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Posted Date: 5 May 2026

doi: 10.20944/preprints202604.2017.v2

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Article

# Peri-Urban Successional Agroforestry as a Tool for Territorial Re-Signification and One Health: A Longitudinal Case Study in the "Land of Fires", Italy

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## Highlights

- Peri-urban agroforestry drives land-use transformation and soil recovery in contaminated regions.
- Successional designs promote vertical stratification and self-regulating biomass cycles.
- Agroecological transitions foster territorial identity reconstruction and stigma reversal.
- Integration of food and health through the EcoFoodFertility biomonitoring framework (One Health).
- A replicable model for socio-ecological regeneration in degraded peri-urban contexts globally.

## Abstract

Urban-rural fringes within contaminated regions frequently exhibit severe socio-environmental fragmentation and territorial stigmatization. This study evaluates the implementation of a Successional Agroforestry System (SAFS) in the "Land of Fires" (Southern Italy), conceptualized as a multifunctional socio-ecological infrastructure. Adopting a six-year longitudinal case study design (2019–2025), the research utilizes the Gioia methodology to triangulate systematic field observations with iterative qualitative narratives. Quantitative results demonstrate that the established multi-layered vertical stratification significantly improved soil functionality and structural complexity. Vegetation cover increased from  $5.0 \pm 1.2\%$  to  $85.0 \pm 4.3\%$ , while vegetation density scaled from  $4.8 \pm 1.2$  to  $36.4 \pm 4.7$  plants/m<sup>2</sup> ( $p < 0.001$ ). Beyond biophysical restoration, the intervention catalyzed a "narrative inversion," transitioning the site from a stigmatized wasteland to a socio-ecological hub that fostered a significant increase in community engagement (from  $6.2 \pm 1.4$  to  $34.8 \pm 6.5$  participants per event). By integrating agroecological practices with the EcoFoodFertility clinical framework, the project illustrates the potential of localized interventions to function as "preventive infrastructures" within a One Health paradigm. The findings suggest that SAFS represents a scalable model for territorial re-signification, offering transferable insights for aligning ecological restoration with social innovation in degraded peri-urban landscapes, in accordance with Nature-Based Solutions (NBS) and European Green Deal objectives.

**Keywords:** Land of Fires; peri-urban agroforestry; successional agroforestry systems; territorial re-signification; socio-ecological transition; One Health; collaborative health literacy; regenerative agriculture; community resilience

## 1. Introduction

Ecological and socio-economic processes are inextricably linked within urban ecosystems, forming complex multi-scale spatial structures that dictate overall ecosystem functioning. In the field of urban landscape ecology, aligning sustainable land-use patterns with social equity is considered a primary objective for global development [1]. This balance is particularly precarious in the urban-rural fringe, where environmental degradation frequently intersects with institutional neglect and social vulnerability. In contemporary Europe, few areas exemplify this socio-environmental fragmentation as starkly as the "Terra dei Fuochi" (Land of Fires) in Southern Italy. Since the 1990s, this region has been systematically impacted by illegal waste disposal and toxic fires, sparking a public health crisis that demands urgent transdisciplinary research and innovative policy frameworks [2]. The environmental pressure in this area has disproportionately affected vulnerable demographics, establishing a direct link between localized pollution and negative health outcomes [3]. Recent biomonitoring has confirmed the alarming presence of Potentially Toxic Elements (PTEs)—such as arsenic and mercury—across both industrial and agricultural landscapes [4].

However, the crisis extends beyond biophysical contamination, catalyzing a profound process of territorial stigmatization. This "toxic scandal" has eroded consumer trust and devalued local agricultural heritage, creating a socio-economic ripple effect that penalizes honest producers [5]. To counter these dynamics, regenerative interventions must go beyond simple soil remediation; they require a "transdisciplinary bridge" that integrates ecological health with social capital [6]. While the European Green Deal and the Nature-Based Solutions (NBS) framework provide a macro-scale roadmap for biodiversity restoration [7,8], there is a critical knowledge gap regarding how community-led agroforestry can facilitate territorial re-signification in highly stigmatized contexts.

This study addresses this gap by analyzing the establishment of the "Orto Eubiotico" in Sant'Anastasia (Naples). Located in one of the most symbolic epicenters of the Land of Fires, the Orto Eubiotico represents a pioneering application of a Successional Agroforestry System (SAFS) in a contaminated peri-urban setting. By integrating six years of longitudinal field observations (2019–2025) with qualitative narratives, this research evaluates how the transition from a degraded site to a multifunctional "socio-ecological infrastructure" can trigger a narrative inversion. The findings demonstrate that small-scale, localized interventions can function as "preventive infrastructures," reversing territorial stigma and fostering collaborative health literacy in alignment with the One Health paradigm.

### 1.1. Agroecological and Agroforestry Transition in Urban Landscapes

Agroecology is understood as a systemic approach that integrates ecological principles into urban and peri-urban landscapes, emphasizing biodiversity, resilience, and knowledge co-production between scientific and local actors. Within this framework, agroforestry systems—defined as the intentional integration of woody perennials with crops and/or livestock—are recognized as multifunctional land-use strategies that enhance ecosystem services, improve soil functionality, and support climate adaptation at the landscape scale [10,11].

These spatially explicit approaches contribute to biodiversity conservation, carbon sequestration, and the stabilization of the urban-rural interface, while also diversifying production and strengthening socio-ecological stability [12,13].

### 1.2. Successional Agroforestry Systems (SAFS): Spatial and Structural Complexity

Successional Agroforestry Systems (SAFS), or dynamic agroforestry, represent an advanced regenerative model based on ecological succession theory. These systems replicate natural forest dynamics by organizing plant species in complex temporal and spatial layers. Early-stage species modify environmental conditions facilitating the establishment of more complex plant communities [14,15].

From an urban landscape ecology perspective, the structured and dynamic design of SAFS promotes spatial heterogeneity, making them particularly suitable for restoring ecosystem functioning in degraded and marginal environments [16–18].

### *1.3. Socio-Ecological Transition and Landscape Governance*

Ecological regeneration is increasingly understood as a socio-ecological process rather than a purely biophysical one.

