaktoren und Herausforderungen, inklusive der Rolle eines nachhaltigen unternehmerischen Ökosystems (Artikel 3) und Schlüsselmerkmale produktiver Partnerschaften, um zu verstehen, warum ein Fall erfolgreich war und der andere scheiterte (Artikel 4).

Forschungsergebnisse beinhalten Schlüsselmerkmale bestehender und nachhaltiger Waldgärten sowie Erfolgsfaktoren um sie zu entwickeln; nämlich das Erwerben komplementärer Fähigkeiten inklusive polykulturellem Landbau und unternehmerischen Kow-how, das Sichern von ausreichenden finanziellen Start-up Mittel und langfristigen Zugang zu Land sowie das Überwinden rechtlicher Barrieren. Unterstützende Institutionen bedarf es insbesondere um die Planungsphase zu integrieren und zu professionalisieren sowie um

Know-how zu alternativen Wirtschaftspraktiken zu vermitteln. Schlüsselmerkmale von produktiven Partnerschaften beinhalten eine unternehmerische Haltung, Zugang zu Unterstützungsstrukturen, eine langfristige Orientierung sowie Engagement für ein nachhaltiges Ernährungssystem. Die Synthese dieser Forschungsarbeit stellt einen detaillierten, ideal-typischen Umsetzungspfad und relevante unterstützende Akteure zur Entwicklung von nachhaltigen Waldgärten dar.

Die Studie bietet ForscherInnen, UnternehmerInnen im Ernährungssystem, VertreterInnen von Behörden sowie AktivistInnen Erkenntnisse, wie wir Waldgärten als Nachhaltigkeitslösung entwickeln und vorantreiben können.

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List of Abbreviations

BFF	Beacon Food Forest
DB	Den Food Bosch
E	Essgarten
FOF	Fazenda Ouro Fino
K	Foodforest Ketelsbroek
KY	Keela Yoga Farm
MW	Mienbacher Waldgarten
FFC	Food Forest Cooperative Phoenix
RQ	Research Question
V	Public Food Forest Lüneburg Volgershall

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In nature's economy, the currency is not money, it is life.

— Vandana Shiva

Preamble

Forests have taught communities to live sustainably for thousands of years, as their relatively 'slow' growth and regenerative practices requires a long-term perspective and collective rules (Parrotta & Trosper, 2012). It is thus not surprising that extractive, non-regenerative forestry practices in Europe in the 17th century led to the introduction of the term 'sustainability', meaning to keep reserves (e.g., seedlings) for later use and users (Carlowitz, 1713). The term developed further in response to poverty and environmental degradation on a global scale and gained momentum through 'The Brundtland Report', which defines the concept as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland-Commision, 1987, p. 41). Discussions around the concept of 'sustainability' and associated policy making and agenda development brought together various actors from across the globe (General Assembly, 2015; Scoones, 2007).

To date, more than 100 definitions and concepts of sustainability have emerged with much debate about what constitutes an integrative perspective and what is perhaps still lacking (Hopwood et al., 2005; White, 2013). While inherently diverse, the definitions share environmental, social and economic aspects, providing a universal guiding framework (White, 2013). The prominent multi-criteria evaluative framework by Gibson (2006), also used as a guide in this work, defines sustainability as a balance of socio-ecological integrity, social justice, human and social well-being as well as livelihood and economic opportunity. With this definition, sustainability is both universal with fundamental, broadly applicable criteria as well as context-dependent on the local socio-ecological conditions (Gibson, 2006).

Despite global debates and sophisticated concepts, however, the rates of natural resource depletion, biodiversity loss and greenhouse gas emissions continue to increase (Lenton et al., 2019; Rockström et al., 2009). A major contributor to these developments is our industrialized food system (Rockström et al., 2020).

1 Introduction

The following introduction gives an overview of sustainability transformations in the food system which is the context of this research (Chapter 3.1), introduces the potential of food forests as a sustainability solution to address industrial food system challenges (Chapter 3.2), and presents the derived research gaps and questions of this research (Chapter 3.3).

1.1 Sustainability Transformations in the Food System

Food systems are often understood as (interlinked) value chains of food, covering all steps from production to processing and consumption to recycling (e.g., Ericksen, 2008; Vermeulen et al., 2012). While these chains allow for a detailed understanding about interlinked activities related to the product life cycle (and potential interventions) (Ingram, 2011), a systems thinking perspective allows for a better understanding of the complex, interlinked subsystems influencing individual and societal demand for and the supply of food (Gowdy et al., 2018). As shown in Figure 1, political and health systems play a crucial role in food system dynamics alongside social, ecological and economic subsystems (Gowdy et al., 2018).

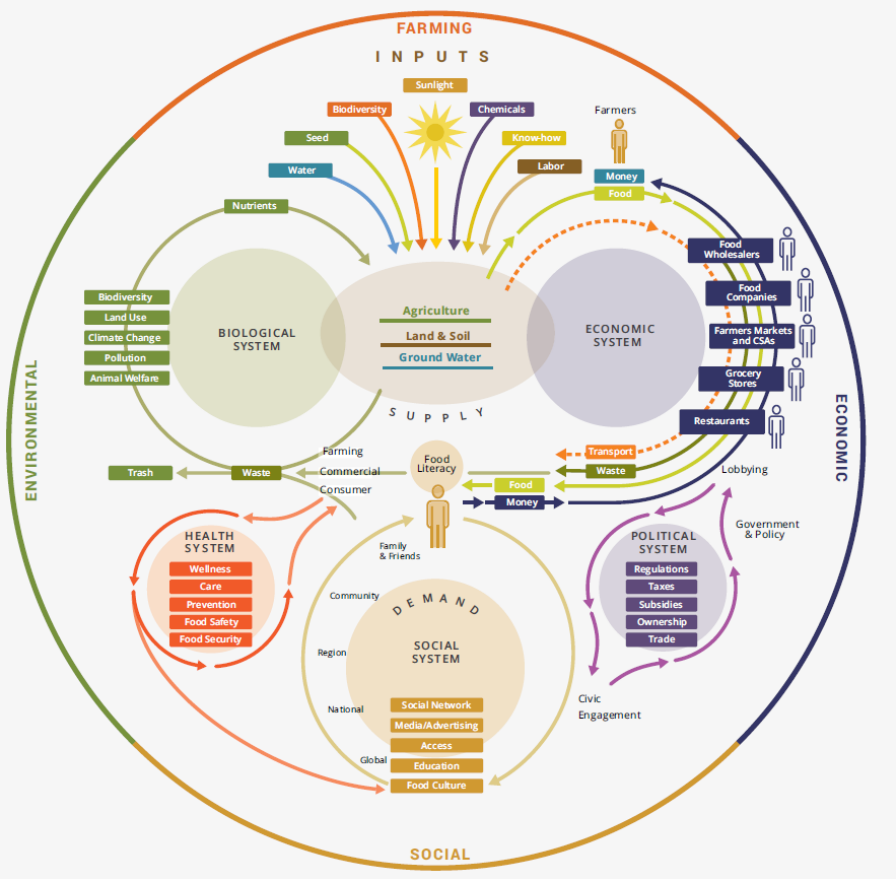


Figure 1: Food system map with multiple subsystems & their interlinkages through material flows & feedback loops (Gowdy et al., 2018)

For example, social systems from the local to the global level are influenced by such aspects as traditions, media and education, which in turn shape the demand for food. On the other hand, ecological factors on a farm such as the land, water and climate as well as farming inputs and economic factors (e.g., marketing outlets) shape the supply of food. Political and health

systems influence both the demand for and supply of food through their regulations, subsidies and taxes (political systems) or by shaping the discourse and incentives for wellness, prevention, food safety and security (health systems). The complexity of food systems contributes deeply to their vulnerability, i.e., the inability to deliver good food to all (Gowdy et al., 2018). This complexity stems from the various actors and activities involved and their conflicting interests across different scales and geographic regions, persistent inequalities in food rights and entitlements, and increasing geopolitical and sectorial interdependencies, amongst others (Ericksen, 2008; Moragues Faus et al., 2017). In addition, food systems contribute to major sustainability challenges.

The industrial food system is by far the largest greenhouse gas emitting sector and causes significant damage to terrestrial, aerial and aquatic ecosystems as a result of increasing industrialization and intensification processes worldwide (Ericksen, 2008; Rockström et al., 2020). Furthermore, the food system causes negative health impacts (Guyomard et al., 2012; Swinburn et al., 2011) and an unfair global distribution of economic benefits (International Assessment of Agricultural Knowledge, Science and Technology for Development [IAASTD], 2009). While globalization has, amongst other factors, eliminated the immediate feedback mechanisms of environmental and social challenges caused by unsustainable activities (Clapp, 2015), population growth and urbanization contribute to changes in dietary patterns that are more resource-intensive and disconnected from the physical places of food production (Garnett, 2011).

The call for a transformation is growing, entailing a radical shift of our food system towards a planetary balance across socio-economic and ecological dimensions, and the consideration of vulnerability, resilience and potential surprise, e.g. by a changing climate, in the future (Bennett et al., 2014; Rockström et al., 2020). Rather than incremental, minor or marginal changes, transformation means a deep, structural and systemic change, although minor changes can contribute (Feola, 2015). Sustainability transformations are defined as "fundamental changes in structural, functional, relational, and cognitive aspects of socio-technical-ecological systems that lead to new patterns of interactions and outcomes" (Patterson et al., 2017). New patterns can include, e.g., practices and policies for organic agriculture, healthy diets and environmentally conscious consumption (Weber et al., 2020). Visions of a sustainable food system are context-dependent but often based around community and well-being, and being locally sovereign (ibid.), and by that reducing food system complexity and lack of transparency on sustainability outcomes. Beyond the food system, such paradigm shifts are required in other extractive, productivity-oriented systems characterized by complex, dynamic, and multi-level entities, which are highly affected by or causing unsustainable practices, such as in energy, mobility, water or urban systems (Feola, 2015; Patterson et al., 2017).

Transformations are understood as emerging through grassroot activities and multiple other factors over several decades (Grin et al., 2010) if not centuries (Fischer-Kowalski & Haberl, 2007) rather than through controlled management approaches (Stirling, 2015). However,

certain system characteristics like feedback processes, lock-in effects and path dependence may allow anticipating, navigating and intervening in developments (Feola, 2015). Other than transformations in general that may entail undesired outcomes, sustainability transformations are normative and goal-oriented towards a desired, sustainable outcome (Feola, 2015). With numerous existing sustainability definitions, the spectrum of outcomes can differ widely and holds potential for manipulation and misuse of the term 'transformation', e.g., for political agendas. Hence, a specific definition is required of what is meant by transformation, what should be transformed, how and by whom (Blythe et al., 2018).

Research on transformations tries to understand and specify how such deep restructuring processes (should) unfold (Loorbach et al., 2017; Patterson et al., 2017). Early transformation research on social problems claims that transformations can only be evaluated in a retrospective perspective (Polanyi & MacIver, 1944). Recent research on 'sustainability transformation' have seen the emergence of diverse approaches that aim to analyze, evaluate and navigate radical shifts in the present or future (Patterson et al., 2017). Most prominent are 'transition' approaches where change is conceptualized to happen at multiple levels (niche, regime, landscape) and across social, technical, institutional and economic systems (Geels, 2002), and can be shaped through collaborative experiments with frontrunners (Loorbach, 2010). While transition approaches often take on a sectoral perspective (e.g., food, energy, mobility), 'socio-ecological transformation' approaches adopt a place-based perspective of human-ecosystem interaction for resilient natural resource management and highlight the role of institutional entrepreneurs and cross-organizational networks to navigate transformative innovation (Olsson et al., 2004; Westley et al., 2011). Similarly, 'sustainability pathways' perspectives argue for more recognition and empowerment of grassroots innovation by governmental actors to act within social and planetary boundaries. 'Sustainability brokers' are proposed that translate and navigate between global challenges and local adaptations (Leach et al., 2012). The perspective of 'transformative adaptation' addresses the vulnerability of cities and the urban poor, dealing with contesting change, values and the fundamental systemic structures that create vulnerability (O'Brien & Wolf, 2010; Pelling & Manuel-Navarrete, 2011). The different use of the terms 'transition' and 'transformation' stems from different etymological schools, and while often used interchangeably, transition research tends to focus more on the sectoral analysis of subsystems, e.g., energy or mobility, while transformation research looks at larger scale changes, e.g., on the local or global scale (Hölscher et al., 2018).

This research draws on several aspects of the presented approaches to transformation and transition research, seeing them mostly as being complementary in terms of the need for a multiple-level change as well as for motivated and skilled individuals that navigate adaptive and reflexive processes and consider power and commitment structures as well as different kinds of knowledge (Patterson et al., 2017). A promising approach – also inspiring this research - to experiment and navigate with new patterns of interactions and outcomes, are real-world experiments or similar prototyping approaches (Grunwald & Wagner, 2015; Schäpke et al.,

2018; Singer-Brodowski et al., 2018). They may *enable* new interactions that lead to locally sustainable food systems by providing pilots that demonstrate implementation mechanisms and management practices, and can be used for learning and transfer activities (Caniglia et al., 2017). Experiments that develop innovative sustainability solutions rather than focusing on analyzing and describing sustainability problems, provide evidence-based and actionable knowledge that is prescriptive about preferable options as well as procedural and instructional on how to solve the problem; these usually focus on designing and implementing solution options (ibid.).

Discussions by diverse stakeholders are required to reach agreement on the subject of transformation, e.g., the unsustainable food system or elements of it like local production or consumption, and form sustainability visions and strategies relevant to respective local contexts (Wiek & Lang, 2016). A common approach is a transdisciplinary setting involving people from different academic disciplines, professional backgrounds and people with a stake in the problem or solution (Lang et al., 2012). In such multi-stakeholder settings, various different knowledge communities are involved and, through that, legitimacy, accountability and ownership of the pilot project may increase (Lang et al., 2012). While collaborations offer much potential in pooling resources and jointly overcoming the various obstacles in change processes, it can be difficult to reach. This rather colloquial term 'collaboration' has diverse meanings and a broad variety of concepts have been studied from various disciplines (Nölting & Schäfer, 2020). For example, in institutional economics, collaboration has been examined through game theory experiments measuring individual economic performance and identifying factors such as trust, reciprocity and reputation that contribute to collaboration (Poteete et al., 2010). In food system research, collaboration is mostly addressed on the level of networks rather than on the level of individual organizations (e.g., Forrest & Wiek, 2021), which could bring a more nuanced understanding of food system transformation. In action research, and later in transdisciplinary and transformational sustainability research, collaboration between science *and* society for solving societal problems is understood as key (Lang et al., 2012; Wiek & Lang, 2016; Wittmayer et al., 2014). Such productive multi-stakeholder collaborations may encourage mutual learning, the joint creation of scientifically and socially relevant knowledge, and they may foster new social relations (Wittmayer et al., 2014). Although, ideal-typically, led by both scientific and societal actors (Lang et al., 2012), often such transdisciplinary research is led by scientists (Polk, 2015) that involve other stakeholders at various level of participation from sharing information and consultation to collaboration and joint decision making (Wiek, 2007). In collaborating, a shared understanding of three different types of knowledge are proposed as relevant for sustainability transformation: system knowledge about the problems and solutions, target knowledge about the desired sustainable future state as well as actionable or transformation knowledge on how to reach this target (ProClim, 1997; Wiek & Lang, 2016).

However, while research has comprehensively provided system knowledge - especially analyzing and describing the problem dimension (e.g., Rockström et al., 2009; Rockström et al., 2020) – and is increasingly contributing to target knowledge (e.g., Wiek & Iwaniec, 2014),

research on how to practically move from the current to the desired state is at a nascent state (Arnott et al., 2020). Such actionable knowledge can include very detailed, process-oriented knowledge from the initiation and planning to the implementation of desired outcomes as well as the surrounding conditions hindering or supporting it (Beier et al., 2017; ProClim, 1997).

Innovative solutions are addressed across the presented transformation concepts as a means to experiment with and achieve a deep shift to desired sustainability outcomes. For a shift of industrial food systems, diverse solutions at nested scales are proposed - from technological innovations to reduce our impact on a large scale to social innovation to organize and practice redefined values and mindsets (Bennett et al., 2014; Herrero et al., 2020; Westley et al., 2011). But how can these often unknown solutions, also called niches, transform the food system? From a multi-level perspective, niches can serve to mainstream by using 'windows of opportunity' on a landscape level, i.e. changes on the political, economic and cultural macro level beyond the influence of the niche, as well as destabilized regimes that are otherwise stable configurations of sectors such as markets, policy, technology, etc. (Geels, 2002). Niches are usually developed in protected spaces as their technology ripens and becomes more effective and efficient (Geels, 2002).

However, for a niche to be influential and replace prior practices, it needs to gain sufficient internal momentum through experiments, learning, price-performance adaptations, supportive networks, etc. (Geels, 2002). A clear understanding about the innovative solution to inform visions and expectations are key for this process (Geels, 2002; Seyfang & Haxeltine, 2012). Furthermore, beyond the micro-level of the individual niche, a context with relevant services that supports and facilitates experimentation across legal, financial, infrastructure, human resource and other relevant dimensions is key (Cohen, 2006). A so called 'sustainable entrepreneurial ecosystem' is a regional community of interactive, supportive public and private organizations to advance sustainability innovation (ibid.).

1.2 Food Forests as a Niche Sustainability Solution

One innovative solution to various sustainability challenges that this research focuses on is sustainable food forests. Food forests are edible ecosystems where a variety of plants grows on three to seven levels, with different products developing over time (see Figure 2). These farming systems mimic natural forest (edge) systems, integrating trees and other perennial plants in food production. As indigenous systems, food forests have existed for more than 4,000 years and are still traditionally used in the (sub)tropics, e.g. in Kerala, India or South America (Ford & Nigh, 2009; Kumar & Nair, 2004). Through permaculture[1] and other back-to-

[1] Permaculture is a holistic design concept with principles initially developed to design farm land (Mollison, 1981). Food forests are one potential product when applying the principles of permaculture. Other design concepts include various indigenous ways (e.g., Ford and Nigh, 2009, Kumar and Nair, 2004), syntropic farming by Götsch (1994) and restoration agriculture by Shepard (2013).

the-land movements, food forests emerged in temperate climate and Western contexts in the 1990s (Hart, 1996; Mollison, 1981).

Figure 2: Food forest with different layers of trees, shrubs, herbs & ground cover (Source: Graham Burnett)

Food forests present a promising solution to address multiple sustainability challenges, adaptable to local contexts. As biodiverse multi-strata agroforestry systems, they provide several co-benefits. Agroforestry has been shown to sequester carbon, limit soil erosion, regulate the micro-climate, increase biodiversity, and create livelihood opportunities (IPCC, 2001; Jose, 2009; Roy et al., 2011). Food forests have been shown to regenerate ecosystems, increase local precipitation, revive springs and soil (Andrade et al., 2020; Schulz et al., 1994). Despite food production, socio-cultural services include education on healthy diets and ecology, recreation and reconnection to nature as well as spaces for community building (Bukowski & Munsell, 2018; Wartman et al., 2018).

As a paradigm shift to the monocultural, short-term profit-oriented and input-intense (herbicide, pesticide, fertilizer, energy, water, etc.) global food system (IAASTD, 2009), food forests focus on long-term polyculture designs and low-input management practices (pruning, mulching, etc.). As food forests restore diversity and are climate-positive (not “just” climate-neutral), they could be considered a ‘strong’ or ‘regenerative’ sustainability solution (Braungart & McDonough, 2009; Rhodes, 2015). Compared to other sustainable agriculture solutions, such as organic farming, which reduces unsustainable agro-chemical practices, however, may still decrease soil organic matter through intensification practices and annual crops, food forests with their perennial plants build soil and enhance biodiversity as well as ecosystem services (Rosati et al., 2021). In times of climate uncertainty, the biodiversity of food forests may be a strategy to increase resilience and reduce food system vulnerability.

However, despite their obvious benefits and a trend in uptake, food forests are still a niche concept rarely known in mainstream culture. In the literature, no consistent definition of food forests exists. Common criteria include a ‘multi-strata design’ and ‘perennial, edible plants’ (e.g., Bukowski & Munsell, 2018; Clark & Nicholas, 2013) . However, this includes small display sites and far stretched edible landscapes. This lack of a more specific definition may undermine a clear public understanding and expectations about what this radical innovation can deliver and thereby undermine wider uptake and mainstreaming into a status quo food system solution (Seyfang & Haxeltine, 2012). Although governance and policy adaptations are also necessary to bring forward support structures for food forests, e.g., by making it an official

land use type, a detailed understanding of what characterizes a (sustainable) food forest is a prerequisite for policy making.

In research thus far, single case studies largely form the basis for showing different ways of designing and managing these systems, with a focus on the social and ecological dimension (e.g., Hammarsten et al., 2019; Knuijt, 2020) but lacking economic data. In a corporate food regime that calls for 'food security' (neglecting overproduction and food sovereignty for human right to food, access to land and water, etc.), yields are a relevant economic argument for mono-cultural production (Holt Giménez & Shattuck, 2011). Yield data – even in larger scale agroforestry systems - is often lacking or only modelled due to the long-term nature of production and diversity of crops (Mosquera-Losada et al., 2012). Yet some studies on food forests show similar or even higher yield (potentials) than conventional mono-cultural systems (Schulz et al., 1994; van Eeden, 2020). A small, but consistently documented site by Scottish pioneer Graham Bell, which started in 1991 on ~800 sqm, reports harvests of peak productivity after 14 years with a total of 1.25 tons of diverse yields (Bell, 2021). This is equivalent to 16 t/ha - as a comparison, average yield of cereals in the UK is 8 t/ha (FAO, 2019). Still, documentation or discussion of yield numbers, working hours or revenues of food forests are rare.

However, a *comprehensive* sustainability solution requires the integration of economic aspects (Schaltegger & Wagner, 2011). Not in exploitative, neoliberal ways but through alternative business models that include socio-ecological criteria like social entrepreneurship or employee-owned businesses and practices that focus on economic viability rather than mere profitability. Although there is a trend in uptake on such alternative business models, experience and support structures are widely lacking (Foucrier & Wiek, 2019). However, small businesses, with their high adaptability, experimentation and risk-taking potential, can be a promising change agent with impact on co-creating sustainable markets (Burch et al., 2013; Loorbach & Wijsman, 2013). In the food system, organic food was initially pioneered by frontrunning farmers, landowners, scientists and nutritionists in protected niches before being taken up by supermarkets in the 1990s (A. Smith, 2006). Small-scale farmers had to professionalize their idealistic organic principles with efficient and effective techniques to create genuine livelihood opportunities (A. Smith, 2006). This was firstly supported by research which improved techniques and outputs, then by organic standards and marketing, and finally by politics, overall creating an established niche with large farms branching into organics and a 10% market share of organic food in the UK (A. Smith, 2006). Similar to the early organic food movement, sustainable food forests are a rather unknown sustainability solution, although, with much potential to contribute to a deep shift in food production by reviving degenerated land, while offering diverse foods as well as educational and recreational services. However, widely lacking are system knowledge on what constitutes sustainable food forest practices, target knowledge on what a sustainable food forest could look like in different contexts, and actionable knowledge on how to reach its successful implementation.

1.3 Research Gap & Question

As highlighted in the previous chapters, there is a lack of actionable knowledge on *how to* develop food forests as a sustainability solution. For one, we lack broader, evidence-based system knowledge on characteristics of existing food forests as well as target knowledge on key features of food forests as a comprehensive sustainability solution. On the other hand, we lack transformation knowledge on how to initiate, plan and implement sustainable food forests in different contexts and with different partners. Thus, the main question of this research is:

> *Main RQ: What are key features of sustainable food forests, and how can they be successfully initiated, planned, and implemented as comprehensive sustainable solutions?*

To better understand this solution and its different options, we need more information on general characteristics (location, size, age, services) of food forests, how they organized and managed, and to what extent food forests are sustainable, measured against a broad set of socio-cultural, economic and environmental criteria (system and target knowledge). This information is currently lacking but would provide a general overview of existing food forests as well as good practice examples in the current system, both contributing to forming clear expectations and visions of desired and impactful solution options (Schot & Geels, 2008; Wiek & Lang, 2016). Hence, the first sub-research question is:

> *RQ 1.1: What are key features of food forests in general and more specifically as a sustainability solution?*

Secondly, this research aims at generating evidence on the success factors in implementing sustainable food forests (transformation knowledge), i.e. the key actions, actors, and outcomes as well as barriers and coping strategies relevant in the implementation process (Forrest & Wiek, 2015). This actionable knowledge about the implementation pathway aims at understanding how food forests with a relative high sustainability performance were implemented. It contributes to informing actions and capacity building for the process to move from the existing to a desired state (Scoones et al., 2020).

> *RQ 1.2: What are success factors and what are barriers in implementing sustainable food forests, and how can barriers be overcome?*

Thirdly, this research aims at nuancing this transformation knowledge by exploring these success factors in more detail. Beyond the success factors on the micro-level of the case, it aims at understanding the role of a supportive context in form of a sustainable entrepreneurial ecosystem (Cohen, 2006). This includes aspects of the formal and informal network within a local sustainable food economy community and the advice services and other resources it offers for sustainable entrepreneurship to thrive (ibid.). As the implementation of a food forest can be a multi-year process (Bukowski & Munsell, 2018), the focus of this research is on the initiation and planning stages.

RQ 1.3: What is the role of a sustainable entrepreneurial ecosystem as a success factor in the early stages of initiating and planning a sustainable food forest?

Finally, based on prior research processes and results, one major success factor, namely multi-stakeholder partnerships, is analyzed to gain more nuanced, actionable knowledge on its role for successful initiation and planning of sustainable food forests. Generally, inter-organizational partnerships across diverse stakeholder groups are key factors in transformation processes towards sustainability (e.g., Fazey et al., 2018; Nevens et al., 2013). The collaboration of diverse stakeholders with access to different resources can support overcoming the multiple barriers in change processes and provide for meaningful results (Lyon et al., 2020). However, their readiness for participating in transformational change processes may differ based on certain characteristics like an individuals' role in the system, alignment to the problem or solution, etc. (Lyon et al., 2020). Prior to investing into long-term partnerships (as food forests require long-term investments), it is relevant to assess their potential for substantial change processes.

RQ 1.4: What are key features of productive, multi-stakeholder partnerships when developing sustainable food forests?

The results of this study aim at informing the work of food entrepreneurs, public officials, urban developers, activists, and researchers interested in building upon current food forest practices from around the world. The insights on the diverse services and sustainability of food forests can help realize their full potential to advance sustainable food systems. The insights on success factors in implementation may contribute to actionable knowledge on how to develop and support sustainable food forest enterprises.

The following chapter presents the transformational sustainability research design used in four studies to answer these research questions. Chapter 3 presents the scientific results, first from each of the four articles and then in a synthesis. Chapter 4 discusses these results and reflects on methodological challenges and success factors. After an outlook in Chapter 5 that gives insights on practical results that span beyond the PhD time, Chapter 6 concludes the framework paper.

2 Research Design

This chapter describes the 'transformational sustainability research' methodology that guided this research. It shows how it was accompanied by other research approaches, applied in a comparative case study approach, in particular in two real-world experiment cases, and adapted in the project phases to accommodate the development logic of sustainable food forests (Chapter 2.1). Following, the specific concepts as well as methods for data collection and analysis used in each article are outlined (Chapter 2.2.). Finally, the underlying assumptions and personal motivation for this research are presented (Chapter 2.3).

2.1 Transformational Sustainability Research

Transformational sustainability research emerged as a process- and solution-oriented research mode within sustainability transformation research to create actionable knowledge (Wiek et al., 2012; Wiek & Lang, 2016). It includes "classical" descriptive-analytical research methods that aim at theory building and generating system knowledge, e.g., of sustainability problems or existing solutions. However, it focuses on creating target knowledge, i.e., comprehensive sustainable goals, and transformation knowledge, i.e., feasible implementation strategies (action plans), on *how to* reach from the problem state to the future vision (Wiek & Lang, 2016). It uses scientific tools and guidelines, including structured procedures and innovate methods such as visioning and backcasting, to facilitate the implementation of evidence-supported solution options and support the navigation of change processes (Fazey et al., 2018; T. R. Miller et al., 2014; Wiek & Iwaniec, 2014). Methods used are diverse and need to be conducted in transparent, systematic and replicable ways (Wiek & Lang, 2016). Chapter 2.1.2 and 2.1.3 show in more detail, which methods were used in this research and how the adapted methodological framework of 'transformational sustainability research' translates into eight project phases from project initiation to transfer and scaling.

Guidelines, principles and practices of other research approaches that are involved in and analyze real-world change and innovation processes creating scientifically and socially relevant, actionable knowledge is guiding this research. Intervention research, used in social and medical settings, provides guidelines on designing and evaluating desirable change processes (Fraser 2010). Phases similar to this research include problem analysis and project planning, gathering and synthesizing of information, designing the intervention, pilot development and testing, evaluation of the experiment, adaptation and dissemination (Thomas & Rothman, 1994). As an interdisciplinary approach, it lacks the involvement of practice partners used in this research during pilot development and testing. Here, participatory action research, developed to navigate local change processes for social improvement, provides more guidance on a micro-level, through phases of action, reflection and adaptation (Reason, Bradbury 2008, Wittmayer et al. 2014). After action phases of implementing activities, reflection phases involve coming together as a group, exchanging on relevant data, success and failure, and adapting for improved actions (Bradbury & Associates, 2017; Reason & Bradbury, 2005). In iterative cycles, it supports joint learning processes throughout the experiments and aims at improving actionable knowledge going deeper into the development of a shared goal (ibid.).

Sustainability transformation research, however, differs from the past research approaches through the universal, yet context-dependent, normative aim of sustainability (White, 2013) which requires explicit discussion by stakeholders.

Hence, transdisciplinary research, the collaboration of diverse stakeholders from academia and outside of academia is a key component to create sustainable solutions in transformational sustainability research (Lang et al., 2012; Wiek & Lang, 2016). Involving multiple perspectives, knowledge and ways of knowing harnesses diverse creative potentials

for sustainable solution options and actionable knowledge on how to implement them. Sustainability can mean different things in different contexts, and need contextualization (Gibson, 2006). A 'boundary object' can support the understanding between different disciplines and backgrounds of stakeholders, and, hence, be the base of their collaboration (Bergmann et al., 2012). In this research, a sustainable food forest was a very concrete integration product with its characteristics jointly discussed at the beginning.

Regular reflection and adaptation are a base of this research. While ideal-typical phases and principles of transdisciplinary and other research modes offer guidance, through its real-world character, each context differs (Lang et al., 2012). In addition, researchers often take on several roles and activities besides classical research, e.g., motivating for change and involving key stakeholders (Wittmayer & Schäpke, 2014). Reflexivity – the practice of deep reflection on underlying values, assumptions, knowledge and their origin as well as the role of the researcher in the process – supports learning and transformational change (Fazey et al., 2018). Throughout this research, I collected auto-ethnographic material in a research diary (Gardiner & Rieckmann, 2015) which supported such deeper reflections, documenting especially the different roles taken as the lead researcher, social interactions and (personal) tension points as well as several shifts in assumptions and values by myself and practice partners (overall 150 entries). It further supported decision making on interventions, general reconstruction of the research process and quality control on the research to be conducted in appropriate, meaningful and effective ways. Deeper reflective (theatre-based) activities and discussions with practice partners, e.g., on the projects purpose, the teams' interconnection and unsustainable decisions were partly facilitated by an external expert (S. Juárez Bourke).

2.1.1 Qualitative Comparative Case Study Approach from Broad to Deep

Since little systematic, evidence-based knowledge exists on food forests, this research started by developing a broad, descriptive-analytical knowledge base through an inventory with 209 food forest cases. It went deeper into case study analysis with site visits and interviews, analyzing the characteristics of different types of food forests and evaluating their sustainability (14 cases) as well as analyzing the implementation pathway of seven cases. Finally in two in-depth cases, it initiated and analyzed real-world experiment to develop sustainable food forests, one in the U.S. and one in Germany (see Figure 3).

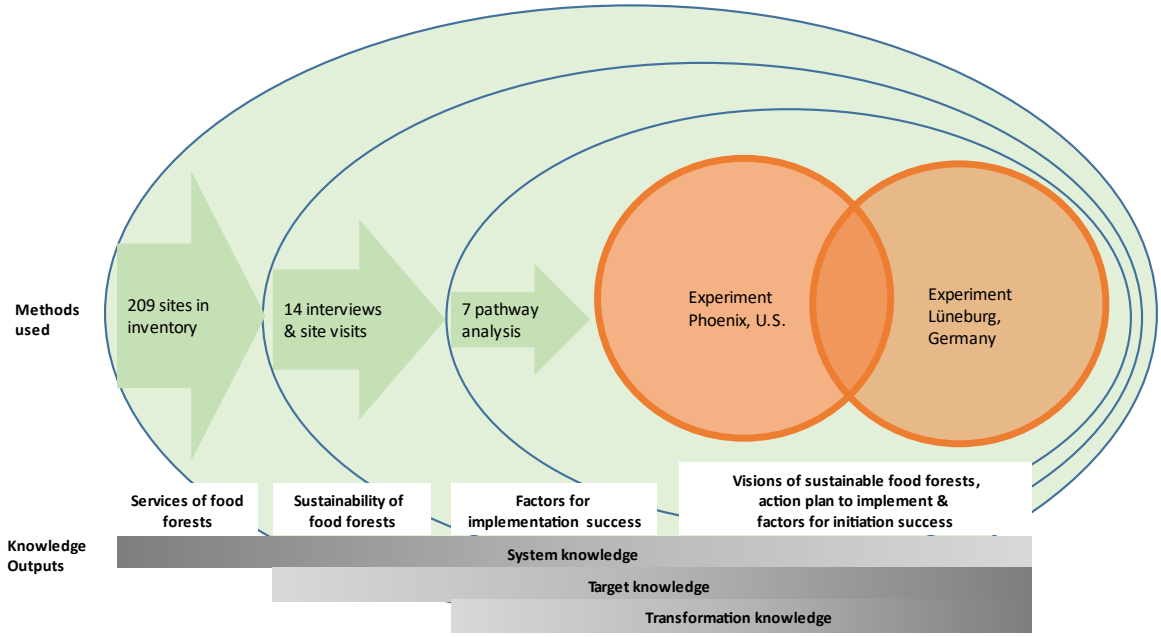


Figure 3: Research design from broad to deep case comparison with methods used & knowledge outputs

The first research stage looked into existing food forests producing system knowledge about their services, organization and management practices as well as target knowledge evaluating their sustainability through classical qualitative research methods. Prior experimenting, the analysis of the implementation process of existing food forests with a relative high sustainability performance produced system and transformation knowledge on factors for implementation success. Analyzing the initiation of two sustainable food forests produced detailed target and transformation knowledge by creating visions and action plans, and by analyzing factors for initiation success and failure. These included some aspects of system knowledge (indicated by the lightly shaded grey bar below the experimental cases in Figure 3) such as the existing support structures through an entrepreneurial ecosystem.

This comparative case study approach from broad to deep advances theory building by providing for a wide knowledge base as well as rich contextual cases (Bryman, 2015), with the later also making "this study a good story with the theory as plot" (Dyer & Wilkins, 1991). This creates not just constructs of general phenomena but clear and detailed knowledge that is easy to understand and memorable (ibid.). Comparing multiple cases showed similarities as well as contrasting features, and by studying individual cases more in-depth, earlier findings can be enhanced and further contextual factors relevant for particular phenomena can be found (Bryman, 2015). Overall, this research approach theorized the practice of sustainable food forest development through empirically based, ideal-typical development pathways with deep, nuanced insights.

2.1.2 Real-world Experiment Cases in Lüneburg and Phoenix

The two case studies (see Table 1 for an overview), one based in Phoenix, Arizona, U.S. and the other in Lüneburg, Germany, were somewhat representative for a larger pool of cases. From the 209 cases captured in the inventory, 46% were run by non-profit organizations

(Albrecht & Wiek, 2021). Hence, the Phoenix case, where the research team collaborated with a NGO consortium, is somewhat representative for a large number of cases. However, only 2% of cases were found where a food forest was run by a public institution (Albrecht & Wiek, 2021). Hence, the case in Lüneburg, were we collaborated with the city administration, is a rare case. Although several cases exist on public land and are generally supported, they are not co-led, by public institutions (e.g., Konijnendijk & Park; Vannozzi Brito & Borelli, 2020). Other, more representative case study partnerships, e.g., with businesses or NGOs, at a suitable location were not available at the time of data collection in Lüneburg. Both cases were selected through a comprehensive site selection process explained further in project phase 3 (Chapter 2.1.3).

Table 1: Experimental case studies to initiate & plan a sustainable food forest in Phoenix & Lüneburg (Article 4, adapted)

	Food Forest Cooperative Phoenix	**Public Food Forest Lüneburg**
		
Location	Spaces of Opportunity, Phoenix, U.S.	Volgershall, Lüneburg, Germany
Partners	Representatives of NGO consortium	City staff (Parks & Recreation Department)
Further stakeholders	University, school, café, local community	Neighbors, NGOs, schools, kindergarten, clinic
Site size (ha)	0,5	0,5
Embedded in	Urban farm (10 ha)	Park (5 ha)
Land ownership	Semi-public school land (lease from Roosevelt school district)	Public green space (City of Lüneburg)
Identified gaps / needs	• Create livelihoods • Provide fresh food • Educate students • Support marginalized communities • Mitigate heat	• Support biodiversity, especially rare insects • Maintain a public site overgrown by nitrophytic plants, mainly blackberries • Revive an old, hidden orchard
Envisioned services of the food forest	Job creation, food production, educational offerings	Environmental services, recreation, education, community building, minor food production

The case in Phoenix is located in South Phoenix, which faces many sustainability challenges including low access to fresh food, heat islands and underdeveloped educational and economic opportunities (Bolin et al., 2005; Brazel et al., 2007; USDA, 2017). *Spaces of Opportunity,* a coalition of local non-profit organizations, founded in 2015, aims to address these challenges through urban agriculture, food entrepreneurship, and education.

The case in Lüneburg is located in a contrasting context with some strong sustainability features including good housing conditions, many green spaces, etc. receiving the German Sustainability Award in 2014. Still, Lüneburg faces sustainability challenges, including environmental pollution, biodiversity loss and economic disparities (Geo-Net Umweltconsulting, 2019; Lehmann, 2019; OECD, 2019). Food production is diverse including organic farms but is dominated by monocultural, mass production (Niedersächsisches Ministerium für Ernährung, Landwirtschaft & Verbraucherschutz, 2017). The envisioned food forests to address these challenges was to be created in a public park with the main partner being the administrative staff of the city's Parks & Recreation Department.

Within the case studies, we used qualitative methods of real-world experimentations, where interventions can generate empirical evidence on solution options (Caniglia et al., 2017; Schäpke et al., 2018). The overall research process in both cases was guided methodologically by an adapted transformational sustainability framework based on Wiek and Lang (2016) with structured procedures for identifying local sustainability gaps, developing an inspirational vision and building a feasible plan of action explained further in the following chapter. Table 2 shows the diverse methods used across project phases in the Phoenix case, including informative methods providing knowledge about sustainable food forests, normative methods to build a sustainability vision, relational methods for team building, instructional methods to create actionable knowledge and reflective methods to adapt the process (Wiek & Lang, 2016). As part of most methods, we used circle dialogue and discussions to include stakeholder perspectives and build trust.

Table 2: Overview of different types of research methods used with practice partners in the Phoenix case

Informative	Normative	Relational	Instructional	Reflective
• Presentations of solutions • Site exploration games • Design expert workshop • Field trips • Community engagement	• Vision building • Peer consultation on envisioned roles	• Networking • Team building • Site exploration games • Theatre-based positioning & activating exercises	• Site selection • Strategy building • Site plan game	• Individual & joint reflections • Mindfulness walk • Theatre-based positioning exercises • Reflection survey
• Circle dialogue & discussions				

Overall, this case study-based research provides for insights on the micro-level of food forests as sustainability solution options and their initiation. The practical results of the experiments develop beyond the PhD, when the initiation and planning turn into the implementation. After the main data collection ended in February 2020, the project teams secured major success factors to implement sustainable food forests in both case study locations, although in Lüneburg with a different partnership and location (see Chapter 5).

2.1.3 Project Phases

The projects were structured into eight phases (see Figure 4). Major adaptations to the transformational sustainability framework include highlighted phases for networking and site selection (Phase 3), familiarization and experiencing (Phase 4) and fundraising and piloting (Phase 6). This underlines their importance in progressing the project, their duration and the different activities and competencies required (e.g., providing solution knowledge, screening and meeting relevant stakeholders).

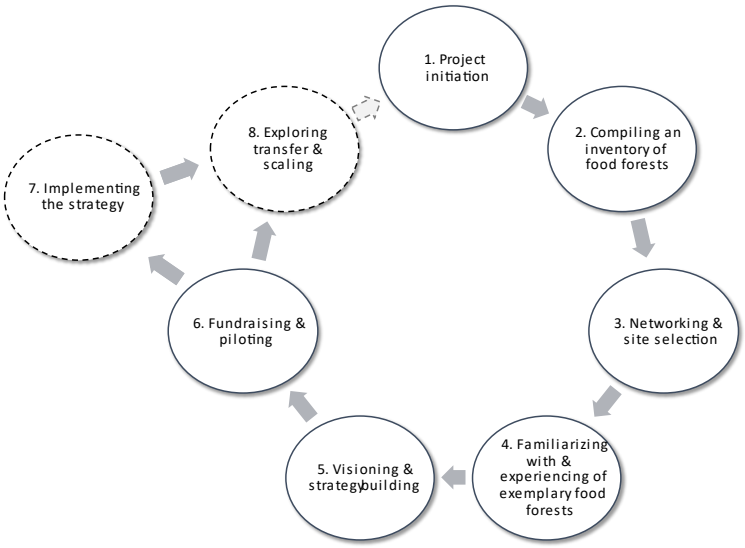


Figure 4: Phases of developing sustainable food forests (Article 3, adapted)

The following list describes the research design, activities and outputs of each phase, indicating the approximate duration for each experimental case. Some phases ran in parallel and some included dormant phases in-between. Overall, the project in Phoenix ran for 3 years and is still ongoing, while the Lüneburg case stopped after about 2 years due to the lack of a functioning transdisciplinary partnership. While most data from the Phoenix case goes up to Phase 6, with some data from phase 7 and 8, the case in Lüneburg stopped in phase 5.

Phase 1 - Project Initiation (12 weeks)

This included defining project objectives, building the initial project team, and securing funds (stipend) and in-kind contributions to support the team during the planning stage.

Phase 2 - Compiling an Inventory of Food Forests (12 weeks)

A pool of good-practice examples compiled in a standardized way using a basic profile, description of their organization, management and implementation history as well as a sustainability assessment of socio-cultural, economic, and ecological criteria (Gibson, 2006) served as the basis for all subsequent phases. The web-based search identified sites that go beyond self-sufficiency, collecting basic information of about 209 food forests, as well as conducting interviews at 14 sites from Western Europe as well as South and North America (see Chapter 2.2.1 and 2.2.2 for further information on the research design of Article 1 and 2).

Phase 3 - Networking and Site Selection (6 weeks)

This phase aimed at selecting a site and practice partners by exploring the suitability of various potential sites through a systematic exploration with analysis and comparison of sites guided by criteria from literature (Eanes und Ventura 2015) and prior research on food forests. Main criteria included size, accessibility by potential user groups, water infrastructure, stakeholder interest and ownership. Potential sites were identified through meetings within the network of the project partners, including city administrators, entrepreneurs, NGOs; as well as through document review and an online search of local food projects in Phoenix and Lüneburg. In Phoenix, a GIS team from Arizona State University supported systematic exploration of suitable sites. Out of 16 analyzed sites, *Spaces of Opportunity* in South Phoenix was determined as the most suitable site. The Memorandum of Understanding, including shared goals and a project timeline, was developed and signed by all project partners in February 2019. In Lüneburg, with less resources, only four sites were identified and analyzed from which *Volgershall* was selected as the most suitable. A collaboration agreement with the city administration was drafted, but not signed by the project partner.

Phase 4 – Familiarizing with and Experiencing of Food Forest Examples (9 weeks)

During consultation meetings with the project partners, the research team presented exemplary food forests (from the inventory), describing the practices, produce, costs and revenue required to develop knowledge and form preferences that informed the subsequent visioning (cf. Wiek, 2015). The project teams discussed how a similar food forest at *Spaces of Opportunity* and *Volgershall* could address local sustainability issues such as urban food desert, heat island, and lack of livelihood opportunities in Phoenix; and biodiversity loss, nitrogen pollution and lack of public site maintenance resources in Lüneburg. The more cognitive familiarization was followed by experiential learning through field trips to provide for a more active learning opportunity. Experiencing is a form of learning that holistically involves the whole person with thoughts, feelings, perceptions, and actions, and hence, accommodates different learner types (Domask, 2007; D. A. Kolb et al., 2001; A. Y. Kolb & Kolb, 2005). The Phoenix team visited two local forest gardens (smaller food forests) to experience their layered design, diversity, and micro-climate, as well as discuss management techniques with the owners. The experiences were captured through an online survey and informed the subsequent visioning activities. In Lüneburg, familiarization activities included a public survey for neighboring households as well as semi-structured interviews and informal conversations with neighboring institutions (clinic, kindergarten, school, nursery, etc.).

Phase 5 - Vision and Strategy Building (6 weeks)

Developing a vision and strategy was facilitated through a series of workshops - three in Phoenix and two in Lüneburg, following structured procedures described in Wiek (2015). A head-hands-hearts approach (Sipos et al., 2008) guided the overall process using structured, interactive and creative methods, e.g., standardized profiles of food forest examples, tasting samples of perennial plants and site design games as well as quality visuals, e.g., color-coded

maps and voting posters. In Phoenix, workshops facilitated additional team building, reflections and specific site exploration by using nature education methods (Cornell, 1989; Cornell University, 2016) and a mindfulness walk (Neugirg, 2017). Several creative professionals supported prototyping of tools as well as reflection and intervention activities, and an external researcher facilitated theatre-based team and energizing exercises (Boal, 2005; Midha, 2010). In Lüneburg, vision building was facilitated by students of a transdisciplinary seminar (Food Forest Lab, summer semester 2019) and included posters that familiarized workshop participants on food forests, a guided imaginary journey (Reich, 2007), a site design game and a graphic recording summarizing the vision.

Visions were analyzed along quality criteria for sustainability visions to develop an inspirational, comprehensive goal (Wiek & Iwaniec, 2014) and adapted with practice partners. A feasible implementation strategy, i.e., an action plan, to reach the vision, was built via a backcasting approach working backwards from the desired vision to the present, and creating relevant milestones, main actives and responsibilities along the way (Kay et al., 2014). In Phoenix, the tangible outputs include an organizational chart of the food forest team, a vision narrative, a draft site plan, and a strategic action plan (see Figure 5, below), incl. financing, business development, land trust development, physical implementation, product development, and education. In Lüneburg, a preliminary shared vision was created but lacked sustainability ambitions as well as commitment from project partners, hence, the project was discontinued in February 2020.

Phase 6 - Fundraising and Piloting (7 months with dormant phases)

In Phoenix, the project team aimed at raising funds (~$50,000 plus) for physical implementation and entrepreneurial scholarships. In addition, a detailed site plan was developed, a business plan was drafted and the action plan was adjusted several times to account for new insights, changes in the team, and emerging opportunities. Modest funds became available for a smaller display site, which led to the implementation of a forest garden at *Spaces of Opportunity*. Progress was reviewed in monthly project team meetings. The team submitted ten grant applications to a number of funding agencies including funds by national government, indigenous associations, and several foundations with project budgets ranging from $25,000 to $220,000, for realizing parts or the entirety of the food forest enterprise. All of them failed to receive funding. Eventually, through conversations at a previous fundraising event, a private donor approached the team representative at Arizona State University (A.W.) and signaled interest in funding the start-up phase. After submitting the comprehensive business plan draft and supporting material as well as a site visit at *Spaces of Opportunity* and a project presentation from the entire team, the donor decided to fund the project to the full extent as requested in February 2021 ($100,000).

Phase 7 – Implementing the Strategy/Action Plan (ongoing)

The action plan and business plan, including plans for recruitment of start-up entrepreneurs, site construction, planting, entrepreneurship training, and so forth commenced implementation from March 2021 onwards (see Figure 5).

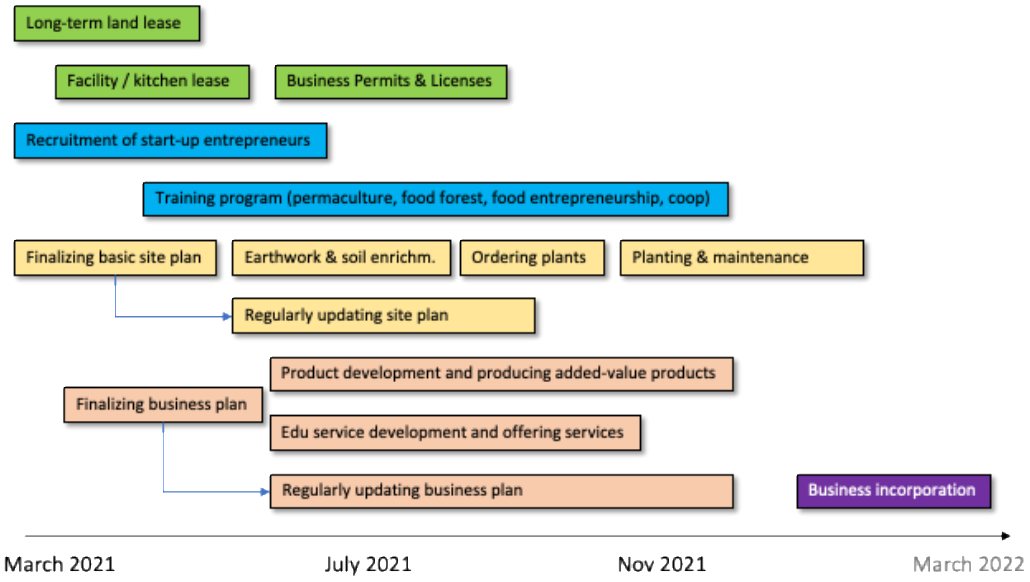


Figure 5: Simplified start-up action plan for the food forest enterprise in Phoenix with different action items (A.Wiek)

Phase 8 - Exploring Transfers and Scaling (4 weeks, periodically ongoing)

To share about the project learnings and initiate a local food forest network, the Phoenix-based project conducted a stakeholder workshop at the end of 2019 that brought together 16 food foresters, entrepreneurs, city representatives, agroforestry experts, researchers, and educators (Albrecht & Wiek, 2020). The workshop familiarized participants with sustainable food forest examples; facilitated exchange and discussion on implementation opportunities, challenges, and coping strategies; and provided networking opportunities among people with an interest in food forests from diverse backgrounds. Similar events are being planned for later in 2021 and 2022 as the implementation progresses.

2.2 Overview of Research Design in the four Articles

Overall, four scientific articles deal with the presented methodology and process. They contribute to answering the research questions, with each new article building on the previous research and deepening the findings around (specific) success factors and the process of developing sustainable food forests (see Figure 6).

The first two articles are reconstructive studies that analyze past activities and their outputs relevant for successful implementation of sustainable food forests. The third and fourth article analyze the two deep case studies on creating sustainable food forests. They can be considered prospective studies as they initiated new, evidence-based solutions based on system, target and transformation knowledge gained in the reconstructive studies. The following subchapters explain how each article contributes to the research questions and its

research design, including concepts used and methods of data collection and analysis, summarized in Table 3, Chapter 3 on the results.

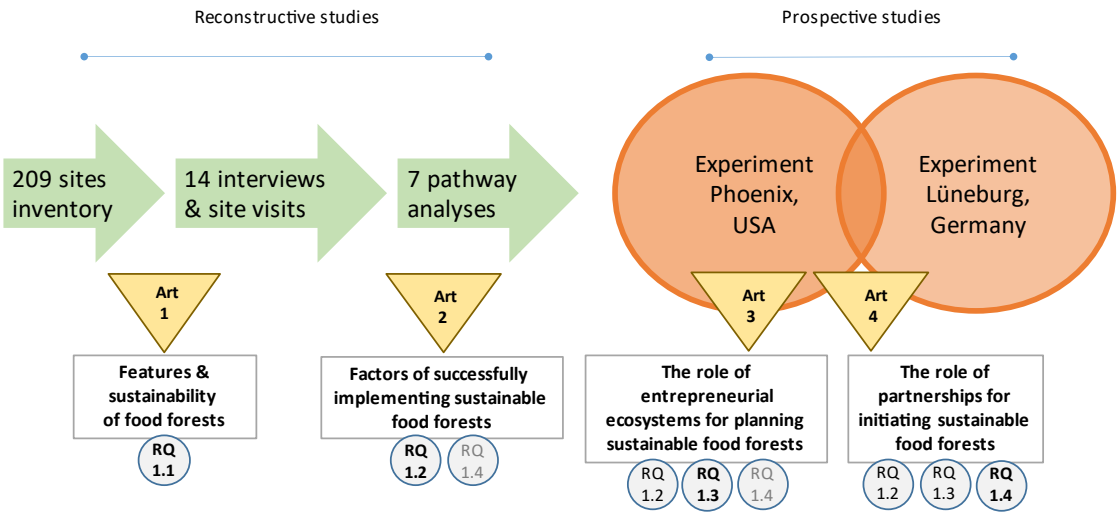


Figure 6: Research design of the reconstructive & prospective studies to answer the research questions in four articles

2.2.1 Article 1 – Broad Data Collection, Interviews and Site Visits at Food Forests

Article 1, by Arnim Wiek and myself, describes the characteristics and services of food forests, and assesses their sustainability, which contributes to answering RQ 1.1 on key features of food forests in general and more specifically as a sustainability solution.

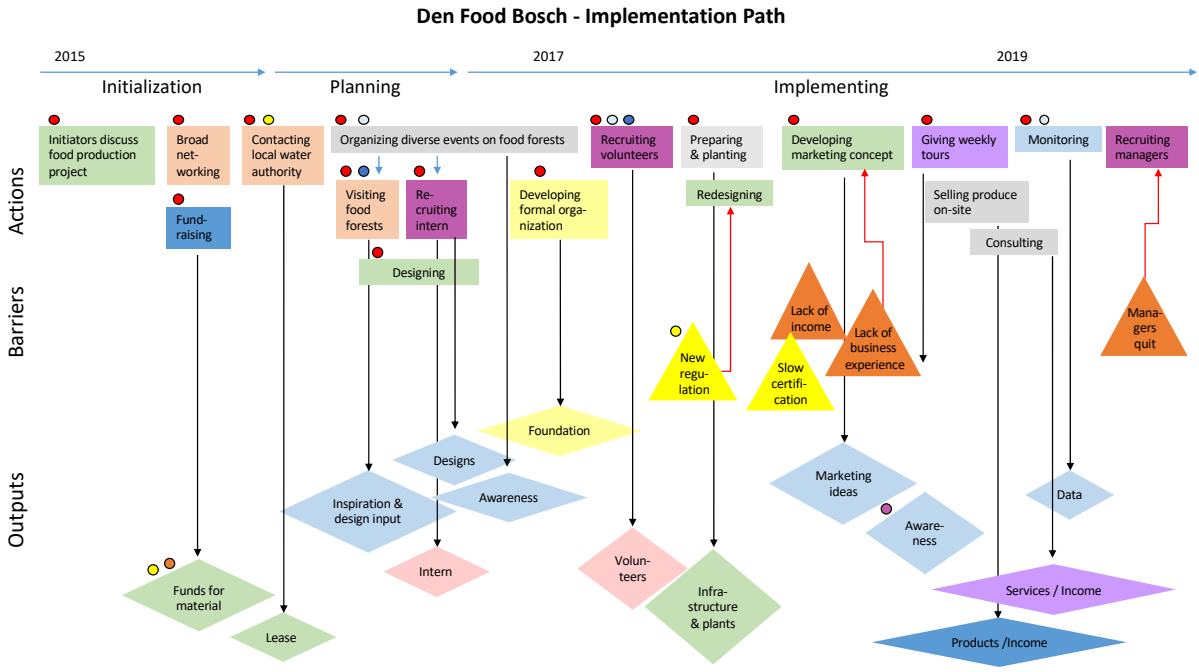
In an explorative way, through a broad, web-based search on food forests and snowball sampling, we identified 209 food forests with activities like commercial food production or education that go beyond self-sufficiency and, hence, potentially have a wider impact on their local food system. Our food forest definition guiding this search was led by common basic criteria ('multi-strata site' with 'mostly perennial edible plants') from Anglo-Saxon literature (e.g., Bukowski & Munsell, 2018; Clark & Nicholas, 2013). For each food forest site, we created standardized profiles, including the main services the site offers and other basic information (location, size, etc.). We identified the main services by standardizing the most common activities carried out at each site, e.g., generating regular income through workshops (main service: education) or selling food from on-site production (main service: food production).

From the inventory, we selected 14 exemplary food forests primarily based on their age and main service to provide insights on a spectrum of activities and development stages. We visited the sites and interviewed the site managers who had initiated the food forest. The semi-structured questionnaire focused on the food forest's organization, management, and implementation process. Codes for data analysis (cf. Bryman, 2015) included form of organization, workforce, management practices, products and services. We assessed each site according to criteria of sustainability identified from literature (Gibson, 2006; Jose, 2009; Park & Higgs, 2018) as well as interviews with agroforestry and food forest experts.

2.2.2 Article 2 – Cross-case Analysis of Implementation Success Factors

Article 2, by Arnim Wiek and myself, analyzes the reconstructed implementation path and relevant success factors of sustainable food forests which answers research questions on success factors, barriers and coping strategies in initiating and planning food forests (RQ1.2). It contributes indirectly to answering RQ 1.4. on key features of productive, multi-stakeholder partnerships as many success factors are provided by partnerships as addressed more in the synthesis (Chapter 3.2.2).

The study applied a framework for analyzing implementation process and outcomes of sustainability solutions to identify barriers and success factors (Forrest et al., 2020; Forrest & Wiek, 2014, 2015). To analyze the implementation path of food forests, we selected seven cases from the inventory and prior research (Article 1) that represented a wide range of services (common activities carried out) and maturity (age of the food forest). Collected data was available for six cases through interviews and site visits, and in one case through extensive research on a prominent case that provided comparable data on the implementation history of the food forest (Bukowski & Munsell, 2018). In each case, we tracked key actions, actors, and outcomes, as well as barriers and coping strategies for the implementation, using standardized analytical categories developed by Forrest and Wiek (2014). For each site, we created a visual pathway as displayed in the example of Den Food Bosch (Figure 7, below), and an implementation narrative to explain the implementation story. Finally, we compared the implementation paths of the seven cases to generalize insights on success factors and barriers, differentiated into behavioral, infrastructural, institutional, and economic factors.



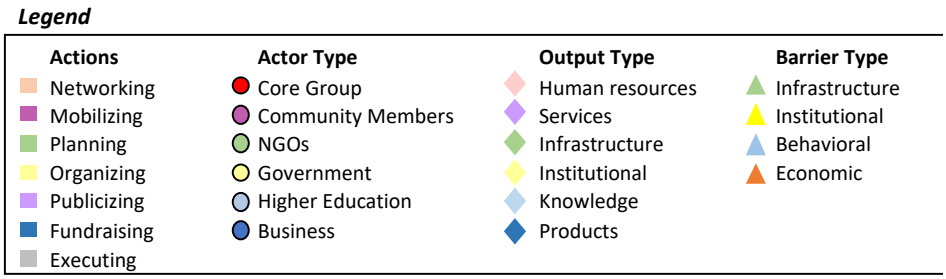


Figure 7: Exemplary implementation path of Den Food Bosch (2015-2019) (Article 2)

2.2.3 Article 3 – Case Study on Developing a Sustainable Food Forest in Phoenix

Article 3, by Arnim Wiek and myself, analyzes the multi-year, experimental case study in Phoenix for success factors in initiating and planning a sustainable food forest which directly contributes to answering RQ1.2. More specifically, it examines the role of the entrepreneurial ecosystem as a key success factor (RQ1.3). It also contributes indirectly to RQ 1.4. on key features of productive, multi-stakeholder partnerships when developing sustainable food forests as the study covers in-depth information on the partnership and collaboration dynamics. It further analyzes implementation success factors of which two are about partnerships, namely recruiting motivated entrepreneurs as well as networking and creating strong partnerships.

Standard case study methods were used in the accompanying research, including direct and participant observations and an auto-ethnographic researcher diary (Gardiner & Rieckmann, 2015; Somekh & Lewin, 2005). Collected data included notes from meetings, workshops, field trips, the review of documents (collaboration agreement, vision and strategy documents, site plan) and a stakeholder survey. Data analysis evaluated the main project phases (presented in Chapter 2.1.1) and their outcomes against the success factors analyzed in prior research (Article 2), and explains the realization of these factors in this case through the lens of a sustainable entrepreneurial ecosystem (Cohen, 2006).

2.2.4 Article 4 – Comparative Study of two Real-world Experiments

Article 4, by Arnim Wiek, Agnes Friedel and myself, compares the two experimental case studies in order to understand why one case was successful and the other case failed and was discontinued. Specifically, we look at one success factor that failed early on in the Lüneburg case, namely creating strong partnerships. In particular, the study aims at finding key features of productive, transdisciplinary partnerships when initiating sustainable food forests. As particular types of partnerships (transdisciplinary, with NGO/public agency partner), this article contributes to RQ 1.3. on features of productive multi-stakeholder partnerships (other types of partnerships are addressed in the synthesis, Chapter 3.2.2). By analyzing which success factors were achieved in both cases, the article also contributes to RQ1.2. With one partnership criteria being about the partner's access to entrepreneurial ecosystem support, it also contributes to insights on the role of the entrepreneurial ecosystem (RQ 1.3). In the wider sense, this study constitutes a basic evaluation of the transdisciplinary methodology, more specifically; it evaluates the results, process and partnership of both cases.

Data was collected through direct and participant observation, a research diary and documents review (minutes, workshop documents, (draft) collaboration agreements, vision and strategy material, criteria-based site comparison). For data analysis, we used an adapted analytical framework for evaluating sustainability experiments (Forrest et al., 2019; Luederitz et al., 2017) focusing on partnerships (Lyon et al., 2020) that were initiated at both cases to develop the food forests as well as their direct, practical results. These include early-stage success factors such as access to land and start-up funds, networking and mobilizing support which we had identified, confirmed and nuanced in previous research (Article 2 and 3). We compared case results, interaction processes, and selection of site and partners at both locations up to the initial familiarization and vision building stage (see Figure 4 on the project phases, between step 4 & 5). At this stage, the partnerships were formed officially and initial discussion on vision elements and direction took place. With one case being located in Lüneburg, Germany and the other in Phoenix, United States, we further compared the broader socio-political, institutional and other contexts that the cases are embedded in.

2.3 Underlying Assumptions and Personal Motivation

The underlying values and norms of what constitutes knowledge, how it is gained and applied, is based on a solution-oriented, pragmatic research philosophy. Epistemologically, this research is guided by pragmatism, where knowledge is produced in an iterative, social process of practical experimentation and theoretical refinement (Caniglia et al., 2021; Fazey et al., 2018; Popa et al., 2015). Knowledge production is understood as context-dependent, e.g., the definition and vision of what constitutes a sustainable food forest varies between locations and communities depending on interests, needs, and more. Hence, a mostly qualitative research approach was chosen. Knowledge as a 'stable belief' rather than a 'truth' allowed an openness for new and different types of knowledge.

Ontologically, from a pluralistic viewpoint, the whole spectrum of philosophies of what constitutes knowledge is acknowledge as relevant (Caniglia et al., 2021). To accommodate this pluralistic view and different types of learners amongst stakeholders in this research, a 'head-hands-heart' approach offered guidance to balance cognitive, psychomotor and affective domains (Sipos et al., 2008). This was applied, for example, in using diverse workshop methods from classic presentations to theater- and nature-education-based methods (e.g., Boal, 2005; Cornell, 1989).

Balancing scientific reliability – using adequate technical evidence and arguments - with social relevance and legitimacy – producing knowledge that is meaningful and respectful to the diverse values and beliefs of stakeholders can be challenging in real-world collaborative settings as encountered in this research (Cash et al., 2003; Popa et al., 2015). To approach this challenge, this research aims at scientific reliability through working systematic, criteria- and evidence-based (Wiek et al., 2012; Wiek & Lang, 2016). The normative and emergent nature of this research can challenge systematic work and requires reflection on, openness to and (re)framing of values and knowledge, and their explicit communication (Fazey et al., 2018). Social relevance and legitimacy is aimed at through the collaborative solution-oriented

dialogue settings combining various values and perspectives of local stakeholders (Lang et al., 2012).

Reflecting on the personal motivation for this research and its methodology, the rate of natural resource depletion and destruction of highly complex ecosystems such as forests that influence our climate, biodiversity and base of life (Schellnhuber et al., 2005) has caused personal feelings of urgency and despair. Despite the global discourse on sustainability issues since the 1990s and a sustainability transformation discourse since the 2000s, evidence on tipping points suggests that we are in a state of planetary emergency: "The stability and resilience of our planet is in peril. International action — not just words — must reflect this" (Lenton et al., 2019, p. 595). In times of emotional distress and uncertainty about complex system dynamics, path dependencies, etc. (Fritze et al., 2008; Waddock et al., 2015), *hope* on the joint creative human forces and seeing a need to act and explore new pathways as a researcher were also a strong driver of this research.

3 Results

3.1 Overview of Scientific Articles

Table 3: Overview of scientific papers including research questions, methods of data collection & analysis as well as results & publication status

Art.	Description	Authors	Research questions	RQ addressed	Main phases	Data collection	Data analysis	Main Results	Status in journal
1	Broad data collection, interviews and site visits at food forests to analyze their services and sustainability	Albrecht, S.; Wiek, A.	What are the general characteristics of food forests? How are food forests organized and managed? To what extent are they sustainable, as measured against a broad set of criteria?	1.1	2 – Compiling an inventory	• Criteria-based web search and snowball sampling • Solution inventory (n=209) • Interviews and site visits (n= 14)	• Case comparison • Quantitative & qualitative data analysis • Sustainability assessment	• Mostly start-ups since 2004 • Common services are education, community building & food production • Most show weak economic sustainability	Published
2	Cross-case analysis of implementation success factors	Albrecht, S.; Wiek, A.	What are success factors, barriers and coping strategies when implementing sustainable food forests?	1.2 1.4	2 – Compiling an inventory	• Sampling for diverse services & age • Interviews, site visits and document analysis (n=7)	• Implementation pathway analysis and comparison	• Nine factors for implementation success, incl. creating strong partnerships	In press
3	Experimental, transdisciplinary case study on developing a sustainable food forest in Phoenix, Arizona	Wiek, A.; Albrecht, S.	How challenging is it to secure the identified success factors? And what is the role of the sustainable entrepreneurial ecosystem in securing them?	1.3 1.2 1.4	3 to 8 – From networking & site selection to exploring transfer & scaling	• Direct and participant observation • Document review (minutes, workshop outputs, etc.) • Stakeholder survey • GIS search and criteria-based site comparison • Auto-ethnographic research diary	• Review of collected data and criteria-based assessment of process • Analysis of success factor and entrepreneurial ecosystem	• Confirms & nuances success factors • Shows relevance of a developed entrepreneurial ecosystem • Shows partnership dynamics	Under revision
4	Comparative case study of the experimental cases on the specific success factor of strong partnerships	Albrecht, S.; Wiek, A.; Friedel, A.	What are key features of productive partnerships when developing sustainable urban food initiatives?	1.4 1.2 1.3	3 to 5 – From networking & site selection to vision building		• Criteria-based case comparison (output, process, partnership)	•Entrepreneurial attitude, accountability and access to support functions as key features of successful collaboration	Submitted

3.1.1 Article 1 - Food Forests – Their Services and Sustainability

The first article answers the question on what constitutes food forests in general and as a sustainability solution. It proposes a more technical definition of food forests including three to seven plant layers in a coherent space and a minimum size of 0,5 ha, and suggests to distinguish them from smaller sites called 'forest gardens'. This article does not adopt this definition to be open for interesting cases, however, the forthcoming articles do so. Generally, food forests in the larger sample are mostly from Western Europe and the U.S. (n=209). 50% are small in size (< 1 acre/0,4 ha, n= 78). Few started in the 1970s, a good number of early adopters started in the 1990s and since 2004, start-ups steadily increased with more than 10 start-ups in most years of the past decade (n=155).

They offer a variety of services: they produce food, regulate and support the environment, and provide social-cultural services (community building, education, recreation). The majority of sites (*n*=209) focuses on education (40%), community building (32%), or food production (11%). Usually, nonprofit organizations or conventional businesses manage them. With their perennial crops, education around food and ecology, and recreational offers, food forests contribute to a diverse food system.

In terms of their sustainability, most perform well on social and ecological criteria but display weaknesses on economic criteria, especially regarding economic viability, lease insecurity and sustainable business model innovation. Best practices were found across the cases, e.g., sustaining livelihoods through specialization on products or services, and for inclusive ownership through cooperative, land trust and foundation models.

3.1.2 Article 2 - Implementing Sustainable Food Forests – Extracting Success Factors Through a Cross-Case Comparison

The second article researches how sustainable food forests can be implemented and what the relevant success factors are in seven cases. Implementation paths differ; however, specific factors were relevant from initiation to implementation for all cases, often in a similar order (see Figure 8).

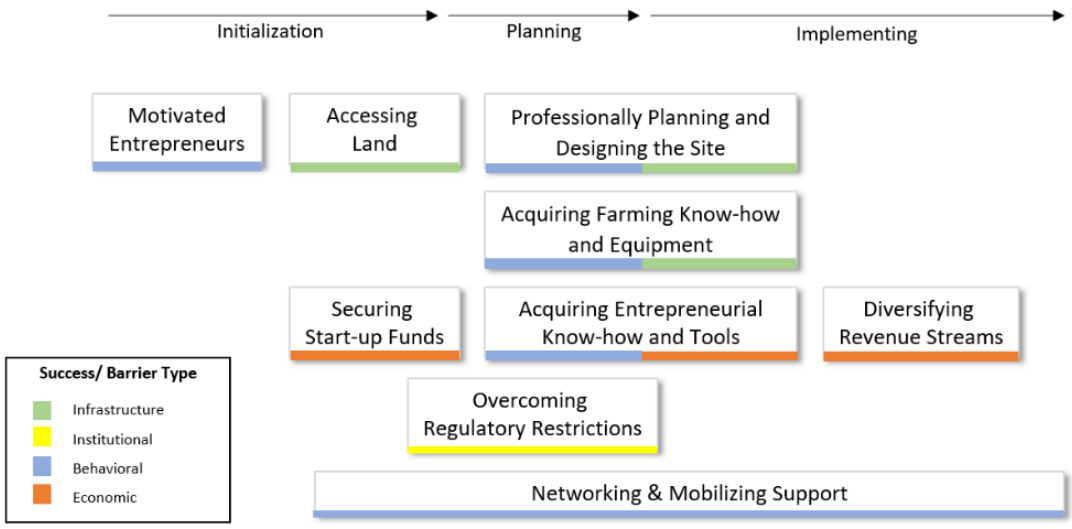


Figure 8: General development path of food forests with relevant factors of success (Article 2)

All nine factors of success are important, independent of the food forests' main services. They are interdependent and influence the sustainability performance of each case. Economic factors like fundraising and acquiring practical entrepreneurial know-how are barriers for many food forests that need advancement, e.g., through training or mentorship. For public matters such as securing access to land or coping with regulatory barriers, negotiations with local authorities or securing professional support (e.g., for licenses or site plan) were success strategies. All identified factors are also relevant for other (food) enterprises, however, the long-term perspective and diversity inherent to food forests brings particular challenges (e.g., high start-up costs, late return-on-investment).

3.1.3 Article 3 - "Almost there" – on the Importance of a Comprehensive Entrepreneurial Ecosystem for Developing Sustainable Urban Food Forest Enterprises

The third article contributes to theory building by confirming the relevance of success factors identified in prior research as well as the importance of a sufficiently developed sustainable entrepreneurial ecosystem that supports the realization of these factors through services such as training, financing, legal advice, and political advocacy. While there is flexibility in securing success factors, the lack of a suite of supporting services can put significant burden on the pioneers developing the site demanding high levels of entrepreneurial creativity, time-consuming experiments and cooperative arrangements. The study shows how fragile the process of initiating and planning a sustainable food forest is as insufficient realization of one key factor (e.g., lack of start-up funds) can slow down or jeopardize the entire success. Regarding the features of the partnership, the study shows motivating factors including alignment with organizational missions (non-profit and educational organizations) and personal values (sustainability, regeneration, healing), financial compensation (my PhD scholarship providing for researching, networking, facilitating as well as project management from initiation to fundraising and piloting), a shared vision to combat urgent, local sustainability challenges and joint activities that built trust in the team. The experimental research provided for more nuanced interpretation of success factors, e.g., on the suite of skills and experiences required by entrepreneurs, and how they may best unfold in a team.

3.1.4 Article 4 - Transdisciplinary Partnerships for Developing Sustainable Food Forests

The fourth article compares the outputs, initiation process and partnership of the two experimental cases, one failing and the other succeeding, showing key features of productive partnerships to develop sustainable food initiatives. More important than the type of organization (government, non-profit, private) seem to be characteristics of partners such as an entrepreneurial attitude which includes motivation to contribute, commitment to food system sustainability including economic aspects such as viability, and readiness for system change. Such characteristics may be less present in a risk-averse, conservation-oriented governmental agency and might require tailored capacity building for a city administration to be a more prominent change agent. Examples of public support for food forests is rare and may be time-consuming to achieve but do exist, e.g., in Seattle, U.S. or Kassel, Germany. As food forests require several years of high up-front time input with 'delayed' returns in yields, careful selection, early on monitoring and reconsideration of partnerships and interaction

process seem key before investing time and other resources and may avoid unproductive and unsustainable path dependencies. The specific context and access to support functions are another influential factor. Both cases lacked a comprehensive entrepreneurial ecosystem with support services such as training and financing. However, in Phoenix, with a broad network in a large city, more options for partnerships and sites were available than in the small town of Lüneburg. Furthermore, in Phoenix, the high urgency for pressing sustainability problems led to a strong shared vision, which the team lacked in Lüneburg.

3.2 Synthesis

The following synthesis brings insights from the four scientific articles and their underlying data together. Characteristics of food forests in general and as a sustainability solution (RQ1.1), directly addressed in Article 1 through broad empirical data, are nuanced with characteristics of the envisioned and planned sustainable food forests in the real-world experiments (Chapter 3.2.1). Complimentary, the broader insights from the inventory and interviews are used to generalize findings from the real-world experiments on success factors for developing sustainable food forests (RQ1.2 addressed in Article 2, 3 and 4) and on the specific success factor of creating strong partnerships (RQ1.4 addressed in Article 4). In particular, the two experimental cases provide nuanced insights into early initiation and planning processes, while seven cases analyzed for their implementation path provide a more general overview up to the later implementation stage (earthwork, planting, etc.). Examples from the inventory and other interviews illustrate or contrast the results further. In a synthesis analysis, Chapter 3.2.2 shows how different partnerships across a broader range of nine cases have contributed to achieving success factors, and how the existence of support services, their lack and coping strategies can give more insights on what is required of an entrepreneurial ecosystem to support sustainable food forests (RQ 1.3).

3.2.1 Sustainable Food Forests

Food forests show a trend in up-take in Western contexts with a majority offering community building and education services, mostly run by people with a socio-cultural background. Around 10% of food forests focus on professional food production, mostly run by people with a professional or academic background related to agriculture or forestry. For most food forests, better integration of economic aspects is relevant to improve their sustainability performance.

Sustainable food forests balance social, ecological *and* economic goals. They provide for improved ecosystem services, and community benefits (e.g., diverse regional and seasonal food, education, aesthetic landscapes) as well as fair wages, economic viability for their staff, and shared decision-making and ownership. The Lüneburg case shows that lack of a shared interest and vision on what characterizes a sustainable food forest hinders their development. Major elements of the jointly created, evidence-based vision and the underlying business plan in the Phoenix case exemplify potential features of a sustainable food forest:

- **Livelihoods**: Community entrepreneurs have full- or part-time jobs in food production, processing, education and agriscaping consulting services and manage the food forest as a cooperative business.
- **Products & Services**: Food forest farmers produce diverse fresh and processed foods that are healthy, organic, and accessible. Food forest educators build capacity in people interested in learning about native foods, healthy diets, healthy soil, food entrepreneurship and a collaborative economy. The community participates in food production, and the food forest improves quality of life through cooler micro-climate, improved water and air quality (including storm water management and carbon storage), and higher biodiversity
- **Longevity & Scale**: An urban farmland trust indefinitely secures the land for sustainable urban agriculture. A revolving fund, e.g., of 10% of the profits, supports start-ups of other food forests.

Several success factors are relevant to develop a sustainable food forest, and their sustainability performance is influenced by the specifics of the implementation process (available funding, practical farming know-how, etc.).

3.2.2 Success Factors & Partnerships for Developing Sustainable Food Forests

To initiate and plan sustainable food forests, in synthesis, five interlinked success factors across four dimensions are relevant (see Figure 9, below). Most success factors are located in the behavioral dimension, namely (1) networking and forming strong partnerships that are resourceful, committed to food system sustainability, and show or support an entrepreneurial attitude, and (2) acquiring and applying a complementary skill set including entrepreneurial, perennial farming and site planning know-how and equipment. (3) Securing sufficient start-up funds, although part of applying entrepreneurial know-how, is highlighted as a separate economic factor due to the need for high up-front investments, late returns and the potentially long duration to secure this factor. (4) Securing long-term land access is the most crucial infrastructure factor. (5) Overcoming regulatory restrictions is an institutional success factor that requires legal literacy. As major restrictive regulations at initiation are related to land access, these factors are covered in one subchapter below.

Compared to the prior findings on food forest's implementation pathways and success factors (Article 2), recruiting motivated entrepreneurs for a core team was a separate factor that is now merged with networking and forming strong partnerships. Although the core team is the first and ideally strongest partnership, characteristics, e.g., of shared values for healthy food and regeneration of land and diversity are similar in other partnerships. The three factors about applying and acquiring skills and equipment from different areas are merged as they require similar activities, e.g., training or mentoring, although often at different intensity and for different topic areas.

Crucial to overcoming barriers and achieving success factors is a fairly developed sustainable entrepreneurial ecosystem, a context that supports the start-up of sustainable enterprises

with relevant services such as legal or financial advice. The below chapters give insights on how different partnerships, active elements of a sustainable entrepreneurial ecosystem, have (not) provided for success factors. Although entrepreneurial ecosystems are broader than existing partnerships, the existence of support services, their lack and coping strategies can give more insights on what is required of such an ecosystem. It is beyond this synthesis to fully assess in how far diverse services dedicated to sustainable (food) businesses exist in the various case study contexts (Germany, Netherlands, Portugal, Brazil, U.S.). Examples are given mostly from the context of the experimental case studies in the U.S. and Germany.

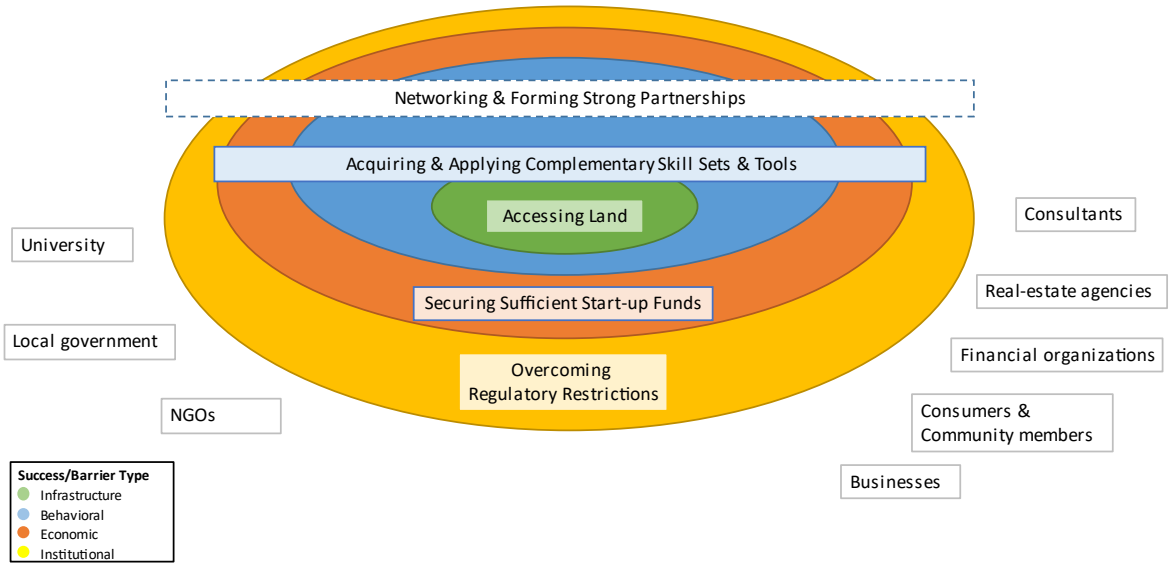


Figure 9: Synthesis of success factors in different areas to develop sustainable food forests, and relevant actors & institutions in the surrounding entrepreneurial ecosystem

Networking & Forming Strong Partnerships

Different partnerships are often essential to secure success factors as they span across different areas and resource needs. Networking broadly across different areas can be a coping strategy when encountering barriers and can potentially secure all success factors. Some partnerships may be more long-term oriented, for example when forming the core team, others may be more short-term, for example for mobilizing volunteers for planting. The importance of specific partnerships may also differ over time with some more relevant in the initiation, planning or implementation stage. Shared values around regeneration of land and people through diverse healthy foods and plants are often a base. However, a shared sustainability vision should go beyond improvement of ecological and social functions, and integrate economic goals in meaningful, context-dependent ways. When selecting and approaching potential partners with important, long-term functions (e.g., for the core team or land access), assessing and addressing their entrepreneurial attitude - their readiness for change, commitment to food system sustainability including economic viability, and motivation to contribute - can be key to avoid dysfunctional partnership. Strong partnerships at other cases confirm this finding from the experimental cases, however, it is mostly businesses that show this attitude. For example, in the case of Mienbacher Waldgarten, the

land owner, a nursery business had planted fruit trees on the land but was unable to manage the site and gladly supported the food forest manager in further developing the site through expertise and other resources. Governmental actors that provided crucial factors like land or funds were rather difficult to work with showing lack of entrepreneurial attitude, e.g., taking two to three years to negotiate on land access (BFF, Waldgarten Britz and Kassel). Hence, it is not surprising that several food foresters access land and funds privately.

Table 4 below shows how food forest initiators and farmers secured success factors through different partnerships from the initiation to implementation stage in nine case studies.

Table 4: Overview of partnership constellations to secure different success factors in nine cases from initiation (red) to planning (blue) and early implementation (green)[2]

		Food Forest Farmers & Initiators			
		Community Members	**NGO**	**Business**	**Higher Education**
Supporter	**Community Members & Consumers**	• Forming core team (BFF)	• Feedback on site plan (BFF) • Planting & management support (BFF)	• Planning support (KY) • Planting support (K, KY, FOF) • Demand (DB, E, MW, KY)	• Feedback on site plan elements (FFC)
	NGOs	• Facilitating access to start-up funds & insurance (BFF)	• Mobilizing volunteers (BFF)	• Advising on start-up funds (K) • Mobilizing volunteers (FFC)	• Facilitating access to land (FFC) • Mobilizing volunteers (FFC)
	Business	• Access to land (MW)	• Mobilizing volunteers (media) (BFF)	• Harvesting support (K) • Demand (K, FOF) • Diversifying revenue streams (MW, E) • Planting support (DB)	• Start-up funds (FFC)
	Government		• Access to land (V, DB) • Start-up funds (BFF)	• Start-up funds (DB, K)	• Access to land (V)
	Higher Education		• Entrepreneurial training (FFC, DB)	• Advising on site and business plan (FFC, DB) • Supporting infrastructure implementation (FFC) • Mobilizing volunteers (E, DB) • Monitoring (DB)	• Forming core team (V, DB)
	Consultants	• Informal consultation on site design (E, DB)		• Advising on site design (FFC, MW)	

Cases from Article 2, 3 and 4: BFF= Beacon Food Forest, DB= Den Food Bosch, E= Essgarten, FOF= Fazenda Ouro Fino, K= Ketelsbroek, KY= Keela Yoga Farm, MW= Mienbacher Waldgarten, FFC= Food Forest Cooperative Phoenix, V= Public Food Forest Lüneburg Volgershall

[2] Simplified presentation of partnerships and success factors. In the initiation stage, several actors started as individual community members or came from higher education, and later formed a business or NGO (reflected by a shift of in columns). Furthermore, some partnerships are more complex, e.g., the Food Forest Cooperative Phoenix was initiated by a consortium of NGOs and academia transitioning into a business or Den Food Bosch consists of a foundation and a business. Data is presented where the respective consortia member or type of organization was more active.