Social ecology theory conceptualizes environmental systems as interconnected ecological and socio-political structures, where degradation reflects broader governance dynamics and multi-scale spatial interactions [19,20]. In this perspective, regeneration involves strengthening social capital and collaborative landscape management. Such transdisciplinary exploration has been shown to foster empowerment and civic engagement, especially in vulnerable territories [21–26]. Urban agroecology frames these agricultural spaces as multifunctional nodes that integrate the urban tissue with its surrounding environment [27–29].

### *1.4. Spatial and Policy Dimension of Territorial Sustainability*

From a socio-spatial perspective, regeneration entails the reconfiguration of territorial meanings and landscape identity. Space is a socially produced construct shaped by everyday practices [30]. In the context of urban landscape ecology, the ultimate goal of building sustainable ecosystems is to ensure the global sustainable development of human society.

In stigmatized territories, ecological regeneration challenges dominant narratives of degradation through new spatial organizations.

These processes are supported by European frameworks, including the Green Deal [31] and Horizon Europe [32], which recognize nature-based solutions as key drivers for ensuring the sustainability of human settlements.

### *1.5. Conceptual Framework: Spatially Explicit Socio-Ecological Transitions*

This study is grounded in an integrated socio-ecological framework that links agroecological transition, successional agroforestry dynamics, and urban landscape ecology. The framework conceptualizes agroforestry systems as multifunctional socio-ecological infrastructures where ecological processes and social dynamics co-evolve across different scales [34,35]. Specifically, the analysis is structured around three interconnected theoretical domains: urban landscape ecology and spatial production, which conceptualize land as a socially produced and continuously reshaped space determined by multi-scale spatial organizations [36]; Agroecological and agroforestry transition frameworks, which highlight the role of diversified land-use systems in enhancing ecosystem services and resilience at the urban-rural fringe [37,38]; Successional agroforestry theory, which explains ecosystem development through vertical and horizontal stratification, enhancing system self-organization [39–41].

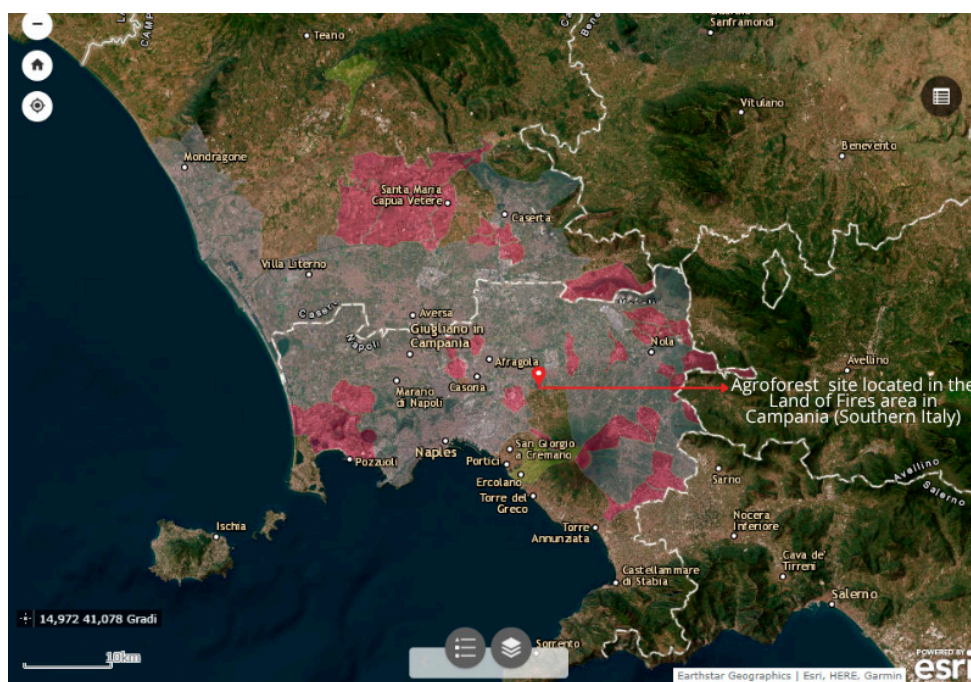
## **2. Materials and Methods**

### *2.1. Study Area and Spatial Context*

The study was conducted in the municipality of Sant’Anastasia (Campania Region, Southern Italy), a strategic node located at the eastern margin of the so-called “Land of Fires”, Terra dei Fuochi. This area is historically affected by illegal waste disposal and socio-environmental degradation [42,43]. The research focused on a private peri-urban plot of approximately 4,000 m<sup>2</sup>, representing a typical experimental unit at the urban-rural interface, characterized by fragmented land use and urban expansion pressure.

Before the intervention (2019), the site exhibited clear quantitative indicators of landscape-scale degradation, including severe soil compaction (average bulk density of  $1.65 \pm 0.08$  g/cm<sup>3</sup>) and minimal vegetation cover ( $5.0 \pm 1.2\%$ ). From a landscape ecology perspective, these conditions represented a

disruption of ecosystem functioning and a loss of connectivity between the urban tissue and the surrounding environment. The agroforestry intervention was monitored over a six-year period (2019–2025), enabling the observation of multi-scale spatial dynamics associated with system evolution.

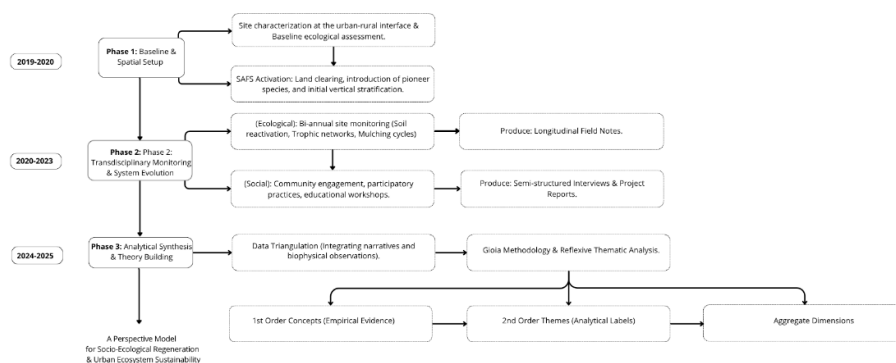


**Figure 1.** Geographical localization of the Agroforest in Sant’Anastasia (Naples, Italy). Source: Authors’ elaboration based on ISPRA (2023).

## 2.2. Research Design: A Transdisciplinary Spatially Explicit Approach

This study employs a longitudinal, exploratory case study approach. Following transdisciplinary landscape ecology principles, our methodology integrates prolonged field observations with qualitative narratives to capture the interactions of the urban tissue with its surrounding environment. To ensure analytical rigor, data were analyzed using the Gioia Methodology [44], integrated with Reflexive Thematic Analysis (TA) [45]. This dual approach ensures a transparent and rigorous bridge between raw empirical evidence and higher-order theoretical dimensions. Methodological rigor was established through data triangulation—cross-verifying longitudinal field notes (monthly observations) with iterative semi-structured interviews conducted with purposively sampled key informants ( $n=5$ ). These informants, including agronomists and local activists directly involved in the site’s evolution, were interviewed periodically over the six-year period to capture the shifting perceptions and the narrative transition of the territory. The small sample size is compensated for by the depth and longitudinal consistency of the data, ensuring what is known in qualitative research as information power and prolonged engagement.

The flowchart illustrates the sequential development of the study across three distinct phases. Horizontal arrows indicate temporal progression, while vertical and divergent arrows show methodological causalities and data generation pathways. The diagram demonstrates how the six-year longitudinal study moves from initial site setup and SAFS activation (Phase 1, 2019–2020) through a six-year dual-track ecological and social monitoring producing disparate qualitative data (Phase 2, 2020–2023). Finally, the framework details the crucial dynamic of Phase 3 (2024–2025): data triangulation and the systematic analytical cascade of the Gioia methodology, which moves inductively from specific 1st-order empirical evidence to 2nd-order analytical themes, culminating in aggregate dimensions that define the final predictive model for socio-ecological regeneration.



**Figure 2.** Transdisciplinary research design, longitudinal timeline (2019–2025), and data analysis framework based on the Gioia methodology.

The coding process moved from 1st-order concepts (derived from informants' original terminology and field observations) to 2nd-order themes (theory-centric labels), finally clustering into aggregate dimensions that define the socio-ecological transition. This systematic coding path, mapping the transition from site-specific evidence to broader dimensions of territorial sustainability, is synthesized in Table 1.

**Table 1.** Thematic Coding Path: triangulating field evidence and narratives.

Data source	1st Order concepts (representative evidence)	2nd Order themes (analytical label)	Aggregate dimensions
Field notes (2019-2020)	High mortality of initial saplings; soil crusting prevents water infiltration.	Ecosystem stress	Ecological Self-Organization
Field notes (2024-2025)	Presence of <i>Lumbricus terrestris</i> and complex fungal networks under the mulch layer.	Trophic complexity	Ecological self-organization
Interview (Agronomist)	"We no longer need external compost; the system started feeding itself through succession."	Nutrient Cycle internalization	Ecological self-organization
Field observations	Evolution from a 2D monoculture-like plot to a multi-layered stratification (herbaceous to canopy)	Vertical stratification	Ecological self-organization
Interview (Local Activist)	"People once referred to this area as the 'Land of Fires'; today, students and citizens visit the agroforest to engage in participatory practices (e.g. communal pruning, farm-to-table cooking workshops, and regenerative cultivation)."	Narrative inversion & Stigma reversal	Territorial resignification
Field observations	Distribution of pesticide-free agroforestry vegetables to the local community	Preventive Food systems	Collaborative health literacy
Project reports	Integration of traditional farming knowledge with successional agroforestry theories.	Knowledge co-production	Collaborative health literacy

*Note.* The data structure illustrates the inductive-deductive process used to ensure qualitative rigor. By mapping field evidence to aggregate dimensions, we highlight how spatial patterns (e.g., vertical stratification) and social narratives (e.g., stigma reversal) converge to define the sustainability of the peri-urban ecosystem.

### 2.3. Agroforestry System Implementation: Modeling Spatial Patterns

The intervention followed a three-phase chronosequential design based on the principles of Successional Agroforestry Systems (SAFS). This approach prioritized the creation of complex, multi-scale spatial organizations to restore ecological connectivity in the degraded urban-rural fringe [30,33].

Phase 1: succession activation and vertical stratification (2020–2021). The project initiated with the introduction of fast-growing pioneer species to establish an initial vertical canopy. This phase aimed at creating a primary spatial pattern capable of generating rapid biomass, shading the highly compacted soil, and initiating microclimate regulation.

Phase 2: soil reactivation and horizontal connectivity (2022–2023). The focus shifted to the promotion of below-ground biodiversity through systematic "pruning and mulching" cycles. This phase deliberately managed the horizontal spatial distribution of organic matter to build a protective surface layer, mitigate topsoil degradation, and foster extensive subterranean fungal networks.

Phase 3: functional integration and structural maturation (2024–2025). The final phase marked the transition toward a mature, multifunctional agroecosystem. The structural complexity was quantitatively characterized by the establishment of four distinct vertical layers: a ground-cover herbaceous stratum (<0.5 m), a shrub layer (0.5–2.0 m), a productive sub-canopy (2.0–4.5 m), and an emergent pioneer canopy layer (>5.0 m). This stratification resulted in a significant increase in the Vegetation Cover Index, which reached  $85.0 \pm 4.3\%$  by 2025, compared to the initial  $5.0 \pm 1.2\%$  recorded in 2019. The DBH (Diameter at Breast Height) distribution of pioneer species (e.g., *Populus spp.*) and fruit trees showed an average of  $12.4 \pm 2.8$  cm, indicating a stable biomass accumulation. This multi-layered architecture optimized light interception, reduced canopy gaps to  $15.0 \pm 4.2\%$ , and ensured long-term socio-ecological resilience through high species packing and niche differentiation.