At the start and heart of every project is a core team or person that initiates the food forest. At private sites, often individuals are responsible, with occasional supporters (e.g., family, friends, volunteers; MW, E, FF, K, KY). At (semi-) public sites, often a core team of two to five people is in charge (BFF, FFC, V, DB). Initiation often starts informally, and during the planning or implementation stage, the initiators usually form an NGO or enterprise to access formal partnerships and other success factors (see more below on *Securing Sufficient Start-up Funds*).

During the planning stage, major activities are site and business planning, which require networking with **experts** in food forestry, legal requirements, site planning and alternative business planning (DB, FFC, KY, BFF). Community members and customers (e.g., of site planning courses) may be involved in researching and providing feedback (BFF, FFC, KY), but require familiarization and guidance. Considering potential customers and their needs, networking with **businesses** to ensure stable demand (K, FOF) or diversify revenue streams through joint services (MW) or community engagement with potential **consumers** and volunteers (FFC, BFF) supports realistic planning. Ensuring sufficient demand often requires early-on creative or social media marketing. Collaborating with a **university** early on can provide quality control and adaptation feedback by monitoring site and business development, and by that, support good practices and legitimacy of food forests (FFC, DB). This can potentially lower regulatory restrictions in the mid to long-term (Green Deal, 2020).

Mobilizing diverse, short-term support for the early implementation stage, e.g., earthwork, irrigation and planting, requires broad networking. For the comparably short-term planting activities (although they might take one to two years), neighboring **farmers** may lend machines or provide plants (DB). Planting may be supported by **friends, neighbors** (BFF, K) and **customers** of seminars (KY, PL), the latter requiring marketing skills. **NGOs** and **universities** may mobilize larger groups of volunteers, combining planting or maintenance with education (BFF, FFC, DB).

Acquiring & Applying Complementary Skill Sets

The various expertise and skills necessary to initiate a sustainable food forest call for a team with a complementary skill set, including know-how for networking and forming diverse supportive partnerships, experience in perennial farming, legal literacy as well as business and site planning know-how. While acquiring farming and entrepreneurial know-how ideally happens in the early stages of initiation or prior, applying these tools takes place mostly in the planning stage and improves through context-dependent experiences in the implementation stage. While some skills can be trained, limited capacities (time, money, etc.) call for expertise in some areas and focused investment to develop lacking areas. Most food foresters tend to have developed social and ecological skills, especially gardening or farming skills, but need strengthening and integration of economic skills. Resistance to conventional or alternative economic practices was experienced in some cases (DB, V) and the lack of their application in most cases. This may require familiarization with (alternative) entrepreneurial know-how and tools but may also need deeper work on mindsets. Loss of experienced entrepreneurs is difficult to compensate due to the specialty skills acquired. Hence, continuous motivation,

e.g., through strong values and a shared vision, conflict mediating mechanisms, and sustained livelihood of entrepreneurs are relevant. Furthermore, their long-term perspective, e.g., through shared or purpose-oriented land ownership and business models is important.

Entrepreneurial ecosystem services that advance these behavioral success factors are commonly provided by university or similar educational institutions and consultants (see Figure 10).

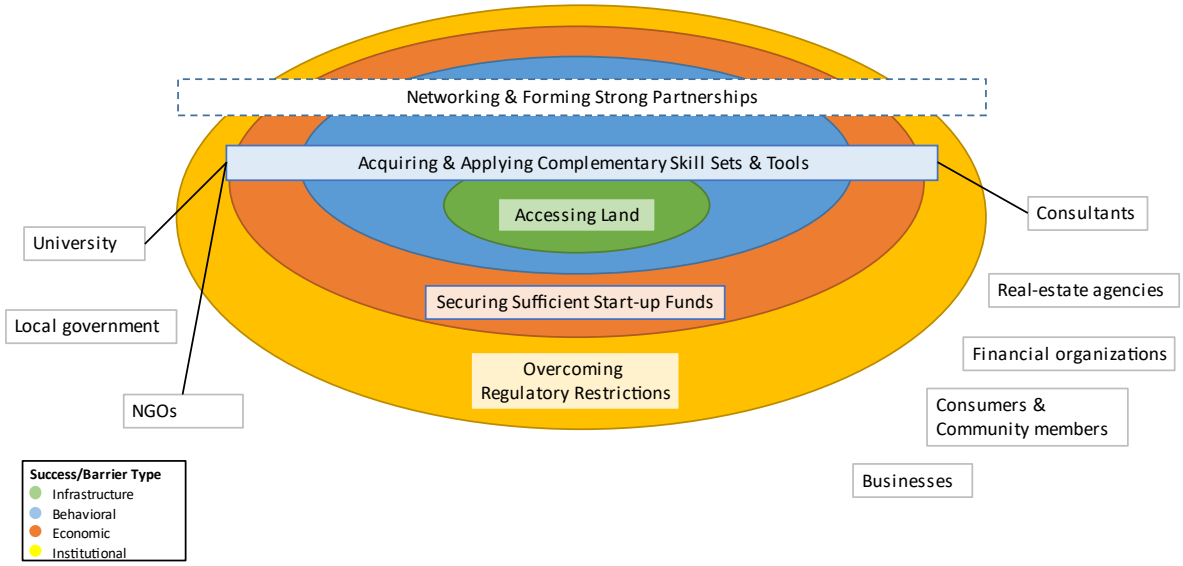


Figure 10: Relevant actors & institutions of the entrepreneurial ecosystem to achieve 'complementary skill sets'

However, in most industrialized contexts, available training on food forests runs from one to ten days, usually with a focus on the socio-ecological dimension and self-sufficiency (permaculture-based courses provided by educational **associations** or consultants). Professional, long-term training opportunity that allows experience and knowledgeable management in different farming seasons, and includes entrepreneurial know-how and legal advice is lacking. As an exception, since May 2021 in the Dutch context, food foresters and an online vendor network started a one-year food forest course including business and legal planning (Green Deal, 2020). Classic courses at **university** can provide advice and training that contributes to site selection as well as site and business planning (e.g., assessing soil and vegetation; advice on plants, products and business models). Universities may also provide specialty expertise (e.g., on irrigation, crowdfunding, keyline design, cooperative businesses) and meeting or event spaces (FFC, V, DB). Moreover, students showed a high interest and motivation to apply their theoretical knowledge supporting food forests (V, FFC, DB). Universities, especially with a focus on applied science, and interdisciplinary expertise in agriculture, forestry, horticulture and innovative business development seem ideal for offering more professional, long-term food forest training. **Consultants** are often pricy and mostly used during initiation prior long-term decisions on the site design (FFC, MW). Consultancy does not guarantee a smooth implementation, nor does it compensate for lack of farming knowledge in the long run (Michelberger Waldgarten, personal communication, April 23, 2021). Lawyers may even charge higher rates as they need to research specialty

knowledge (Waldgarten Rehfelde, personal communication, March 27, 2021). Farming **mentors**, more common informal consultants, often derive from prior work-experience, trainings or visits at other food forest or permaculture farms. Inviting them for giving seminars on-site strengthens the relationship, provides income and updated professional advice (KY, DB, E; Waldgarten Nietklitz). Institutional mentorship for young farmers is a highly demanded instrument recently offered in Germany by the Support Association for Ecological Farming (Födergemeinschaft Ökologischer Landbau), that arranges and funds 1-year mentorships and training for diverse agricultural start-ups, favoring farms that already have accessed land successfully.

Securing Sufficient Start-up Funds

Food foresters have often acquired start-up funds but they are mostly earmarked for infrastructure and not for their livelihood. Coping strategies include a low-cost lifestyle (DB), prior savings (KY), retirement (FFC) or having another job (E, K, FFC). Fundraising a stipend can support livelihoods of food foresters during implementation and training in the first year where there are no yields (FFC). Activities for securing start-up funds should start early on as implementation of food forests is resource intense, and fundraising can be time-consuming due to having to identify suitable funds, write applications and await long response rates. Even when unsuccessful at donor events, well-prepared presentations can attract private donors, that, combined with a comprehensive business plan draft and supporting material as well as a site visit and personal contact, can provide the necessary funds (FFC).

Entrepreneurial ecosystem services that advance these behavioral success factors are commonly provided by financial organizations or local government (see Figure 11).

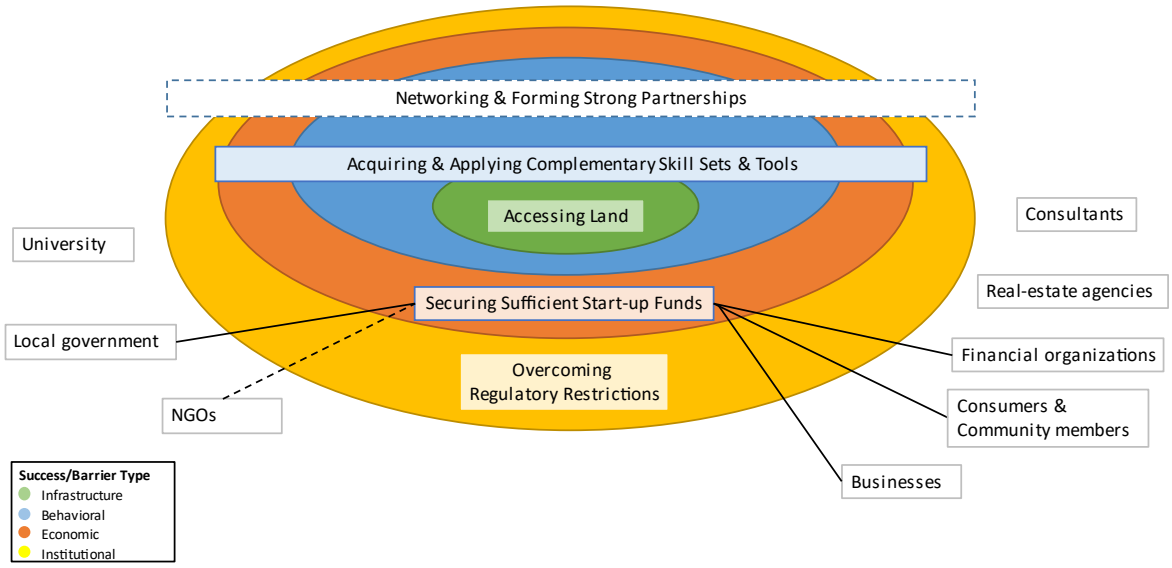


Figure 11: Relevant actors & institutions of the entrepreneurial ecosystem to 'secure sufficient start-up funds'

Financial organizations can provide loans, impact investment and social finance options. However, there are unique features to food forests, including their complex structure and high sustainability aspirations that are difficult to assess, and their late return on investments (after

10-20 years), which can seem too risky for classical financial organizations. In Germany, GLS bank provides alternative loans for sustainability and agriculture projects, including agroforestry farms (e.g., Hof Lebensberg), however, none of the German food forests interviewed have taken a loan here. Some food foresters expressed apprehension to classical financing mechanisms (DB), and as few develop solid business and financing plans, formal requirements for loan applications are lacking. This underlines the relevance of a previously presented support requirement: Training in business planning for sustainable food enterprises, which could be provided by an entrepreneurial ecosystem. More common fundraising activities by food foresters are crowdfunding and grant applications. Crowdfunding platforms allow funding by **community members** and offer a low threshold in the setup of campaigns. In Germany, food foresters on average only reached 6.000€, which may be equivalent to 10% of costs for a 0,5ha food forest (Schroeder, 2020). Skilled crowdfunding can raise larger amounts as the successful campaign of agroforestry farm Hof Lebensberg shows. They acquired more than 200.000€ for planting 30.000 trees (Hof Lebensberg, 2020). Grants by **governmental organizations**, usually earmarked for infrastructure and socio-ecological goals (BFF, DB, K), provide for higher start-up funds but require administrative literacy and early-stage application. Furthermore, experiences in Phoenix, Arizona and Lüneburg, Germany showed that few grants covered truly sustainable projects (including environmental, social *and* economic sustainability) as well as longer implementation phases (2-3 years). **Philanthropic businesses**, more common in the U.S., can be alternative funders for complex, innovative and long-term sustainable food business start-ups like food forests due to the personal contact that allows better familiarization (FFC). In general, to access start-up funds, formalization early on can be an important strategy as funds can be provided by various formal actors like local governments and businesses. As a coping strategy, **NGOs** or educational institutions can act as fiscal agents to allow fundraising before formalization (BFF, FFC).

Accessing Suitable Land Through Long-term Oriented Legal Frameworks

Another important early-stage success factor is site selection, which this research comprehensively approached (see Chapter 2.2.2, Phase 3). Several food foresters privately bought land in marginal locations without access by public transport to gain relatively large and affordable land (K, KY, E). On public sites, negotiations can be resource intense, as they can take several years due to permits or diverging interests, potentially without success or an appropriate lease length above 30 years (BFF, V, FFC). In particular at a public location, balancing a suitable location with suitable partners can be difficult (V, BFF). Private ownership or short-term leases can endanger food forests as the recent sale of Essgarten (Kreiszeitung, 2021) and the lease termination for urban development at Café Botanico (M. Höfft, personal communication, March 9, 2021) show. Some food foresters trust in the yearly lease extension, which might work out more successfully in a rural location and with a land owner that is also a neighbor and friend (MW). Others even take the perspective of being a nursery due to the short-term lease at an urban site (Peace of Land). However, as trees grow slowly, tenure insecurity mostly prohibits professional food production. Furthermore, soil in both rural and

urban locations is often degraded and requires several years to build up. Hence, a long-term perspective to stay on the land, and respective land security rights, are essential. As with accessing funds, formalization early on or partnering with NGOs as a lease taker can be an important land access strategy.

Sustainable entrepreneurial ecosystems for long-term agricultural land access are highly underdeveloped. Potentially, several actors can provide for access to land (see Figure 12), from classic real-estate agents to local government or NGOs such as churches – high-volume landowners and co-initiators of several food forests - as well as consortia of consumers and businesses through land cooperatives.

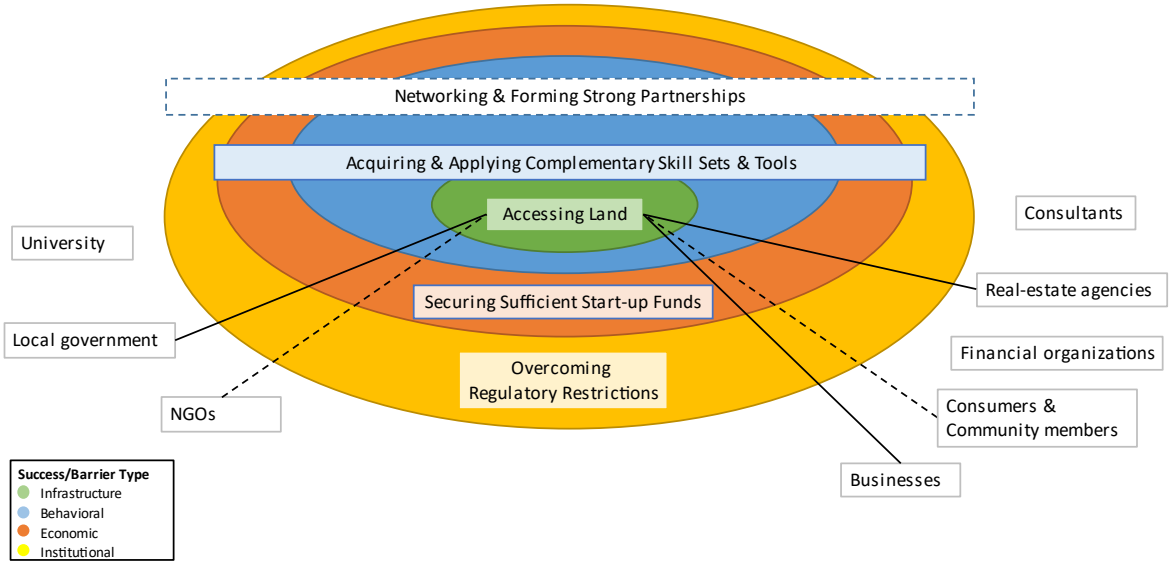


Figure 12: Relevant actors & institutions of the entrepreneurial ecosystem to 'access suitable land'

In both regions of the case study experiments, (peri)urban farm land is under pressure of housing and business development, or large-scale monopolizing farms. Strategies for securing agricultural land for a viable local food economy are lacking. In Phoenix, a local **NGO** started forming an alliance with the mission to create a regional land trust for farmland, also collaborating with our practice partners; yet, progress is slow, compared to the pace of land being converted and developed. In Lüneburg, no regional support exists. On a national level in Germany, several cooperative **businesses** formed to secure land for organic agriculture (e.g., Bioboden eG, Kulturland eG). However, there is more demand for land being secured than capacities to secure. For access to public land, there are different gradients of support experienced, depending on the **governmental** body, their roles and interests. An environment-related agency like the local water authority may be more aligned with sustainability goals and be an active partner that supports the food forest (DB) than an intermediate agency that manages property for the city (Peace of Land) or a governmental administration for public sites that may oppose economic activities (V). Lack of explicit high-level policy support may muffle administrative agency support (V). Interestingly, only a few from 209 scanned food forests were co-initiated by a proactive governmental actor (Kassel, Germany; Atlanta, U.S.). In the Dutch contexts, several public sites managed by the Coöperatie

Ondergrond in Rotterdam serve commercial community food production in exchange for education and maintenance.

Legal frameworks often inhibit or do not incentivize long-term, tree-based land management. Along with the annual crop production paradigm, yearly leases are common agricultural practices. With a short-term perspective, planting trees is unprofitable, as they take space without producing in the first years, and potentially endanger the agricultural status of land (e.g., in Germany, a near natural vegetation can turn into a non-returnable protected landscape element) (Böhm & Hübner, 2020). Despite funding for agroforestry being offered by the **EU** since 2007, several countries, including Germany, do not use these funds and have not registered agroforestry as an official land use type (ibid.). Officially defining and registering biodiverse agroforestry systems like 'food forest' as a land use type is a unique advancement in the Netherlands (Green Deal, 2020). The administrative ignorance in many countries can lead to additional burdens and absurd requests like implementing a compensation area for changing the land to a food forest (MW). Overall, regulatory restrictions are very context dependent, however, they often lack flexibility and room to experiment with innovative approaches.

3.2.3 Ideal-typical Implementation Path for Sustainable Food Forests and its Supporters

With these more nuanced insights on success factors, existing partnerships as well as lacking support structures, Figure 13 explores an ideal-typical implementation path for sustainable food forests with more intricate process activities and ideal-typical supporters. It shows that in the beginning, ideally entrepreneurs acquire professional know-how from higher education in programs that account for perennial farming and planning, sustainable entrepreneurship and food system regulations. Programs over a longer period of time allow to form an entrepreneurial mindset and experience different farming seasons. The building of the core team, its sustainability vision and action plan, as well as formal organization is supported by an external facilitator or consultant specialized in sustainable food business start-up to ensure quality visioning, planning as well as team building. Access to land and funds can come from diverse public and private actors who value and support the development of sustainable food businesses. Depending on the local context and services focused on, additional skills may need to be acquired from higher education or consultants to overcome regulatory restrictions, and plan the site and business professionally. Community members as well as potential business or private customers can support the planning process through participation processes ensuring the local integration and meeting of demands. For food forests with strong socio-cultural services, a community planning approach is well equipped with the necessary participation resources. University supports monitoring, evaluating and adapting of the process and outputs considering a comprehensive sustainability vision. Before implementation, plants are propagated and seeded on-site as well as ordered and acquired at nurseries businesses. Nurseries are well equipped with edible, perennial plants and provide information on their yield and caretaking. Furthermore, before acquiring farming equipment, e.g., for earthwork, propagation or irrigation, researching and testing of different tools is supported by businesses well equipped for small-scale farming. Networking starts at initiation.

It is focused on realizing all underdeveloped success factors and supported by NGOs and mentors through their network and events that build purposeful, long-term partnerships. During the planning stage, networking focuses on finding professional feedback, and prior implementation on mobilizing hands-on support, both supported by higher education and NGOs. Furthermore, the actors of the sustainable entrepreneurial ecosystem in the region of the food forest are well connected with and support each other.

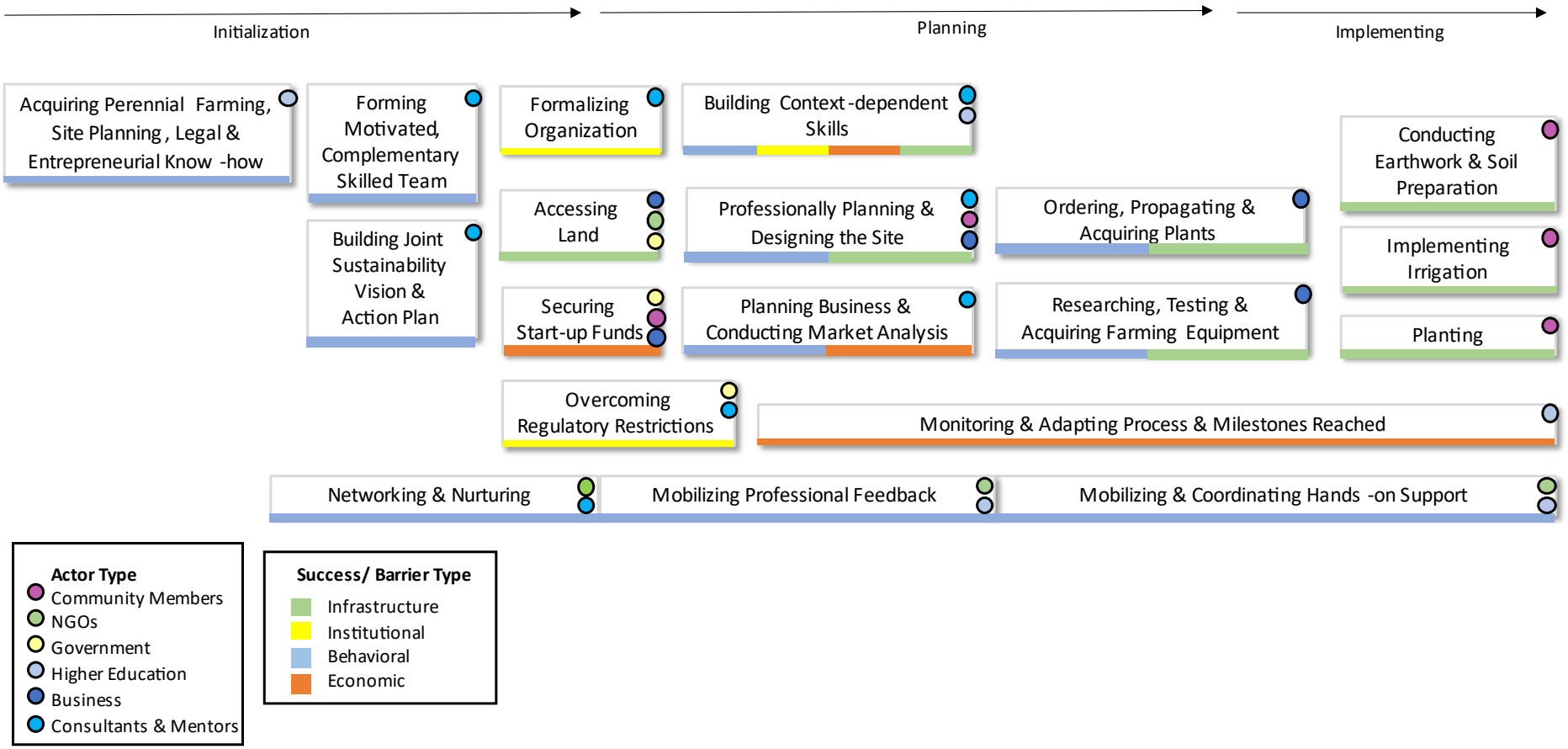


Figure 13: Ideal-typical development path for sustainable food forests with main activities across different areas & relevant supportive actors from the initiation to implementation stage

Compared to the previous implementation chart based on empirical insights (Article 2), in this process chart, the planning stage is more built out, which allows for more foresight, effectiveness and targeted decision making. To move from the informal sector of trial-and-error into a more formal and planned food forest development, in particular, the role of institutions of higher education stands out as a base, providing study programs that prepare individuals for this specialty food entrepreneurship with interdisciplinary, practice-oriented skill sets. Furthermore, the role of mentorship and consultation support structures throughout the initiation and planning stage stands out, which might be an alternative strategy without such study programs available. This more detailed, colorful implementation path shows even more, how expertise and resource needs from different areas are required throughout the process. Especially in the transition phase from initiation to planning, diverse partners can support the process. This points to the need for a larger core team of initiators or diversely specialized experts to successfully navigate multiple partnerships in diverse areas of expertise.

4 Discussion

4.1 Developing Food Forests as a Sustainable Food System Solution

Focusing on developing professional food production services of food forests seems relevant to seize their full potential as a sustainable food solution, utilizing underdeveloped income options and sustaining the livelihood of food foresters. With their radically different, climate-positive and regenerative design compared to industrial food production, food forests are mostly developed in protected niche settings. However, like other grassroot innovations, these settings are often protected by 'shielding' or 'nurturing' rather than 'empowering' activities (A. Smith & Raven, 2012). The current trend of food forests to focus on education and community building nurtures and provides protective space for experimenting. However, it lacks empowerment to either conform with the competitive food production mainstream, e.g., by price-performance adaptations, or stretch the incumbent regime, e.g., by gaining trust from policy or incumbents to invest (ibid.). A 'balanced empowerment' approach may support individual development of food forests and control by more formal institutions to anchor professionalism and directionality while ensuring motivation and engagement (Bugge & Siddiq, 2021). In food production, this quality control may come from governmental and formal educational institution involved in agriculture, forestry and food business development that are open to innovative approaches. As this research was only successful in initiating one food forest focused on professional food production, further accompanied research pilots need to show how this can be accomplished in different contexts, including (peri-)urban and rural locations, and with different types of partnerships, including NGOs, governmental actors and businesses.

Planning their enterprise as a professional business from the beginning, is done by few food foresters as this research has shown. Aiming at mimicking nature, they grow the food forests as a 'living organism' for a better life for themselves and others. Eventually they generate some incomes but often neglecting to sustains themselves and accepting personal burdens.

As the paradox of lacking self-care in the care industry shows (Chipu & Downing, 2020; J. J. Miller et al., 2018), caring for 'others' may go with undermining personal self-care, and requires balancing practices. Balancing tensions between the various social, environmental and economic goals are a common challenge in sustainably-oriented, mission-driven enterprises (Schaltegger & Wagner, 2011; Żur, 2020). More so, in the 'lively business' based around a food forest ecosystem, these tensions show to be highly unbalanced towards socio-ecological goals, neglecting economic aspects. However, business planning activities early on can shed light on financial needs and income realities, identify knowledge gaps to strengthen and provide confidence. Trial and error experiments are relevant, however, 30 years of experience by food forest pioneers in industrial contexts and centuries of indigenous knowledge provide for comprehensive know-how that can be built on (Giezen, 2018; Götsch, 1992; Schulz et al., 1994; Shepard, 2013). Various growth modeling instruments exist for simpler agroforestry systems that can support the planning process (Burgess et al., 2019), and need to be further developed to integrate more complex designs and specialty crops.

Acquiring a multi-functional mind- and skill-set to initiate a complex sustainable food enterprise is not an easy undertaking but seems key to balance the various goals and tasks of sustainable food foresters. Research on the initiation of pluralistic farms that offer multiple services and products and innovative sustainable food enterprise confirms the need for various highly developed skills, strong values for creative and meaningful work activities, and confidence often gained through experiments (Antoni-Komar & Lenz, 2021; Seuneke et al., 2013; J. Smith et al., 2012). It further shows that the underlying beliefs of the farmers are highly relevant and that developing new entrepreneurial identity and mindset are time-consuming processes (ibid.). They require finding ones role in the complex food system and redefining the meaning of entrepreneurship, which is marked by the conventional productivist and reductionist paradigm, and its associated logic (Seuneke et al., 2013; J. Smith et al., 2012). Working in marginalized contexts, e.g. with high poverty rates, food deserts, etc. as in South Phoenix, where these solutions may be most needed, it can be difficult to recruit entrepreneurs with relevant skills and mindsets (Morris & Tucker, 2021). Support structures that form sustainable entrepreneurial mindsets and skill sets across different contexts, e.g., through educational institutions, are widely lacking (Bernardi & Azucar, 2020; Uvarova et al., 2021). Although, university is often the main supporting institution in developing (food) sustainable enterprises, and has been supportive for food forest development, it needs to provide for more practical education including interpersonal techniques, education for business start-up, and support the access to diverse networks and viable markets (Bernardi & Azucar, 2020; Malecki, 2018). It may also contribute to overcoming structural injustices by supporting underprivileged students. Research on university curricula and other professional educational formats for agroforestry in industrial food systems is at a nascent state, mostly covering short-term courses, i.e. two to seven days (Hemmelgarn et al., 2019; Mendelson et al., 2021). Further approaches with more long-term, comprehensive educational formats on agroforestry, food forests and links to sustainable food business development are required

that empower to harness food forests' multi-functionality and account for different seasons, services and development stages.

Accessing suitable land through legal literacy, purpose-oriented partnerships and policy support needs fundamental shifts, including shifts in our relationship to land. Most food foresters access their land privately. However, private land ownership is a deeply rooted concept based on Roman law which often facilitates private capital accumulation, land take and soil degradation (Creutzig, 2017; Stankovics et al., 2020). The other common option of public land access often comes with high negotiation costs and use restrictions. Niche innovations practice alternative, shared and purpose-oriented land ownership models that understand land as a common good, however, require policy support or decrease of barriers in legal frameworks on various scales (Rosol, 2020). Such models can provide for land access and control rights, as well as shared decision-making structures and hence, offer a *long-term* management perspective for food foresters. A 'windows of opportunity' for policy changes may derive from the recent decision on national support for agroforestry in Germany (Deutscher Bundestag, 2021), although it is far from supporting land access and start-up concerns. Navigating the complex interplay of land policy at various scales and matching ownership models required regulatory literacy. And again, deeper de-commodificating shifts of land-related ownership mindsets may be required seeing food not as a mere commodity, but understanding food as part of the local culture, livelihoods and shaping the landscape (Jackson et al., 2021; Webb et al., 2020). Forming partnership based on these values may offer the long-term land access needed for food forests. Even deeper values, to reflect on, are expressed by the indigenous perspective of 'not owning the land, but belonging to it' (F. Brandao, personal communication, July 23, 2017).

Accessing suitable start-up funds can be strengthened through planning and forecasting activities. Looking at further cases and partnerships only confirms the presence of public grants related to their socio-environmental services and limited to infrastructure costs. Business loans can be unsuitable for innovative but risky entrepreneurial endeavors (Bernardi & Azucar, 2020). A comprehensive business plan can improve the chance for acquiring a loan, and provide further options beyond the highly competitive grant scene to acquire start-up funds that include staff cost and business development. It can be used for discussions with business angels, family and friends. Similar shared values as related to land access may be a relevant base. Public seed funds for innovate food businesses, not used by any of the interviewed food forests, are an often lacking but promising support instrument (ibid.).

Key features of strong supportive partnerships include an entrepreneurial attitude, long-term orientation and holistic food values. Strong partnerships to develop sustainable food forests support their professionalization and value food beyond being a commodity. Ideally, they are focused on long-term impacts and innovation in the food system, allowing for a more comprehensive understanding of the complexity and barriers, and can provide a potentially relevant network for further support. For wider impact in the food system, partnerships work on both niche and regime levels to foster regional innovation cultures (Bernardi & Azucar,

2020). This means involving policy and incumbants that support and interact with a community of innovative practitioners, ideally, based on purpose-oriented dialogue and long-term commitments (ibid.). Formulating clear and ambitious goals as a mission, like 'covering 10% of urban land with food forests by 2050', can help policy makers to steer the directionality and adoption of innovation (Hekkert et al., 2020). To involve public administration as change agents and partners, tailored capacity building and structural changes may be required to overcome the lengthy initiation phases observed in multiple cases. Public-private partnership pioneers in the Netherland showcase potential pathways working across economic, institutional and educational dimensions. They develop market-conforming, production-oriented pilot projects, supportive policy and educational Open Access resources like efficient business plan templates that can sustain the livelihood of the food forest farmer, and allow wider uptake and impact on the local food market (Green Deal, 2020). Further research on how these cross-organizational partnership unfold is needed to understand dynamics, barriers and success factors.

4.2 Methodological Challenges and Success Factors

Reflecting on the design, implementation, evaluation and dissemination of the experiments, several principles successfully guided the research through challenges throughout the project. Principles are structured corresponding to the project phases (Chapter 2.2.) and are discussed with the conceptual framework on essentials for action-oriented transformation research (Fazey et al., 2018) and further relevant research. All essential seem relevant throughout the project but some stood out more in certain phases, and the analysis may show what has been (under)developed in the respective phases.

Overall, from designing to evaluating the experiments, the process-oriented approach going through phases from initiation via familiarization to vision and strategy building, etc., was a helpful methodological guide providing for structure and a clear ontology but also flexibility in the real-world settings. "Researching-by-doing" (Lang et al., 2012), moving relatively fast from knowledge to implementing action and conducting research while co-leading a multi-stakeholder process, requires competences hardly trained for in academia such as interpersonal and normative skills to facilitate change processes, deal with conflicts and reflect on normative goals (Wiek et al., 2012). Besides being in the roles of being a (self-)reflexive scientist and networker (Wittmayer & Schäpke, 2014), other roles were that of an 'advanced project manager' (working with scientific tools and principles), creative facilitator and motivating coach. While this allows access to relevant data, it also poses several challenges such as self-evaluating the own work (Wiek et al., 2014) as well as balancing diverse tasks that may stretch the comfort zone and require self-care practices (Sellberg et al., 2021). Evaluation challenges were approached by documenting data transparently and explaining evaluative statements. Furthermore, article 4 includes a comprehensive analytical reflection on the outputs, process and partnership in both experiments.

Table 5: Overview of project phases, their practical & methodological challenges & success factors or coping strategies & corresponding essentials for action-oriented transformation research (Fazey et al., 2018)

	Project Phase [Chapter 2.2.]	**Practical Challenges**	**Methodological Challenges**	**Methodological Success Factors or Coping Strategies**	**Main Corresponding Essentials for Action-oriented Transformation Research** (Fazey et al., 2018)
1	Project Initiation	Sustainability problems in industrial food systems	Complex, wicked problems	Multi-faceted capacities to initiate action-oriented transformational research	1. Focus on transformations 2. Focus on solution processes, 3. Focus on 'how to' practical knowledge 4. Approach research as occurring from within 7. Take a multi-faceted approach to understand and shape change 10. Be reflexive
2	Compiling an Inventory of Food Forests	Unknown niche solution with diverse characteristics	Lack of solution knowledge	Compiling evidence-based solution knowledge as a base	2. Focus on solution processes 3. Focus on how to practical knowledge
3	Networking, Partner & Site Selection	Lack of resources, esp. compensating time of practice partner; limited suitable sites in Lüneburg	Multiple roles as researcher	Networking with a pragmatic, systematic and flexible research mindset and selecting partners ready for sustainable food system change	1. Focus on transformations 5. Work with normative aspects 6. Seek to transcend current thinking and approaches 10. Be reflexive
4	Familiarization with & Experiencing of Exemplary Food Forests	One-sided thinking; dysfunctional partnership in Lüneburg	Multiple roles as researcher, lack of data collection on capacities built	Familiarizing partners with comprehensive sustainability solution	2. Focus on solution processes 5. Work with normative aspects
5	Visioning & Strategy Building	Different priorities, one-sided thinking, lack of ownership & lack of funds for partners and accompanying research	Multiple roles as researcher, evaluating own research	Applying diverse methods, attentive communication and reflective, iterative learning cycles for meaningful sustainability visions and strategies	6. Seek to transcend current thinking and approaches 8. Acknowledge the value of alternative roles of researchers 9. Encourage second order experimentation and change 10. Be reflexive
6	Fundraising & Piloting	Lack of suitable funding options for sustainable food businesses	Lack of monitoring on pilot performance	Balancing stamina and non-attachment in fragile, time-sensitive piloting processes	2. Focus on solution processes 5. Work with normative aspects 6. Seek to transcend current thinking and approaches
7	Implementing the Strategy [Phoenix]	Lack of funding to coordinate implementation & conduct research	[end of main research time, covered in Chapter 4.3. on Limitations]	Implementation based on prior achievements, in-kind contributions and a strong partnership	9. Encourage second order experimentation and change
8	Exploring Transfer & Scaling [Phoenix]	Lack of funding for transfer & scaling activities		Knowledge transfer in one stakeholder workshop & a blog-establishing seminar	8. Acknowledge the value of alternative roles of researchers

Phase 1: Multi-faceted Capacities to Initiate Action-oriented Transformational Research
Reflecting on my personal background, different key skills and experiences seem relevant that encouraged me to initiate this research, and empowered and guided me personally to move through various roles, out-of-comfort zone and shifts of perspectives. These relate to six out of the nine essential for action-oriented transformation research (Fazey et al., 2018).

Prior this research, I had gained comprehensive system knowledge on the status quo of industrial food systems through a Master on *Integrated Natural Resource Management* at the agricultural faculty of *Humboldt University of Berlin*, motivating me to contribute to sustainable food solutions (Essential 2). I further had developed interpersonal and facilitation skills through short trainings in non-violent communication, sociocracy, nature education and mediation, and co-facilitated workshops while working at the environmental policy think tank *Ecologic Institute*. There, I contributed to research projects on EU soil policy, agricultural pollution, transformation processes, and art for sustainability. Overall, my inter- and transdisciplinary education and work experience helped me to develop associative thinking and supported a multi-faceted approach to change, including an openness to learn from different perspectives and form a common language (Essential 4). Reflecting on key competencies for sustainability scientists (Wiek et al., 2011), while interpersonal and system-thinking competencies had been built through diverse experiences, other relevant competencies were weaker and built during this research, namely anticipatory, normative and strategic competencies (Essential 5, 6, 8).

Sensing the urgency to act on sustainability problems, e.g., by experiencing true wilderness in Australia and realizing its loss in Europe, and, witnessing the increase in depleted monocultural landscapes worldwide, combined with some understanding of the complexity of our ecosystem, motivated my focus on transformations (Essential 1) in the industrial food system. Growing up in a 'hands-on', craft-experienced family that managed a home garden supported an affinity to 'how to' practical knowledge (Essential 3) as well as sustainable food production. More than 10 years of practice in yoga and meditation supported reflection (Essential 10) and self-care capacity with intense retreats like Vipassana meditations that heighten awareness and sense of unity (Essential 4) provided confidence to stretch my comfort zone and transform emotions like fear or anger into attention for setting boundaries and clearer communication. Due to the common lack of sufficient funds for action-oriented transformational research (Krellenberg et al., 2019), beyond care for society and science, it should integrate the personal aspects of *self-care* by transdisciplinary researchers and frontrunning practice partners (Sellberg et al., 2021).

Phase 2: Compiling Evidence-based Solution Knowledge as a Base
Compiling the inventory as well as visiting and interviewing different types of food forests through classical research methods prior experimenting, provided for an important base to familiarize stakeholders, showing different options, (un)successful practices and important success factors during their development (Essential 2, 3). However, the more we went into

practice, the more detailed, context-dependent knowledge was becoming necessary, requiring further solution expertise and collaboration.

Phase 3: Networking with a Pragmatic, Systematic and Flexible Research Mindset and Selecting Partners ready for Sustainable Food System Change

Throughout this research but especially in the scoping phase, we met with diverse stakeholders from grassroot activists to policy makers and from entrepreneurs to academics. Our research mindset in the various phases was **'**to be prepared' with systematic structure, foresighted, thorough planning and evidence-based criteria and data, and 'go with the flow', being open and flexible in the process. Besides more formal reflection formats, short reflective moments on a daily basis in the team or by oneself were essential to keep up (Essential 10). We successfully applied transdisciplinary design principles, e.g., creating clear roles, partial professional facilitation, however, did not follow the ideal-typical phases outlined by Lang et al. (2012). Due to limited resources, especially in funded staff, a more pragmatic research approach allowed moving relatively fast from knowledge to action with reflection-based adaptations and small interventions. This, however, requires partners that are ready, willing and motivated to change as well as aligned with the sustainability problem or solution (Essential 1). It was appropriate and generally successful working with hands-on, time-restricted NGOs running a start-up farm to fight pressing local sustainability problems. It, however, did not work out with an administrative agency constricted by silo-thinking that lacked authority, motivation (reflected by unresponsive communication) as well as positive experiences and trust in participatory processes. To overcome current thinking and approaches, work with normative aspects and focus on transformation (Essential 1, 5, 6) in this case would have required resources beyond a PhD thesis. In both cases, from this stage on, having a strong interdisciplinary partnership was essential – not only for the diverse expertise but also for motivation, peer reflection, advice and access to other resources.

Phase 4: Familiarizing Partners with Comprehensive Sustainability Solution

The focus on developing a sustainability solution (Essential 2) motivated both practice partners and further supporting partners to collaborate, however, in both cases, we encountered one-sided solution thinking on either the ecological or the social dimension as the collaboration unfolded. In Phoenix, working with diverse formats that uncovered tension points and repeatedly showing the deficits from an underdeveloped economic dimension supported a shared sustainability understanding (Essential 5). In Lüneburg, lack of a shared understanding on a comprehensive sustainability definition, beyond motivation by insect loss, contributed to failure. At this stage, reflection formats should include the explicit consideration of an exit option in case of dysfunctional partnerships as these are the most common reasons for failure in transdisciplinary research (Fam & O'Rourke, 2020).