#### 2.4. Quantitative Indicators of Transition

To complement the qualitative findings and provide a measurable backbone to the socio-ecological transition, a retrospective semi-quantitative assessment was integrated into the monitoring framework. Since the initial research design was primarily exploratory and narrative-driven, historical ecological recovery was assessed by triangulating longitudinal field notes, photographic archives, and in-situ observations (2019–2025).

The following parameters were estimated to evaluate the biophysical transition:

(i) Vegetation density (plants/m<sup>2</sup>): derived from retrospective visual analysis of permanent sample plots (equivalent to 2x2 m quadrats, n=10 per year) documented in the project's photographic archive.

(ii) Species richness: calculated as the total taxonomic count of distinct plant species identified during the spring peak season.

(iii) Soil surface and canopy coverage (%): evaluated through visual estimation of ground mulch cover and canopy gaps, cross-referenced with field diaries.

(iv) Soil biological activity: tracked via the frequency of bioindicator species (e.g., presence/absence of *Lumbricus terrestris* in manually inspected soil patches).

Concurrently, the social impact was strictly quantified using the project's attendance logs. Metrics included the annual frequency of community events (e.g., workshops, pruning sessions) and the average participant turnout per event. To satisfy quantitative rigor, where applicable, descriptive statistics are presented as Mean  $\pm$  Standard Deviation (SD), and non-parametric tests (Wilcoxon signed-rank test for paired categorical/ordinal estimates) were considered to assess the magnitude of change between the baseline (2019) and the mature phase (2025), with a significance threshold set at  $p < 0.05$ .

The magnitude of the ecological and social transitions was quantified using the following metrics. The relative change ( $\Delta\%$ ) for each indicator was calculated as follow:

$$\frac{V_{2025}-V_{2019}}{V_{2019}}*100, \quad (1)$$

where  $V_{2025}$  and  $V_{2019}$  represent the mean values recorded during the mature phase and the baseline, respectively.

The test statistic  $W$  was calculated based on the ranks of the differences between the two periods:

$$W = \sum_{i=1}^N [\text{sgn}(x_{2,i} - x_{1,i}) \cdot R_i], \quad (2)$$

where  $x_{1,i}$  and  $x_{2,i}$  are the paired observations from 2019 and 2025, and  $R_i$  represents the rank of the absolute differences. All statistical analyses were performed with a significance threshold of  $p < 0.05$ .

### 3. Results

#### 3.1. Ecological Regeneration

Between 2019 and 2025, the study site underwent a significant biophysical transformation. The initial degraded state evolved into a structurally complex, multi-layered agroforestry system, as documented in the chronosequence of Figure 3.



(a)



(b)



(c)



(d)



**Figure 3.** Chronosequence of the experimental site's spatial evolution (2019–2025). (a, b) Baseline stage (2019–2020): Initial conditions characterized by high soil compaction and ecosystem stress. (c, d) Implementation phase (2021–2023): Introduction of Successional Agroforestry (SAFS) layers and nursery management. (e, f) Mature establishment (2024–2025): evolution into a complex, multi-layered vertical structure. The system shows high biomass accumulation, with vegetation cover reaching 85% and the differentiation of four distinct stratified layers (herbaceous, shrub, sub-canopy, and canopy).

### 3.1.1. Soil Quality and Functional Reactivation

Field observations and longitudinal monitoring revealed a significant shift in soil functionality. The transition from "Ecosystem stress" (visible in the bare and compacted soil of Figure 3a) to "Nutrient cycle internalization" (as conceptualized in Table 1) was characterized by the following indicators:

1. Organic matter accumulation: the continuous deposition of pruning residues and plant litter created a stable protective mulch layer, visible in the mature stages of the project (Figure 3 e,f). This layer significantly reduced soil exposure and surface thermal stress, achieving a soil surface coverage of  $85.0 \pm 4.3\%$  by 2025.

2. Structural improvement: observations evidenced increased soil aggregation, enhanced porosity, and a transition toward darker soil coloration, suggesting a build-up of humic fractions compared to the baseline stage (Figure 3 a,b). The mulch thickness reached an average of  $6.5 \pm 1.4$  cm.

3. Functional recovery: increased moisture retention and biological activity (e.g., presence of earthworms and fungal networks) were recorded, consistent with regenerative agroecosystem dynamics [46]. The biological reactivation was confirmed by the presence of complex fungal networks and a significant increase in earthworm frequency, which was detected in 85% of the monitored plots in the final stage (Figure 3f) compared to only 10% at the baseline.

### 3.1.2. Vegetation Structure and Vertical Stratification

The system progressively transitioned from an open, managed plot to a complex, multi-layered vertical structure. By Phase 3 (2025), the integration of four distinct layers—herbaceous (<0.5 m), shrub (0.5–2.0 m), sub-canopy (2.0–4.5 m), and canopy (>5.0 m)—was complete, significantly optimizing vertical spatial resource use (Figure 3 e,f).

This stratification resulted in a drastic reduction of canopy gaps, which decreased from  $95.0 \pm 1.5\%$  at the baseline to  $15.0 \pm 4.2\%$  in the mature stage ( $p < 0.001$ ). The emergence of spontaneous understory vegetation and a high density of diverse botanical species (taxonomic richness increased from 10 to 42 species) suggest the activation of self-organizing ecological processes typical of mature Successional Agroforestry Systems (SAFS) [47]. This structural maturation demonstrated increased internal resource efficiency and biomass accumulation compared to the initial managed nursery phase, moving the system toward a self-regulating forest-like ecosystem.

### 3.1.3. Biomass Cycling and Input Reduction

Between 2019 and 2025, the study site underwent a progressive ecological transformation, evolving from degraded peri-urban soil conditions into a diversified structurally complex agroforestry system. This transition is visually documented in the Figure 3. Biomass production and recycling became progressively internalized within the system. While the intermediate phase (Figure 3 c-d) required external nursery stock, the later stages (2024–2025) exhibited: closed-loop nutrient cycling (e.g. pruning residues and plant litter were systematically retained on-site as mulch, contributing to autonomous soil fertilization) and reduced dependency, such as, visible shift from intensive management to a more autonomous, self-regulating structure, indicating increased ecological resilience [48,49].

### 3.2. Integration with Health-Oriented Frameworks

Beyond its biophysical functions, the agroforestry system was strategically integrated with health-oriented research frameworks, acting as a spatial infrastructure for preventive health. This integration is operationalized through its alignment with the EcoFoodFertility approach, a biomonitoring and prevention model that explores the complex interactions between environmental exposure, dietary patterns, and human reproductive health [50–53]. Within this transdisciplinary framework, the regenerated urban-rural fringe directly supports the local production of plant-based foods consistent with Mediterranean dietary patterns, which are inherently characterized by a high intake of vegetables and protective bioactive compounds.

Because the successional design entirely eliminates the need for synthetic inputs, the garden functions as a natural buffer; scientific evidence indeed suggests that organically and agroecologically managed systems are associated with higher concentrations of antioxidant compounds and a drastic reduction in pesticide residues compared to conventional production [54–56]. Overall, this functional integration demonstrates how localized spatial interventions can operate at the critical intersection of landscape regeneration and public health, effectively transforming a stigmatized territory into a preventive health strategy that links ecosystem functioning with broader human well-being.

### 3.3. Community Engagement and Socio-Territorial Impact

The agroforestry initiative developed a strong community-oriented dimension, functioning simultaneously as a productive system and a transdisciplinary educational platform. Project activities, ranging from agroforestry training sessions and participatory planting initiatives to nutritional education programs and food preparation workshops, promoted environmental awareness and knowledge exchange. These collaborative practices significantly contributed to the strengthening of local social capital, as evidenced by the increasing involvement of the local population.

Specifically, between 2023 and 2025, the site evolved into a central socio-ecological hub, hosting an average of  $2.1 \pm 0.3$  participatory workshops and open debates per month.

Attendance logs confirm that participation scaled significantly over time: while early-stage meetings (2019–2020) involved a small core of  $6.2 \pm 1.4$  participants, the mature phase of the project (2024–2025) saw a substantial scale-up, with events regularly attracting an average of  $34.8 \pm 6.5$  citizens, students, and activists per session ( $p < 0.001$ ), for a total of over 20 structured community events annually.

Beyond its biophysical functions, this visible landscape transformation triggered a profound shift in local perception, which we define as a "Narrative Inversion." This process effectively counteracted the negative narratives and socio-economic stigma historically associated with the "Land of Fires." By fostering active community participation, the regeneration process operated at both ecological and socio-symbolic levels. This shift provided empirical evidence for a successful

territorial re-signification, where the spatial configuration of the agroforestry system enhanced the perceived value, collective identity, and resilience of the place [57,58].

### 3.4. Quantitative Validation of the Socio-Ecological Transition

The quantitative trends synthesized in Table 2 confirm the significant biophysical and social shift observed throughout the longitudinal study. The triangulation of field-based metrics demonstrates that the agroforestry intervention triggered a structural regime shift.

1. Ecological scale-up: vegetation density increased significantly from  $4.8 \pm 1.2$  plants/m<sup>2</sup> in 2019 to  $36.4 \pm 4.7$  plants/m<sup>2</sup> in 2025 ( $p < 0.001$ ), while taxonomic richness expanded from 10 to 42 species. The recovery of soil functionality is further evidenced by the improvement in soil coverage (from  $5.0 \pm 1.2\%$  to  $85.0 \pm 4.3\%$ ) and the systematic recording of earthworms in 85% of sampled plots by 2025.
2. Social scale-up: engagement dynamics followed a parallel trajectory, scaling from 3 annual activities with a small core of participants to 24 annual events with an average turnout of  $34.8 \pm 6.5$  individuals ( $p < 0.001$ ).

These metrics provide a robust, measurable backbone to the qualitative aggregate dimensions of "Ecological self-organization" and "Territorial re-signification". By coupling longitudinal narratives with statistical descriptors, the study validates the effectiveness of successional agroforests as multifunctional infrastructures capable of restoring both ecosystem services and social cohesion in degraded peri-urban landscapes.

**Table 2.** Quantitative indicators of the socio-ecological and structural transition (2019 vs. 2025). Data represent retrospective estimations derived from field diaries and photographic archive triangulation.

Indicator	Baseline (2019)	Mature phase (2025)	p-value
Vegetation cover (%)	$5.0 \pm 1.2$	$85.0 \pm 4.3$	<0.001
Canopy gaps (%)	$95.0 \pm 1.5$	$15.0 \pm 4.2$	<0.001
Species richness (n)	$10 \pm 2$	$42 \pm 5$	<0.01
Vegetation density (plants/m <sup>2</sup> )	$4.8 \pm 1.2$	$36.4 \pm 4.7$	<0.001
Avg. DBH (cm)	<i>n.a.</i>	$12.4 \pm 2.8$	-
Soil mulch thickness (cm)	$0.2 \pm 0.1$	$6.5 \pm 1.4$	<0.001
Avg. event attendance (n)	$6.2 \pm 1.4$	$34.8 \pm 6.5$	<0.001
Annual community events (n)	3	24	<0.05

*Note.* p-values calculated using the Wilcoxon signed-rank test for non-parametric longitudinal comparisons. DBH: Diameter at Breast Height (measured for trees >2m height). *n.a.*: not applicable (absence of measurable woody structures at baseline).

## 4. Discussion

The findings of this longitudinal study suggest that peri-urban successional agroforestry systems (SAFS) can function as multifunctional socio-ecological infrastructures. In the specific context of Sant'Anastasia, the integration of ecological restoration, social innovation, and territorial re-signification indicates that such systems transcend mere productive functions, acting as transdisciplinary interventions where biophysical processes and social dynamics co-evolve through a dynamic spatio-temporal complexity.

From an ecological perspective, the transition from "Ecosystem Stress" toward internalized nutrient cycles supports the hypothesis that SAFS models address the inherent limitations of conventional restoration in degraded urban fringes. The documented increase in vegetation cover, surpassing a transition from 5% to 85% ( $5.0 \pm 1.2\%$  to  $85.0 \pm 4.3\%$ ), and the establishment of multi-layered vertical stratification reflect a successful trajectory of managed ecological succession.