Phase 5: Applying Diverse Methods, Attentive Communication and Reflective, Iterative Learning Cycles for Meaningful Sustainability Visions and Strategies

Focusing on solution processes by applying vision and strategy building techniques (Essential 2) formed the methodological base but was orchestrated by other key essentials to navigate in real-world settings. In both cases, funding structures fostered scientific leadership, causing initial vagueness and ownership issues which showed in this phase as it demanded more resources (e.g., attention, time) from the partners. Our partners in Phoenix were motivated and present regularly at meetings, however, with several other responsibilities, lacked time to prepare for or lead activities until funding became available. We encouraged collaboration and joint decision making through diverse methods from more informative or normative to instructional, relational and reflective (see Table 2, Chapter 2.1.2). Furthermore, as our partners were rather hands-on, balancing cognitive with affective and practical activities was key. Experiential formats like the mindfulness walk and field trip were most talked about and referred to after (Essential 6, 9). This confirms research findings on the relevance of creative, interactive methods with visualizations and informal conversations in action-oriented research (Fazey et al., 2018; Fraser & Galinsky, 2010; Lang et al., 2012). Combining these diverse techniques with transparent communication, e.g., addressing values and power issues, we experienced increased awareness, bonding and trust. "Simple" techniques were also key, e.g., to encourage decision-making (preparing evidence-based options with questions on key issues to decide on), harvest knowledge and decisions (asking for consent, mind-mapping) and set boundaries for unsustainable directions. This required skills in attentive listening, diplomatic communication, mediation and negotiation (Essential 8).

Joint reflection and adaptation took mainly place during vision and strategy building as well as developing site and business plan (Essential 10). Chaos, frustration or irritation were important indicators to reflect on and potentially intervene, and using them for the creative process to improve our collaboration, actions and vision. We intervened when the process stagnated (e.g., with energizing exercises, role creation) or went off agreed-upon quality criteria (e.g., unsustainable choices). This refers only to the Phoenix case as relevant response was lacking in Lüneburg. Deeper reflective (theatre-based) activities and discussions (e.g., on the projects purpose, the teams' interconnection and unsustainable decisions) made fears, values and assumptions more explicit. Data collection on (deeper) reflections could be more systematic e.g., along a framework of transformative learning (Kitchenham, 2008; Sipos et al., 2008). The research diary captured mostly social interactions and (personal) tension points as well as several shifts in assumptions and values (e.g., seeing "weeds" as biomass or potential products) but did not harvest its full potential. The methodological approach to use research diaries is often vaguely documented (e.g., Hölscher et al., 2021; Wanner et al., 2020) and explicit guidelines for transdisciplinary researchers to use it as a tool for interventions, navigating different roles and self-care are lacking. A structured approach could include potential obstacles (areas) across different research phases and questions for reflection on the research process and its quality (appropriateness, effectiveness, transparency, etc.) as well as personal behavior, emotions, values, assumptions and beliefs. For longer term

projects, different sections such as lists of things to cover, recent inner and outer events, milestones reached, intersections of roads (not) taken to identify unresolved issues, daily log, and dialogues to clarify relationships (Janesick, 1999; Progroff, 1977) may provide another structure for deeper reflections. A modular approach could help craft this for individual research projects and different learning approaches (audio, visual and/or written data) as well as ways to analyze and reflect on the data and process, e.g., through maps and pathways (Parmentier-Cajaiba, A. & Cajaiba-Santana, G., 2020).

Phase 6: Balancing Stamina and Non-attachment in Fragile, Time-sensitive Piloting Processes
In Phoenix, most challenging was the lack of anticipating inertia and structural obstacles, namely financing, which caused a one-year stagnation. With most success factors in place, patience and frustration tolerance amongst team members were crucial. The partnership was strong enough to endure it, had developed a comprehensive vision and taken small in-kind steps from the action plan (Essential 2, 5). A alternative, private funding sources provided for the resources to continue both the implementation in Phoenix as well as my research finalization (Essential 6). In Lüneburg, the almost ideal location of the site - accessible, diverse neighborhood, etc. – had caused perseverance in approaching the unresponsive practice partner. In hindsight, the site attachment came at high costs, as the experiment failed and much unfruitful time had been spent. The research team became more sensitive of time resources, especially after investing more than a year into a case that failed. In Phoenix, the research especially learned to better account for the time budget of practice partners, including sickness, tiredness and farming peak season, and their research teams' time budget, e.g., later decision criteria on an intervention taking place inside or outside included 'stress level'. Aspects of time and timing like election times or different routines or pace are often underestimated in transformation research (Kristof, 2021) and could be accounted for more in reflection processes .

4.3 Limitations of this Research

While this research contributed to generating actionable knowledge and enabled new interactions to develop sustainable food forests, due to lengthy and fragile real-world processes, we only contributed to comprehensive knowledge generation on the initiation and planning stage but not the full implementation outcomes. In a way, this exemplifies the tensions between navigating (and researching on) change and its open-ended and emergent nature (Patterson 2017).

The complexity of real-world processes is not to be underestimated by simplifying graphs. Transformational sustainability research takes time and care, it is as real as life gets.

In hindsight, the initial goal of implementing two sites *and* doing transfer activities in two international locations was very ambitious considering the lack of a comprehensive support structure, especially in the Lüneburg context. We did start the implementation of one food forest (Phase 7) based on prior achievements, in-kind contributions and a strong partnership, and conducted one workshop in the Phoenix case to transfer knowledge gained in the pilot

project (Phase 8). Sustainability *outcomes* or transformational impact were *not* assessed for this early stage (initial phase) of developing the food forests as this is more appropriate at later stages after implementation. It further remains to be evaluated how our partners perceived their *overall* learning process (e.g., changed assumptions, and cognitive, interpersonal and practical capacity built). Deeper reflection along a framework of transformative learning might answer this and build further capacity. Further research is required to demonstrate implementation mechanisms and management practices, provide comprehensive learning and transfer activities as well as analyze the contributions to a sustainable local food system to provide substantial evidence on successful actionable knowledge. To better generalize insights of the experimental cases and improve transferability of this multi-functional and adaptable solution, follow-up interviews with the broader sample of cases and research on their context could support more nuanced insights about their key features for different services, how supportive partnerships developed and unfolded, and the role of a sustainable entrepreneurial ecosystem in providing support services.

Ideally, a team would conduct this type of research and share results about the project as well as the scientific work. The rich experimental cases provided for comprehensive data that was only partly collected and analyzed. The "researching-by-doing" mode (Lang et al., 2012) implies a priority on solving the real-world problem rather than scientific outcomes, which shows in our process and project results. While we still created scientific knowledge, an improved setup, e.g., in a dedicated project team, could leverage project impact both scientifically and practically.

With a need for multi-level change approaches along structural, functional, relational and cognitive dimensions for fundamental shifts (Patterson et al., 2017), complementing the micro-level approach of this research with a more systemic and structural perspective on the meso and macro level, e.g. on food forest impact in the health system or local food economies could contribute to transformational research insights. This could include, for example, for structural barriers, bringing together diverse food foresters with governmental (and other) actors on a regional, national or international level, to understand how to overcome restrictive regulations. Or in the health system, bringing together care and wellness professionals with food foresters to explore their implementation at elderly homes or resorts.

4.4 Contributions

4.4.1 Scientific Contributions

This research provided a broad general knowledge base on existing food forests, mostly in industrial food systems, and a more technical definition of food forests to improve administrative literacy. It further provides a first evaluation on the sustainability of food forests and nuanced insights on success factors on how to develop them based on a broader cross-case and in-depth case analysis. This research further contributes to theory building by confirming the importance of potent partnerships and sustainable entrepreneurial ecosystems in supporting start-up endeavors (Cohen, 2006; Lyon et al., 2020), in particular in realizing success factors for food forest development.

In transdisciplinary research, this study may provide solution-oriented researchers, especially in their early-career stage, with methodological insights around challenges, success factors and coping strategies. It covers a case of failure which is rare in success-biased science (Fam & O'Rourke, 2020). It confirms and nuances insights on transdisciplinary partnerships, especially for the early project stage when forming the partnership (scoping phase), which lacks adequate coverage (Bennich et al., 2020).

4.4.2 Practical Contributions

Two durable project teams were created in both case study locations to develop sustainable food forests, a transdisciplinary team in Phoenix including practitioners envisioning to become long-term entrepreneurs, supportive organizers and researchers, and an interdisciplinary team in Lüneburg.

In Phoenix, furthermore, the team secured a suitable site with mid-term security through a lease for 10+ years, and sufficient start-up funds for infrastructure, plant setup, start-up salaries, etc. through a private donation ($100.000). Additionally, several professional plans were created: A comprehensive action plan based on extensive food forest research, a reiterated site plan supported by a landscape architect and an evidence-based business plan (see Appendix A2.2). Familiarization activities build theoretical know-how about food forest farming and on cooperative business planning. The team further implemented a small display site.

Further practical outputs are a report on a transfer workshop in Phoenix (see Appendix A2.1). In Lüneburg, three transdisciplinary seminars, with overall 82 students learning about food forests and their development, further led to a blog publishing on interesting cases and good practices as such information was lacking in German language and for Germany-based cases.

5 Outlook: Beyond the PhD

In real-world, multi-stakeholder endeavors, projects do not suddenly stop when data collection ends but may rather just begin.

In the Phoenix case, we reached major success factors - securing start-up funds and recruiting entrepreneurs - in spring 2021 after the graduate school that funded this research had ended. During the stagnation in Phoenix, due to lack of start-up funds, two new partnerships emerged in Lüneburg. After the initial failure, the interdisciplinary partnership was still motivated to initiate a site. In Lüneburg, through the university-based network, we started developing a display site for the Leuphana University campus and a 1ha site with a permaculture farm through transdisciplinary project seminars and Bachelor theses.

Figure 14: Vision draft for the new Lüneburg food forest (Jacob Schweigler, Leuphana Food Forest Lab 2021)

In my 'scientivist ecosystem' several partnerships emerged. From early on, a news reporter and friend approached me for conducting a long-term documentary and accompanied many stages of the research, providing for quality photos, a short film for funders, further reflection of myself and partners, and feedback on community outreach material. It demanded extra time resource and created some bias, but mostly in motivational ways taking the interviews or projects more serious. The documentary is scheduled to finish filming in spring 2022 after major plantings in both Lüneburg and Phoenix, and may contribute to further familiarization about sustainable food forests and how to develop them.

In the final stages of implementation, which this research prepares but does not cover, transformation knowledge is embedded in the end product and services of the implemented food forest. In this 'research for practice' (Hope, 2016), the food forest is like an artwork build through practical and technical knowledge that developed in the process of implementing it. Due to high levels of tacit knowledge involved, it is more enigmatic and difficult to capture through scientific means but needs the experience for understanding.

6 Conclusion

Food forests with their diverse productive, socio-cultural and environmental services, can address several problems industrial food systems cause such as malnutrition, economic disparities, biodiversity loss, climate change or lack of food literacy. However, the lack of integrating economic aspects hinders seizing their full potential and advancing their uptake as sustainable food system solutions. This study aimed at finding key features of sustainable food forests, and actionable knowledge on how to successfully initiate, plan, and implement them as comprehensive sustainable solutions.

Sustainable food forests balance social, ecological *and* economic goals including improved ecosystem services, diverse food production and socio-cultural services while being economic viability and collaboratively managed. To advance as a comprehensive sustainability solution,

formalization and professional procedures (e.g., planning, monitoring/accounting) as well as shared ownership structures that support long-term management are required.

The implementation of food forests with their pluralistic characteristics (multi-functional, multi-strata, multi-year crops) in reductionist-oriented industrial food systems (mono-culture, mono-expertise, mono-year crops) poses various barriers from access to land and start-up funds, restrictive regulations to lack of specialty know-how. Strong partnerships, characterized by an entrepreneurial attitude and alignment with food system sustainability are key to support their professionalization and improved development as a sustainability solution.

Supporting the implementation of sustainable food forests as a researcher is a complex endeavor requiring cognitive, interpersonal, anticipatory and strategic competences, e.g., to facilitate diverse partnerships, manage diverse socio-economic and ecological goals. In our richly evaluated case, critical factors were (1) a systematic and flexible research mindset, (2) diverse methods engaging head, hand and heart, (3) pragmatic solution orientation and (4) regular reflective practices. In the real-world experiments, we overcame barriers like the initial fatigue in shared problem definition and economic sustainability by being flexible and going with the action-oriented flow but patiently and persistently reminding of our shared goals and intervening with focused exercises, as well as ending a dysfunctional partnership. Comprehensive support structures could leverage transformational sustainability research.

Practitioners and researchers may learn from the multiple demonstrated food forest cases, their strength and challenges, and detailed implementation pathways for sustainable food forests. Researchers interested in transformational sustainability research may use this approach and its reflection on challenges, success factors and coping strategies as a guide to carefully craft their research. Further research is needed on the sustainability outcomes of the implemented food forest in Phoenix, meso and macro level research on food forest impact to sustainable local food (sub)systems, as well as transfer and scaling mechanisms. Furthermore, application-oriented guidelines for early-career transformational sustainability researchers are recommended.

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Appendix

A.1 Scientific Articles

A.1.1 Article 1

Albrecht, S. & Wiek, A. (2021).

Food Forests – Their Services and Sustainability.

Journal of Agriculture, Food Systems and Community Development.

10 (3), 91–105.

DOI: 10.5304/jafscd.2021.103.014.

Journal of Agriculture, Food Systems, and Community Development
ISSN: 2152-0801 online
https://foodsystemsjournal.org

Food forests: Their services and sustainability

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Submitted July 29, 2020 / Revised October 22, 2020, and February 8, 2021 /
Accepted Febuary 8, 2021 / Published online July 10, 2021

Citation: Albrecht, S., & Wiek, A (2021). Food forests: Their services and sustainability.
Journal of Agriculture, Food Systems, and Community Development, 10(3), 91–105.
https://doi.org/10.5304/jafscd.2021.103.014

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.

Keywords

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

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Funding Disclosure

This research was made possible through the graduate school 'Processes of Sustainability Transformation' at Leuphana University Lüneburg, funded by the Robert Bosch Stiftung (12.5.F082.0021.0).

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 (Konijnendijk & 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	• Workplace with protective gear, diverse work activities, precautionary measures • Activities for community benefit, social justice, environmental regeneration
	Contribution to community wellbeing	• 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	• Learning activities for cognitive, normative, affective, and motoric development
Environmental Criteria	Water conservation and soil formation	• Measures for water conservation (e.g., drip irrigation, rainwater harvesting) and soil formation (e.g., chop-and-drop, mulching, Terra Preta)
	Cool microclimate	• Cooling and shading measures, e.g., dense, multi-strata design with high canopy cover and ground cover, surrounded by green infrastructure
	High biodiversity	• High species diversity and cultivation of rare varieties (flora), undisturbed areas for fauna, connection to green corridors
Economic Criteria	Economic viability	• Sustaining livelihoods of staff by providing fair wages (for at least one part-time position) and covering operating costs
	Formalized organization	• Reliability and foresight, for example, through having a site plan, tracking yields, bookkeeping, registered organization, related professional background
	Shared ownership and decision-making	• 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 organizations 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 1. Geographical Distribution of Food Forest Sample (n=209)

Map created with Leaflet.

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

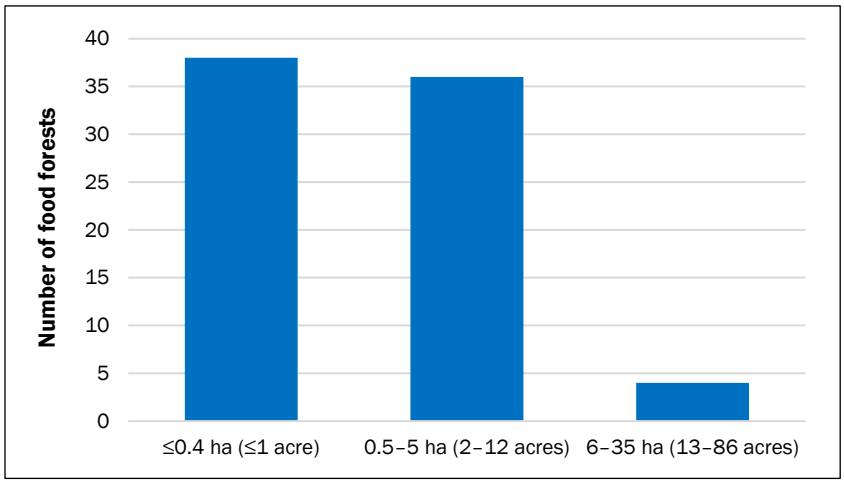


Figure 3. Number of Food Forest Started by Year, 1971–2017 (n=155)

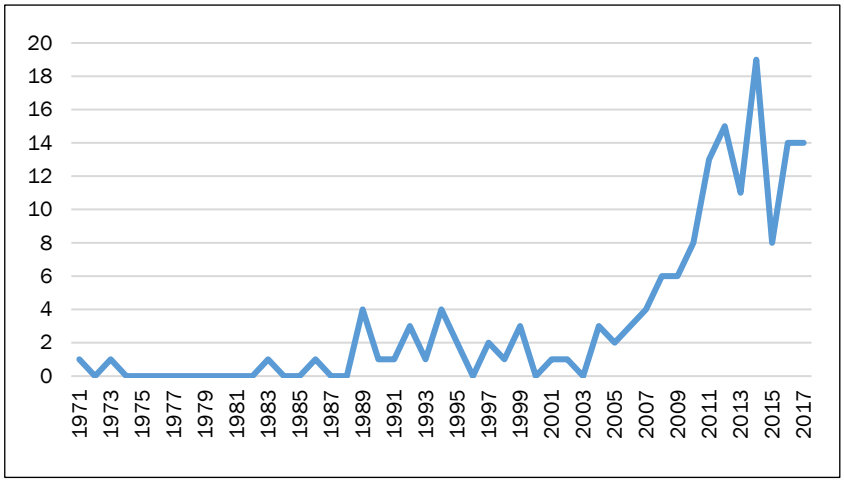
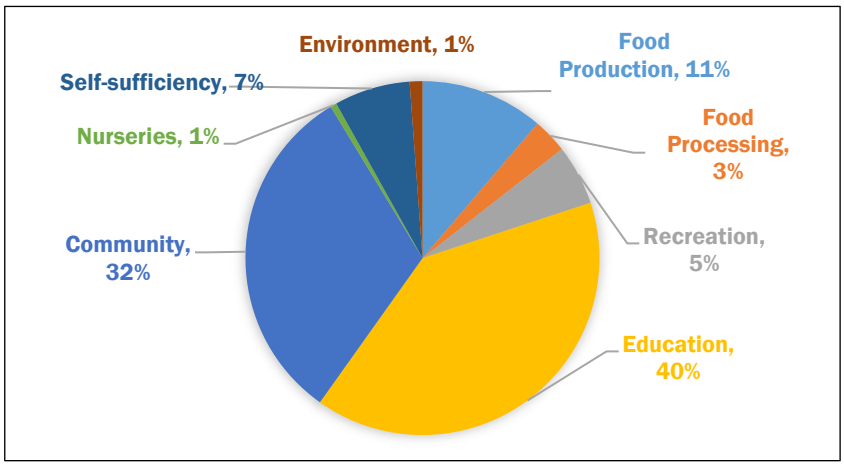


Figure 4. Main Services of Food Forests (*n*=209)



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 AgroParisTech, 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

	Social-Cultural criteria			Environmental criteria			Economic criteria			
Food Forest Cases	**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**	**Average Score**
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

Journal of Agriculture, Food Systems, and Community Development
ISSN: 2152-0801 online
https://foodsystemsjournal.org

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
Permakultur-garten 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.

Acknowledgments

We would like to thank all food foresters for offering their insights in interviews and during site visits. We also would like to thank two anonymous reviewers for their constructive comments on an earlier version of this article.

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A.1.2 Article 2

Albrecht, S. & Wiek, A. (2021, in press).

Implementing Sustainable Food Forests –
Extracting Success Factors Through a Cross-Case Comparison.

Journal of Agriculture, Food Systems and Community Development.

Journal of Agriculture, Food Systems, and Community Development
ISSN: 2152-0801 online
https://foodsystemsjournal.org

Implementing sustainable food forests: Extracting success factors through a cross-case comparison

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Submitted March 10, 2021 / Revised May 20 and June 27, 2021 / Accepted June 30, 2021 / Published online December 21, 2021

Citation: Albrecht, S., & Wiek, A. Implementing sustainable food forests: Extracting success factors through a cross-case comparison. *Journal of Agriculture, Food Systems, and Community Development, 11*(1), 183–200. https://doi.org/10.5304/jafscd.2021.111.019

Abstract

Food forests are multistrata ecosystems that provide healthy food, livelihood opportunities, as well as social-cultural and environmental services. With these features, food forests address several problems industrial food systems cause. While the overall number of food forests is continuously increasing worldwide, the rate of uptake is still low. This study reconstructs in detail how different types of food forests (n=7) were realized, mostly in Europe, with a focus on organization and management. Findings confirm and add to previous studies indicating that the successful implementation of food forests depends on long-term land access, sufficient start-up funds, and adequate farming and entrepreneurial know-how, among other factors. While these are not unique factors compared to other farm and food businesses, sustainable food forests face particular obstacles to secure them. This study offers guidance to food entrepreneurs, public officials, and activists on how to successfully implement food forests to realize their full sustainability potential.

Keywords

Food Forests, Forest Gardens, Food Economy, Food Entrepreneurship, Implementation Paths, Case Studies

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Funding Disclosure

This research was made possible through the graduate school 'Processes of Sustainability Transformation' at Leuphana University Lüneburg, funded by the Robert Bosch Stiftung (12.5.F082.0021.0).

Introduction

The conventional globalized food system causes negative externalities worldwide (Garnett, 2011; Rockström et al., 2020; Tilman & Clark, 2014). Considering that climate tipping points are in reach (Lenton et al., 2019), sustainable food system solutions are urgently needed. Food forests are multifunctional ecosystems that might offer such a solution, or at least part of it, through a variety of services, including food provision, livelihoods, and environmental services, among others (Albrecht & Wiek, 2021). We define a food forest as a coherent, multistrata space with a majority of edible perennial plants, a minimum size of 1 acre (~0.5 ha), and 10% canopy cover to provide forest-like ecosystem services and significant food production. We focus here on food forests as business or nonprofit endeavors that go beyond self-sufficiency. We define food forest managers as entrepreneurs, even if they often act through alternative markets and organizational modes, as they offer products or services to the public and generate an income from their activities.

Food forests have been developed and cared for by Indigenous people around the world for thousands of years (Ford & Nigh, 2009; Kumar & Nair, 2004). The number of 'modern' food forests worldwide has been steadily increasing since the 2000s, yet, the overall number is still small and the rate of uptake is low (Albrecht & Wiek, 2021). This is due, in part, to a conflict of economic paradigms: food forests, particularly those with ambitious sustainability goals, are oriented toward long-term and optimally balanced co-benefits, while mainstream business culture pursues short-term profit maximization, which creates obstacles for the implementation of food forests under current economic conditions. A good share of food forests therefore have been created as nonprofit organizations, private side businesses, or public-private partnerships (Albrecht & Wiek, 2021), including many (community) food forests on public urban sites (Konijnendijk & Park, 2020; Vannozzi Brito & Borelli, 2020). However, making them economically viable by generating sufficient income for maintenance and livelihoods often conflicts with the interest of public lease givers or community-oriented initiators, even if no profit is generated (Bukowski & Munsell, 2018). These food forests also often struggle with insufficient funding and over-reliance on volunteers. In addition to these barriers to general uptake, it seems reasonable to assume that the sustainability performance of food forests is also influenced by the specifics of the implementation process (available funding, practical farming know-how, etc.). While there is some empirical evidence that these challenges hamper the wider uptake of food forests in general (Belcher et al., 2005; Björklund et al., 2019) and the adoption of sustainable practices in particular (Albrecht & Wiek, 2021), there is a lack of in-depth understanding of the most relevant factors of implementation success over time.

This gap is not surprising considering the nascent state of academic research on food forests. The majority of recent studies describe the social-cultural and environmental benefits of food forests, often through single case studies (Park & Higgs, 2018; Riolo, 2019; Schafer et al., 2019; Wartman et al., 2018); offer insights on basic features, services, and sustainability of food forests through comparative empirical studies (Albrecht & Wiek, 2021); or provide practical guidance on creating food forests (Bukowski & Munsell, 2018; Remiarz, 2017). A few studies focused explicitly on success factors of implementation. A study on forest gardens in Southeast Asia and South America identified as success factors diversifying income, integrating other farming systems, choosing crops that mature within 5-10 years and are commercially valuable, as well as possessing substantial environmental knowledge and securing land tenure (Belcher et al., 2005). A recent study of 12 food forests in Sweden revealed that concepts and designs that match location, intended services, and beneficiaries are critical for developing successful food forests (Björklund et al., 2019). Furthermore, healthy soil properties, water availability, wildlife pressure, professional designs, appropriate equipment, good management practices (e.g., sufficient working hours, short distance between site and residence), and sufficiently large size (for food production) were identified as success factors, too.

An in-depth understanding of the implementation paths that food forests pursue, however, is missing. The present study attempts to bridge this

gap by extracting factors of implementation success from a comparative study of select cases. We reconstructed the implementation paths of seven diverse food forests, mostly in Europe, with a particular focus on organization and management, based on document analysis, interviews and site visits (data were collected in 2018). The sample was composed to reflect primarily diversity in main services provided and maturity or age of the food forest.

The findings provide guidance for food entrepreneurs, public officials, and activists on how to implement sustainable food forests (or to support implementation). Therefore, we also describe common barriers that should be anticipated and planned for.

Research Design

This study uses a framework for analyzing the process and outcomes of sustainability solutions in order to identify general factors of success (Forrest & Wiek, 2014). This framework has been applied to community development and water governance (Forrest et al., 2020; Forrest & Wiek, 2015), and seems most applicable to sustainability solutions that are being developed and implemented over long periods of time (10 or more years), including food forests.

We selected seven food forests from a large sample of cases compiled in an inventory (n=209) and from a subsample of cases we conducted detailed case studies on (n=14) (Albrecht & Wiek, 2021). Of the seven selected food forests, five are in Europe (two in Germany, two in the Netherlands, and one in Portugal), one is in South America (Brazil), and one is in North America (USA). We selected the seven cases based on the following criteria: first, the cases represent a broad diversity of main service and maturity or age (Table 1); and second, the cases are well documented through primary or secondary data. The main services consist of the common activities carried out at each food forest, with implications for organization and management (Albrecht & Wiek, 2021). By including different age groups, we provide insights on the different practices of early pioneers versus late adopters. The Brazilian case was selected to include a mature case (over 10 years) with a focus on professional food production, which is rare in Europe and the U.S. Data on six cases is based on semistructured interviews and site visits that focused on the organization and management over the course of the implementation process (data collected in 2018). The case study on the Beacon Food Forest is based on extensive recent research by Bukowski and Munsell (2018), which provides comparable data and allows the inclusion of a successful and renowned community-based case from the U.S. The other socio-cultural cases focus on regenerative and/or educational services. By design, all food forests provide various environmental services; however, some stand out through their eco-centric design and management (e.g., limited visitor access, minimal management), such as Foodforest Ketelbroek.

We reconstructed the implementation paths of the selected seven food forests up to stable management based on primary data (observations, interviews) as well as secondary data (reports, website, etc.). We structured the implementation into a number of phases and tracked key actions, actors, and outcomes, as well as barriers and coping strategies, using standardized analytical categories developed by Forrest and Wiek (2014). For each site, we created a visual pathway and an implementation narrative.

Finally, we compared the implementation

Table 1. Overview of Food Forests Selected for this Study

Main Services	Young Cases <5 years	Established Cases 5–10 years	Mature Cases >10 years
Food Production Services	Den Food Bosch (NL)	Foodforest Ketelsbroek (NL)	Fazenda Ouro Fino (BRA)
Social-Cultural Services	Keela Yoga Farm (PRT)	Mienbacher Waldgarten (GER), Beacon Food Forest (USA)	Essgarten (GER)
Environmental Services		Foodforest Ketelsbroek (NL)	

paths systematically in order to generalize insights on success factors and barriers across cases, differentiated into behavioral, infrastructure, institutional, and economic factors. We pragmatically differentiate (partial) *success* from (partial) *failure* of the food forest using a set of sustainability criteria (see Table 2), developed in prior research (Albrecht & Wiek, 2021) based on literature on sustainability (Gibson, 2006), agroforestry and food forests (Jose, 2009; Park & Higgs, 2018), as well as expert interviews. If one or more criteria were not met at all (scoring 0), we considered the food forest to have partially failed (regarding its overall sustainability ambition) and explored the reasons for this.

An Exemplary Implementation Path: *Den Food Bosch*, the Netherlands

Den Food Bosch is a showcase site for regenerative food production that has operated since 2017 on 2.5 acres (1 ha) near the city of s'Hertogenbosch, colloquially known as "Den Bosch" (population about 150,000). Its intricate food forest design (Figure 1), mostly inspired by permaculture and syntropic farming, allows harvesting on all layers (Figure 2). Produce is sold weekly on-site. Additional sales channels and processing options are currently under development.

Den Food Bosch is governed by a foundation that contracts food forest managers who are responsible for generating their income. Students from HAS University of Applied Sciences (which focuses on agricultural and food technologies, with about 3,500 students) in s'Hertogenbosch occasionally conduct research and volunteer on-site. The local water authority owns the land.

Considering its young age, Den Food Bosch already performs well with an overall average sustainability score of 1.4 out of 2 (Table 2). However, while it performs strongly on social and ecological criteria, it shows some weaknesses in the economic

Table 2. Sustainability Performance of Den Food Bosch in 2018 (2=fully met, 1=somewhat met, 0=not met) Applying the Multidimensional Set of Criteria Developed in Albrecht & Wiek (2021)

	Criterion	Qualitative Assessment	Score
Socio-cultural Criteria	Meaningful, safe employment and activities with social purpose	Pioneers in alternative biodiverse farming; high stress of start-up with intensive production and without financial security	1
	Contribution to community wellbeing	Regional, seasonal, fresh and organic food supply at affordable prices	2
	Capacity-building	Volunteer events for experiential learning; tours to familiarize neighborhood with food forests; consultation services	2
Environment Criteria	Water conservation and soil formation	Close to waterways for stormwater management; developing water-holding capacity Mulch, organic fertilizer, and chop and drop management with biomass plants	2
	Cool microclimate	Young site; high layer diversity	1
	High biodiversity	High species diversity and cultivation of rare varieties; connection to green corridors	2
Economic Criteria	Economic viability	Insufficient income from early product sales and consultation for two full-time managers; lack of established sales channels or processing options (leftover produce); break-even estimated after 3-4 years, high profitability predicted, but no financial security for the first years	0
	Formalized organization	Foundation; evidence-based site plan; monitoring yield and environmental parameters	2
	Shared ownership and decision making	Foundation with a board for long-term decision-making; land owned by water authorities and leased by foundation (insecure tenure, though)	1
	Overall Score Average		**1.4**

Figure 1. The Trellis at Den Food Bosch Runs in a Semicircle Suncatch

Figure 2. Den Food Bosch in 2018, Nine Months After Planting on Seven Different Layers

performance, especially regarding overall economic viability.

How did Den Food Bosch reach this point? What were major actions and outcomes? Who was involved? What were barriers and how were they overcome? Below, the implementation path of Den Food Bosch is described and visualized (Figure 3).

Initialization Phase

Four undergraduate students of agriculture at the HAS University of Applied Sciences started discussing food production alternatives (beyond the standard agriculture curriculum) in 2015. In fall 2016, the students organized a kick-off meeting and other events (movie nights, gardening workdays) on a potential food forest project.

Planning Phase

The students then organized additional workshops, field trips and info events, partly supported by renowned food forest experts and the university, in order to draft an initial food forest plan. As part of this effort, the core group networked and identified four potential sites for the food forest by early 2017. They eventually leased 2.5 acres (1 ha) of land in a small municipality near s'Hertogenbosch,

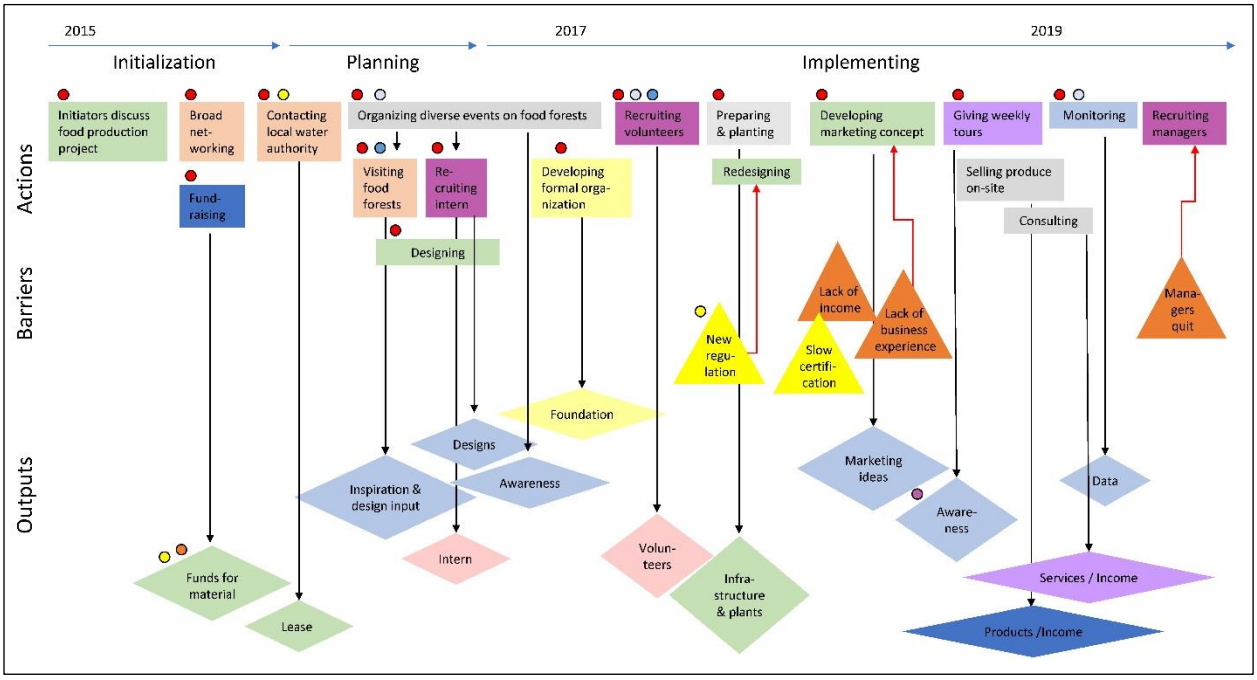
owned by the local water authority. In parallel, they raised funds for materials (e.g., plants, infrastructure) from the local municipality and the AgriFood Capital Foundation. In late 2017, a forestry student with practical experience in syntropic farming completed the site design for the food forest in an undergraduate thesis.

Main Implementation Phase

The core group formed the Den Food Bosch foundation with a board advising on strategic decisions, and two of the former students started working as managers handling the daily operations of the food forest. They recruited volunteers for support, mostly from the university, and implemented the site plan between fall 2017 and spring 2018, including fence construction, mulching, and planting.

The two managers offered weekly tours to familiarize neighbors and guests with the project and to market the produce. At this early stage, the income of the managers was mostly generated through sales of annual vegetables and small consultation contracts, while additional revenue streams (e.g., produce processing, selling at farmers market) did not yet exist. The business plan, however, remained underdeveloped, and the managers faced financial insecurity, in part due to the small local consumer base. In late 2019, after 2 years of operating Den Food Bosch, the two managers quit and returned to Germany (where they started a regenerative agriculture project on a 124-acre [50-ha] site in the Pfalz). Six months later, by mid-2020, the Den Food Bosch foundation recruited two new site managers.

Figure 3. Implementation Path of Den Food Bosch, 2015–2019



Legend

Actions	Actor Type	Output Type	Barrier Type
Networking	Core Group	Human resources	Infrastructure
Mobilizing	Community Members	Services	Institutional
Planning	NGOs	Infrastructure	Behavioral
Organizing	Government	Institutional	Economic
Publicizing	Higher Education	Knowledge	
Fundraising	Business	Products	
Executing			

Main Factors of Success

A variety of factors enabled the implementation of Den Food Bosch. In the Netherlands, food forests are fairly well known and even legally defined for regulatory authorities. In 2018, stakeholders from government agencies, NGOs, and practitioners signed a memorandum entitled "Green Deal Food Forests" that financially supports the planning and implementation of food forests. Also, the local water authority was interested in research on water-holding capacity, and thus agreed to a favorable leasing contract. In summary, Den Food Bosch had favorable institutional conditions for implementation. In addition, the core group was made up of students/ graduates from an agriculture degree program at a nearby university who had some practical experience in food forestry. This allowed for leveraging agricultural expertise (e.g., for developing the site plan and the planting), contacting food forest experts, mobilizing volunteers, accessing meeting and event spaces, and obtaining resources for planning, monitoring, and planting. Finally, the two managers dedicated a great deal of time and hard work to the project, without adequate compensation. One reason was their motivation to gain in-depth food forest experience applicable beyond Den Food Bosch (which they now leverage in their new project in the Pfalz).

Main Barriers

While Den Food Bosch was quite successfully implemented, with a fully developed food forest design in place and a good sustainability performance (Table 2), there are factors that hindered its progress. Both business and financing plans were underdeveloped, leading to a lack of sufficient income for the managers. In addition, the team encountered regulatory barriers. During the planting process, local waterway regulations changed. This required adapting the design (to increase the distance to the waterways) and accommodating management changes by the local water authority. Furthermore, pursuing organic certification was put on hold as the certification process was judged to be too time-consuming. However, organic certification is required for sales at the organic market, which would have yielded higher profit margins. When the two managers, who had been instrumental in planning and implementing the food forest, left, Den Food Bosch lost a lot of organizational memory about site design and management.

Success Factors and Barriers of Food Forest Implementation

The reconstructed seven food forest implementation paths (similar to the example of Den Food Bosch presented in the previous section) indicate specific success factors and barriers related to organization and management for each food forest (Table 3).

From this base, we derive a set of general success factors and barriers, differentiated into behavioral, infrastructure, institutional, and economic factors (Figure 4). Despite context-specific features of each case, all cases display some of these general factors that influence their sustainability perfor-

Figure 4. Factors of Success When Implementing Food Forests

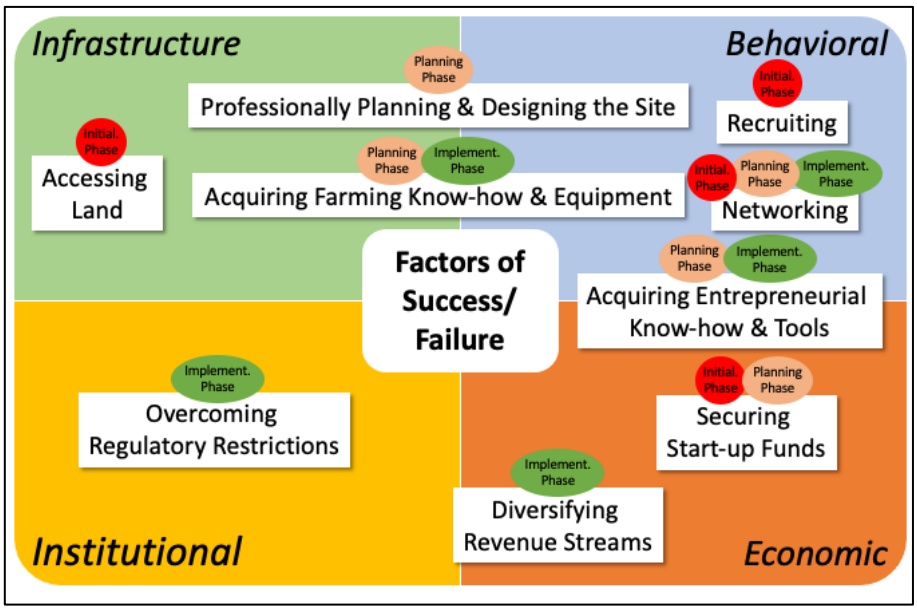


Table 3. Main Success Factors and Barriers of Implementing Food Forests

Name, Location, Ownership	Start	Main Functions	Size	Success Factors	Barriers
Essgarten Germany, metro-hinterland Private	1990	Recreation, Education (Self-sufficiency)	6.2 ac 2.5 ha	• Motivation related to healthy food and entrepreneurial attitude (experimental, creative, outgoing, entertaining, caring) • Land access (affordable land) • Equivalent to start-up funds (independent income, low costs, hobby) • Professional design advice (landscape architect and permaculture trainer) • Farming know-how (gardener; permaculture trainer for seminars) • Entrepreneurial know-how (experience gastronomy, orangery for events)	• Lack of expertise on specialty plants • Challenges with managing volunteers • Regulatory barriers (gastronomy certificate)
Fazenda Ouro Fino Brazil, rural Private	1993	Food Production, Education (Self-sufficiency)	62 ac 25 ha	• Motivation related to healthy food and self-sufficiency • Professional planning (with pilot) • Farming and entrepreneurial know-how (agronomy, syntropic farming) • Diverse revenue (high-value cash crops and services) • Equipment (for food processing)	• Degraded land (former pasture) • Lack of staff (harvesting) • Lack of practical farming know-how
Foodforest Ketelsbroek Netherlands, urban hinterland, Private	2009	Food Production, Education	5.9 ac 2.4 ha	• Motivation related to previous food entrepreneurship experience; Network • Land access (affordable land) • Equivalent to start-up funds (independent income, low costs, earthwork funds) • Farming know-how (agricultural consultant, gardener) • Diverse revenue (education, consultancy, food), supportive customers, local demand (co-harvesting food businesses)	• Degraded land (former monoculture)
Beacon Food Forest USA, urban metro Public	2011	Community, Education	7 ac 2.8 ha	• Motivation related to education, community building and land stewardship (senior expertise, long-standing involvement in urban policy); Network and partnerships (access to land, grants, expertise and volunteers) • Professional site plan (permaculture class, landscape architect, community involvement) • Farming, design & community engagement know-how (landscape architecture, organic farming, community projects)	• Tenure insecurity (unspecified long-term agreement) • Restrictive regulations (e.g., water conservation, land access) • Loss of funds (some trees dying or struggling, overharvesting)

continued

Table 3, continued

Name, Location, Ownership	Start	Main Functions	Size	Success Factors	Barriers
				• Start-up funds (~US$135.000 for participatory design and initial set-up) • Media coverage (further funds, partnerships and volunteers) • Supportive regulations (urban policy prioritizing tree cover and urban agriculture)	
Den Food Bosch Netherlands, urban hinterland Semi-public	2016	Food Production, Education	2.5 ac 1.0 ha	• Motivation related to learning and demonstrating healthy food production; Network (senior expertise, landowners, students) • Land access (collaboration with local water authority) • Start-up funds (for infrastructure and plants) • Professional site plan (student thesis) • Farming know-how (forestry, agriculture, syntropic farming) • Supportive regulations ("Green Deal Food Forests")	• Degraded land (former monoculture) • Lack of funds (income) • Lack of practical business experience • Restrictive regulations (e.g., certification process)
Keela Yoga Farm Portugal, rural Private	2017	Education, Recreation (Self-sufficiency)	2.5 ac 1.0 ha	• Motivation related to healthy food and self-sufficiency; Network (work & knowledge exchange with locals, plus volunteers) • Start-up funds (focused savings, low costs) • Professional planning (diverse pilot, focused main area) • Know-how in farming (permaculture) and recreation (yoga) • Diverse revenue (yoga retreat, education)	• Learning a new language • Accessing land (long search, high prices) • Drought • Regulatory restrictions (immigration)

mance (Wiek & Albrecht, 2021). It is important to recognize that these factors are dependent on an existing sustainable entrepreneurial ecosystem (Cohen, 2006), which includes, among others, the availability (pool) of suitable land, financing options for sustainable businesses, and regulations favorable to agroforestry (Albrecht & Wiek, in press). In the following, we focus on the general success factors and barriers related to organization and management, and touch on structural elements of the entrepreneurial ecosystem only in passing.