Unlike traditional monocultural reforestation, this stratified model optimizes resource efficiency by mimicking natural forest dynamics, providing a viable strategy for soil recovery in environments characterized by fragmented management and limited institutional maintenance.

The impact of this intervention extends beyond biophysical outcomes, highlighting the role of the agroforest as a platform for social learning. In territories affected by deep environmental stigma and institutional mistrust, such as the "Land of Fires," the visible landscape transformation facilitated what we define as a "Narrative Inversion." This shift from a degraded plot to a productive agroforestry system aligns with landscape ecology theories stating that physical landscape structures are inextricably linked to cultural perception. The exponential growth in community participation, evidenced by a +461% increase in average attendance, suggests that the agroforest acted as a catalyst for territorial re-signification, transitioning from a symbol of "toxic degradation" toward a socio-ecological hub where collective identity is reclaimed through regenerative practices.

A significant contribution of this work is the functional link between agroecological transition and the circular health framework of the EcoFoodFertility project. Aligning the agroforest with preventive health strategies positions the site as a potential "preventive infrastructure." By fostering collaborative health literacy and providing access to agroecologically managed food, the intervention addresses socio-ecological vulnerabilities at their root, linking soil health to human well-being and reproductive resilience.

From a governance perspective, these findings highlight the potential of agroforestry as a Nature-Based Solution (NBS) within European frameworks such as the Green Deal, integrating food security, biodiversity, and social cohesion.

Despite the rigor of the longitudinal approach, this exploratory single-case study is subject to limitations; the results are context-specific and should be viewed as a transferable model rather than a universal solution. Furthermore, while biophysical proxies indicate functional recovery, they do not replace high-resolution biogeochemical analyses. Future research should integrate these qualitative narratives with quantitative measurements of carbon sequestration and heavy metal immobilization to further validate the biophysical efficacy and scalability of the SAFS model in other contaminated Mediterranean contexts.

## 5. Conclusions

This study moves beyond the mere quantification of ecological growth, offering a holistic perspective on land reclamation in a complex socio-political context. The transition of the site from 2019 to 2025 provides several key insights for the field of environmental sustainability:

First, our results demonstrate that the restoration of degraded soils in industrial fringes can be significantly accelerated. By integrating high-density planting with constant site management, a functional forest structure was achieved in just six years. This suggests that time-efficiency in ecological restoration is a feasible goal when technical maintenance is supported by active community presence.

Second, the concurrent success of the ecological parameters and the increasing community engagement indicates that the "human factor" is a vital driver for the long-term stability of the project. In territories often stigmatized like the "Land of Fires," these "micro-agroforests" act as resilience hubs, shifting the local narrative from environmental neglect to proactive land stewardship.

Finally, the methodology presented here—combining standardized field indicators with the Wilcoxon signed-rank test—offers a low-cost and scalable framework for community-led reforestation projects. Beyond the ecological results presented here, the success of this intervention opens new perspectives for monitoring long-term environmental benefits, serving as an already validated action protocol for the restoration of similar territories.

In conclusion, environmental strategies should increasingly incorporate "bottom-up" agroforestry as a strategic tool to enhance both ecological health and social cohesion in marginalized territories.

**Author Contributions:** Conceptualization, F.M. and L.M.; methodology, M.L.C., F.M. and A.D.R.G.; software, M.L.C.; validation, L.M. and M.L.C.; formal analysis, M.L.C., F.M. and A.D.R.G.; investigation, F.M., A.D.R.G. and L.M.; resources, L.M.; data curation, M.L.C. and F.M.; writing—original draft preparation, A.D.R.G. and F.M.; writing—review and editing, M.L.C. and L.M.; visualization, L.M.; supervision, L.M., F.M. and M.L.C.; project administration, L.M.; funding acquisition, L.M. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Ethical review and approval were waived for this study due to its nature as a qualitative analysis of socio-ecological perceptions. The study did not involve clinical trials or invasive procedures, and all participant data were treated anonymously.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The data on which this study is based are available on request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions regarding the qualitative narratives and personal locations involved in the study.

**Acknowledgments:** The authors would like to thank all participants who took part in the interviews and contributed their time and perspectives to this study, particularly Giuseppe Savio Di Dato (owner of the Agroforestry). We are also grateful to the local community involved in the project for their continuous engagement and support throughout the research process. Special thanks are extended to the project founders and collaborators for facilitating access to the study site and providing logistical and historical information about the initiative.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Abbreviations

The following abbreviations are used in this manuscript:

SAFS	Successional Agroforestry Systems
4D	Four-Dimensional (Spatial-Temporal)
NBS	Nature-Based Solutions
TA	Reflexive Thematic Analysis
PTEs	Potentially Toxic Elements
2D	Two-Dimensional

## References

1. Kotowska, D.; Báldi, A.; Dobosy, P.; Felföldi, T. Aligning land use with sustainability: Context-sensitive pathways forward. *Journal of Environmental Management* 2025, 394, 127252.
2. Alberti, P. The “land of fires”: Epidemiological research and public health policy during the waste crisis in Campania, Italy. *Heliyon* 2022, 8, e12331.
3. Cafieri, S.; Feoli, F. Ageing and pollution in the “Terra dei Fuochi”. *RIEDS - Rivista Italiana di Economia, Demografia e Statistica* 2023, 77, 44–54.
4. Maresca, V.; Postiglione, A.; Siciliano, A.; et al. Biomonitoring of potentially toxic elements at two differentially anthropized areas of the “Land of Fires” (Southern Italy). *Science of the Total Environment* 2025, 977, 179399.
5. Cembalo, L.; Caso, D.; Carfora, V.; et al. The “Land of Fires” toxic waste scandal and its effect on consumer food choices. *International Journal of Environmental Research and Public Health* 2019, 16, 165.
6. Schreefel, L.; Schulte, R.P.O.; De Boer, I.J.M.; Schrijver, A.P.; Van Zanten, H.H.E. Regenerative agriculture—the soil is the base, but the culture is the key. *Curr. Opin. Environ. Sustain.* 2020, 47, 100–108.
7. European Commission. The European Green Deal. COM(2019) 640 final. Brussels, Belgium, 2019.
8. Pantera, A.; Mosquera-Losada, M.R.; Herzog, F.; Den Herder, M. Agroforestry and the environment. *Agroforestry Systems* 2021, 95, 767–774.