Recruiting Motivated Entrepreneurs

Motivated entrepreneurs—whether initiators or recruited ones—are the key seed for a food forest. In most cases, an individual or a small group (two to four people) starts the endeavor. Most of them live in or near the food forest and run it as a family business. Some of the food forests on public land are managed by communities (e.g., Beacon Food Forest). Food forester managers develop the food forest as fulfilling work, are keen to educate themselves and others on food, are entrepreneurial in overcoming obstacles, and are driven to contribute to a sustainable food system.

> *My motivation was … when I was studying in Eberswalde international forestry ecosystem management … we talked only about the problems …. So,*

half of the students were in a big crisis. … I needed some kind of solution. That I want to work on something actively and I want to see that there are ways where we can actually feel like you belong to the planet, and we are not only here to destroy it. And then, food forests were … the answer. Because it's about how men and nature can live together and how you can live in your environment without being a nuisance. (Janine Raabe, Den Food Bosch, 2018, Figure 5)

Figure 5. Janine Raabe and Paul Müller, Den Food Bosch, 2018

Photo: Maud Dieminger.

They often hold both individualistic values of satisfying work and self-direction as well as collectivist values of public goods such as an intact environment. The economic viability of the food forest is often considered a means to fulfilling work and achieving environmental and/or social goals. Accordingly, food forests are often initiated as a hobby or side business primarily with social and environmental goals. Only later, and not in all cases, it might successively transition into professional operations. The entrepreneurs of Essgarten, for example, collected unusual edible plants for 10 years before realizing the business potential. The managers of socio-cultural food forests often have a background in health or education (e.g., physiotherapists at Essgarten; yoga teacher at Keela Yoga Farm), while managers of food forests that focus on food production often have a background in agriculture (e.g., agriculture and forestry at Den Food Bosch; agronomy and biodiversity at Fazenda Ouro Fino).

The case of Den Food Bosch shows that the loss of motivated and knowledgeable entrepreneurs during the early implementation phase (years one to three) poses a major barrier to the overall success as the first years are critical for establishing the multiple strata of the food forest (irrigate, prevent overgrowth, etc.) and laying the basis for economic viability.

Accessing Land

A major challenge for food forest initiatives is land access. Urban development pressure and high prices often lead to short-term lease contracts, small sites, or less suitable locations for food forests. Larger sites are in rural or hinterland locations, difficult to access for volunteers or guests, and often with limited access to farmers markets and other distribution locations. Innovative land access models such as land trusts or partnerships with public institutions (e.g., water authorities) or private institutions (e.g., retirement homes) can mitigate this challenge, but only to some extent. Beacon Food Forest, for example, partnered with the city of Seattle's Department of Neighborhoods to gain formal site access. However, negotiations took almost three years, and their tenure continues to be insecure. Mienbacher Waldgarten leases the land from a neighbor who runs a nursery and benefits from the produce. Although land tenure is not formally secured, there is mutual trust based on similar values regarding environmental education and edible plants. The land for Foodforest Ketelsbroek and for Keela Yoga Farm was purchased using personal savings. While this financing option secures land access, shared ownership and decision-making, such as through a land trust or an easement, would allow for more permanently securing land for regenerative agriculture in general and food forests in particular. Developing food forests as cooperative businesses could mitigate this deficit, too. Another

common challenge is the poor soil quality at many sites, often caused by prior land use (e.g., monoculture farming, urban site). This often requires several years of remediation activities and building a healthy soil base. Several sites have water access on or close to their land (e.g., ponds, streams, well), which is crucial for establishing plants over the first few years.

Securing Start-up Funds

Most implementations of food forests lack sufficient start-up funds during the first 2 to 3 years, when infrastructure and plant set-up require investments and while revenue is very low. Common coping strategies are lowering the cost of living, using personal savings, or working at other jobs. While some food foresters are able to raise external start-up funds, they are often earmarked for infrastructure and educational events and rarely for wages. Over more than seven years, Beacon Food Forest was developed through the work of volunteers, until a registered nonprofit organization was formed and funding for two part-time positions was secured. Private funds may become available through partnerships like at Mienbacher Waldgarten, where the property owner, who is interested in the produce from the food forest, funded a seminar house. General fundraising know-how is critical for long-term implementation success, and accessing social and/or sustainable financing options (as far as there are any available) aligns the sustainability ambition of the food forests with their funding sources.

Professionally Planning and Designing the Site

Careful planning and site design are important success factors for food forests, in particular for those with a community orientation or aspirations for high productivity. Such planning and design can benefit from (in-kind) expert advice, student thesis projects, or stakeholder workshops. Den Food Bosch, for example, organized workshops with experts and the university community to develop a detailed site plan. Beacon Food Forest adopted a community-based planning approach, which is resource-intense but creates broad buy-in and long-term support for the food forest. For large food forests with focus on food production service(s), pilot projects allow for fail-safe learning as part of the implementation process. For example, Fazenda Ouro Fino and Keela Yoga Farm started with a highly biodiverse design of a small area, followed by a more efficient design with high-yielding crops.

Acquiring Entrepreneurial Know-How and Tools

The lack of practical business know-how, gained through experience, or resistance to conventional financial instruments (e.g., loans) commonly hinder professional implementation of food forests. Food foresters are rarely competent in business planning, fundraising, investment, bookkeeping, payroll, human resources, and marketing. Instead, motivation and activities are overly focused on the main service(s) the food forest is being developed for (food production, education, etc.), often based on personal sacrifices. To sustain livelihoods, entrepreneurial know-how is best developed prior to or very early in the implementation phase. A shift of mindset may also be required, balancing the value of biodiversity and organic development with effective and efficient design and management techniques. Some of the sampled food forests have used professional business and organizational practices to reach economic viability. The core team at Beacon Food Forest, for example, has established formal human resources procedures to train its volunteers and to deliver its workshops, which, in return, have convinced funders and secured a sufficient level of revenue. At Fazenda Ouro Fino, the focus on specialty crops, and at Essgarten on specialty events, accompanied with specific procedures and marketing, make these food forests economically viable. At Ketelbroek, keeping management costs in check secures economic viability; site maintenance requires only minimal effort at this point, and harvesting is done together with business customers.

Acquiring Farming Know-How and Equipment

Insufficient farming and food forest know-how is a common implementation challenge. The diversity of plants and services can be overwhelming, and trial and error often leads to expensive plant loss and design flaws. Lack of qualified staff hinders effective food forest implementation, too. For

Figure 6. Henrique Souza, Fazenda Ouro Fino

Photo: Sebastian Becker

example, Essgarten with 1,200 species requires special skills that volunteers were not able to acquire; thus, it hosted interns from an agricultural university. With increased production focus (Den Food Bosch) or diverse clients (Essgarten), skill requirements increase, which can be compensated only to some extent by creativity and perseverance.

> *Back in 1993, the challenges were immense. But they were important to develop our knowledge, new technologies, and ripen. The lack of knowledge was definitely the biggest challenge. We didn't know how to build the farm and had no money. There weren't any examples of a food forests in Brazil, and we were pioneers. … But I consider the willingness-to-do as a mandatory resource. … Now we offer 2-year courses to train professional food foresters to gain the necessary experience.* (Henrique Souza, Fazenda Ouro Fino, translated, 2018, Figure 6)

Specific professional training in farming, forestry, ecology, and/or in education, social work, and design helps develop the specific services of a food forest. Expertise can also derive from personal contacts, site visits, or collaboration. Complementary to the know-how, food forests require professional equipment for the main products and services (e.g., processing machines, guest facilities) to reach economic viability. Off-grid equipment can enhance independence and minimize cost over the long term. Fences can protect young plants from wildlife. And so forth.

Overcoming Regulatory Restrictions

Restrictive policies and regulations can create major barriers for food forests. For example, food processing associated with a food forest can require certificates and safety measures that may be costly to acquire or may significantly limit the product range. Regulatory agencies often do not recognize agroforestry or food forests as a legitimate type of land use.

> *This was agricultural land, and my landlord said that we change this to garden land as we advertise it as a garden and have classes and people here. Then we had to have a landscape architect come here and create a plan and so on. And the requirement was that we create a compensation site.* (Hannelore Zech, translated, 2018, Figure 7)

Figure 7. Hannelore Zech (left) with her landlord, Mienbacher Waldgarten

Photo: Lisa Leuoth

Food foresters have either worked with or around governmental agencies to overcome regulatory barriers, e.g., by providing a professional site plan or installing relevant gastronomy infrastructure; or they gave up on product ideas or other non-compatible plans. The city of Seattle, on the other hand, passed a policy to allow community-led public land management, which enabled the development of Beacon Food Forest on a public site. Beacon Food Forest also benefits from Seattle's policies that prioritize tree-cover and urban agriculture and provide respective funds. Water conservation restrictions, however, still pose certain barriers, but the food forest team found creative solutions to comply with them. A broad, national policy solution has been implemented in the Netherlands, where stakeholders from government, NGOs, and practitioners signed a "Green Deal Food Forests" in 2018 to create a regulatory framework that supports implementation of food forests nationwide.

Diversifying Revenue Streams

The multitude of food forest services allows for diversifying revenue streams over time. Fazenda Ouro Fino, for example, started with specialty food items for the local and international market, but added trainings as the food forest matured and syntropic farming grew popular. Foodforest Ketelbroek started with consultation and education; later, with growing demand from the local gastronomy, food sales became a main source of revenue. Marketing, in particular through social media, is an important means to achieve diversification. At Essgarten, for example, private dinners turned into wider demand for recreational and educational events. A basket of specialty products sent to gardening magazines triggered wide media attention and broadened the customer base. Public food forests, like Beacon Food Forest, are mostly bound to acquiring public and private grants as their tenure agreements restricts regular business income generation. In this case, exploring social purpose corporation status (a legitimate corporate form in Washington state since 2012) might be a way to overcome this barrier to economic viability over the long term.

Networking and Creating Strong Partnerships

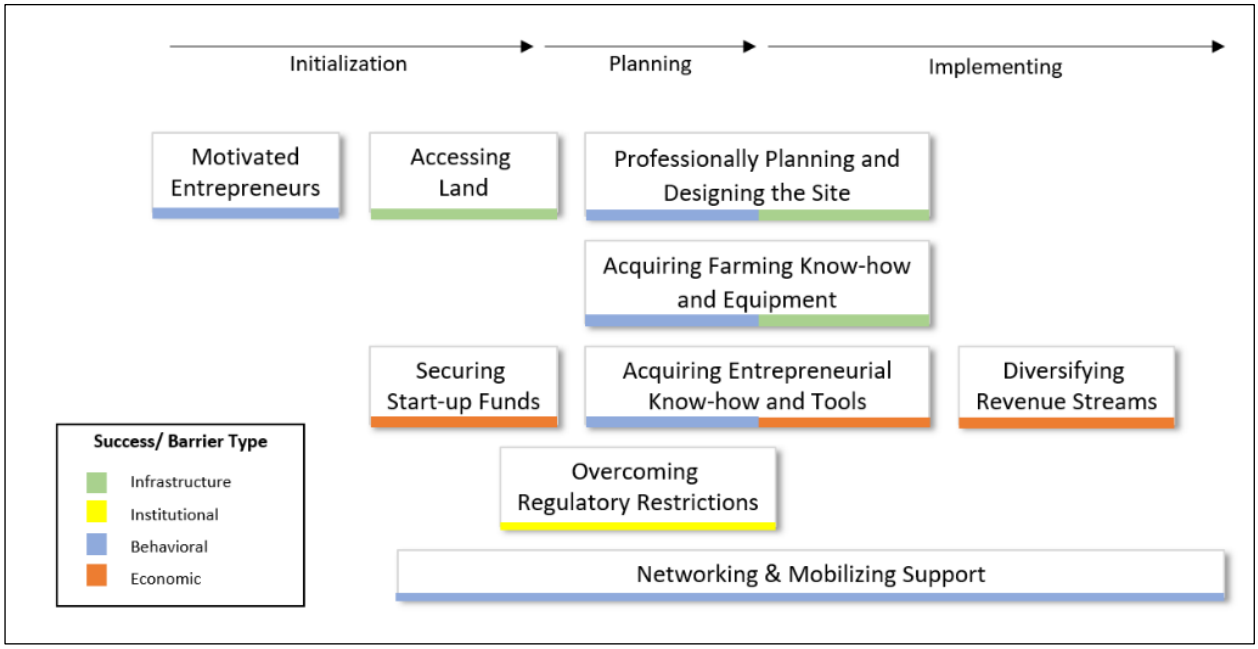
Networking and creating strong partnerships are key accompanying activities for early-stage success, for instance in accessing land and raising start-up funds, and they continue all the way into the implementation stage (e.g., for diversifying revenue). The entrepreneurs of Den Food Bosch, for example, visited many food forests to acquire know-how and develop partnerships that were later leveraged in the planning and implementation stage. Essgarten benefited from pro bono design advice by a landscape architect friend. Networking with peers is a key source of inspiration for many food forests, e.g., learning from indigenous food forests in Kenya, permaculture food forests, or Ernst Götsch's food forest. Shared values pertain to seeking solutions for a world in crisis, learning from nature (e.g., Gaia, Pachamama), and experimenting with uncommon foods.

Success Factors and Barriers Mapped onto the Development Phases

While all nine factors of success are important, independent of the food forests' main services, they come into play differently over the course of the food forest development (Figures 4 and 8). It all starts with motivated entrepreneurs, followed by securing access to land and start-up funds (Initialization). The planning phase and early implementation phase then require detailed site planning and overcoming regulatory barriers as well as acquisition of specific farming and/or food and entrepreneurial knowledge, plus infrastructure. For the main and later implementation phase, expanding and adjusting the knowledge and know-how as well as diversifying revenue streams become important factors. Networking and mobilizing support, e.g., mentorships that enable the entrepreneurs to become self-motivated and resilient, are critical activity during the entire development process.

Findings from the seven case studies suggest that economic factors are critical in each of the three stages. There is room for experiments and mistakes, but they should be limited. For example, Essgarten evolved organically without much planning (and many mistakes), but later received professional advice that improved its economic viability. Younger food forests often start with high

Figure 8. General Development Path of Food Forests with Relevant Factors of Success



motivation and thorough designs, but to be successful, they need to advance fundraising activities and acquiring practical entrepreneurial know-how—major barriers for many food forests. The path of Den Food Bosch exemplifies these patterns. A group of motivated agricultural students oriented toward healthy food production and business development initiated the food forest, with access to expertise and early regulative support. Initial fundraising secured land access and some limited start-up funds. The site was well planned and designed. Implementation quickly advanced due to previously acquired specific farming know-how. However, despite some business training at the university, there were gaps that prevented the development of a sustained livelihood for the main staff, which led to high stress levels. Eventually, the initiators left their positions, which casts doubt on the overall success.

Discussion

Food forest implementation is a comprehensive endeavor that depends on behavioral, infrastructure, institutional, and economic factors pertaining to organization and management. Some of these factors can be secured through general strategies such as education and training, while others call for more specific strategies such as networking with particular actor groups.

For example, similar to studies on other grassroot movements (e.g., LeBlanc et al., 2014), our findings point to the need for sustainable business training and advice in the set-up of food forests to overcome major financial barriers. In particular, entrepreneurial know-how in fundraising seems to be one critical business factor for successful implementation (Albrecht & Wiek, 2021). Food foresters, similar to social entrepreneurs, often seem to be challenged by balancing the pursuit of the public good *and* paying sufficient attention to the economic viability of their enterprises (Schaltegger & Wagner, 2011). While their reservations are well justified considering the prevalence of exploitative neoliberal business practices (e.g., profit maximization), they nevertheless demonstrate a lack of sustainable business know-how. Sustainable business models, such as cooperative businesses, social purpose enterprises, or benefit corporations, offer options for pursuing both environmental and social goals *and* economic viability. On the other hand, their collectivist values (e.g., intact environment, social wellbeing) allow food forest entrepreneurs to tap into resources provided through similarly collectively oriented network partnerships

(Tiessen, 1997). Balancing both pursuits seems to be the solution here, even if that is challenging to realize.

For other success factors, such as accessing land and securing start-up funds, specific strategies need to be adopted, such as starting the food forest enterprise as a cooperative business with a broader investment base, or collaborating with NGOs that co-fund access to farmland and thus might be open to co-fund food forests (e.g., the Kulturland eG in Germany or the American Farmland Trust in the U.S.), or enabling farm succession to food foresters who are not family members. For public matters such as securing access to public land or public funds as well as coping with regulatory barriers, negotiations with local authorities or securing professional support (e.g., for licenses or site plan) might be promising strategies. These examples also point to the interdependence of success factors, in this case between these factors and networking with government agents and potential funders.

The findings confirm previous research on success factors of food forests in particular regions (Belcher et al., 2005; Björklund et al., 2019), namely the importance of specialty entrepreneurial and farming know-how, land tenure, and professional site and management plans. This study offers a more systematic exploration of the success factors and barriers covering economic, infrastructural, behavioral, and institutional factors, and mapping them over time. We found that these factors are robust across geographic regions and, for the most part, also across different services provided. Implementation paths differ in some specifics, and some factors come in earlier or later, but on a general level, all success factors are relevant to the cases studied here. Networking and creating strong partnerships should be considered a superior factor as it can facilitate securing all other success factors. Here, shared values of having a solution orientation, ecocentrism, and cultivating uncommon foods, as well as sustainable food systems in general were observed, as suggested in other studies (e.g., Wartman et al., 2018). Entrepreneurs and partners are often highly motivated by these values at the beginning; however, to ensure ongoing motivation, barriers need to be overcome and values need to be matched by sustainable practices and structures, such as through long-term land access, shared decision-making, and economic viability.

Generally, these success factors apply to most farm and food enterprises. However, since food forests pursue long-term benefits and focus on high biodiversity, they grapple with these factors in quite different ways. High start-up funds need to be secured to yield success, which then only manifests over the mid- to long-term. While food forest entrepreneurs appreciate the diverse and natural work environment they engage with, they tend to reject or underestimate the economic requirements to sustain their livelihood. Trainings in how to secure social-finance investments and how to adopt alternative (sustainable) business practices and models (e.g., cooperative businesses) may help overcome these barriers. For training in specialty farming, the challenge is often to find locally relevant information on complex plant combinations. To a certain degree, trial and error testing remains the best strategy. However, work experience at agroforestry and permaculture farms or orchards in similar climates, online or in-person training and research on perennial polycultures, and advice from specialty landscape architects can minimize the risks in designing and managing the site.

Some cases, while successful, did not exactly follow the sequence of the implementation process described above. For example, Essgarten implemented an edible homestead as a hobby first, mostly through a trial-and-error approach. It later explored site adjustments and business options when the food forest was in a mature state. While there are such successful cases based on incremental changes and iterations, they are exceptions. For most food forests, sequencing from initial conceptualization through planning and design to implementation seems a robust recipe for success. For example, the findings suggest that food forests with a focus on food production benefit from developing a professional site design (with a focus on high-value specialty crops) and a solid business plan (with direct marketing channels) at the beginning. Compared to older sites, recent start-ups thoroughly planned the implementation process with access to senior expertise (e.g., Den Food Bosch). It is promising to see how young food

forest managers like those at Den Food Bosch adopt permaculture and syntropic farming, developed in tropical climates in the 1990s, with intricate designs for temperate climates. Furthermore, some younger food forests contribute to structural changes with more purpose-oriented forms of ownership (through foundations). A more detailed cross-case analysis of such uptakes may provide further insights into how to best advance broad adoption of these practices. The time seems ripe for more advanced pilots, such as recent cross-sectoral projects in the Netherlands (Green Deal, 2020) that aim at advancing food forestry across the country through large-scale pilots, monitoring programs, and advancing recognition of food forests in government and administration.

The findings of this exploratory study are limited, primarily due to the small and diverse sample of food forests. Pragmatic sampling was required because of limited documentation, time, and financial resources. The analyzed cases are located in different regions and situated in different contexts, with preference given to Europe and North America; hence, findings cannot be generalized beyond this sample. In-depth case studies and comparative analysis should be conducted to broaden and deepen insights on entrepreneurial motivations, social-cultural backgrounds of entrepreneurs, and more, and their influence on food forest success. While this study focused on success factors directly tied to the organization and management of food forests, further studies should identify the structural elements in the entrepreneurial ecosystem that support or hinder success of food forests.

Conclusions

Food forests are differently implemented. Yet specific factors ought to be considered for each phase of the implementation, with economic factors being particularly influential on success. From early on, acquiring business and specialty farming know-how, securing start-up funds for infrastructure *and* staff, and securing long-term land access are the most crucial success factors. This calls for novel funding and land access schemes that support the start-up of sustainability-oriented food forest entrepreneurship (cooperative businesses, benefit corporation, etc.) that aims at producing food and securing livelihoods, while offering social and environmental services. The long-term perspective that tree growth and generation-spanning solutions require calls for committed, purposeful partnerships that last. The success factors identified here need to be validated and nuanced through additional case studies, particularly on food forests outside Europe, and related cross-case comparisons. Complementarily, broader studies on structural factors of the entrepreneurial ecosystem need to expand this research on implementing food forests.

Acknowledgments

We would like to thank all food foresters for offering their insights in interviews and during site visits. We also would like to thank three anonymous reviewers for their constructive comments on an earlier version of this article.

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Wiek, A., & Albrecht, S. (in press). "Almost there"—On the importance of a comprehensive entrepreneurial ecosystem for developing sustainable urban food forests. *Urban Agriculture & Regional Food Systems.*

A.1.3 Article 3

Wiek, A. & Albrecht, S. (2021, under minor revision).

"Almost there" –
on the importance of a comprehensive entrepreneurial ecosystem for developing sustainable urban food forest enterprises.

Urban Agriculture & Regional Food Systems.

Received: 26 April 2021 | Accepted: 23 December 2021

DOI: 10.1002/uar2.20025

Urban Agriculture & Regional Food Systems OPEN ACCESS

SPECIAL ISSUE URBAN AGROFORESTRY

Almost there: On the importance of a comprehensive entrepreneurial ecosystem for developing sustainable urban food forest enterprises

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Abstract

Sustainable food forests offer multiple benefits to urban sustainability challenges. Research to date mostly describes structure and services of individual food forests but provides little evidence and guidance for implementation. This study analyzes and evaluates an ongoing, multiyear, transdisciplinary project developing a sustainable urban food forest enterprise in Phoenix, AZ, through a collaboration between researchers and a coalition of nonprofit organizations. Unlike other food forest projects run by nonprofit organizations, this food forest originated as a sustainable enterprise that would provide jobs and livelihood opportunities in an economically marginalized urban area while pursuing social and environmental goals such as providing healthy food and a cooler microclimate. Efforts to date have built a coalition of supporters, secured a suitable site, codeveloped a vision and an action plan, and fundraised a major start-up donation. We evaluate these outcomes against a suite of success factors derived from implementation of other food forests and explain challenges in realizing these factors through the lens of a comprehensive sustainable entrepreneurial ecosystem. Data for the accompanying research was collected through direct and participant observations, review of project documents, informal conversations, a stakeholder survey, and research diary reflections. Research findings indicate that despite achieving all the success factors, at least to some extent, the underdeveloped sustainable entrepreneurial ecosystem jeopardizes long-term success and multiplication efforts. These findings confirm the importance of a sufficiently developed entrepreneurial ecosystem for successful development of sustainable food enterprises. They offer guidance to food entrepreneurs, urban developers, and city officials on how to develop and support sustainable food forest enterprises.

1 | INTRODUCTION

Urban areas struggle with a plethora of sustainability challenges. Food-related sustainability challenges include land degradation, water contamination, climate change contributions, negative health effects, as well as an unequal distribution of economic benefits (Garnett, 2011; IAASTD, 2009; Swinburn et al., 2011; Tilman & Clark, 2014). Sustainable food forests have emerged as a promising solution to address multiple urban sustainability challenges adaptable to local contexts. They are biodiverse, multistrata agroforestry systems that focus on food production and yield several additional benefits including sequestering carbon, limiting soil erosion, improving the water cycle, regulating the microclimate, increasing biodiversity, offering sociocultural services and creating livelihood opportunities (Jose, 2009; Nair & Garrity, 2012; Roy et al., 2011). Organized as multifunctional hybrids, many food forests pursue several of these services and benefits (Albrecht & Wiek, 2020). With technical specifications, a food forest is a coherent, multistrata space with mostly edible perennial plants, a minimum size of ~0.5 ha (1 acre), and 10% canopy cover to provide forest-like ecosystem services and significant food production (Albrecht & Wiek, 2021a). Even in urban areas, such multistrata food-producing polycultures, have begun to emerge as 'urban agroforestry' or 'urban food forestry' including small or spread-out edible landscapes (Borelli et al., 2017; Clark & Nicholas, 2013; Lovell, 2010, 2020). One reason for this uptake in urban areas is that food forests seem to be particularly potent solutions to a plethora of urban sustainability challenges, offering benefits through healthy food provision, satisfying jobs, cooling effects, green spaces accessible to the public, and more (Clark & Nicholas, 2013). Of the >200 food forests analyzed by Albrecht & Wiek (2021a), 108, or 52%, are in urban areas. Specifically, in the southwestern United States, a recent study identified 12 out of 14 food forests/gardens located in (peri-)urban areas (Allen & Mason, 2021).

Research has recently begun to investigate structure and services of individual food forests (e.g., Riolo, 2019) and larger samples of food forests (Albrecht & Wiek, 2021b). Most research addresses the sociocultural and environmental effects of food forests (e.g., Park & Higgs, 2018; Wartman et al., 2018). Practical handbooks offer guidance on the physical design of food forests (e.g., Crawford, 2010). A few reports cover how food forests offer livelihood opportunities (Remiarz, 2017; Shepard, 2013), while a broad comparative study indicates that the economic dimension is underdeveloped in many food forests (Albrecht & Wiek, 2021a). According to this study, one main reason for this gap is that food forests are often developed as variations of community gardens, run by nonprofit organizations, and relying on volunteers as workforce, as opposed to sustainable enterprises. Very few food forests are directly managed by a city administration, such as the Atlanta Browns Mill food forest, which offers an approach to long-term management through public governance and funds.

Core Ideas

- Sustainable food forest enterprises offer multiple benefits to urban sustainability challenges.
- It can be challenging to secure all factors that influence successful implementation.
- Securing these factors benefits from a comprehensive sustainable entrepreneurial ecosystem.

A 'sustainable' food forest is a managed ecosystem that produces healthy food, is economically viable (self-sustaining), and generates environmental and social co-benefits. It ought to comply with a set of sustainability criteria (Albrecht & Wiek, 2021a): environment criteria, for example, the food forest uses water efficiently, creates cooling effects, and maintains high biodiversity; economic criteria, for example, the food forest is economically viable and owned by the food foresters (e.g., worker cooperative); and sociocultural criteria, for example, the food forest facilitates community building, a safe and healthy work environment, and engages youth with nature and healthy food.

Most food forests struggle with one or more of these criteria (Albrecht & Wiek, 2021a). In fact, many food forests are not economically viable. This is due to structural challenges (e.g., economic marginalization or lack of supportive policies) as well as underdeveloped business plans and entrepreneurial skills or over-reliance on volunteers. For food forests to become sustainable and potentially be more widely adopted as urban sustainability solutions, it seems promising to develop them as sustainable 'enterprises' securing economic viability in addition to creating environmental and social benefits (Burch et al., 2013, 2016; Remiarz, 2017). Sustainable enterprises are businesses that balance pursuits of economic viability with broader social and environmental goals as the core of their mission (Evans et al., 2017; Schaltegger et al., 2012). Innovative business models that center on sustainability, integrating economic, social, and environmental goals, include particular types of social enterprises, cooperative businesses, benefit corporations, and others. Successful development of such ambitious enterprises calls for the ingenuity and dedication of entrepreneurs (Weber et al., 2020). Yet, it also depends on several different but often interlinked 'success factors.' Recently, Albrecht and Wiek (2021b) have empirically identified success factors for implementing sustainable food forests, including accessing suitable land, securing sufficient start-up funds, and developing relevant know-how.

These success factors, in return, depend on a 'sustainable entrepreneurial ecosystem' (Cohen, 2006), which is a network of businesses and organizations that provides services and support including financial services, training opportunities, legal advice, political advocacy, and supportive regulations within a region (Malecki, 2018). As research on sustainable enterprises shows, such an ecosystem is the base for successful development of sustainable businesses (e.g., Cohen, 2006; Uddin et al., 2015). While many regions still struggle with providing a functional entrepreneurial ecosystem for sustainable food forests (and similar endeavors), there are some exceptions. In the Netherlands, for example, a large public–private partnership facilitates an entrepreneurial ecosystem that supports food forest development across the country through the adoption of policies, implementation of pilot projects, and coordination of research (Green Deal, 2020).

However, research on implementation, success factors, and supportive entrepreneurial ecosystem functions for sustainable food forest enterprises is still at a nascent stage. Thus, the research questions of this study are: How challenging is it to secure the identified success factors for realizing sustainable food forests? And what is the role of the sustainable entrepreneurial ecosystem in securing them?

We address these questions through a case study on an ongoing, multiyear, transdisciplinary project developing a sustainable food forest enterprise in Phoenix, AZ. This project is a collaboration between researchers and a coalition of nonprofit organizations (see section 2.1). It applied a sustainable business development framework leading from familiarization and experiencing, through visioning and strategy building, to piloting and implementation (see section 2.2). We evaluate the project outputs vis-à-vis the success factors for developing sustainable food forest enterprises (Albrecht & Wiek, 2021b) and the components of a sustainable entrepreneurial ecosystem (Cohen, 2006) (see section 2.3). Accompanying research combined direct and participant observation, project document review, and other methods to answer the research questions. The food forest in Phoenix, at the time of this writing, is almost implemented with major milestones achieved (e.g., securing start-up funds, developing site and business plans), but phases of stagnation and other turbulences continue to jeopardize the overall success. In summary, there is growing evidence that food forests can offer various benefits, particularly in urban areas, if carefully planned and designed as sustainable enterprises, accounting for economic, environmental, and social needs, and if being supported through a sustainable entrepreneurial ecosystem. The results of this study provide in-depth insights for food entrepreneurs, urban developers, and city officials on how to develop and support sustainable food forest enterprises as a solution to combat multifaceted urban sustainability challenges.

2 | DEVELOPING A SUSTAINABLE FOOD FOREST ENTERPRISE IN PHOENIX, AZ

2.1 | Case study selection

In fall 2018, representatives from the coalition of nonprofit organizations called 'Spaces of Opportunity' and researchers from Arizona State University formalized a long-term partnership on a transdisciplinary project to create a sustainable food forest enterprise at Spaces of Opportunity in South Phoenix.

South Phoenix is historically stigmatized as a zone of racial exclusion, economic marginalization, and environmental degradation (Bolin et al., 2005). A large share of Latinx and African American communities lives here, and, despite efforts by nonprofit organizations and the city administration, educational and economic opportunities are still underdeveloped. Compared with other areas, housing prices are low, and levels of air pollution and obesity are high (Boucher et al., 2021; Cutts et al., 2009). Although historically a place of agricultural production, South Phoenix is a food desert with little or no access to fresh, affordable, and healthy food in walkable distance (USDA, 2017). Leapfrog development—were land developers jumped to cheaper parcels—created urban sprawl and leaves behind parcels of undeveloped land (Heim, 2001). Sparse shade and green spaces combined with continuous development of building and infrastructures increases the urban heat island effect (Brazel et al., 2007; Zhang et al., 2017). These challenges call for multifunctional, sustainable solutions, such as sustainable food forests, that provide livelihood opportunity, healthy food, and a cooler microclimate.

Spaces of Opportunity was founded in 2015 to address these challenges in South Phoenix through urban agriculture, food entrepreneurship, and education. The initiative was created by nonprofit organizations located in South Phoenix including the Orchard Community Learning Center and TigerMountain Foundation. The initiative centers on a ~7.7-ha (19-acre) site (1200 W Vineyard Rd, Phoenix) that hosts an incubator farm, community gardens, and a weekly farmer's market (Figure 1). The site is leased for 10 yr from the Roosevelt School District (2015–2025) with options to extend the lease or enter an alternative ownership arrangement (e.g., land trust). Spaces of Opportunity cooperates with the City of Phoenix administration (permits, etc.) and Arizona State University (research and development) as well as with the nearby V.H. Lassen Elementary School including the jointly operated Healthy Roots Café and Culinary Classroom located on the school premises.

Accessing a suitable site is one of the main success factors to develop a sustainable food forest (Albrecht & Wiek, 2021b). The site for the food forest was selected based on

FIGURE 1 Spaces of Opportunity ~7.7-ha (19-acre) incubator farm in South Phoenix. The yellow box indicates the planned location for the ~0.5-ha (1-acre) food forest in the southeast section of the site (source: adapted Google Maps)

TABLE 1 Suitability of the site at Spaces of Opportunity for creating a sustainable food forest enterprise

Suitability criterion	Fulfillment at the site of Spaces of Opportunity
Urban location	South Phoenix, AZ
Urban sustainability challenges	Food desert, low-income area, low canopy cover, few green spaces, low educational attainment
Size of > ~0.5 ha (1 acre)	Coherent area of ~0.5 ha (1 acre)
Access to key stakeholders	Close to potential users (five schools in walking distance, established food distribution channels) and potential entrepreneurs (members and network of Spaces of Opportunity)
Favorable land ownership	Ten-year lease with school district, with the option for extensions, and interest in developing an alternative land ownership arrangement (e.g., a land trust)
Favorable regulations	No restrictions to agricultural land use; options for infrastructure permits
Critical infrastructure and resources	Irrigation channels (water), connecting paths, composting site, storage and processing facilities, farmers market (on Spaces of Opportunity site)
Access to relevant expertise	Access to fruit tree experts and farmers

several criteria. Compared with the other 15 screened locations, the site at Spaces of Opportunity is embedded in a neighborhood in need of sustainable development, is sufficiently large, offers access to potential users and entrepreneurs, and so forth (Table 1). In summary, the site at Spaces of Opportunity either scored higher than the other sites on critical criteria or at least fulfilled them sufficiently.

2.2 | The transdisciplinary project in Phoenix: Design and outputs

The transdisciplinary food forest project at Spaces of Opportunity applied a framework for sustainable business development. This framework combines developing capacity for adopting sustainable business practices (Wiek, 2020) and sustainable business planning through visioning, strategy building, and pilot testing (Wiek & Lang, 2016). The capacity-building approach aimed at balancing cognitive, affective, and practical components using visual, experiential, and interactive activities to enhance the chance of continuous application and engage different types of learners (Kolb, 2014; Sipos et al., 2008). The project is transdisciplinary in nature (Lang et al., 2012), which entails a collaboration between researchers from Arizona State University and the Spaces of Opportunity coalition of nonprofit organizations. The project started in 2018 and is structured into eight phases of different durations, ranging from a few weeks to several

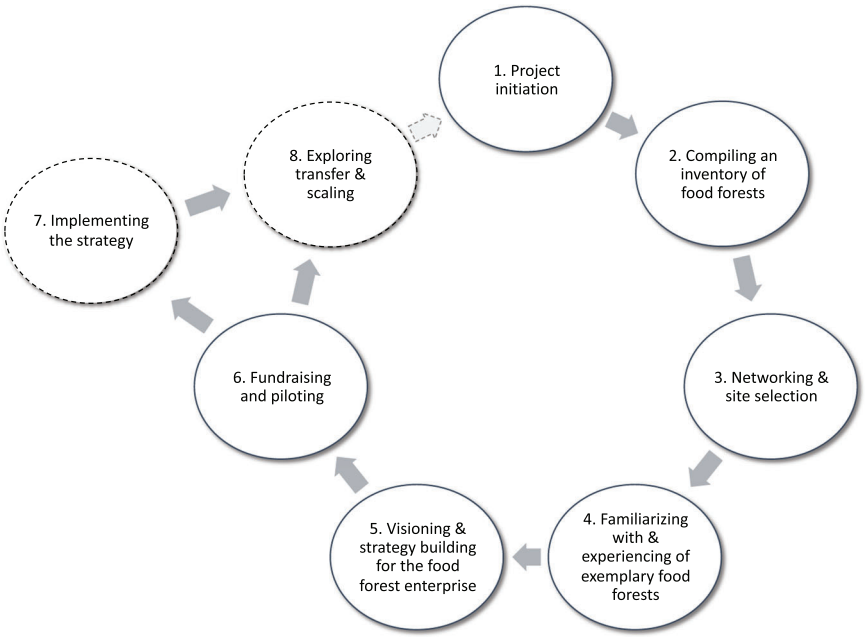

FIGURE 2 Phases of the transdisciplinary project developing a sustainable food forest enterprise in Phoenix, AZ (Phases 7 and 8 are ongoing)

months, and spanning over more than 2.5 yr overall (with dormant periods in between) (Figure 2).

Some of the phases overlapped or ran in parallel. For example, after the project initiation (Phase 1), the inventory of food forests (Phase 2) was continuously expanded and then further used during networking and site selection (Phases 3) and familiarizing with and experiencing exemplary food forests (Phase 4). Or, after vision and strategy building (Phase 5), their refinement and piloting (Phase 6) ran in parallel with first explorations of transfer and scaling (Phase 8). Also, the sequence of phases is structured in a circle to indicate various iterations as well as the intention of the project to become a source of inspiration for other food forest enterprise start-ups in Arizona (and beyond). Compared with other food forests (Albrecht & Wiek, 2021b), the development of the food forest in Phoenix included a comprehensive planning phase. Finally, the project is still ongoing, and thus, not all phases have been completed at the time of this writing (Phases 7 and 8). While the food forest is almost but not fully implemented yet, the development process already generated several outputs (Table 2).

2.3 | Design of accompanying research

Over the duration of the project, we conducted an accompanying case study to evaluate the main project phases and their outputs (Table 2). Success factors for developing sustainable food forests, such as recruiting motivated entrepreneurs and accessing suitable land, served as evaluative criteria (Albrecht & Wiek, 2021b). We focus on those factors most relevant in the initiation and planning stage (Factors 1–4; Table 2). Other factors are only briefly addressed as to indicate the overall status of the business development.

Challenges to secure these factors are explained through the lens of a comprehensive sustainable entrepreneurial ecosystem (being in place or not). Since research on entrepreneurial ecosystems is still at a nascent stage (Alvedalen & Boschma, 2017), we adapted the early work by Cohen (2006) on sustainable entrepreneurial ecosystem components and aligned them with the success factors for sustainable food forests (Albrecht & Wiek, 2021b). Table 3 connects the success factors relevant for sustainable food forest development with the components of a comprehensive entrepreneurial ecosystem in the region (Arizona) and operationalizes the success factors and the ecosystem components through two sets of guiding questions. It shows how behavioral, economic, institutional, and infrastructure factors for successful development on the enterprise level (micro level) can be fostered by and, to some extent, depend on sustainability-oriented support services offered by the entrepreneurial ecosystem in the region (macro level). The questions guided the qualitative analysis of data collected.

Data was collected through standard case study methods (Somekh & Lewin, 2005) including direct and participant observations (meetings, workshops, field trips, site visits), review of documents (memorandums of understanding, vision documents, draft site plan, strategy documents), informal conversations, a stakeholder survey, and research diary reflections (Albrecht, unpublished data). Information about the state of the entrepreneurial ecosystem was based on >5 yr of experience through applied research on local businesses and the local economy in Arizona.