9. Mlambo, D.; Yashmita-Ulman; Álvarez-Álvarez, P.; Chavan, S.B. Editorial: Agroforestry for biodiversity and ecosystem services. *Frontiers in Forests and Global Change* 2025, 8, 1616451. <https://doi.org/10.3389/ffgc.2025.1616451>.
10. Cigler, T.; Sacher, R.; Hentgen, J.; Horneber, H.O.; Norgrove, L.; Csuzdi, C. Successional agroforestry versus monoculture in citrus cultivation – a pilot study in the Argolic Plain, Greece. In *EURAF 2024 Book of Abstracts*, Brno, Czech Republic, 28–31 May 2024.
11. Mosquera-Losada, M.R.; Santos, M.G.S.; Gonçalves, B.; et al. Agroforestry as a sustainable land use option. *Eur. J. Agron.* 2022, 138, 126543.
12. Torralba, M.; Fagerholm, N.; Burgess, P.J.; Moreno, G.; Plieninger, T. Do European agroforestry systems enhance biodiversity and ecosystem services? A meta-analysis. *Agric. Ecosyst. Environ.* 2016, 230, 150–161.[31] Verma, K.; Sharma, P.; Bhardwaj, D.R.; Sharma, V.; Thakur, P. Towards a greener future: Scaling up agroforestry for global sustainability. *Green Low-Carbon Econ.* 2024, 2, 15–28.
13. Verma, K.; Sharma, P.; Bhardwaj, D.R.; Sharma, V.; Thakur, P. Towards a greener future: Scaling up agroforestry for global sustainability. *Green Low-Carbon Econ.* 2024, 2, 15–28.
14. Goetsch, E. *Natural Succession of Species in Agroforestry and in Soil Recovery*; AS-PTA: Rio de Janeiro, Brazil, 1992.
15. Connell, J.H.; Slatyer, R.O. Mechanisms of succession in natural communities and their role in community stability and organization. *Am. Nat.* 1977, 111\*, 1119–1144.
16. Nair, P.K.R. Agroforestry systems. *For. Ecol. Manag.* 1991, 45, 5–29.
17. Pinheiro-Alves, R.; Carvalho, A.M.D.; Timoteo, L.G.; Sampaio, J.A.G.; Hoffmann, M.R.; Coser, T.R.; Bielefeld Nardoto, G. Carbon and nitrogen dynamics in a successional agroforestry system in the Neotropics. *J. Biotechnol. Biodivers.* 2021, 9, 131–141.
18. Mosquera-Losada, M.R.; Santos, M.G.S.; Gonçalves, B.; Ferreiro-Domínguez, N.; Castro, M.; Rigueiro-Rodríguez, A.; González-Hernández, M.P.; Fernández-Lorenzo, J.L.; Romero-Franco, R.; Aldrey-Vázquez, J.A.; et al. Policy challenges for agroforestry implementation in Europe. *Front. For. Glob. Change* 2023, 6, 1127601.
19. Aconciamesa, L. Corte europea e Terra dei fuochi: La tutela pratica ed effettiva del diritto alla vita in caso di esposizione a fonti di inquinamento. *Diritti Umani e Diritto Internazionale* 2025, 19, 343–371.
20. Bookchin, M. *From Urbanization to Cities: Toward a New Politics of Citizenship*. Cassell: London, UK, 1995.
21. Dal Borgo, A.; Bocchi, S.; Capocéfalo, A.; et al. Agroforestry for the city: Farmscaping the urban fringe through transformative and participatory action research in Milan. *Agroforestry Systems* 2025, in press.
22. *Journal of Environmental Management*. Regenerative farming as climate action. *Journal of Environmental Management* 2023, 335, 117425.
23. Peeters, J.; Willems, B.; Jacobs, S.; Martin, G. Regenerative agriculture in the 2020s: A global review of soil, climate, productivity, and socio-economic evidence (2020–2025). *Frontiers in Sustainable Food Systems* 2025, 9, 45–62.
24. Arnstein, S.R. A ladder of citizen participation. *Journal of the American Institute of Planners* 1969, 35, 216–224.
25. Cornwall, A. Unpacking “participation”: Models, meanings and practices. *Community Development Journal* 2008, 43, 269–283.
26. Seyfang, G.; Smith, A. Grassroots innovations for sustainable development: Towards a new theoretical framework. *Environmental Politics* 2007, 16, 584–603.
27. *FAO Regional Office for Europe and Central Asia*. *Managing Natural Resources Sustainably and Preserving Biodiversity in a Changing Climate*. FAO Regional Priority Programme, 2024.
28. Specht, K.; Zoll, F.; Siebert, R. Urban agriculture: Social, environmental and economic benefits beyond food production. *Global Food Security* 2022, 34, 100651.
29. Dudek, A.; Rosa, M. Regenerative agriculture as a sustainable system of food production: Concepts, conditions, perceptions and initial implementations in Poland, Czechia and Slovakia. *Sustainability* 2023, 15, 15721.
30. Lefebvre, H. *The Production of Space*. Blackwell: Oxford, UK, 1991.