We co-led the transdisciplinary project developing the food forest enterprise and conducted the accompanying research at the same time. In such a process, researchers wear 'different hats' at different times (Wittmayer & Schapke, 2014). While the 'double-duty' model offers some advantages, such

TABLE 2 Overview of the transdisciplinary project phases and respective outputs

Phase		Outputs
1	Project initiation	Project coalition among representatives from Spaces of Opportunity, researchers from Arizona State University, and a few interested entrepreneurs Scope-of-work document mapping out project goals and the procedure to achieve them, document vetted by urban policy makers and agroforestry experts Memorandum of Understanding, based on scope-of-work document, signed by all partners In-kind planning contributions ranging from expert inputs to event volunteering during the planning phase of the project. One lead researcher (S.A.) with a 3-yr research stipend
2	Compiling an inventory of food forests	Inventory of 200+ food forests that offer primarily services in food production, education, and community building, capturing size, age, location, organization, etc. (Albrecht & Wiek, 2020) and challenges for implementation (Albrecht & Wiek, 2021b) Informed site selection as a definition of a food forest (coherent site, minimum size) and common challenges and success factors were translated into site selection criteria (ownership, accessibility, regulations, infrastructure, expertise) Also used for initial networking and familiarizing of (potential) partners with different types of food forests through visuals and comparative overviews
3	Networking & site selection	GIS maps for systematic exploration of suitable sites (developed by ASU researchers) Out of 15 analyzed sites, a ~0.5-ha (1-acre) site at Spaces of Opportunity was selected (Figure 1, Table 1)
4	Familiarization with & experiencing of exemplary food forests	Through formal and informal trainings as well as site visits at urban (food) forest gardens, the project team developed basic knowledge about food forestry, i.e.: • Exemplary food forests, history, services, structures, management, benefits, and challenges • Layers, plants, companion planting, high biodiversity, high production intensity • Cost, yields, products, revenue, native foods suitable for food forests • Alternative corporate forms (e.g., worker cooperative, B Corp) • Alternative ownership arrangements (e.g., land trust) • Resource (water) needs, irrigation infrastructure • Team also developed their collaborative capacities, recognizing interdependence and mutual interests, as well as building trust and confidence in each other
5	Visioning & strategy building	Shared vision of the sustainable food forest enterprise at Spaces of Opportunity outlining management, products, services, land tenure, and other features for the year 2030 Strategy/action plan, consisting of 54 action items and 13 milestones, structured into action domains, including fundraising, recruitment, business development, earthwork, planting, initial processing, and documentation throughout
6	Fundraising & piloting	Business start-up fund (secured after 10 unsuccessful grant applications; based on sustainable business plan draft (Wiek & Albrecht, 2021), a site visit at Spaces of Opportunity and a project presentation from the entire team, a private donor decided to fund the project to the full extent ($100,000)) Additional business concepts prepared through a cooperative business development program for a beverage company (Khalife et al., 2021), a feasibility study on developing Spaces of Opportunity into a land trust (Mercer et al., 2020), and community conversations on preferred plants and food products A small ($2,000) grant, used to develop a semi-functional display forest garden (~1,500 sqft / ~140 sqm)
7	Implementing the strategy	Business plan draft and site design (design supported by student work and paid consultants) Implementation outputs to date: team of start-up entrepreneurs, earthwork, entrepreneurship training, etc. (ongoing)
8	Exploring transfer & scaling	A workshop helped creating a state-wide network of stakeholders interested in or involved in food forest projects, compiled knowledge on local challenges, coping strategies, supportive actions, and transferability (Albrecht & Wiek, 2020) Results were shared with the participants and distributed through the Southwest Agroforestry Action Network (SWAAN) who supported some of the fundraising activities

TABLE 3 Correspondence between the success factors for developing sustainable food forest enterprises (Albrecht & Wiek, 2021b) and relevant components of a sustainable entrepreneurial ecosystem (Cohen, 2006) supporting such enterprises

	Success factor for developing sustainable food forests (Albrecht & Wiek, 2021b)	Guiding question	Sustainable entrepreneurial ecosystem component (Cohen, 2006)	Guiding question
1	Recruiting motivated entrepreneurs	Is the food forest developed and managed by entrepreneurs who aim to provide for livelihoods, while producing healthy food, and generating environmental benefits?	Pool of skilled workers (university)	Are there training opportunities for sustainable food businesses and entrepreneurship available in the region?
2	Accessing suitable land	Is the food forest site large enough etc. and does the ownership structure allow for long-term access to the land (>30 yr)?	[Pool of suitable and affordable commercial properties (local government, real-estate agencies)]	Are there suitable and affordable properties for urban agriculture available in the region?
3	Securing sufficient start-up funds	Are there sufficient funds for land access, infrastructure, plant setup, start-up wages, etc. available?	Tax incentives, subsidies, grants (local government) Capital services (financial organizations)	Are there accessible financing options for the start-up of sustainable enterprises (with late ROIs) available in the region?
4	Professionally planning and designing the site	Are there sufficiently complete business and site plans available that fully incorporate sustainability (ecological, sociocultural, economic) criteria?	Technical expertise (consultants) Training opportunities (university)	Are there consulting services on sustainable food business and site planning and development available in the region?
5	Acquiring farming know-how and equipment	Are there sufficient knowledge, skills, tools for long-term, multistrata site management as well as food production and processing available?	Technical expertise (consultants) Training opportunities (university)	Are there specific training opportunities for food forests (e.g., specialty crop, polyculture, or diversity farming), and relevant equipment available in the region?
6	Acquiring entrepreneurial know-how and tools	Are there sufficient knowledge, skills, tools on sustainable business practices and models available, incl. organizational know-how for structured procedures, roles, and tasks, as well as an entrepreneurial mindset?	Start-up, financial, legal support (consultants, financial organizations) Training opportunities (university)	Are there specific training opportunities for sustainable business practices and models (e.g., cooperatives, B corps) and tools (e.g., revenue templates, plant data base) available in the region?
7	Informal and formal networking	Are there opportunities to meet stakeholders and potential supporters across sectors, in particular stakeholders that can address underdeveloped success factor?	Network of peers (businesses) Networks of other ecosystem actors (government, financial organizations, etc.)	Are there platforms and forums for exchanges on agroforestry and urban farming as well as sustainable business practices available in the region?

(Continues)

TABLE 3 (Continued)

	Success factor for developing sustainable food forests (Albrecht & Wiek, 2021b)	Guiding question	Sustainable entrepreneurial ecosystem component (Cohen, 2006)	Guiding question
8	Diversifying revenue streams	Are there plans and practices in place that generate revenues from multiple products and/or services to ensure resilience and coverage of livelihoods?	[Financial, legal support (consultants, financial organizations)] [Reliable demand (consumers)]	Are there consulting services for small-scale, multifunctional farms in the region and are consumers willing and able to pay for local, small-scale farming products?
9	Overcoming regulatory restrictions	Is there sufficient knowledge of local regulations, especially regarding land use and services planned, and procedures to navigate restrictions?	Eliminating bureaucratic red tape (local government)	Is there legal support for sustainable food business (e.g., favorable land use regulations)?

Note. Square brackets indicate components we added to the ecosystem concept.

as access to data that would not be accessible otherwise, we also encountered tensions and conflicts at times; most notably, the challenge of evaluating one's own work (Wiek et al., 2014). While ideally there would be a separation between the transdisciplinary team and the evaluating team, limited financial resources often prevent this. The team committed to avoiding biases in the self-evaluation by transparently documenting data points and justifying the evaluative statements. A comprehensive reflection is offered in a doctoral framework paper (Albrecht, 2021).

3 | REVIEW OF PROJECT OUTCOMES AGAINST SUCCESS FACTORS AND SUSTAINABLE ENTREPRENEURIAL ECOSYSTEM

Here, we review the presented project outputs (Table 2) against the success factors (Table 3, left side) and explain challenges in realizing these factors through the lens of a comprehensive sustainable entrepreneurial ecosystem (Table 3, right side).

3.1 | Recruiting motivated entrepreneurs

The project was initiated and advanced all the way to the actual implementation phase (and beyond) through a small team of motivated 'change agents,' or, in other words, through an alternative business development team. Drivers for motivation included alignment with organizational missions (nonprofit and educational organizations), personal values (sustainability, regeneration, healing), as well as financial compensation (a PhD scholarship for the lead researcher, S.A.); the latter provided for researching, networking, facilitating as well as project management from initiation to fundraising and piloting (Phase 1–6). Maintaining a sufficient level of motivation, however, was difficult over the course of the project particularly during the long series of unsuccessful fundraising efforts. Creating a shared vision to combat pressing, local sustainability challenges, such as lack of healthy food, heat island effects, and social injustices (Phase 5), contributed to perseverance. Joint activities also had built trust in the team and helped to push through these phases of stagnation, with some team members demonstrating leadership by identifying or contributing to fundraising efforts, for example. As monthly stipends became available for the start-up entrepreneurs (after securing a major start-up donation)—who would actually build and run the cooperative food forest enterprise—the development team was eventually able to recruit five motivated start-up entrepreneurs.

The challenge in fully securing this success factor, in particular prior to fundraising the major start-up donation, points to a deficit in the sustainable entrepreneurial ecosystem of Arizona. Economic development is dominated by conventional processes mostly supporting standard businesses and relying on self-motivated, highly educated, and somewhat affluent entrepreneurs to pursue their goals. Targeted support for starting a benefit corporation or a cooperative business is very limited particularly for women, people of color, veterans, and other underrepresented groups. Such services are currently provided by a few lawyers and finance professionals, a few peer businesses (e.g., Technicians for Sustainability in Tucson), a nonprofit organization (Arizona Cooperative

Initiative), and a research team at Arizona State University (Sustainable Food Economy Lab). There are no dedicated training or business development services provided for starting a sustainable (food) business in Arizona, neither through government agencies, nonprofit organizations, nor the universities. The alternative business development team that enabled this specific project came together through self-organizing rather than through a dedicated mandate, and it does not constitute a stable organization or network that would be filling this void for similar start-up efforts in the future. Conventional business education and preparation for standard jobs at large corporations does not create a pool of motivated entrepreneurs who are willing and skilled to secure loans and other means to start a sustainable (food) business in Arizona. Yet, the sustainable entrepreneurial ecosystem has very recently received some notable additions, namely, a benefit corporation consultancy (Thrive Consultancy, since fall 2020) dedicated to sustainable business development as well as the first sustainable cooperative business development program in Arizona through the City of Phoenix (approved at the City Council meeting on 17 Mar. 2021).

3.2 | Accessing suitable land

Finding a suitable site of at least ~0.5 ha (1 acre) for the food forest enterprise in metropolitan Phoenix was time intensive and for quite some time unsuccessful because of financial and land-use constraints (Phase 3). The systematic and criteria-based approach, supported by geographical information system and local land-use experts, proved to be beneficial for identifying promising sites and eventually helped identifying the Spaces of Opportunity farm as most suitable. The consortium has informally agreed to lease ~0.5 ha (of the ~7.7-ha [19-acre] site) to the food forest enterprise, yet the formal approval is still pending. In this respect, the project was able to secure this success factor. However, a food forest reaches its full productive capacity as of operational Year 10, which calls for a long-term (>30 yr) lease arrangement. Although the landowner (Roosevelt School District) is supportive of the project in general, the long-term lease or other forms of stable land access over several decades have not been officially pursued and approved.

Like the previous success factor, the challenge of securing long-term land access points to a deficit in the sustainable entrepreneurial ecosystem of Arizona, in general, and metropolitan Phoenix in particular. With several local farms at risk of losing their land leases to housing and business development, the region has not yet found a way in securing (urban) agricultural land in support of a viable local food economy. For most food production businesses, land lease costs are far too high to allow for reaching economic viability in a reasonable time frame (2–3 yr). Despite efforts from the City of Phoenix to support and advance local food entrepreneurship, little progress has been made on securing long-term land access for urban agriculture including food forests. A local nonprofit organization (Local First Arizona) has begun to build and coordinate activities of an alliance with the mission to create a regional land trust for farmland; yet progress is slow compared with the pace of land being converted and developed.

3.3 | Securing sufficient start-up funds

As described above, securing the start-up funds for this project was tedious and took several years despite the wide range of fundraising efforts undertaken including standard grant proposals, leveraging funding through networking, and a major competition (Phase 6). Several internal factors contributed to this challenge. First, as mentioned above, the team had little or no experience with actual business development. Thus, retreating to the more familiar fundraising activities and grant opportunities for nonprofit and educational organizations is understandable, yet did not match the actual nature of the project (business) and the most suitable financing options (loans, effect investment, social finance options). Second, there were also some competing fundraising interests in the team, as some team members wore several 'hats.' Thus, fundraising efforts were often prioritized toward their home organization or the Spaces of Opportunity farm in general rather than toward the novel food forest enterprise. Finally, the team did not sufficiently anticipate the obstacles to be encountered and delayed prioritizing fundraising activities for too long.

In addition, this challenge was aggravated by a gap in the sustainable entrepreneurial ecosystem, namely, a lack of dedicated funding and financing services for sustainable (food) businesses. First, there are the unique features of urban agriculture and the even more specific ones of urban food forests; for example, their complex structure and synergistic nature as well as the delay between planting and reaching high productivity (after 10 yr), which are not understood by financial organizations. Second, most grant-giving and financial organizations struggle with the integrated sustainability aspiration of the proposed project, namely that the project pursues economic development (of a new type) and social as well as environmental goals. Finally, the project and the team does not neatly fit into the simple categorization of either being a nonprofit organization that pursues public benefits or a for-profit organization that pursues private economic benefits. The start-up funds were eventually secured rather by accident; a private donor learned about the food forest enterprise start-up project who understands and appreciates its complex nature and ambitious aspirations. The legislation for new corporate forms in Arizona, namely, benefit corporation statues

(since 2014) and comprehensive cooperative business statues (since 2016), could offer more stable financing options (if and when fully endorsed). Both corporate forms support the pursuit of private economic benefits and public benefits.

3.4 | Professionally planning and designing the site

Participatory planning expertise within the team, dedicated team members (e.g., lead researcher), (paid) external consulting and student support, and community engagement helped developing a professional vision and site plan based on a comprehensive set of sustainability criteria as well as a robust strategy (action plan) and a detailed business plan draft (Phase 5–7). Not all parts of the business plan were fully developed because the plan is intended to invite and encourage the start-up entrepreneurs to deeply engage with the plan and make it theirs (transfer of ownership). All team members were engaged and motivated to contribute to the site planning, while the actual business plan development was mostly undertaken by the project leaders (authors of this paper). Securing this success factor largely benefited from provided funding for the lead researcher through a PhD scholarship.

The sustainable entrepreneurial ecosystem, like the previous factors, does not offer stable planning support services. Because of extra efforts from the team, experts (e.g., in landscape architecture, permaculture, cooperative business practices) were recruited and university resources were leveraged, which required, in all cases, specific negotiations and developing genuine planning support services. The gap identified for the recruitment of motivated and skilled start-up entrepreneurs extends into this area as well; Arizona, in general, and metropolitan Phoenix, specifically, do not host stable organizations that offer specific and comprehensive business planning for urban farming and food businesses with ambitious sustainability aspirations. While Arizona State University, through its (discontinued) Prepped program, and the University of Arizona Cooperative Extension offered and still offer some valuable services to farmers and food entrepreneurs, they do not cover urban agriculture, sustainability, business model innovation, or novel food production and processing structures and processes (e.g., food forests).

3.5 | Securing the remaining success factors

The remaining success factors are relevant for later stages of the implementation and the actual operation of the food forest enterprise (Phase 7). Some of them have been anticipated and already secured through financial resources, which allow for leasing land and facilities as well as purchasing equipment and plants. Expertise in the team or partnerships allow for providing specific trainings to the start-up entrepreneurs including specific food forest management techniques and how to run a cooperative (food) business. Through existing networks, team members can leverage informal and formal networking to create business partnerships, cooperate with anchor institutions, and share resources and experiences. Securing the remaining success factors, namely diversifying revenue streams and overcoming regulatory restrictions, has been prepared through high product diversity outlined in the business plan draft as well as through the creation and composition of an advisory board to support the start-up entrepreneurs in navigating regulatory obstacles. Yet, there are several uncertainties that will require additional efforts to fully secure these success factors. Like the previous findings, the sustainable entrepreneurial ecosystem for these factors displays several gaps that would need to be bridged for full functionality.

4 | DISCUSSION

The planning and early implementation processes of a sustainable food forest enterprise in South Phoenix, with all its setbacks and preliminary achievements, offers numerous insights regarding success factors and sustainable entrepreneurial ecosystem for food forest development, in particular, and urban agriculture, in general. Four insights connected to our research question stood out.

First, the project confirms the importance of most of the success factors as well as their interdependence as outlined in Albrecht & Wiek (2021b). Recruitment of motivated start-up entrepreneurs, accessing suitable land, securing sufficient start-up funds, and professional planning and site design were and continue to be critical factors in this project, and the other factors are expected to become relevant over the course of the start-up phase. In line with previous research on small farm and food business development (DiGiacomo et al., 2003), insufficient realization of any of these critical factors created major obstacles for the project, slowing down progress (e.g., land access) or bringing it almost to a halt (e.g., start-up funds). Most of these factors are well known in the context of sustainable business start-ups (e.g., Hoogendoorn et al., 2019). However, the findings also offer more nuanced interpretations of the success factors. For example, considering the complexity of the aspired food forest enterprise (e.g., multistrata natural system, food production and processing, and cooperative business structure), recruiting only motivated start-up entrepreneurs would not suffice. Experiences with the business development team and research on capacity building for complex organizations (Taylor-Powell & Boyd, 2008) suggest that complementary skill sets (e.g., farming, education, sustainable business development), team orientation, and basic project management knowledge are critical conditions to this broader success factor. Some of these might be built over

the course of the start-up phase (cf. "trainings, coaching, mentoring" as success factors), but resources, time, and capacities are limited. Hence, integrating team members with business background can be crucial when working with environmental and social entrepreneurs (Schaltegger & Wagner, 2011) to recruit a team of motivated start-up entrepreneurs for a sustainable enterprise. In the marginalization context of our case, recruiting entrepreneurs can be challenging because of lack of business literacy, scarcity mindset, intense nonbusiness pressures, and lack of safety nets, which can limit development of an entrepreneurial mindset (Morris & Tucker, 2021).

Second, it is very challenging to secure all the critical success factors if the sustainable entrepreneurial ecosystem is not sufficiently developed. The project encountered many obstacles in realizing these factors and often relied on special initiatives from team members, generous offerings from partners within the network, or luck. At times, this is not even a result of a lack of leadership or conducive regulations (e.g., novel corporate forms do exist in Arizona) but rather is due to a lack of stable support services that would allow taking advantage of such regulations (Knapp et al., 2016). In most cases, challenges stem from the overreliance on the conventional model of economic development that places emphasis on self-motivated, highly educated, and somewhat affluent start-up entrepreneurs, thereby, systematically sidelining women, people of color, and other marginalized groups that do not have sufficient access to these resources (Edmondson, 1999).

Third, there is flexibility in securing these success factors. In fact, the project analyzed here confirms the importance of entrepreneurial creativity in the absence of a sufficiently developed sustainable entrepreneurial ecosystem. For example, the success factor 'recruiting motivated entrepreneurs'—who take it all on themselves to develop the business—was not the strategy pursued here. In the presented case, most of the planning and preparation work was done by an alternative business development team, which seems a viable option for similar endeavors. Yet, flexibility has its limits and needs to be carefully navigated as not to jeopardize overall vision achievement. A good example is the factor 'land tenure,' which is important for long-term investments such as food trees (Belcher et al., 2005; Rois-Díaz et al., 2018). While our research confirmed the main components of sustainable entrepreneurial ecosystems (Cohen, 2006), providing a pool of suitable and affordable properties was added as a key component in support of urban agriculture businesses. Private land ownership can be a risky strategy, as food forests exceed the lifetime of managers, and life transitions, like aging, death, relocation or divorce, can lead to removal or decline of food forests (Allen & Mason, 2021; Bukowski & Munsell, 2018). Considering the development pressure in most metropolitan areas, public–private partnerships for accessing suitable land, as pursued in this case, seems promising as (underutilized) public land can be used for sustainable farming at affordable cost. Yet, it is a somewhat risky strategy because, while providing land tenure security, it may also limit entrepreneurial land use or require time-intensive change of codes and regulations that may or may not happen (Bukowski & Munsell, 2018; Remiarz, 2017). With heavy reliance on special initiative and conducive circumstances, such initiatives will remain exceptions and only the further development of the sustainable entrepreneurial ecosystem will allow transfer and multiplication (see Malecki, 2018). However, pioneering projects like the one analyzed here are important for bridging gaps in the ecosystem. The cooperative business development program recently seed-funded by the City of Phoenix draws on early efforts of this food forest enterprise start-up project (Khalife et al., 2021). In conjunction with the outreach and networking activities (Phase 8), niche efforts can eventually grow into stable services provided to a broad spectrum of entrepreneurs with sustainability ambitions.

And fourth, the findings of this study point to the fact that a mature sustainable entrepreneurial ecosystem is essential for sustainable (food) business and economic development. Society would be ill-advised to think that a sustainable and just food economy happens because businesses 'just do the right thing.' Current structural injustices favor privileged entrepreneurs, and a sustainable entrepreneurial ecosystem needs to be fully developed for everyone to get a fair chance at sustainable entrepreneurial success. Most of the identified challenges and the extra need for entrepreneurial improvisation and ingenuity can be explained through gaps in the existing ecosystem. Other cities have demonstrated how to support sustainable and cooperative business development more comprehensively through a broad spectrum of services (Sutton, 2019).

5 | CONCLUSIONS

Successful planning and implementation of urban food forests, in particular, and urban agricultural, in general, relies on a suite of interconnected success factors. Although the shared vision of a sustainable food forest enterprise that combats pressing urban sustainability challenges can provide strong motivation for and spark perseverance in entrepreneurs and supporters, insufficient realization of even just one success factor (e.g., insufficient start-up funds) might jeopardize the entire success. Thereby, realizing these factors heavily depends on the sufficient development of a sustainable entrepreneurial ecosystem providing support services such as training, financing, legal advice, political advocacy, among others. If this ecosystem is not in place or not to a sufficient degree, significant additional burden is put on start-up entrepreneurs or alternative business development teams. This study contributes to theory building by confirming the

importance of the previously identified success factors and the sustainable entrepreneurial ecosystem supporting start-up endeavors in successfully realizing these factors. This study implies for start-up entrepreneurs and alternative business development teams that high levels of entrepreneurial creativity, ingenuity, and cooperative arrangements are needed if the sustainable entrepreneurial ecosystem is insufficiently developed. Urban developers and city officials are advised to partner with urban agriculture pioneers, such as urban food forest entrepreneurs, to develop or enhance the ecosystem that enables sustainable food forest enterprises to emerge and thrive.

ACKNOWLEDGMENTS

This research was made possible within the graduate school "Processes of Sustainability Transformation," which is a cooperation between Leuphana University of Lüneburg and the Robert Bosch Stiftung. Stefanie Albrecht gratefully acknowledges financial support from the Robert Bosch Stiftung (12.5.F082.0021.0). Arnim Wiek acknowledges financial support from the Social Sciences and Humanities Research Council of Canada (TRANSFORM: Accelerating Sustainability Entrepreneurship Experiments at the Local Scale, 50658-10029), as well as from the Belmont Forum and the Joint Programming Initiative Urban Europe (Globally and Locally-Sustainable Food-Water-Energy Innovation in Urban Living Labs (GLOCULL), 730254). We would like to thank our project partners from Spaces of Opportunity, especially John Wann-Ángeles, Amy Simpson, Darren Chapman, Bruce Babcock, and Sowan Thai for the fruitful collaboration over the past several years. We would like to thank the Sustainable Food Economy (former) lab members Dr. Nigel Forrest, Nicholas Shivka, and Hanna Layton for support in facilitating events and assisting with grant applications; Prof. Daoqin Tong, Jordan Smith, Kevin Carranza, Yueling Li, and Kelly Bitler for GIS support; Sadhbh Jouarez Bourke for facilitation support; Maud Dieminger and Kelly Baur for visual documentation of the project and the research; Jacq Davis and Pamela Mace for the field visit of their forest gardens; and V.H. Lassen Elementary School for hosting project events.

AUTHOR CONTRIBUTIONS

Arnim Wiek: Study conceptualization; Data collection and analysis; Writing-original draft; Writing-review & editing. Stefanie Albrecht: Study conceptualization; Project management; Data collection and analysis; Writing-review & editing.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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How to cite this article: Wiek, A., & Albrecht, S. (2022). Almost there: On the importance of a comprehensive entrepreneurial ecosystem for developing sustainable urban food forest enterprises. *Urban Agriculture & Regional Food Systems*, *7*:e220025. https://doi.org/10.1002/uar2.20025

A.1.4 Article 4

Albrecht, S., Wiek, A. & Friedel, A. (2021, submitted).

Transdisciplinary Partnerships for Developing Sustainable Food Forests.

GAIA.

Transdisciplinary Partnerships for Developing Sustainable Food Forests

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Submitted to GAIA

***Lead text**: Comparing the initiation of two sustainable food forests, key partnership features show to be an entrepreneurial attitude, access to support functions, and commitment to food system change*

Abstract

Developing sustainable food initiatives such as food forests is a promising path to respond to sustainability challenges associated with the industrial food system. While success factors for food forests have been identified, including suitable land, start-up funds, and expertise, little is known about the partnerships that can help to secure them. This study compares two cases of developing sustainable urban food forests in Phoenix, U.S. and in Lüneburg, Germany. While both cases were initiated by university researchers, the German case was a partnership with the city administration, and the U.S. case was a partnership with non-profit organizations. This study focuses on the initiation and planning stage of the initiatives, and analyzes the cooperation and outomes in these transdisciplinary partnerships. Findings suggest that success/failure is influenced by entrepreneurial attitude, access to support functions, and cooperation grounded in time commitment, accountability, and trust; while other aspects such as type of partner (city government vs. NGOs) seem to be of lesser relevance. We discuss the findings against relevant literature and draw conclusions for developing potent transdisciplinary partnerships for sustainable food initiatives early on.

Keywords: food forests, sustainability solutions, food system transformation, transdisciplinary partnerships

1. Introduction

The contemporary agricultural and food system dominated by large multi-national corporations is responsible for a plethora of negative environmental, social, and economic impacts, including significant greenhouse gas emissions, soil degradation, biodiversity loss, food waste, malnutrition, worker exploitation, concentration of economic gains, and more (Clapp 2018; Popkin and Reardon 2018; Rockström et al. 2020). There are various efforts to address these issues and transform food systems towards sustainability from the micro to the macro scale (Kropp, Antoni-Komar, and Sage 2020; Weber et al. 2020). In urban areas, innovative agricultural and food initiatives include more recently urban food forests (Wiek and Albrecht 2021; Krishnan et al. 2016).

Food forests are multi-functional agricultural systems that offer a variety of services, including food provision, livelihoods, environmental services, and opportunities for recreation and education (Albrecht and Wiek 2021). They seemed to be particularly beneficial to urban areas because of the multiple services they offer to address urban problems, e.g., urban food deserts, heat island effects,

lack of economic opportunities, insufficient green spaces, as well as low space-efficiency of urban agriculture (Clark and Nicholas 2013; Krishnan et al. 2016). While recent studies have revealed success factors for sustainable food forests such as securing land, start-up funds, and expertise (Albrecht and Wiek 2021, in press) as well as general support functions for them (Albrecht and Wiek 2021), little is known about the role of partnerships for their success/failure. The features of partnerships are of relevance particularly in the *early* stages of sustainable food initiatives due to inertia and high transaction costs to change them at later stages (Baldy 2019).

Partnerships across diverse organizations have been identified as key factors in transition and transformation processes towards sustainability (e.g., Nevens et al. 2013; Fazey et al. 2018). For the collaboration of researchers and practitioners in *transdisciplinary* partnerships, targeted selection of actors with relevant experience, expertise and interests, as well as design of an organizational structure that coordinates competences, roles and responsibilities, and decision-making processes, are relevant (Lang et al. 2012). Considerable resources are required for designing transdisciplinary projects aligning the goals of researchers and practitioners, developing a joint understanding of key concepts, building trust, and accounting for reflection and adaptation cycles (Rose and Maibaum 2020; Lux et al. 2019; Schmidt et al. 2018). This includes applying interactive methods to engage various stakeholders at appropriate levels of participation (Fazey et al., 2018; Lang et al., 2012; Wiek, 2007). Professional facilitation can support open communication, joint reflection, and mediation processes across the partnership (Lang et al. 2012; Moschitz 2013).

In food systems research in particular, most studies address partnerships on the aggregate level of networks (i.e., alternative food networks) rather than investigating partnerships on the level of individual food initiatives and organizations (e.g., Forrest and Wiek 2021). Micro-level research would be beneficial for nuancing the theory of food system transformation, while supporting sustainability efforts of small food initiatives. This is a critical base for transfer and scaling efforts towards larger system changes (Lam et al. 2020). Such research would also help advance the theory of the entrepreneurial ecosystem conducive to sustainable food forests (Wiek and Albrecht 2021).

Against this background, we address the following question: *What are key features of productive partnerships when developing sustainable urban food initiatives?* We conducted a comparative study on two transdisciplinary projects that aimed to develop sustainable food forests, one in Lüneburg, Germany, and the other one in Phoenix, Arizona, USA. While the food forest in Phoenix is funded and under full development (Wiek and Albrecht 2021), the endeavor in Lüneburg failed in the planning stage. Both cases are different in outcomes (success/failure) and process elements (partnering organizations, etc.). Yet, they share common features such as goal (sustainable food forest), initialization (by university researchers), and timeline (several years), which allows for a meaningful comparison.

The insights from this study might inform a variety of stakeholders interested in developing sustainable urban food initiatives, including alternative business developers, food initiatives run by non-profit organizations, economic and community development departments in local government, sustainability offices in city administration, and university researchers. While based on a comparison of few cases, the findings might be transferrable to other locations and settings due to the very different features and contexts of the cases investigated.

2. Description of Cases and Contexts

This qualitative study compares two partnerships in developing sustainable urban food initiatives (food forests) to explain (to some extent) why one succeeded, while the other failed, and to extract key features of productive partnerships for urban food initiatives. Both cases were embedded in very different broader demographic and socio-political contexts (Tab. 1).

Phoenix is a major metropolitan area in a semi-arid desert, while Lüneburg is a medium-sized city within the temperate climate zone. Lüneburg, like many cities in Germany, has some strong sustainability features, including good social and health provision services, good housing conditions, high rate of public educational attainment, many green spaces, renewable energy, area-wide public transit, affordable access to healthy food, societal commitment to mitigate climate change, and so forth. Lüneburg received the German Sustainability Award in 2014. Nonetheless, Lüneburg faces are a number of sustainability challenges, including economic disparities, climate change in form of heavy rainfall and flooding, and increased traffic and nitrogen pollution (OECD 2019; Geo-Net Umweltconsulting 2019; Lehmann 2019). Food production is diverse including organic farms but is dominated by monocultural, mass production (Niedersächsisches Ministerium für Ernährung, Landwirtschaft und Verbraucherschutz, 2017). Phoenix struggles with a much wider range of sustainability issues and on a much larger scale including exploitative business practices, excessive GHG emissions, significant urban heat island effects, sparse green spaces, food deserts, racial exclusion, economic marginalization, and environmental degradation (Ross 2011; Lacagnina et al. 2017). In both cities, a growing population is leading to urban sprawl (yet, at different scales and rates).

Table 1: Contexts of the cases – Features of the cities (data from 2019, if not indicated otherwise)

	Phoenix, Arizona, USA	**Lüneburg, Lower Saxony, Germany**
Inhabitants	1.6M	78,000
Diversity	White: ~43% Hispanic or Latino: 43% Black or African American: ~7% Native American: ~2% Asian: ~4%	German nationality: ~90% Other nationalities: ~10% (Poland, Turkey, etc.)
Education attainment	High School diploma: ~82% Bachelor's degree (or higher): 29%	High School diploma: ~94% Bachelor's degree (or higher): ~21%
Poverty rate	~18% (below poverty line)	~14% (at risk of poverty)
Climate	Semi-arid	Temperate
Urban challenges	• Urban sprawl • Urban heat island • Lack of green space • Food deserts • Racial exclusion • Environmental degradation • Economic disparities	• Urban sprawl • Urban heat island • Biodiversity loss • Weather extremes • Nitrogen pollution • Economic disparities
Food economy	A few local (organic) farms and alternative food schemes (CSAs, farmers markets), however, largely dominated by industrial players City government launched $9M food system resilience initiative in 2021	Food cooperatives, CSAs, farmers market, organic food stores, zero-waste grocery stores, supermarkets offering local foods, conscious customers Food policy council (since 2019)

Culture	Corporate, convenience, disconnection from nature	Green city, disconnection from food production, romantic "nature" image
Political & institutional	Top-down, mainstream media reporting, no protection of land for urban agriculture	Bottom-up, citizen-led initiatives (e.g., Grüngürtel West), media reports on large-scale insect decline, no regulation for agroforestry

Both projects were initiated by university researchers; yet, operating in different research settings (Tab. 2). The core research teams were similar in size; yet, the project at Arizona State University could rely on the expertise, assistance, resources, and network of a research group focused on sustainable food economy (Link) with senior (>15 years) expertise in multi-stakeholder transdisciplinary project work, while the project at Leuphana University had to work with a more constrained pool of assets.

Table 2: Contexts of the cases – Features of the research environments (data from 2019)

	Research Environment at Arizona State University	**Research Environment at Leuphana University Lüneburg**
Institute	Sustainable Food Economy Lab	Institute for Ethics and Transdisciplinary Sustainability Research
Main Researchers	1 PhD student (S.A.), 1 professor (A.W.)	1 PhD student (S.A.), 1 academic staff (A.F.)
Available expertise	• Food forest research • Food businesses and economy • Sustainable business practices & models • Sustainable solution research • Transdisciplinary research (>15 years)	• Food forest research • Transdisciplinary research (<3 years) • (Forest) Ecology • Soil Science
Assistance	• GIS experts (professor & master students) • Landscape architects (professor & master student) • Process facilitators (master students, PhD student)	• Undergraduate students (transdisciplinary seminars) • Ecologists for soil tests and biodiversity monitoring
Resources	• Lab room with workstations • Funds available for events, catering, public transportation, etc.	• Office space • Laboratories for ecological research • Funds for workshops and guest lecturers
Transdisciplinary Network	Direct access to a broad network of actors in the local food economy	Indirect access to a small network of actors in the local food economy

The food forests projects differed in several key features (Tab. 3). In Phoenix, the researchers collaborated with a consortium of non-profit organizations (*Spaces of* Opportunity) that had initiated an urban farm, which the food forest is embedded in (Wiek and Albrecht 2021). In Lüneburg, the main partners of the researchers were administrative staff of the city's Parks & Recreation Department, and the food forest was envisioned to be created in a public park.

Table 3: Key features of the two food forest projects

	Food Forest Project Phoenix	**Volgershall, Lüneburg**
Location	Spaces of Opportunity, Phoenix	Volgershall, Lüneburg
Partners	Representatives of NGO consortium	City staff (Parks & Recreation)
Further stakeholders	University, school, café, local community	Neighbors, NGOs, schools, kindergarten, clinic
Site size (ha)	0,5	0,5
Embedded in	Urban farm (10 ha)	Park (5 ha)
Land ownership	Semi-public school land (lease from Roosevelt school district)	Public green space (City of Lüneburg)
Identified gaps / needs	• Create livelihoods • Provide fresh food • Educate students • Support marginalized communities • Mitigate heat	• Support biodiversity, especially rare insects • Maintain a public site overgrown by blackberries • Revive an old, hidden orchard
Envisioned services of the food forest	Job creation, food production, educational offerings	Environmental services, recreation, education, community building, minor food production

The first two contexts illustrate demographic, social, geographical, climatic, and other differences on the scale of the city (Tab. 1) as well as differences of the research environments the projects were embedded in (Tab. 2). The overview of key features (Tab. 3) indicates differences in partnerships (non-governmental vs. governmental administration), locations (urban farm vs. public park) and addressed needs. Apart from obvious differences in orientation and set-up, a good number of these factors offer some explanatory power for how the two projects unfolded differently (which will be discussed further below).

3. Research Design

This study focuses on the *initial phase* of developing sustainable food forests, which offers the most immediate insights for the targeted stakeholder groups, while allowing to reveal early success/failure indications without needing to wait for the full completion of the projects. The initial project phase is here defined as spanning from early contacts and goal definition to the completion of an action plan ready for implementation (Albrecht and Wiek 2021, in press).

For each of the initiatives, we describe and analyze *outputs*, *partners*, and *interaction processes* (Tab. 4-6). Compared to elaborate evaluative schemes (e.g., Luederitz et al., 2017), we adopt a *basic* evaluative scheme focusing on the early-stage development outputs as well as the partnership features (partners, interaction processes) of the sustainable food forests to establish some reasonable causal links (while also considering other contextual factors – see above).

For identifying, assessing, and comparing the *outputs* of the initiatives, we adapted the set of success factors identified in Albrecht & Wiek (2021b), as spelled out in Table 4.

Table 4: Output criteria (adapted from Albrecht & Wiek (2021b))

Output Criterion / Success Factor	**Guiding Question**	**Specifications**
Motivated entrepreneurs / organizers	Is the food forest developed by entrepreneurs who aim to provide for livelihoods, while producing healthy food, and generating environmental benefits?	(0) None (1) Proxies (2) Full team
Suitable site secured	Is the food forest site large enough etc. and does the ownership structure allow for long-term access to the land (>30 years)?	(0) No (1) Limited lease (2) Unlimited lease / purchase
Sufficient start-up funds	Are there sufficient funds for land access, infrastructure, plant setup, start-up wages, etc. available?	(0) None (1) Some funds (2) Full funds
Professional plans	Are there sufficiently complete business and site plans available that fully incorporate sustainability (ecological, socio-cultural, economic) criteria?	(0) None/under-developed (1) Complete plan(s) (2) Tested plan(s)
Farming know-how and equipment	Are there sufficient knowledge, skills, tools for long-term, multi-strata site management as well as food production and processing available?	(0) None/minor (1) Some experience (2) Multi-year expertise
Entrepreneurial / organizational know-how and tools	Are there sufficient knowledge, skills, tools on sustainable business practices and models available, incl. organizational know-how for structured procedures, roles, and tasks, as well as an entrepreneurial mindset?	(0) None/minor (1) Some experience (2) Multi-year expertise

For identifying, assessing, and comparing the *partners* of the initiatives, we adopted a framework developed for partnerships in sustainability transformations (Lyon et al. 2020) and combined it with the concept of the entrepreneurial ecosystem (Wiek and Albrecht 2021), as spelled out in Table 5. These criteria align with transdisciplinary principles of achieving joint understanding of the problem, shared objectives, as well as involving project partners with relevant expertise and resources (Lang et al. 2012). Especially at the start, prior work relations can increase transdisciplinary team productivity (Stokols et al. 2008) and, just as novel enterprises, transdisciplinary research also calls for various support mechanisms (Lux et al. 2019).

Table 5: Partner criteria (adapted from Lyon et al. (2020) and Wiek & Albrecht (2021))

Partner Criterion	**Guiding Question**	**Specifications**
Motivated to contribute to the initiative	Have the partners expressed interest in actively contributing to the development of the sustainable food forest, e.g., through a cooperation agreement?	(0) No/Low (1) Medium (2) High
Committed to food system sustainability	Are the partners explicitly oriented towards comprehensive sustainability (all dimensions) of food systems?	(0) Not/Insufficient (1) Moderate (2) In full support
Ready for system change	Are the partners involved in food system transformation towards sustainability?	(0) No/Lagging (1) Aspiring (2) Pioneering
Relevant expertise and resources	Do the partners have professional knowledge, skills, and resources (e.g., equipment, funding) for food forest development (farming/gardening, business practices, community engagement, etc.)?	(0) Major gaps (1) Minor gaps (2) Complete set
Sufficient power / authority	Have had the partners sufficient power / authority to enact the changes envisioned?	(0) No/minor (1) Some (2) Sufficient
Access to support functions	Do the partners (through their networks) have access to support functions of the entrepreneurial ecosystem (training, financing, etc.)?	(0) Access to some functions (1) Access to all functions (2) Access to all functions

For identifying, assessing, and comparing the *interaction processes* among the partners, we used a combination of criteria from different strands of literature on sustainability governance and public participation (Sipos, Battisti, and Grimm 2008; Poteete, Janssen, and Ostrom 2010; Luederitz et al. 2017; Wiek 2007), as spelled out in Table 6. These criteria align with transdisciplinary principles and approaches of using diverse, engaging methods, mitigating conflict and building trust through open communication, and offering appropriate levels of participation (Lang et al. 2012; Fazey et al. 2018; Wiek 2007).

Table 6: Criteria for interaction processes (adapted from Luederitz et al., 2017; Poteete et al., 2010; Sipos et al., 2008; Wiek, 2007)

Interaction Criterion	**Guiding Question**	**Specifications**
Spectrum of interaction processes	Do the partners engage with each other and the food forest initiative through different modes of interaction, including analytical, creative, emotional, experiential, reflective ones?	(0) One dominant mode (1) A few different modes (2) Full spectrum
Dealing with conflict	Do the partners constructively deal with conflicts, communicating openly about their (conflicting) perceptions, feelings, and needs?	(0) Intimidated/suppressed (1) Partly addressed (2) Fully addressed
Building trust	Do the partners build trust through reciprocal and repetitive interactions and transparent communication?	(0) Low (1) Medium (2) High
Accountability	Do the partners take time to work on the initiative and follow through on commitments in a timely fashion?	(0) Insufficient (1) Some irregularities (2) Sufficient time & follow-through
Level of engagement	Do the partners sufficiently cooperate on the important aspects of the initiative?	(0) Uni-directional information sharing & consultation (1) Collaboration (2) Joint decision-making

In both case studies, data was collected through participant observation, research diary, and documents review (meeting minutes, workshop documents, etc.). For the data analysis, we determined the level of alignment with the evaluative criteria for outputs, partners, and interaction processes, and compared them between the two cases.

Sustainability *outcomes* were *not* assessed for this early stage (initial phase) of developing the food forests as this is more appropriate at later stages, namely, during or after implementation (Albrecht and Wiek 2021). However, we reviewed to what extent sustainability elements were accounted for in the initial project phase, including, for example, integration into action and business plans. Thereby, we followed the definition of a sustainable food forest being a food-producing, multi-layered ecosystem of at least 0.5ha in size and 10% canopy cover that offers environmental benefits (food, storm water capture, etc.), social benefits (green space, shade, etc.), and is economically viable over a long period of time (cf. Albrecht and Wiek 2021). Jointly developing a sustainable food forest was the shared goal and served as a "boundary object(ive)" or integration product that supported the collaboration across different disciplines and backgrounds (Bergmann et al. 2012).

4. Research Results

We compare outputs, partners, and interaction processes for both food forest projects to explain (to some extent) why one project succeeded, while the other one failed, and to shed light on the key features of productive partnerships for sustainable urban food initiatives.

4.1. Outputs

The food forest project in Phoenix fully or partially secured all of the early-stage success factors, while the project in Lüneburg struggled to secure any of them (Tab. 7). In particular, the main partnership with the city failed to be sufficiently built out. The only lasting output was the interdisciplinary team at the university that formed to support sustainable food forest development in the region.

Table 7: Early-stage outputs of the two food forest projects

Output Criteria	Food Forest Project Phoenix	Food Forest Project Lüneburg
Motivated entrepreneurs / organizers	(2) Committed transdisciplinary team of organizers to implement the sustainable food forest; team of motivated entrepreneurs for long-term management	(0) No transdisciplinary team emerging from outreach and engagement activities to implement the sustainable food forest. (An interdisciplinary team formed.)
Suitable site secured	(1) Mid-term security through lease for 10+ years; land trust discussion initiated	(0) No lease or easement
Sufficient start-up funds	(2) Funds for infrastructure, plant setup, start-up salaries, etc. through private donation ($100.000)	(0) No start-up funds
Professional plans	(2) Comprehensive action plan based on extensive food forest research; reiterated site plan by landscape architect; some plants tested at display site; evidence-based business plan	(0) Evidence-based, but under-developed action plan, lack of feedback
Farming know-how and equipment	(1) Theoretical know-how through familiarization activities; one entrepreneur and one researcher with multi-year forest gardening experience	(0) Minor understanding of food forests through familiarization activities (two workshops); two researchers with (forest) gardening experience
Entrepreneurial / organizational know-how and tools	(1) Some experience through workshop on cooperative business planning; one researcher with expertise on sustainable business models; lack of organizational leadership in entrepreneurs' team	(0) None, partial resistance to entrepreneurial activity even for minor compensation of core work

4.2. Partners

Searching for reasons that can explain the significantly different early-stage outputs of both projects, we first turn to the project partners in both cases (Tab. 8).

Although only minor direct relationship existed among the partners prior to the food forest project in Phoenix, organizations and individuals forged a partnership that pooled a multitude of assets. Formalized motivation to cooperate, high commitment to, and readiness for system change, as well as access to expertise, resources, and support functions characterize this partnership.

The partners in the food forest project in Lüneburg, on the other hand, struggled with forging a functional partnership in almost all dimensions. A couple of barriers are worth highlighting. One was the

lack of partners with business/economic expertise to ensure that *all* dimensions of sustainability are equally pursued. Despite the initiative's sustainability orientation, business pursuits were rejected ("no revenue generation on public spaces") or shifted to non-profit pursuits (donations, grants). Innovative public-private partnership options such as a multi-stakeholder cooperative business or a city-run food forest service were not explored. Staff from the city administration was protecting the status quo, fearing to leave known territory. Also, although aspiring to system change (mostly verbally), staff lacked experience in positive community engagement activities, felt overburdened with other responsibilities, and struggled with assuming leadership for this project within city administration.

Interestingly, while both projects started with a fresh partnership within insufficiently developed sustainable entrepreneurial ecosystems in both regions, the project partners in Phoenix grew into a functional partnership that secured all necessary resources, while that did not happen in Lüneburg.

Table 8: Partners characteristics in the two food forest projects

Partner Criteria	**Food Forest Project Phoenix**	**Food Forest Project Lüneburg**
Motivated to contribute to the initiative	(2) Explicit interest in jointly developing a sustainable food forest, formally expressed in an agreement of cooperation	(0) Main partner interested in low-cost site management solution through minor contributions; organizations (school, kindergarten, clinic) interested in using food forest but not willing to help developing it
Committed to food system sustainability	(2) In full support of comprehensive food system sustainability with a focus on the social dimension due to personal backgrounds but aspiring to balance it with ecological and economic dimensions	(0) Insufficient focus on ecological services (mostly pro insect diversity), low interest in socio-cultural dimension, and resistance to economic dimension
Ready for system change	(2) Pioneering by providing fresh food, education on healthy food and farming, community engagement in an area with little to no access to fresh food (food desert)	(1) Aspiring towards system change by providing urban farm boxes to citizens and participating in visioning process for a sustainable city
Relevant expertise and resources	(1) Experienced in and tools for annual gardening and orchard farming; under-developed business practices despite incubation farm and on-site farmers' market; highly developed community engagement and grant acquisition practices; major grant provides resources	(0) No (positive) experience with community engagement, farming/gardening and business practices; minor resources to clear the site from dominant blackberries (already pending task) and potential earthwork
Sufficient power / authority	(2) Lead organizations that initiated the urban farm were involved with direct decision-making power on farm-related issues	(1) Lead of department for green spaces with land management authority but on lowest city admin level with three organizational units above
Access to support functions	(1) Access to some support functions (funding, training), despite underdeveloped entrepreneurial ecosystem in the region	(0) No access, within underdeveloped entrepreneurial ecosystem; especially lack of official support for city admin staff to be actively involved in system change

4 .3. Interaction processes

The different interactions among the partners during the early stages of the two projects (Tab. 9) offer additional explanations for the differences in project outputs described above.

Both projects followed a similar process from networking and site selection to topical familiarization, visioning and strategy building (action plan) (Wiek & Albrecht, 2021). The initiating researchers led

these transdisciplinary processes and tried to engage the partners in various ways as well as encourage joint decision making through interactive workshops and meetings (Wiek, 2007). While these efforts were generally successful in Phoenix, the partnership in Lüneburg lacked accountability. While the partners in Phoenix expressed eagerness to move forward ("We'd have liked to have the food forest already developed yesterday!") and followed through on requests and tasks, the partners in Lüneburg hesitated to move from visioning to strategy building, expressing doubts (conflict aversion) and being unavailable (e.g., receiving responses took weeks, at times; the important presentation to City Council was canceled). This built vs. eroded trust over time.

Table 9: Interaction processes in the two food forest projects

Interaction Criteria	**Food Forest Project Phoenix**	**Food Forest Project Lüneburg**
Spectrum of interaction processes	(2) Broad spectrum, including analytical (presentations), creative (site design game), emotional (team building with theater-based methods), experiential (field trips), reflective (mindfulness walk, reflection survey) interactions	(1) Mostly analytical interactions (partner meetings, public survey), two interactive workshops with creative interactions (familiarizing presentation and posters, imaginary journey and vision design game)
Level of engagement	(2) Joint decision making on all major project matters, e.g., joint vision, strategy building, fundraising, setting-up of display site	(0) Mostly information sharing and consulting, lack of city partner engagement in visioning and strategy building, e.g., only attending one of the two public workshops
Dealing with conflicts	(2) Internal conflicts emerged on various issues (goals, organization, roles, etc.) and were addressed by bringing different perspectives etc. into the open and forging compromises	(1) At both public workshops, external conflicts emerged (objections and complaints from citizens) and were addressed by explaining the benefits of the project; internal conflicts emerged from misalignment of goals and insufficient commitment, but were left unaddressed
Accountability	(1) Somewhat balanced contributions despite time restrictions, e.g., during peak farming season, and follow-through on agreed-upon actions; yet, some team members were more invested than others.	(0) Insufficient time investment and lack of follow-through on agreed-upon actions
Building trust	(2) High level of trust through aligned perspectives and values and fostered through regular communication and meetings, openness to address of challenges, and reciprocal contributions	(0) Decreasing levels of trust due to misalignment in perspectives and values (e.g., community engagement), unresponsiveness of city partner, and hence, irregular meetings, avoidance to address challenges, and unbalanced contributions

5. Discussion

The initiation of sustainable food forests in two contrasting cases offers insights on the important features of partnerships, in particular transdisciplinary ones, for these and similar sustainable urban food initiatives.

When starting the projects, in both locations, the researchers used a clear set of criteria to explore suitable *sites* and other features of the projects. However, there were only few *partner* requirements, and the selection was rather opportunistic. This lack of attention saw a dysfunctional partnership

emerging in the Lüneburg case, which mostly came about due to the lack of alternative suitable sites. Finding in a city a suitable 0.5ha site (minimum size requirement) is not an easy undertaking. However, starting with a smaller display site and stronger partners may be the better alternative. Furthermore, in Lüneburg, the research team had little expertise in conducting transdisciplinary projects, while in Phoenix, the co-leading researcher had more than 15 years of (international) experience in navigating multi-stakeholder transdisciplinary processes. This allowed the team to tap into critical skills such as guiding and focusing discussions while engaging with the larger sustainability vision using diplomatic and subtle communication techniques (practiced over years). As indicated in the literature (Rose and Maibaum 2020), many projects, as the one in Lüneburg, struggle with building transdisciplinary research teams with the relevant skill mix, i.e., academic rigor and pragmatism, interpersonal and facilitation skills, as well as comprehensive sustainability commitment.

Partnering with a city administration, as it was the case in Lüneburg, does not present an obstacle *per se*. Other city administrations have supported successful food forests, e.g., in Kassel, Rotterdam, Atlanta and Seattle, WA (Albrecht & Wiek, 2021a). Similarly, partnering with NGOs, as it was the case in Phoenix, does not present an advantage *per se*. Several food forests implemented by NGOs struggle with economic viability as a key feature of sustainability (Albrecht & Wiek, 2021a). Considering the need for risk-taking, one might argue that suitable partners may rather be found in the private than in the public or non-profit domains (Walters and Ramiah 2016; Chen and Bozeman 2012). However, while this might ensure economic viability, conventional business developers are rarely sufficiently trained and experienced in the competencies necessary for developing *sustainable* businesses (Hind, Wilson, and Lenssen 2009; Rainey 2010). This points to the importance of developing comprehensive sustainable entrepreneurial ecosystems for advancing such initiatives (Wiek & Albrecht, 2021). Thus, more important than the type of organization seem to be the key features of the partners and partnership itself, as well as the contexts they are embedded in, as presented above. We will discuss these aspects in the following.

Entrepreneurial attitude towards sustainability (i.e., motivated to contribute to the initiative; committed to food system sustainability, including economic viability; ready for system change) and *access to support functions* such as training, or financing (directly or indirectly) seem to be the features decisive for success or failure in the presented cases. Entrepreneurial attitude towards sustainability in city administrations requires a shift from environmental protection to comprehensive sustainability, from conserving to innovation, and from risk-aversion to risk-taking (Chen and Bozeman 2012; Walters and Ramiah 2016). Research on local government administrators as change agents points to the importance of corresponding skills, e.g. to mobilize cross-organizational networks, initiate trust-building dialogue, as well as identify and seize windows of opportunity (F. Westley et al. 2011; Olsson, Folke, and Hahn 2004). The case in Lüneburg illustrates the lack of these assets (Tab. 8) and gaps in related resource allocations. While funds for pilot projects were available in Lüneburg, they were not tailored to start-up needs. For example, when requesting start-up funds for trees, the partners offered instead monitoring support for the *implemented* food forest. In contrast, significant start-up resources were fundraised for the food forest in Phoenix, specifically earmarked for developing it as a sustainable business (to ensure economic viability). While the non-profit organizations involved in the case in Phoenix had no to very little experience in (social) enterprise development, and continued to struggle developing a sustainable entrepreneurial attitude, the partnership with university researchers sparked this attitude across the project team (stemming from the researcher with a background in sustainable business development). Alignment of personal and professional commitments, as well as their ratification through a formal agreement, helped further anchoring this attitude as a main driver of the project. Both cases were not able to rely on comprehensive sustainable entrepreneurial ecosystems,

which are underdeveloped in both regions (Wiek & Albrecht, 2021). However, in Phoenix, there were a few more support functions available to which access was mostly facilitated by the research environment the food forest project was embedded in (Tab. 2). The city administration of Phoenix also offered indirect support by strengthening some ecosystem components through multi-year food action planning and a well-funded large food system initiative (Tab. 1). This points to the importance of contextual factors for the success of such projects, beyond immediate partner and partnership features.

The cooperation in these two partnerships was significantly different, as presented above (Tab. 9). The type, level, and nature of the interactions were instrumental for creating accountability and trust (or not). This can be illustrated with the aspect of *time* investment. Developing a sustainable food forest requires several years of high up-front time input with 'delayed' returns in yields (Albrecht and Wiek 2021, in press). Hence, utilizing available time wisely from the very beginning prevents unconducive path dependencies and draining energy in such projects. While partners struggled in both projects to make sufficient time due to resource constraints and full workload, the partners in the food forest project in Phoenix overall and eventually managed to do so; in particular, they were active and responsive when needed most. This highlights the importance of *timing*, i.e., being active at 'crunch time', in addition to spending sufficient time on the project. In time-constrained project settings, being resourceful is critical and requires carefully weighing pros and cons. In the Lüneburg case, for example, the researchers involved students in the project's early stages through transdisciplinary seminars. While this generated benefits for the project, it also required major time commitment to a complex educational setting (Wiek and Kay 2015). In return, this may have distracted from more persistently demanding responses and input from the city partner.

Going back to contextual factors, one might speculate if the challenges encountered in the Lüneburg case might have been, at least in part, due to the fact that the food forest was planned on public land, which is unlike most food forests which are realized on private land (Albrecht and Wiek 2021). Yet, successful food forests have been implemented on public land, too, e.g., by the City of Atlanta that runs a 3ha public food forest. However, other cases, illustrate the range of challenges associated with this feature. The *Beacon Food Forest*, developed on public land in partnership with the City of Seattle, for example, required multi-year efforts in community engagement and adapting regulations (Bukowski and J. Munsell 2018). The plans for an urban farm at *Los Olivos*, a public park in Phoenix, has faltered despite successful multi-year public engagements (Trimble 2018) due to prohibitive regulations. Working on a public site may also restrict livelihood opportunities and limit economic viability (Bukowski and J. Munsell 2018). Especially on green spaces, city officials favor food forests to serve socio-cultural purposes (80%) over food access (20%) (Coffey et al. 2021). Specific land classifications seem relevant when working with a public partner, e.g., the food forest in Phoenix is being developed on the particular land classification of 'school land' which involves other administrative agencies and regulations than for 'public parks'. Finally, the (perceived) urgency of the addressed challenges play a role, too; for example, in Phoenix, there is broad commitment to counter the urgent food desert challenge, which triggered broad support of the food forest on public land.

What this study contributes to the theory of transdisciplinarity is confirming the importance of designing a functional partnership in the early project stage prior to investing significant time in anything else. Converting on problem understanding and goals etc. are the outcomes that build the base of transdisciplinary projects (Lang et al. 2012). Thus, the early stage should allow for ending the partnership in case of (major) diverging interests and priorities, as this is a common factor for failure in transdisciplinary research (Fam and O'Rourke 2020). Beyond interest and competence (Lang et al. 2012), commitment, confidence, and power are critical capacities in transdisciplinary partnership

(Keeler et al. 2019). While these can be built, it requires considerable time and resources, which are often not available (Krellenberg et al. 2019). These capacities also relevant for the researchers. While funding in both projects was covered for the lead researcher (S.A.), senior expertise in transdisciplinary research might have shifted the course of the project in Lüneburg.

The limitations of this research are the small number of cases and their contrasting contexts. The cases represent two partnership constellations, one with an NGO consortium and one with a city administration. Other relevant cases would be partnerships, e.g., with different city departments (e.g., economic development), (food) enterprises, or other associations which might yield different outcomes and offer additional critical partnership features. Being embedded in contrasting contexts led to opportunities and limitations. For example, in Phoenix with a broad network in a large city, we had multiple options for partnerships and sites, while in the smaller city of Lüneburg and lacking contacts, choices were more limited. There may have been other relevant factors influencing both projects; yet, project resources were limited, hence, independent accompanying research to collect such data was lacking. Rather, we co-led the project developing the food forest and at the same time conducted accompanying research which led to challenges of self-evaluation (Wiek et al. 2014).

6. Conclusions

This comparative study on the initiation of sustainable food forests in Lüneburg and Phoenix, the first with a governmental partner on a public site that failed and the second with non-governmental partners on a semi-public site that is in the process of being implemented, demonstrates the relevance of functional transdisciplinary partnerships for the success/failure of such projects. Sustainable food initiatives in general, and food forests in particular, require major investments of time and other resources; hence, partners need to be entrepreneurial and resourceful while cooperating in functional ways, led by a shared, comprehensive sustainability vision that includes economic viability of the initiative. More important than the type of organization (government, non-profit, private) seem to be these key features of the partners and partnership itself, as well as the contexts they are embedded in. Constructively used, the findings offer guidance to practitioners and researchers interested in transdisciplinary partnerships to advance sustainable food initiatives. The gaps observed point to the need for tailored capacity building, in particular in city administration. In addition, future research should validate more systematically the identified features across a large number of cases with different transdisciplinary partnerships.

Acknowledgments

This research was made possible within the graduate school "Processes of Sustainability Transformation", which is a cooperation between Leuphana University of Lüneburg and the Robert Bosch Stiftung. S.A. gratefully acknowledges financial support from the Robert Bosch Stiftung (12.5.F082.0021.0). A.W. acknowledges financial support from the Social Sciences and Humanities Research Council of Canada (TRANSFORM: Accelerating Sustainability Entrepreneurship Experiments at the Local Scale, 50658-10029), as well as from the Belmont Forum and the Joint Programming Initiative Urban Europe (Globally and Locally-Sustainable Food-Water-Energy Innovation in Urban Living Labs (GLOCULL), 730254). The authors would like to thank John Wann-Angeles, Darren Chapman, Amy Simpson, Hanna Layton, Nick Shivka, Sadhbh Juarez Bourke, Elizabeth Ferguson,

Doaqin Tong, Kevin Carranza, Kelly Bitler, Yueling Li, and the 22 students of the first Leuphana food forest lab in summer 2019 for various contributions to the food forest projects.

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A.2 Reports and Plans

A.2.1 Transfer Workshop Report

Albrecht, Stefanie; Wiek, Arnim (2020).

Implementing Sustainable Food Forests:
A Transfer Workshop for Stakeholders in Arizona.
Tempe, Arizona.
Available online at: https://web.asu.edu/slfee/publications-0

Implementing Sustainable Food Forests

A Transfer Workshop for Stakeholders in Arizona

Stefanie Albrecht and Arnim Wiek

January 2020

Sustainable Food Economy Lab

ASU School of Sustainability
Arizona State University

Sustainable Food Economy Lab

The *Sustainable Food Economy Lab* supports and advances sustainable food economies and enterprises through solution-oriented research in collaboration with stakeholders and researchers. We believe in the value of food that is healthy and delicious, fairly priced and broadly accessible, while produced in environmentally friendly ways along the entire life cycle, with high standards of animal welfare. We also believe in the value of food that provides decent, stable jobs, while supporting local communities and cultures.

The Sustainable Food Economy Lab is part of the School of Sustainability at Arizona State University.

slfee.lab.asu.edu

Citation

Albrecht, S., & Wiek, A. (2020). *Implementing Sustainable Food Forests – A Transfer Workshop for Stakeholders in Arizona.* Sustainable Food Economy Lab, School of Sustainability, Arizona State University, Tempe, Arizona.

Photos

Photos by courtesy of Kelly Baur.

Acknowledgements

This work was partially funded by the Robert Bosch Stiftung, Program "Research for Sustainability", Project "Processes of Sustainability Transformation" (12.5.F082.0021.0), carried out jointly by researchers from Leuphana University of Lüneburg, Germany and Arizona State University, USA.

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Table of Content

Preface

Food forests address a number of climate change and sustainability challenges. They mimic natural forest ecosystems with a majority of plants being edible such as fruits, nuts, vegetables, mushrooms, and medicinal plants. In the U.S., more than 90 food forests and forest gardens exist.

In Arizona, there is a growing community of practitioners and scholars interested in creating new food forests by using available evidence from existing ones (U.S. and worldwide). While there is strong interest, knowledge, skills, and resources are limited, and thus a support network is needed.

Over the past two years, researchers in the *Sustainable Food Economy Lab* at ASU's School of Sustainability have visited and conducted a broad comparative study on food forests in North America, South America, and Europe (Albrecht & Wiek, 2020a). In addition, we have visited several food forests (and forest gardens) in Arizona and engaged with various partnering organizations to create a food forest at *Spaces of Opportunity* (urban farm incubator) in South Phoenix (Albrecht & Wiek, 2020b). An in-depth comparative study is currently also being conducted on a food forest project in Lüneburg, Germany (Albrecht & Wiek, 2020c). From our research projects and practical collaborations, we got the impression that the time is ripe to bring the community of food forest stakeholders together.

So, we organized a stakeholder workshop in December 2019 with the objectives: to familiarize participants with food forests in Arizona (case studies); to discuss opportunities, challenges, and coping strategies when implementing food forests in Arizona; and to provide networking opportunities for stakeholders from different parts of the state.

The workshop brought together 16 participants from universities, government agencies, and non-profit organizations across Arizona, including practitioners, scholars, experts, entrepreneurs, and newcomers. The workshop activities offered a variety of options for exchange and joint learning. The insights are compiled in this report.

On request of several participants, we also provide some background information on food forests, the challenges they address, and the benefits they are generating. We are currently finishing a series of relevant publications that we will make accessible to the participants, too.

It seems that the community of food forest stakeholders is off to a good start with respect to exchanging insights and experiences, informing about upcoming opportunities, coordinating activities, and partnering on new food forest initiatives. This should provide motivation for further growing a state-wide food forest movement over the coming years and decades.

Sustainability Problems and Food Forests as Solution

The dominant industrial food system in North America and Europe is characterized by unsustainable development, contributing to land degradation, water contamination, climate change, negative health impacts, as well as an unfair distribution of economic benefits. The transformation of this food system towards sustainability requires widespread innovations. Recent research has accumulated valuable insights on sustainable solutions in all domains of the food system (Weber et al., 2019).

One of them are food forests. Food forests exists around the world and are one of the oldest ways of food production, mimicking natural ecosystems by using multiple layers including trees, bushes and groundcover (Ford & Nigh, 2009). They offer a promising solution to produce healthy food, including fruits, vegetables, herbs – in environmentally sound, economically viable, and socio-cultural acceptable ways.

In addition, food forests provide co-benefits such as shading structures and cooling effects (mitigating urban heat islands), among others. Sufficient green infrastructure effectively reduces and buffers urban heat and air pollution. High vegetation density and strategic placement of green spaces can further increase cooling effects through accumulation, in particular in urban areas. In addition, edible and community-engaging spaces may decrease traffic and mitigate contributing factors to heat and air pollution. Food forests adopt the biodiverse, multi-strata design of nature, and have been demonstrated as effective solutions for mitigating urban heat and air pollution (Salbitano et al., 2015). Furthermore, food forests benefit the community by providing visually pleasant environments.

Large food forests (>1 acre) exist in arid and semi-arid regions around the world, while in Arizona mostly smaller forest gardens and edible landscapes have been pioneered. While the benefits are undeniable, in particular in urban areas, they have some fallacies (Van Dooren et al., 2018). For example, food forests, similar to community gardens, are often challenged by the fact that purely volunteering-based initiatives often fail within a few years, in particular, in regions where volunteering activities are not common or not affordable. Alternative concepts of developing food forests with a stronger entrepreneurial component that provide real livelihood opportunities might be a promising to cope with this challenge.

This insight has inspired a team of practitioners and ASU researchers to develop the first urban food forest in Phoenix. A designated 1-acre lot has been secured at *Spaces of Opportunity*, a 19-acre incubator farm in South Phoenix. With support of food forest and permaculture experts, a site design has been developed with input from the community and various organizations active in South Phoenix.

South Phoenix is historically challenged by environmental degradation, economic marginalization, and racial exclusion. Housing regulations pushed communities of color south of the Salt River on contaminated industrial sites. Minority communities continue to live here, and, despite efforts by non-profit organizations and the city administration, still lack livelihood opportunities and educational attainment. Although historically a place of agricultural production, South Phoenix is an area with little to no access to healthy and affordable food in walkable distance. Sparse shade and green space combined with continuous development of building and infrastructures increases the urban heat island effect. There is a need for multi-functional solutions that address these inter-linked challenges. A food forest, as envisioned, could be one of them.

Basics of Food Forests

Food forests are coherent, multi-strata spaces with a majority of edible perennial plants, a tree canopy cover of more than 10% and a minimum size of 1 acre (~0.5 ha). Smaller spaces of multi-strata design can be distinguished as forest gardens. Food forests are intended to function as self-regulating ecosystems with forest-like ecosystem services. Depending on its surroundings (e.g., no other green infrastructure), food forests might require more than 1 acre to provide forest-like ecosystem functions. Figure 1 illustrates the basic layered structure of a food forest.

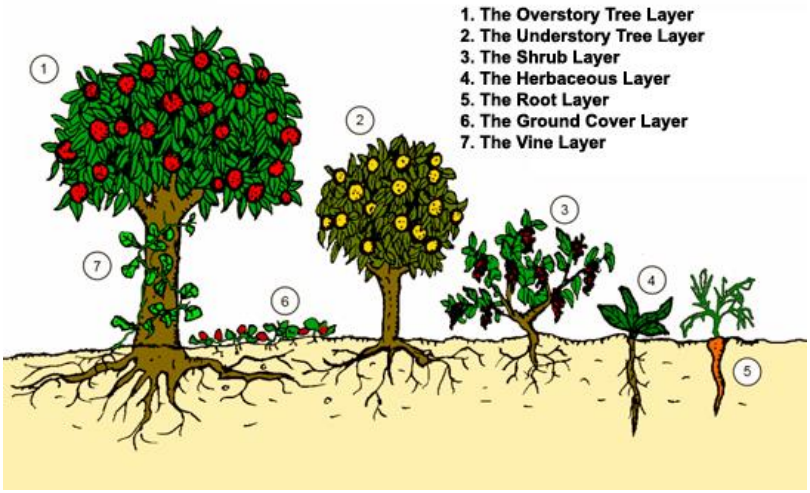

Figure 1: Seven layers of a food forest (Source: Graham Burnett)

Food forests are multi-functional spaces (Fig. 2). Food production and education often provide for livelihood opportunities and revenue. In addition, food forests can yield environmental co-benefits, including high biodiversity, cool microclimate (shade), and carbon sequestration, to name a few. They also often offer space for recreation and community development. Depending on its main and side functions, design and management of food forests vary.

Figure 2: Functions of food forests

Examples of Food Forests by Main Function

As indicated above, food forests have several functions. Yet, in reality, most food forests were created and are managed with one or few main functions in mind such as food production, education, or community development (Albrecht & Wiek, 2020a, Bukowski & Munsell, 2018, Remiarz, 2017). In the following, we provide a few prominent examples for these main functions based on our own empirical studies (visits and interviews) and literature (e.g., McLain et al., 2012). (The photos are from indicated websites.)

1. Food Production

Name	*Den Food Bosch*
Location	Den Bosch, Netherlands
Created	2017
Size	2,5 acres
Management	Two food forest farmers with background in agriculture and forestry (degrees)
Organizational form	Foundation
Ownership	Land is owned by local water authority
Activities	Weekly on-site food sales and tours; Monitoring with local watershed management group and university (yield, biodiversity, water holding capacity)
More information	https://denfoodbosch.org/en/

2. Education

Name	*Mienbacher Waldgarten* [= "Food Forest"]
Location	Mienbach, Germany
Created	2010
Size	3,7 acres
Management	One farmer-educator
Organizational form	Privately owned
Activities	Tours, workshops and seminars (main income sources) on permaculture, self-sufficiency and food processing, on-site and at several schools (children and adults)
More information	http://mienbacher-waldgarten.de

3. Community Development

Name	*Beacon Food Forest*
Location	Seattle, USA
Created	2009/10
Size	8,6 acres
Management	30 core members in steering committee; teams for site development team, nutrition team, etc.; volunteers (2016: 14,500 volunteer hours, more than 80 regular volunteers)
Organizational form	Non-profit organization; since 2019 with two part-time staff members for fundraising, coordination, and community outreach
Activities	Monthly work parties, community events, private patches, collaboration with diverse NGOs
More information	https://beaconfoodforest.org

4. Other Functions and Examples

For additional and more in-depth case studies on the main functions of food forests, please consult Albrecht & Wiek (2020a) or other relevant literature (e.g., Riolo, 2019).

Food Forests in Arizona

A few food forests already exist in Arizona, for example, *Bean Tree Farm*, a 20-acre saguaro and ironwood forest farm with learning center, as well as *Wisdom Culture Life*, a 34-acre food forest with an off-grid start-up farm. These food forests are larger than 1 acre, which allows for developing critical ecosystem functions of a forest. That differentiates food forests from forest gardens and edible landscapes.

Several forest gardens and edible landscapes have been created especially in cities in Arizona, for example, *Epic Yard Farm* and *Longevity Garden* in Tempe, and a forest garden in the Dunbar/Spring Neighborhood in Tucson. In Phoenix, we have noticed a trend towards forest gardens that often include water-intense tropical plants. Please visit for an overview this website of Local First Arizona.

Due to the semi-arid climate of Arizona, a *sustainable* food forest would mainly consist of native and desert-adapted plants, and potentially (heirloom) Mediterranean plants to increase food productivity. Rainwater harvesting and drip irrigation are sustainable practices to conserve and efficiently use precious water resources. Figure 3 illustrates exemplary layers and plants of a food forest that would mostly consists of native and desert-adapted plants in Arizona.

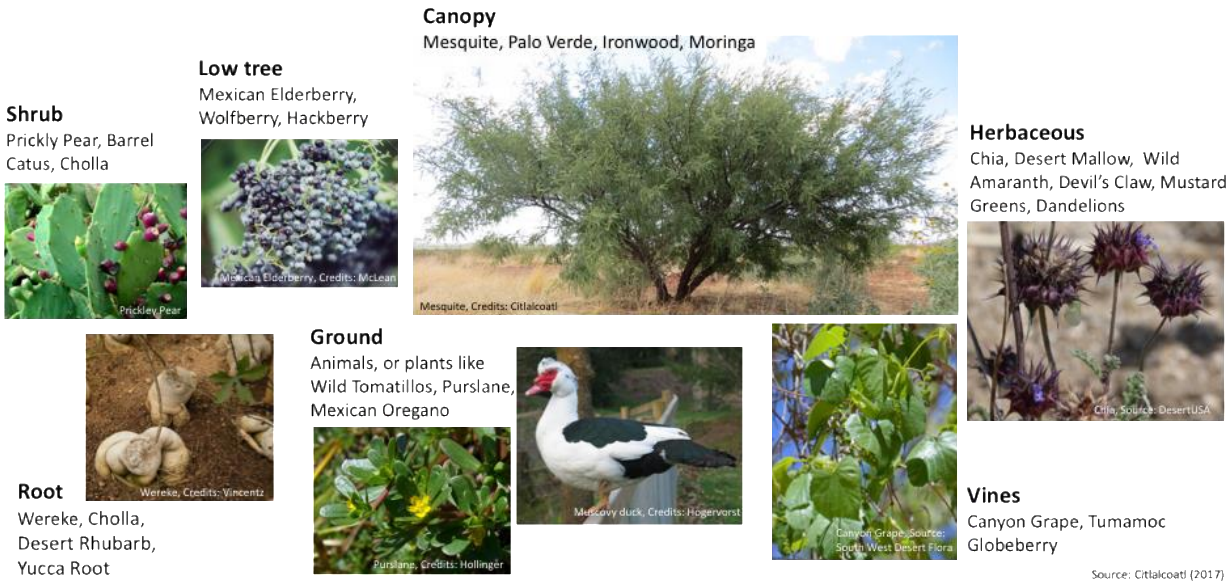

Figure 3: Exemplary layers of a food forest with native and desert-adapted plants in Arizona

There are several other food forests under development in Arizona. They are designed with sustainability in mind and they differ with respect to the main functions they ought to fulfill – ranging from food production through cooling effects to education.

While all of these efforts are applaudable, it would be unwise not to take full advantage of the available evidence from existing food forest project across the states, the country, and worldwide. In particular, being aware of the main stages of the implementation process, its opportunities and challenges, as well as how to cope with the latter, might significantly increase the chances of success.

The Food Forest Project at *Spaces of Opportunity*

Spaces of Opportunity is a coalition of non-profit organizations located in South Phoenix including the Orchard Community Learning Center, TigerMountain Foundation, Unlimited Potential, and Desert Botanical Garden, working in close collaboration with the Roosevelt School District, the city administration, and Arizona State University to address local sustainability and food challenges through urban agriculture and food entrepreneurship. The vision of *Spaces of Opportunity* is to provide families in South Phoenix with economic and livelihood opportunities as well as affordable access to healthy food, including recognition of cultural traditions and native plants. To this end, an incubator farm, community gardens, a food forest, and a farmer's market are being created on a 19-acre site in South Phoenix (at 1200 W. Vineyard Rd.). *Spaces of Opportunity* also collaborates with the nearby VH Lassen Elementary School, including the jointly operated Healthy Roots Café, located on the school premises.

The food forest is a key component of *Spaces of Opportunity* to create healthy food and provide livelihood opportunities to low-income community members while mitigating urban heat island effects and providing hands-on training on plants, urban agriculture, and food processing to children and adults. Food forest operations generate revenue and lead to the provision of livelihood opportunities, which enhances the chances of long-term maintenance and success.

Benefits of the food forest include:

1. Produces food that is healthy, organic, and accessible.
2. Creates long-term livelihood opportunities for community entrepreneurs.
3. Improves quality of life through cooler micro-climate, improved water and air quality (including storm water management and carbon storage), and biodiversity.
4. Educates people on native foods, healthy diets, healthy soil, diverse food production & processing, food entrepreneurship, and the collaborative economy.
5. Engages the community through participation in food production, e.g., through voluntary reward schemes, events, and educational programs.

In fall 2018, a team with representatives from the *Spaces of Opportunity* organizations and ASU formed to develop the food forest concept. In spring 2019, the team created a vision and action plan for implementing the food forest at *Spaces of Opportunity*. As part of this process, a site was selected and a basic design for the food forest created (see next section).

The operation of the forest includes a number of key actors. Two food forest entrepreneurs will be responsible for maintaining the forest, harvesting, processing, and marketing its produce, giving tours, and providing training – all activities from which they earn income. The food forest entrepreneurs will also be involved in developing partnership with local businesses, for value-added forest products. Managers and staff from the *Spaces of Opportunity* partner organizations will provide management and business development support, including consultancy services to other local food forest startups. Staff from partners, the VH Lassen Elementary School and other schools, will lead educational activities for children

and adults. The forest will also be site of ongoing research in collaboration with Arizona State University into the ecological, environmental, economic, and social impacts and best practices of the forest.

In the context of this workshop, we would like to shed more light on the specifics of the implementation process. While nearing its completion, it is still ongoing and has passed through a variety of phases (Fig. 4) that might be worthwhile considering when starting food forest projects across the state:

1. *Idea formation* with defining objectives and building the initial project team (securing some funds to support team in planning stage).
2. *Compiling an inventory of food forests* that go beyond self-sufficiency, scanning 200 food forests and forest gardens, and conducting interviews at 20 sites.
3. *Networking & site selection* informed by a set of criteria, GIS maps, and a database of potential municipal sites in Tempe and Phoenix. Made contact to leadership, discussed the project idea, and selected *Spaces of Opportunity* as the pilot site.
4. *Familiarizing* the newly formed team with food forest examples from the inventory, their management and business practices. Visiting local forest gardens to experience their design and management.
5. *Creating vision & building strategy*, producing an organizational chart of the food forest team, a vision narrative, a draft site plan, and an action plan with eight action domains, incl. finanacing, business development, land trust development, physical implementation, products development, and education.

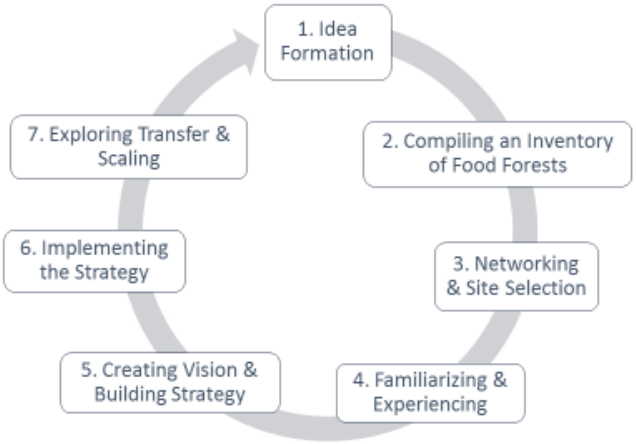

Figure 4. Sequence of implementation phases for food forest initiatives

6. *Implementing the strategy* with first actions focused on fundraising (~$50,000 plus) for physical implementation and entrepreneurial scholarships. In addition, a detailed site plan was developed (see next page).
7. *Exploring transfer & scaling*: workshop with stakeholders (documented here; see below).

There are various ways of successfully planning, developing, and implementing a food forest. We do not suggest that the process outlined below is the only one or the best one to do so. However, the outlined process was successful so far and has allowed integrating a number of perspectives and areas of expertise. We went to several iterations on some of the activities described, but also kept the overall process in focus – continuously moving forward towards the implementation.

Design of the Food Forest at *Spaces of Opportunity*

The design for the food forest site in the southwestern section of *Spaces of Opportunity* (1200 W Vineyard Rd, Phoenix) was developed in collaboration with the farmer and permaculture designer Zotero Citalcoatl.

The forest consists of mostly native and deserted adapted plants and Mediterranean heirloom plants. Plants are selected to produce market-viable fruits, nuts, vegetables, mushrooms and medicinal herbs.

Transfer Workshop Basics

The stakeholder workshop took place at Arizona State University (Tempe Campus) on December 2, 2019. It brought together 16 people from universities, government agencies, and non-profit organizations, including entrepreneurs, city representatives, agroforestry experts, educators, and future food foresters.

Initially, we had hoped to integrate a food forest experience into the workshop to create a shared point of reference (and some tangibility for newcomers). Unfortunately, we were not successful in securing a tour. The second-best option, we thought, would be to provide a culinary experience instead. Thus, we sourced locally and provided a lunch buffet that was inspired by potential produce from food forests, i.e., perennial plants. The buffet offered, among other edibles, yaupon tea, prickly pear lemonade, mesquite bread, pecan spread, carob treats, wolfberry, pickled asparagus and mushrooms (see picture).

The objectives of the workshop were:

- Familiarize participants with sustainable food forest examples (worldwide) as well as with the implementation process of the food forest at *Spaces of Opportunity*
- Facilitate exchange and discussion on implementation opportunities, challenges, and coping strategies as well as implementation support for food forests in Arizona
- Provide networking opportunities among people with an interest in food forests (or edible landscapes) from diverse backgrounds

Invitations were sent out "strategically" to have representation from all areas relevant to the implementation of food forests (Fig. 5).

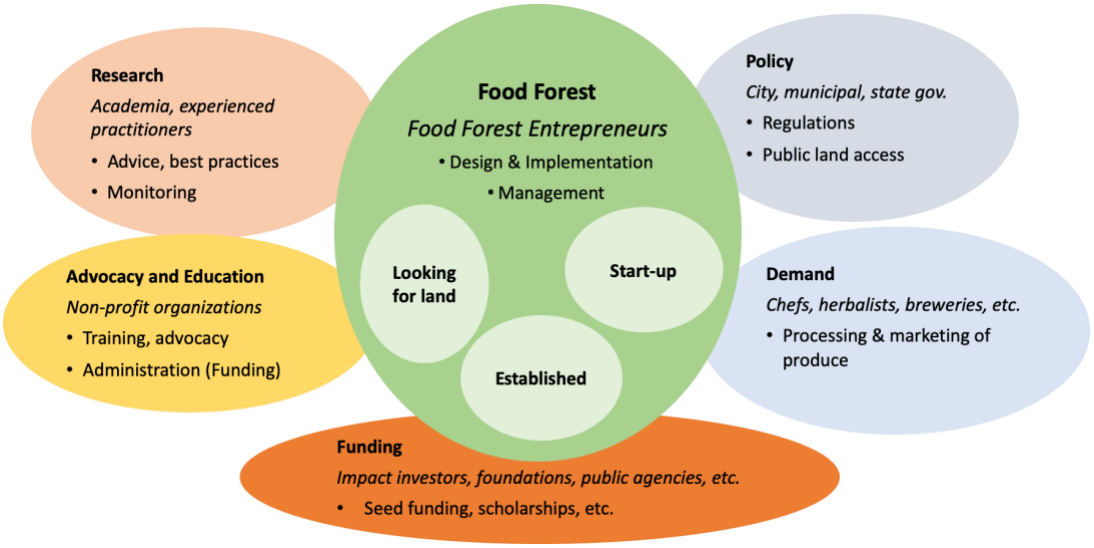

Figure 4: Network of actors relevant to support food forest implementation

The following participants followed our invitation (Tab. 1).

Table 1: Workshop participants with position, institution, and location

	Position and Institution	**Location**
James Allen	Prof, School of Forestry, College of the Environment, Forestry and Natural Sciences, NAU	Flagstaff
Darren Bingham	Master Student, Sustainable Communities, NAU	Flagstaff
Amy Bird	Senior Manager, Social Enterprise Lending, RSF - Social Finance	Phoenix
Kelly Hedberg	Program Instructor & Founder, DIG IT! Outdoors	Tempe
Valentina Hernandez	Director of Integrated Nutrition Services & Health Education Manager, Mountain Park Health Clinic	Tempe
Braden Key	Director of Sustainability, City of Tempe	Tempe
Carol Manetta	Founder, Reap Goodness (Start-up worker coop etc. / food forest project)	Tombstone
Andy Mason	Coordinator, Southwest Agroforestry Action Network (SWAAN); former Director, National Agroforestry Center, US Forest Service	Carefree
Susan Norton	Program Manager, University Sustainability Practices, ASU	Phoenix
Van Patterson	Start-up Food Forester, Master of Sustainability Solutions Alumni, ASU	Tucson
Josh Pike	Intern, Sustainability Office, City of Tempe	Tempe
Kate Radosevic	Food & Farm Initiatives Manager, Local First Arizona	Phoenix
Eric Sirvinskas	Master Student, Sustainable Communities, NAU	Flagstaff
Will Taff	Intern, Sustainability Office, City of Tempe	Tempe
Kristen Theos	Start-up Food Forest Manager, AZ Worm Farm	Phoenix
Samantha Zah	Local Climate Action and Local Food Economy Coordinator, City of Tempe	Tempe

Challenges and Coping Tactics for New Food Forest Projects

After the introduction to food forests and the implementation process of the food forest at *Spaces of Opportunity*, participants were grouped to explore three food forest start-ups by workshop participants (see pictures below). The initiators facilitate rich discussions about the various challenges they have encountered and coping tactics they have applied.

Van Patterson explaining challenges of conserving earthwork in Tucson.

Kristen Theos talking about water conservation challenges at the site she manages in South Phoenix.

Carol Manetta outlining her vision of a rural food forest on 60 acres in Tombstone.

The discussion yielded a number of relevant insights and connected stakeholders to ongoing initiatives. The insights are summarized in the following table (Tab. 2).

Table 2: Overview of four food forest start-ups in Arizona, their challenges, and coping tactics

Project	Team	Size & Location	Main Function	Stage	Challenges	Coping Tactics
ASU & Spaces of Opportunity	University & NGOs	1 acre, South Phoenix	Food production & education	Phase 6: Fundraising	• Securing seed funding • Lack of entrepreneurial borrowers	• Networking • Proposal writing • Moving forward with in-kind contributions
AZ Worm Farm, Kristen Theos	Business	1 acre, South Phoenix	Year-long food production	Phase 6: Planting	• Draught-appropriate & cost-efficient irrigation (current: flood irrigation) • No water conservation culture • Immediate production vs. careful planning • High revenue, high-water, exotic crops vs. draught tolerant native crops	• Rainwater capture & harvesting • Using building roofs (government, MPHC, etc.) for water donations • Arizona Rare Fruit Growers • Desert Harvesters
Van Patterson	Private	3.3 acres, Tucson	Draught-tolerant food production + transfer & scaling	Phase 6: Earthwork & planting	• Conservation values vs. development decisions (removing or keeping existing plants, fencing to protect crop from wildlife, digging by hand to preserve existing vegetation) • Soil quality limiting crop choices	• Fenced veggie garden • Swales • Soil amendments
Reap Goodness, Carol Manetta	NGO & universities	60 acres, Tombstone	Local food production, processing + showcase	Phase 5: Vision & strategy building	• Funding • Student transport logistics • Water scarcity • Native Indian American hesitation about collaboration due to political context • Informal land agreement	• Approach municipalities & associations for rural development funding • Water retention • Collaborations • Agro-tourism & contracts with local restaurant

Table 3 provides an overview of the various implementation challenges that exists for local food forest initiatives, clustered by using the network categories introduced above (Fig. 5).