31. European Commission. The European Green Deal. COM(2019) 640 final. Brussels, Belgium, 2019.
32. European Commission. Horizon Europe – The Framework Programme for Research and Innovation 2021–2027. Brussels, Belgium, 2021.
33. Presidenza del Consiglio dei Ministri. Piano Nazionale di Ripresa e Resilienza (PNRR). Roma, Italy, 2021.
34. Bookchin, M. *From Urbanization to Cities: Toward a New Politics of Citizenship*. Cassell: London, UK, 1995.
35. Folke, C.; Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change* 2006, 16, 253–267.
36. Mosquera-Losada, M.R.; Santos, M.G.S.; Gonçalves, B.; Ferreiro-Domínguez, N.; Castro, M.; Rigueiro-Rodríguez, A.; González-Hernández, M.P.; Fernández-Lorenzo, J.L.; Romero-Franco, R.; Aldrey-Vázquez, J.A.; et al. Agroforestry as a sustainable land use option. *Eur. J. Agron.* 2022, 138, 126543.
37. Franco, R., Aldrey-Vázquez, J. A., Sobrino, C. C., García-Berrios, J. J., & Santiago-Freijanes, J. J. (2023). Policy challenges for agroforestry implementation in Europe. *Frontiers in Forests and Global Change*, 6, 1127601.
38. Torralba, M.; Fagerholm, N.; Burgess, P.J.; Moreno, G.; Plieninger, T. Do European agroforestry systems enhance biodiversity and ecosystem services? A meta-analysis. *Agric. Ecosyst. Environ.* 2016, 230, 150–161.
39. Milz, J.; Jacobi, J.; Velasquez, F.; Schneider, M. Four-dimensional agriculture: Successional agroforestry for ecological and socio-economic resilience building. In *Proceedings of the Tropentag 2011: Development on the Margin*, Hamburg, Germany, 5–7 October 2011.
40. Peneireiro, F.M.; Pires, A.R.K. Successional agroforestry systems: principles and methods for a regenerative agriculture. In *Agroforestry Systems: Experiences and Lessons*; CATIE: Turrialba, Costa Rica, 2014; pp. 112–125.
41. Maggi, E.; Bertocci, I.; Vaselli, S.; Benedetti-Cecchi, L. Connell and Slatyer’s models of succession in the biodiversity era. *Ecology* 2011, 92, 1399–1406.
42. De Feo, G.; Ferrara, P. The history of the waste management crisis in the Campania region of Italy. *Waste Management* 2014, 34, 2686–2695.
43. Munafò, M.; Congedo, L.; Luti, T.; Tabilio di Camati, S. Land consumption and urban expansion in Italy: Trends and indicators. *ISPRA Report* 2023.
44. Gioia, D.A.; Corley, K.G.; Hamilton, A.L. Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *Organ. Res. Methods* 2013, 16, 15–31.
45. Byrne, D. A worked example of Braun and Clarke’s approach to reflexive thematic analysis. *Qual. Quant.* 2022, 56, 1391–1412.
46. Lal, R. Soil organic matter. *Agron. J.* 2020, 112, 3265–3277.
47. Gliessman, S.R. *Agroecology: Researching the Ecological Basis for Sustainable Agriculture*. Springer: New York, NY, USA, 1990.
48. Altieri, M.A.; Nicholls, C.I.; Henao, A.; Lana, M.A. Agroecology and the design of climate resilient farming systems. *Agronomy for Sustainable Development* 2015, 35, 869–890.
49. Senanayake, R. *Analog forestry: an introduction*. Monash University: Melbourne, Australia, 1987.
50. Montano, L.; Iannuzzi, L.; Rubes, J.; Avolio, C.; Pistos, C.; Gatti, A.; Raimondo, S.; Notari, T. EcoFoodFertility – Environmental and food impact assessment on male reproductive function. *Andrology* 2014, 2(Suppl. 2), 69.
51. Bergamo, P.; Volpe, M.G.; Lorenzetti, S.; Mantovani, A.; Notari, T.; Cocca, E.; Cerullo, S.; Di Stasio, M.; Cerino, P.; Montano, L. Human semen as an early, sensitive biomarker of environmental exposure of healthy men living in highly polluted areas: A pilot biomonitoring study of trace elements in blood and semen and relationship with sperm quality and RedOx status. *Reprod. Toxicol.* 2016, 66, 1–9.
52. Montano, L.; Bergamo, P.; Andreassi, M.G.A.; Lorenzetti, S.; The role of human semen as an early and reliable tool of environmental impact assessment on human health. *Spermatozoa - Facts and Perspectives*, InTechOpen 2018, 978-1-78923-171-7.
53. Montano, L. Medeubiotics: Building resilience against environmental pollutants through agroecology, organic Mediterranean diet and eubiotics to protect ecosystem, soil and human health. In *Abstract Book of the Centennial Celebration and Congress of the International Union of Soil Sciences*, Florence, Italy, 19–21 May 2024; ID ABS WEB 138251.

54. Montano, L.; Maugeri, A.; Volpe, M.G.; Micali, S.; Mirone, V.; Mantovani, A.; Navarra, M.; Piscopo, M. Mediterranean diet as a shield against male infertility and cancer risk induced by environmental pollutants: A focus on flavonoids. *Int. J. Mol. Sci.* 2022, 23, 1568.
55. Corsetti, V.; Notari, T.; Montano, L. Effects of the low-carb organic Mediterranean diet on testosterone levels and sperm DNA fragmentation. *Curr. Res. Food Sci.* 2023, 7, 100636.
56. Santonastaso, M.; Mottola, F.; Iovine, C.; Genuardo, V.; Montano, L.; Piscopo, M.; Palmieri, I.; Rocco, L. Protective effects of anthocyanin and  $\alpha$ -tocopherol against titanium dioxide nanoparticle-induced DNA damage in human sperm cells. *Exposure and Health* 2025, Volume 17, Issue 2, pp. 523-535
57. Pretty, J. Social capital and the collective management of resources. *Science* 2003, 302, 1912–1914.
58. Nassauer, J.I. Culture and changing landscape structure. *Landscape Ecology* 1995, 10, 229–237.
59. Berkes, F. Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. *Journal of Environmental Management* 2009, 90, 1692–1702.
60. Mooney, H.A. Ecosystem Functioning and Human Well-Being: An Ecological Perspective. *Annual Review of Ecology and Systematics* 2002, 33, 1–21.
61. ISPRA. I numeri della Terra dei Fuochi. Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA): Roma, Italy, 2023. Available online: <https://www.isprambiente.gov.it/it/attivita/terra-dei-fuochi/i-numeri-della-terra-dei-fuochi> (accessed on 29 April 2026).

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