Table 3: Overview of food forest implementation challenges in Arizona

Areas	Main Challenges
Funding	• Seed funding • Lack of entrepreneurial borrowers
Research & Expertise	• Logistics of student transport • Site-specific physical design (water harvesting, infrastructure, existing plants, soil profile) • Lack of expertise by decision makers
Demand	• Lack of knowledge on specialty crops • Fast revenue vs. growing time • Contractual requirements by large buyers (e.g., limiting other partners, timeframe)
Policy	• Lack of distinct, administrative definition of food forests • USDA funds only for agricultural producers (not urban)
Advocacy & Education	• Fear of wildlife, insecurity • Climate-inappropriate plant preferences • Food safety issues, e.g. at foraging and tasting events

The compiled challenges provide an evidence-supported reference point for actions in support of food forest initiatives. They spread across all relevant areas of support (funding, policy making, demand, etc.) and require a coordinated effort to avoid unnecessary redundancies and to utilize synergies. Not all challenges are “deal-breakers” though. It is important to prioritize the challenges as funds, time, and capacities are limited.

The compiled challenges provided a robust base for an informed discussion about actions of support.

Potential Actions of Support

In the second small-group discussion round, participants explored potential actions that stakeholder groups could take to support food forest initiatives (cf. Fig. 5, above). The three action areas (and corresponding stakeholder groups) addressed by the participants (based on their preferences) were: research/education, demand, and policy.

Action Options for Researchers and Educators

- Collaborate with universities' agro-business schools: courses, classes, internships
- Involve students in research (1-2yr timeframe): surveys, case studies, short-term studies
- Establish public demonstration sites with associated research (e.g., on campus) in each city
- Inform policy making
- Provide evidence (database) on:
  - Types of food forests & income by function
  - Yield, plants, viability
  - Management practices (e.g., pest control)
  - Matrix of benefits (e.g., CO_2, micro-climate, health, food, property value, soil, water)
  - Rate of adoption

Action Options for Food Outlets and Consumers

- Attract institutional customers such as organizations (schools, clinics, etc.), restaurants, resorts
- Offer flexible contracting or co-harvesting to attract more institutional customers
- Initiate fundraising efforts for food foresters (CSA model)
- Support storytelling, education, and awareness building at events (e.g., by cities, LFAZ), e.g.,
  - on food processing of native foods
  - cooking demonstration and taste education
  - on food forests as a solution for food insecurity, diabetes, recreation, etc.
- Strengthen local supply chains, e.g., establish infrastructure for delivery of fresh, local food

Action Options for Policy Makers and Government Administrators

- Build coalitions between city-county-national level
- Identify potential homeowner associations (HOA) for collaboration (patchwork of regulation but partly innovative, sustainability targets, e.g., water saving, sustainable landscaping)
- Show successful pilots in HOA, parks, right-of-way landscapes
- Anticipate arguments against and prepare counter arguments (food safety, pests, property value)
- Define food forests in public documents: USDA Farm Bill, state policy, city policy
- Influence Forest & Farm Bill Coalition

- Access funds for food forests, e.g. from USDA Forest Service
- Develop policy documents:
    - Check match of urban community garden policy in Tempe and other cities
    - Model maintenance agreements (easy to reproduce templates with standards for upkeep, harvesting, management of fallen fruits and animals)
    - Rezone parks and public spaces as eligible for food production
    - Work towards water policy that supports multi-functional landscapes (e.g., lower water price for food-producing sites)

Outlook

There was broad agreement among all participants that such stakeholder workshops offer valuable opportunities for learning, exchange, and networking. Participants also concurred that a strong support network of stakeholders fulfilling and coordinating different functions is an important condition for growing the movement and succeeding in food forest implementation initiatives.

For the emerging stakeholder network, a few key action items were proposed:

- Sharing progress on the presented and other food forest projects in Arizona on an annual base
- Gathering annually for a state-wide conference / symposium on food forests
- Jointly visiting and learning more about food forest projects in Arizona
- Exchanging relevant information on food forest opportunities

A few specific opportunities were shared after the workshop:

- Potential site visit at Bee Oasis forest garden in Mesa in spring
- SWAAN Conference in Tucson, March 17-19, 2020. With keynote speaker Dr. Kathleen Merrigan, ASU Swette Center for Sustainable Food Systems, and Brad Lancaster, Rainwater Harvesting for Drylands and Beyond. Please visit: https://swaan-site.org

  The conference includes several field trips:

  - Mission Garden, Tucson: Timeline gardens covering 4000 years with extensive tree and garden plantings
  - Dunbar-Spring Neighborhood, Tucson: Neighborhood foresters' tree-planting program in public rights-of-way supported by water harvesting and Brad Lancaster's permaculture homestead with water harvesting, solar power and edible trees
  - Harris Heritage Growers, Sonoita: Tour of U-Pick Family Farm in southern Arizona with trees, crops and animals

There are also significant food forest activities advancing in Europe (Van Dooren et al., 2018). It would be beneficial to utilize our international scholars to keep informed and transfer relevant insights from these projects, too.

Business Plan Draft

for the *Opportunities Food Forest*

A Sustainable Food Forest at *Spaces of Opportunity* in South Phoenix

Arnim Wiek, Stefanie Albrecht

In Collaboration with John Wann-Ángeles, Darren Chapman, Amy Simpson

(Visuals by Elizabeth Ferguson)

Updated February 2021

Sustainable Food Economy Lab

ASU School of Sustainability
Arizona State University

SPACES OF OPPORTUNITY

A.2.2 Business Plan Draft Phoenix

Wiek, Arnim; Albrecht, Stefanie (2021).

Business Plan Draft for the Opportunities Food Forest –
A Sustainable Food Forest at Spaces of Opportunity in South Phoenix.

Tempe, AZ.
Sustainable Food Economy Lab,
School of Sustainability, Arizona State University.

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Table of Content

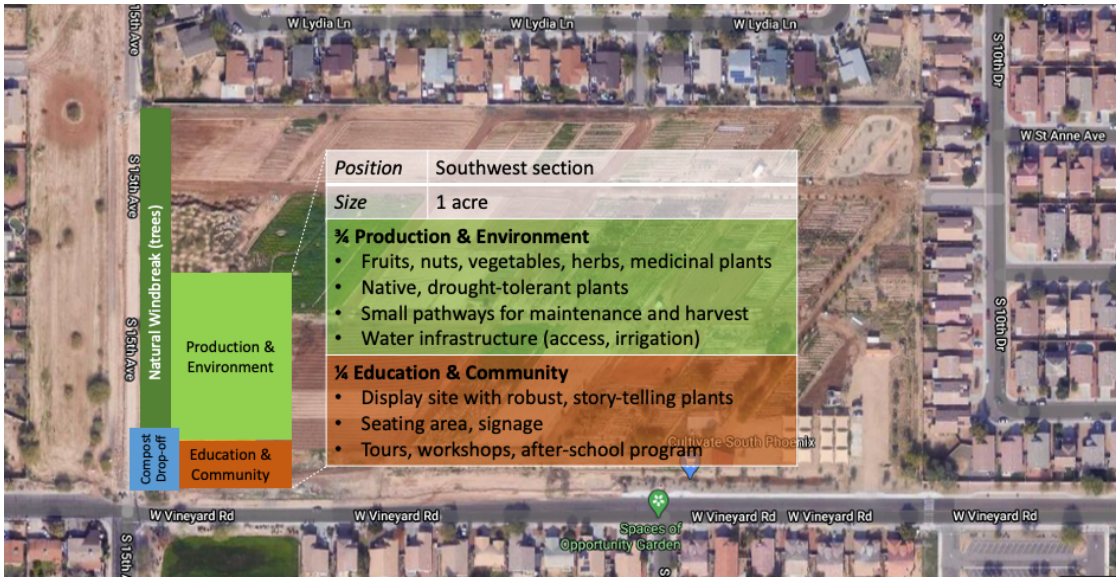
This business plan guides the development of the *Opportunities Food Forest* enterprise over the year 2021-22. It is subject to change depending on more detailed planning as well as the input and feedback of the recruited food forest entrepreneurs. These entrepreneurs will eventually resume ownership and run the *Opportunities Food Forest* enterprise.

Business Profile

KEY FEATURES	
Name	*Opportunities Food Forest*
Goal/Identity	Viable business that offers quality jobs, produces healthy foods, provides educational opportunities, and mitigates urban heat
Location	South Phoenix, *Spaces of Opportunity*
Infrastructures	1 acre food forest; storage, processing, sales, educational facilities
Products & Services	Fresh produce, food products, medicinal products (fruits, nuts, herbs, etc.) Educational offerings (courses, workshops, etc.)
Workforce	5-7 full-time and part-time worker-owners (2031)
Revenue	~$370,000 (2031)
Corporate Form	Cooperative Benefit Corporation
MARKET ANALYSIS	
Problem	Lack of jobs, healthy food, food literacy, green/shaded spaces
Customers	Community members, anchor organizations, food businesses
Competitors	Other urban farmers, supermarkets
Competitive Advantage	Fresh, local, high-quality foods produced with purpose Flexible, high-quality educational offerings
MARKETING STRATEGY	
Sales Channels	On-site farmers market, food businesses, anchor organizations, online
Activities	Partnerships, on-site events, social media campaigns, food festivals
MANAGEMENT	
Business Development Team	Arnim Wiek (sustainable business training), Stefanie Albrecht (plants, products), John Wann-Ángeles (partnerships, marketing, education), Darren Chapman (recruitment, training), Amy Simpson (plants, products, education), others (e.g., for site planning)
Key Partnerships	*Spaces of Opportunity* (strategic planning, recruitment, marketing, storage facility, farmers market, etc.) *V.H. Lassen Elementary School* (commercial kitchen, storage facility) Anchor organizations (*Mountain Park Health Center*, *Sprouts*, etc.)
KEY START-UP ACTIVITIES	
04/21 – 03/22	Recruitment and training of food forest entrepreneurs (5-7)
04/21 – 09/21	Construction and planting
10/21 – 03/22	Harvesting, food processing, first educational offerings

Location and Infrastructures

The *Opportunities Food Forest* will be located on the urban farm site of *Spaces of Opportunity* in South Phoenix. The address is: 1200 W Vineyard Rd. See approximate location in the map below.



The site of the food forest is about **1 acre in size** and will be fully planted in a way to mimic a **natural layered forest ecosystem**, with all plants being edible or usable for marketable products, including fruits, nuts, vegetables, mushrooms, herbs, and medicinal plants. There will be a number of **small pathways** running through the site, designed for maintenance, harvesting, and educational activities. The site will also feature **water infrastructure** including an access point to the main water channel (entering the food forest on the southeastern side from the farm), a drip irrigation system across the site, as well as water harvesting infrastructure. Along the western side, there will be a **natural wind break** vegetation. And on the southern site (road access), there will potentially be a site for neighborhood **compost drop-off**.

The enterprise will also maintain and process produce from the smaller **forest garden** on the other side of the *Spaces of Opportunity* farm site (southeast section).

In addition to the food forest, the enterprise will use a number of nearby **facilities for storage, processing, and sales**. For storage, including tools, fresh produce, food products, and medicinal products, the enterprise will use facilities on the farm (southeast section), as well as storage space at *V.H. Lassen Elementary School* (potentially). For food processing, i.e., the actual manufacturing of food products through drying, freezing, cooking, conserving, etc., the enterprise will be using the certified **commercial kitchen** at *V.H. Lassen Elementary School*. For sales, the enterprise will be using a **farm stand** at the shaded farmers market on the farm (southeast section).

In addition to the food operations, the *Opportunities Food Forest* enterprise also offers a number of educational formats (courses, workshops, etc.). They will be delivered on site (food forest), in the shaded market area (southeast section) as well as in a **classroom** and the commercial kitchen at *V.H. Lassen Elementary School*. There will be small educational infrastructures (e.g., signage) installed on-site.

Products and Services

The *Opportunities Food Forest* enterprise will generate revenue through food production, educational services, and urban heat mitigation.

First, the enterprise will produce a range of **marketable food products**, including flour and nutritional powders from mesquite, carob, moringa, and others; jams and dried fruits from figs, apples, and peaches; jams and medicinal syrups from elderberry, wolfberry, hibiscus, and others; and pickles, teas, and other specialty foods from prickly pear, lavender, mushrooms, and others. The figure below indicates the correspondence between the layered food forest and the specific food products generated from the harvest. The food forest will grow **23 different fruits, tree beans, vegetables, mushrooms, herbs, and medicinal plants** – and can produce **19 food products**. There will be a focus on native, climate-adapted plants, including mesquite, carob, prickly pear, chiltepin, and other native edible plants – to demonstrate good water and land stewardship and to generate nutrition-rich and high-value products that offer rich culinary experiences and reconnect people to local history.

Second, the enterprise will offer a number of **educational services**, including regular tours of the food forest, overall food forest workshops (from one-day intensive to several weeks), and various specialty courses and workshops on nutrition, medicinal herbs, cooking, permaculture, soil fertility, and other topics. Offerings will be tailored to a number of different target groups, including health-conscious consumers, hobby gardeners and cooks, as well as students of various ages. In addition, **consulting services** might be offered, too.

While the described food products and educational services will generate standard revenue streams, the other services, i.e., **heat mitigation and aesthetics**, require a different approach to revenue generation. These services are critical for Phoenix overall and South Phoenix in particular, considering rising temperatures, aggravated urban heat island effects, heat-induced health impacts, and lack of green spaces. **Grant opportunities** targeting heat mitigation and health-related issues will be pursued to generate additional funds for the enterprise.

Food Products

Food Product	*Food Forest Ingredient(s)*
Nutritional powders	Moringa, dragon fruit
Energy balls	Carob, mesquite
Flour	Mesquite, carob
Dried fruit	Fig, apple, peach, plum, quince, jujube
Sweet potato chips	Sweet potato
Pesto	Sweet potato leaves
Mushrooms	Mushroom
Jams	Fig, apple, peach, prickly pear, plum, quince, jujube, Egyptian onion
Pickles	Prickly pear, Egyptian onion
Dried herbs & spices	Chiltepin pepper, lavender
Tea (dried leaves)	Yaupon, hibiscus, lemon verbena
Tea (cold drink)	Chiltepin, hibiscus, lemon verbena
Juice	Apple, peach, prickly pear, pomegranate, aloe vera, dragon fruit
Cider	Apple, pear
Regular syrup	Prickly pear, elderflower, apricot
Medicinal syrup	Elderberry, wolfberry, hibiscus
Essential oil	Lemon verbena, lavender
Soap	Lavender, lemon verbena
Flowers	Lavender

The product range develops over time (see introduction to the Operating Budget, below).

Educational Offerings

	Duration	*Frequency*
On-site tour	2h	Weekly
Food forest workshop	1 day	Monthly
Intensive food forest course	5 days * 6h	2x annually
Nutrition class	4h	Monthly
Medicinal herbs workshop	4h	Monthly
Cooking class	4h	Monthly
Practical permaculture workshop	4h	Monthly
Soil fertility workshop	4h	Monthly

Grant Opportunities for Food Security and Heat Mitigation

- Local climate adaptation grants
- USDA programs

Corporate Form and Governance

The *Opportunities Food Forest* enterprise is being developed as a **sustainable enterprise** in which sustainability is anchored *at the core* (not as an add-on). Thus, it will be incorporated either as a **benefit corporation** (AZ legislation on benefit corporations, 2014) or as an **employee-owned cooperative business** (AZ legislation on cooperative businesses, 2016), which means it will be incorporated as one, but operates as a **cooperative benefit corporation** (maybe even B Corp certified). This corporate form ensures that the enterprise pursues its environmental and social goals with the same emphasis as the goal of becoming economically viable (no unduly trade-offs). The enterprise's sustainability plan is detailed in the next section.

As an employee-owned cooperative business, the *Opportunities Food Forest* enterprise will follow these guidelines (based on the recommendations of the *National Cooperative Business Association*):

- **Non-discriminatory Access**. Worker-owners (employees) are not being selected or rejected based on gender, social, racial, political, or religious factors.
- **Democratic Control**. The worker-owners (employees) of the enterprise undertake all critical business activities, including strategic planning and decision making, collectively; each worker-owner has the same rights and responsibilities (each one has one vote).
- **Economic Participation**. The worker-owners (employees) of the enterprise participate equally in meeting enterprise's economic needs and benefiting from its success. Each worker-owner contributes an equal investment (share) when joining the enterprise. In return, each worker-owner is equally participating in the distribution of profits (dividends, if any).
- **Independence**. The cooperative enterprise is in its strategic orientation and operations not unduly influenced by external stakeholders such as investors. When entering a partnership, the enterprise does not compromise any of its other principles (e.g., democratic control).
- **Education, Training, Information**. The enterprise offers continuously opportunities for education, training, and information exchange so that all worker-owners (employees) can equally and effectively contribute to the success of the enterprise and advance sustainability beyond the boundaries of the business.
- **Cooperation**. The enterprise supports and assists other cooperative businesses and collaborates to advance the sustainable cooperative economy in Arizona and beyond.
- **Concern for Community**. The enterprise actively contributes to the sustainable development of the community in South Phoenix by sourcing, investing, and collaborating locally.

The *Opportunities Food Forest* enterprise is being developed to empower community members with limited entrepreneurial opportunities. The final say in determining the corporate form and governance structure of the enterprise (incl. bylaws, etc.) will be with the recruited food forest entrepreneurs.

Sustainability Plan

As opposed to conventional businesses, the *Opportunities Food Forest* enterprise is designed with **sustainability at its core**, integrating environmental, social, and economic goals. The donations and grants to start or support this enterprise can therefore be considered a type of '**impact investment**' with the primary objective of creating lasting positive environmental, social, and economic impacts in the community of South Phoenix.

When the *Opportunities Food Forest* enterprise is up and running, it will demonstrate the following **20 sustainability features** (based on common BIA, ESG, SDGs, and other sustainability criteria):

	Environmental Objectives	
1	Renewable energy (operations and transport)	50%+ renewable energy for all tools & appliances
2	GHG emissions reduction or offsetting	Offsetting GHG emissions caused by distribution
3	Rainwater harvesting & water-efficient practices	Rainwater harvesting, drip irrigation, low-flow, etc.
4	Organic farming practices	Regenerative permaculture (no pesticides, etc.)
5	Local and sustainable sourcing	Remaining ingredients sources from Arizona
6	Food waste recycling/composting	All food waste (incl. from kitchen) composted on-site
7	Sustainable packaging, reduction, recycling	Minimal and reusable packaging (with refund)
8	Cleaning substances	100% biodegradable
	Social Objectives	
9	Diverse workforce for gender, race, skills	50%+ women, people of color, people with disabilities
10	Employee safety	Exceeding national and state standards
11	Wages, benefits, retention, training	Fair wages, full benefits, 90% retention, div. trainings
12	Employee ownership and participation	100% employee-owned cooperative business
13	Projects and/or donations for public benefit	50% of profits donated to projects with public benefit
14	Sustainability communication / advocacy	Enterprise advocates for sustainability (media, etc.)
	Economic Objectives	
15	Economic viability	Economically viable (no profit maximization)
16	Reserves	25% of profits for reserves (→ times of crisis)
17	Local and/or social financing	Banking with local credit union; impact investors
18	Economic cooperation and mutualism	Advancing the sustainable cooperative economy in AZ
	Transparency and Verification	
19	Sustainable performance monitoring	Quarterly monitoring & reporting wrt all objectives
20	Sustainability certification(s)	B Corp certified (score >100)

For a sustainable enterprise to be credible, it is imperative that all performance claims are being validated through **independent audits**. Thus, the last two practices (monitoring and certification) create accountability and offer sponsors and supporters a clear indication of delivery (or not) on the sustainability aspiration and promises set forth.

Market Analysis

South Phoenix is historically challenged by **environmental degradation**, **economic marginalization**, and **racial exclusion**. Housing regulations pushed communities of color south of the Salt River on contaminated industrial sites. Minority communities continue to live here, and, despite efforts by non-profit organizations and the city administration, still **lack sufficient livelihood and educational attainment opportunities**. Although historically a place of agricultural production, South Phoenix is now an area with little to **no access to healthy and affordable food in walkable distance**. Sparse shade and green space combined with continuous development of building and infrastructures increases the **urban heat island effect** and causes negative health impacts. To address these inter-linked challenges, there is a need for novel and sustainable urban agriculture solutions such as the *Opportunities Food Forest* enterprise.

Customers: Community members, anchor organizations, food businesses

Competitors: Other urban farmers, supermarkets

Competitive Advantage:

- Fresh, local, high-quality foods produced with purpose
- Flexible, high-quality educational offerings

[to be completed during start-up phase]

Marketing Strategy

Sales Channels: On-site farmers market, food businesses, anchor organizations, online

Activities: Partnerships, on-site events, social media campaigns, food festivals

[to be completed during start-up phase]

Management and Partnerships

Business Development Team

Name	Organization	Background /Experience	Project Role & Responsibility
John Wann-Ángeles	Co-Founder, *Spaces of Opportunity* (since 2017) Founder, Orchard Community Learning Center (since 2011)	• Project based learning • Fruit tree, composting, & restorative agriculture expertise	Project Lead Educational programming
Prof. Arnim Wiek	Director, Sustainable Food Economy Lab, School of Sustainability, Arizona State University (since 2016)	• Implementing innovative sustainability solutions • Food economy and entrepreneurship expertise	Sustainable business education
Stefanie Albrecht	PhD student on food forests (will graduate in 2021)	• M.Sc. Integrated Natural Resource Management at agricultural faculty (2016)	Supporter
Darren Chapman	Co-Founder, *Spaces of Opportunity* (since 2017) Founder & CEO, *TigerMountain Foundation* (since 2007)	• Large local network • Community gardens expertise • Workforce development expertise	Recruitment of entrepreneurs & entrepreneurship education
Amy Simpson	Culinary Class Teacher, V.H. Lassen Elementary School, Roosevelt School District (since 2019)	• Former *Spaces of Opportunity* Farmer • Community Educator (since 2017)	Educational programming

Food Forest Positions

1. Food Forester with focus on farming
2. Food Forester with focus on food processing
3. Food Forester with focus on food processing
4. Food Forester with focus on educational services

Key Partnerships

Spaces of Opportunity: strategic planning, recruitment, marketing, storage facility, farmers market, etc.

V.H. Lassen Elementary School: commercial kitchen, storage facility

Anchor organizations (institutional clients): Mountain Park Health Center, Sprouts, etc.

Arizona State University: internships, volunteers, student projects

Orchard Community Learning Center: farming know-how, volunteers

TigerMountain Foundation: farming know-how, entrepreneur recruitment, volunteers

Operations (Years 1-3)

The worker-owners of the *Opportunities Food Forest* enterprise will spend their working hours mainly on producing, processing, and selling marketable food products as well as providing educational services and consulting activities (as outlined in the section "Products and Services"). The grant writing activities will be organized by the partnering organizations.

The following tables provide an estimate of monthly workload for the different areas and activities over the first years. These are average estimates that account for seasonal variability without detailing the variance over the course of a year.

Available monthly working hours are: 20h (= 50%) x 4 (weeks) x 4 (worker-owners) = **320 hours/month**

Food Production

Food Production Activity	*Monthly Workload [hours]*
Watering	20
Mulching, clipping, inspecting health, pruning, etc.	10
Harvesting	30
Conserving (milling, drying, cooking, etc.)	90
Packaging	20
Selling (market, online, etc.)	40
Marketing	20
Admin (bookkeeping, etc.)	20
TOTAL	**250**

Educational Offerings

Education Service Activity	*Monthly Workload [hours]*
Preparation	20
Delivery of instruction	30
Marketing	10
Admin (bookkeeping, etc.)	10
TOTAL	**70**

Operating Budget (2022)

The operating budget for the *Opportunities Food Forest* enterprise applies to the first operating year after the start-up year (2021), which will be 2022. The financial forecasts in the next section offer projections for the 5-year (2026) and 10-year (2031) horizons.

The *Opportunities Food Forest* enterprise manages a **living ecosystem**, i.e., the food forest, that will mature over time with **peak productivity as of year 10** (see Appendix). Accordingly, the product range (see section "Products and Services", above) develops over time. During the start-up year (2021), the food forest entrepreneurs specify the business plan for 5-7 specialty products to focus on. Products like jams, pickles, pesto, dried fruits, and (medicinal) syrups can get easily processed, and mostly call for recipe development. Other products require specialty appliances and equipment as well as advanced processing knowledge and experience. Flour from tree beans, for example, needs to get processed by a hammermill. However, not all appliances and equipment need to be purchased (let alone, newly), but can be leased or used for free (strategic partnerships). For example, a hammermill can be leased through the *GrowPHX Collaborative*. Juice, cider, and essential oil production require a professional juicer, fermentation and distillation equipment. Mushrooms can be grown outside in shaded areas (infrastructure) from the beginning and in the shade of a mature food forest as of Year 6-7. Yet, as there is a lack of reliable data on mushroom yields in desert food forests, this is a more experimental part of the business with uncertainty associated to it (this is why we used conservative numbers in the budget and the forecasts).

The operating budget and the financial forecasts are based on a number of specific plans. We have included an exemplary revenue plan for the food production in the appendix.

All numbers are based on verified internet sources, requested quotes, or other real-world examples, in part from existing food forest projects. A few numbers (e.g., insurance) still need to get fully verified for the *Opportunities Food Forest* enterprise.

The three revenue streams, i.e., from food sales, from educational services, and from grants, have already been describe above (section "Products and Services").

Expenses include: Payroll for a workforce of 5-7 worker-owners, who will be compensated in the first year part-time (~50% at $20,000 each) and will reach full employment by Year 5, the latest (see "Financial Forecasts", below). Expenses for the leases of the food forest area, commercial kitchen, storage space, and market stand as well as utility costs for water and electricity (kitchen, storage) benefit from the strategic partnerships described above (section "Management and Partnerships"). Material expenses include (annual) costs for tools, seeds, plants, other food ingredients, packaging, etc. (while appliances will be part of the start-up budget – see section below). Insurance expenses pertain to a multi-peril crop insurance as well as a liability insurance for educational consultants. Service fees cover administration, including bookkeeping and marketing, as well as legal counseling, repairs, commissions for sale services, etc. Depreciation of farming tools and processing appliances varies and is estimated as a lump sum here. There is no interest budgeted due to the start-up fundraising efforts. Diverse unexpected expenses are included in the budget and the forecasts due to uncertainties of living ecosystems.

REVENUE	**2022**
Revenue from Food Sales[1]	$80,000
Revenue from Educational Services	$20,000
Grants	$20,000
Other Revenue	$0
Total Revenue	***$120,000***
EXPENSES	
Payroll [5 part-time (~50%) worker-owners; $20,000 each][2]	-$100,000
Leases [food forest area, commercial kitchen, storage space, market stand][3]	-$5,000
Utilities [water, electricity (kitchen, storage)][4]	-$500
Material [tools, seeds, plants, other food ingredients, packaging, etc.][5]	-$10,000
Insurance [multi-peril crop insurance, liability insurance][6]	-$1,000
Service fees [administration, legal counseling, repairs, commissions, etc.][7]	-$2,000
Depreciation [farming tools and processing appliances][8]	-$1,000
Interest	$0
Others (div. unexpected expenses)	-$5,000
Total Expenses	***-$124,500***
Income before Taxes	**-$4,500**
Federal and State Corporate Taxes [24.9%; federal (20%) plus AZ (4.9%)]	$0
Net Profit/Loss	**-$4,500**

[1] See food production plan in the appendix.

[2] 2020 average farmer salary in Phoenix is ~$43,000 (salary.com).

[3] Based on *Spaces of Opportunity* information, plus *Local First AZ* Community Kitchen rates.

[4] Based on *Spaces of Opportunity* information and *APS* renewable energy rates.

[5] Based on start-up budget sources.

[6] Standard multi-peril crop insurance ($500) [fcsamerica.com] and specific liability insurance ($500) [hiscox.com].

[7] Based on start-up budget sources.

[8] Standard depreciation rate (over 10 years).

Financial Forecasts for 2026 (Year 5) and 2031 (Year 10)

REVENUE	**2022**	**2026**	**2031**
Revenue from Food Sales	$80,000	$190,000	$270,000
Revenue from Educational Services	$20,000	$40,000	$80,000
Grants	$20,000	$10,000	$0
Other Revenue (Consulting)	$0	$10,000	$20,000
Total Revenue	***$120,000***	***$250,000***	***$370,000***
EXPENSES			
Payroll	-$100,000	-$200,000	-$250,000
Leases	-$5,000	-$10,000	-$10,000
Utilities	-$500	-$1,000	-$1,000
Material	-$10,000	-$20,000	-$30,000
Insurances	-$1,000	-$2,000	-$2,000
Service fees	-$2,000	-$5,000	-$10,000
Depreciation	-$1,000	-$2,000	-$4,000
Interest	$0	$0	$0
Others	-$5,000	-$5,000	-$5,000
Total Expenses	***-$124,500***	***-$245,000***	***-$312,000***
Income before Taxes	**-$4,500**	**$5,000**	**$58,000**
Federal and State Corporate Taxes (24.9%)	$0	-$1,250	-$14,500
Net Profit/Loss	**-$4,500**	**$3,750**	**$43,500**

Assumptions include: reducing dependence on grants as the enterprise matures; the older and fuller-developed the food forest is, the more educational opportunities can be offered; similarly, consulting opportunities (e.g., for other food forests under development) increase with experience, too; by Year 5, all worker-owners are close to fully employed (80-100%) at ~$40,000 annual income, plus dividends; by Year 10, at $50,000 annual income, plus dividends; leases and utilities continue to benefit from the long-term strategic partnerships (see section above); expenses for material (e.g., tools, appliances, packaging) and services increase as the enterprise grows.

Start-up Budget (2021)

Building Implementation Capacity	***$ 51,000***
Four part-time traineeships as food forest entrepreneur (1 year)	$ 40,000
Permaculture, agroforestry, cooperative business trainings	$ 4,000
Educational programming	$ 4,000
Volunteer coordination	$ 3,000
Implementation	***$ 49,000***
Plants (trees, bushes, vines, groundcover), seeds, water	$ 15,000
Appliances for food processing	$ 12,000
Infrastructure (e.g., shading, shed, benches, signage)	$ 7,000
Earthwork and pathway construction	$ 5,000
Tools and material (e.g., shovels, gloves)	$ 5,000
Fees for incorporation, administration, IT	$ 3,000
Marketing	$ 2,000
Total	**$100,000**

Traineeships support committed entrepreneurs in food forest training and business plan refinement. They work with a core group of volunteers.

Trainings of the entrepreneurs in permaculture, agroforestry, and cooperative business necessary for managing a food forest enterprise; provided by local experts.

Educational programming from *Orchard Community Learning Center* staff to develop the educational offerings in a way that the food forest entrepreneurs can become instructors and trainers.

Volunteer coordination from *TigerMountain Foundation* for the planting of the food forest which will be conducted in several teams at different sections on weekends spread out over 3 months.

Plants, seeds, water includes diverse trees, bushes, vines, groundcover, water, and compost cost for 1 year (based on planting list, research at nurseries, pilot forest garden at *Spaces of Opportunity*).

Appliances for food processing include a solar dehydrator, a juicer, a Vitamix, a small bottling system, a table-top mill, as well as fermentation and distillation equipment.

Earthwork by *Spaces of Opportunity* staff includes soil removal and distribution, flattening, forming of swales/waterways, and preparation of footpaths.

Infrastructure includes pathways and drip irrigation system (pipes, 5,000-gallon water tank), as well as a shed for storage of tools, some basic shade structures, signage and benches for community.

Tools and materials include shovels, gloves, snippers, harvesting trays, a woodchipper, as well as reusable packaging material for pilot products.

Fees include start-up expenses for business incorporation, administration, and IT set-up.

Marketing includes flyers, invitations, a web page setup, as well as an opening event with tastings, tours and presentations to create awareness for the food forest in the community.

Start-up Activities and Timeline

We are seeking funding for the start-up over a 12-month period to implement the physical food forest and build the capacity in food entrepreneurs to operate it. The project includes the following **activities**:

1. **Earthworks, construction and planting**: grading, contouring, ditch digging, topsoil addition, path laying, hut construction, planting, etc. Performed by volunteers and trainees, coordinated and managed by partner organizations.
2. **Training for four food forest entrepreneurs (trainees)**: learning to apply agroforestry, permaculture and water harvesting techniques and principles, cooperative business development for food products and services, through a combination of hands-on learning, formal instruction, and mentorship, from partner organization experts.
3. **Setting up monitoring systems**: designing and implementing monitoring and data collection systems on practices, yields, ecosystem properties and environmental effects. Performed by staff from partner organizations and trainees.
4. **Developing educational programs**: programming for school children and adults on native foods, healthy diets, healthy soil, food production & processing, food entrepreneurship, and the collaborative economy. Performed by staff from partner organizations, including schools.
5. **Business development**: Identifying and developing commercial opportunities, including sales of forest products, developing value-added products, forming business partnerships, and developing a marketing plan. Performed by staff from partner organizations and trainees.
6. **Outreach and promotion**: Developing promotional media and materials, holding informational events, and communicating with the public. Performed by staff from partner organizations and trainees

Timeline

- April 2021 – March 2022: Training entrepreneurs in food forest management and operation
- April 2021: Detailed surveying and planning, ordering plants
- May 2021: Earthwork (excavating, grading, shaping, spreading compost & mulch)
- June 2021: Constructing path, installing fixtures & waterways
- September – December 2021: Preparation and planting with volunteers
- January – March 2022: development and testing of added-value products; educational programs
- February 2022: Training volunteers in food forest management
- March 2022: Opening event
- March 2022: Evaluation, adaptation if necessary

Appendix

Food Production – Edible Plants, Productivity Projections, Revenue Projections

Land	Strata	Plant	Spatial needs: Quantity	Spatial needs: Spacing [ft]	Spatial needs: Spatial Need [sft]	Irrigation	Productivity: Mature Plant Productivity [lb]	Productivity: Group Productivity Year 1 [lb]	Productivity: Group Productivity Year 5 [lb]	Productivity: Group Productivity Year 10 [lb]	Productivity: Productivity Period [yrs]	Food Products	Revenue: Price of *Processed Plant* [per lb]	Revenue: Year 1	Revenue: Year 5	Revenue: Year 10
20 %	top	Carob	8	32	8,192	low	100	0	600	800	10-100	Flour, energy balls	$10	$0	$6,000	$8,000
		Mesquite	10	20	4,000	low	66	0	495	660	2-50	Flour	$12	$0	$5,940	$7,920
		Moringa	15	10	1,500	low	5	0	56	75	2-20	Nutritional powder	$25	$0	$1,406	$1,875
40%	high	Apple	10	16	2,560	medium	40	0	200	400	5-20	Dried fruit, juice	$7	$0	$1,400	$2,800
		Fig	10	17	2,890	medium	15	0	60	150	6-50	Dried fruit	$7	$0	$420	$1,050
		Peach	10	15	2,250	high	50	0	375	500	4-20	Dried fruit, juice	$7	$0	$2,625	$3,500
		Quince	10	15	2,250	medium	320	0	2,400	3,200	3-70	Dried fruit	$7	$0	$16,800	$22,400
		Plum	10	15	2,250	low	120	0	900	1,200	4-20	Dried fruit	$7	$0	$6,300	$8,400
		Jujube	10	15	2,250	low	30	0	225	300	3-100	Dried fruit	$7	$0	$1,575	$2,100
60%	medium	Dragon fruit	50	3	450	medium	40	0	400	2,000	3-25	Nutritional powder	$25	$0	$10,000	50000
		Pomegranate	60	10	6,000	low	50	0	1,200	3,000	4-50	Dried fruit	$7	$0	$8,400	$21,000
		Prickley pear	60	5	1,500	low	40	0	0	2,400	7-30	Dried fruit	$7	$0	$0	$16,800
		Yaupon	50	10	5,000	medium	1	0	50	50	2-30	Cold brew, tea leaves	$70	$0	$3,500	$3,500
		Mexican elderberry	100	6	3,600	low	1	30	70	100	1-30	Syrup	$13	$390	$910	$1,300
		Wolfberry	100	4	1,600	low	1	20	100	75	1-10	Dried fruit	$13	$260	$1,300	$975
80 %	low	Lemon verbena	500	1	500	medium	1	100	500	375	1-10	Cold brew, tea leaves	$15	$1,500	$7,500	$5,625
		Chiltepin	500	3	4,500	low	0.5	50	250	188	1-50	Dried fruit	$25	$1,250	$6,250	$4,688
		Hibiscus	400	5	10,000	medium	4	640	1,600	1,200	1-5	Cold brew, tea leaves	$25	$16,000	$40,000	$30,000
		Aloe vera	300	3	2,700	low	6	360	1,800	1,350	1-7	Smoothie	$7	$2,520	$12,600	$9,450
		Lavender	400	3	3,600	medium	0.25	20	100	75	1-12	Cold brew, tea leaves	$18	$360	$1,800	$1,350
		Mushroom	N/A	N/A	2,000	medium	N/A	700	2,000	3,000	7-20	Mushrooms	$18	$12,600	$36,000	$54,000
		Egyptian onion	1,000	0	90	low	4	4,000	2,000	1,500	1-6	Chutney	$7	$28,000	$14,000	$10,500
		Sweet potatoe	3,000	1	3,000	high	0.5	1,500	750	0	1	Pesto	$7	$10,500	$5,250	$0
		23	**6,613**					**7,420**	**16,131**	**22,598**		**19**		**$73,380**	**$189,976**	**$267,233**

A.3 Declaration of Authorship

Following the Guideline for Cumulative Dissertations of Leuphana University Lüneburg[1](§16, §12), the following tables detail my individual contribution, the contribution of all co-authors and the relative weight of my authorship for each of the four scientific articles.

Research Article 1

Title	**Food Forests – Their Services and Sustainability**
Authors	Albrecht, S.; Wiek, A.
Authors' contributions	SA & AW designed the study, SA developed the method, collected and analyzed the data, and wrote the original draft of the manuscript, which was edited and finalized with AW
Declaration of authorship (weighting factor)	Predominant contribution (1.0)
Publication status	Published (2021) in *Journal of Food Systems, Agriculture and Community Development,* a double-blind peer reviewed, transdisciplinary journal
Presentations at conference or policy event	Agroforestry Research Trust (2021): International Forest Garden / Food Forest Symposium (2021), UK (online), 31st May – 4th June 2021, URL: https://www.agroforestry.co.uk/symposium-programme/ Umweltbundesamt / German Environmental Agency (2021), Invited presentations at Division I: Sustainability Strategies https://www.umweltbundesamt.de/das-uba/wer-wir-sind/organisation/fachbereich-i

Research Article 2

Title	**Implementing Sustainable Food Forests – Extracting Success Factors Through a Cross-Case Comparison**
Authors	Albrecht, S.; Wiek, A.
Authors' contributions	SA & AW designed the study and developed the method, SA collected and analyzed the data, and wrote the original draft of the manuscript, which was edited and finalized with AW
Declaration of authorship (weighting factor)	Predominant contribution (1.0)
Publication status	Accepted for publication, in press (2021) in *Journal of Food Systems, Agriculture and Community Development,* a double-blind peer reviewed, transdisciplinary journal
Presentations at conference or policy event	Agroforestry Research Trust (2021): International Forest Garden / Food Forest Symposium (2021), UK (online), 31st May – 4th June 2021, URL: https://www.agroforestry.co.uk/symposium-programme/ Umweltbundesamt / German Environmental Agency (2021), Invited presentations at Division I: Sustainability Strategies https://www.umweltbundesamt.de/das-uba/wer-wir-sind/organisation/fachbereich-i

Research Article 3

[1] Accessible at https://www.leuphana.de/fileadmin/user_upload/fakultaet3/files/Promotion/RL_Kumulative_Dissertation_Fak_N_Stand_01_2012.pdf

Title	**"Almost there" – on the Importance of a Comprehensive Entrepreneurial Ecosystem for Developing Sustainable Urban Food Forest Enterprises.**
Authors	Wiek, A.; Albrecht, S.
Authors' contributions	SA & AW designed the research projects together. SA collected the case study data. SA and AW analyzed the data on success factors for the case, in particular, AW analyzed the results for the local entrepreneurial ecosystem. SA and AW wrote and reviewed the manuscript together.
Declaration of authorship (weighting factor)	Equal contribution (1.0)
Publication status	Under minor revision in *Urban Agriculture & Regional Food Systems,* double-blind peer reviewed, multi-disciplinary *journal*
Presentations at conference or policy event	Umweltbundesamt / German Environmental Agency (2021), Invited presentations at Division I: Sustainability Strategies https://www.umweltbundesamt.de/das-uba/wer-wir-sind/organisation/fachbereich-i

Research Article 4

Title	**Transdisciplinary Partnerships for Developing Sustainable Food Forests**
Authors	Albrecht, S.; Wiek, A.; Friedel, A.
Authors' contributions	SA & AW designed the research projects together. SA collected and analyzed the data for both cases. SA and AW wrote the original draft of the manuscript. SA, AW and AF reviewed and edited the manuscript.
Declaration of authorship (weighting factor)	Predominant contribution (1.0)
Publication status	Submitted (2021) in *GAIA,* a double-blind peer reviewed, transdisciplinary journal
Presentations at conference or policy event	Umweltbundesamt / German Environmental Agency (2021), Invited presentations at Division I: Sustainability Strategies https://www.umweltbundesamt.de/das-uba/wer-wir-sind/organisation/fachbereich-i

Declaration:

I avouch that all information given in this appendix is true in each instance and overall.

_____

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Declaration

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I hereby declare that I have neither undertaken nor applied to undertake any other doctoral assessment.

I hereby declare that the thesis entitled “Developing sustainable food forests - Key Features, Success Factors, and Transdisciplinary Partnerships” has not been submitted to any other academic institution, that I have submitted the thesis only as part of this and of no other doctoral assessment, and that I have not previously failed any other doctoral assessments.

I hereby declare that the thesis submitted “Developing sustainable food forests - Key Features, Success Factors, and Transdisciplinary Partnerships” is all my own work and has been produced without any unauthorized assistance. I have not used any aids or material other than that specified. I have referenced all sources used.

Berlin, October 14th 2021