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Exploration of the Technologies Application Experience of Landscape-Scale Green Infrastructure by the Conservation Fund

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Abstract: As the earliest discussed concept of Green Infrastructure (GI), Landscape-scale GI, in the form of an ecological network capable of balancing development and conservation, has received widespread attention. Its multifunctionality is one of the important features. However, the lack of information and funding, weakness of management authority and technical support make the practice of Landscape-scale GI challenging. Compared to GI adapted in stormwater management, which has comprehensive guidance from theory to practical technologies by officials during its introduction and promotion in other countries, Landscape-scale GI, despite a rich theoretical research foundation, is often overlooked due to insufficient summary research on practical techniques. To address this gap, this study uses mixed methods research to comprehensively analyze 27 Landscape-scale GI practical projects led by the Conservation Fund over the past 20 years to explore patterns in their technical applications. Through qualitative analysis, we standardized and classified descriptive information for these 27 projects and, combined with statistical analysis, clarified the practice development trends committed to balancing development and conservation. The quantitative analysis concentrated on the corresponding relationships between technical applications and project objectives, and GI functions. Based on this, the study categorized the technologies used, summarizing core technologies applicable to most Landscape-scale GI practices, providing some support for the promotion of Landscape-scale GI.

Keywords: Green Infrastructure (GI); landscape-scale; mixed methods research; economy development; environment protection; core technology/tool

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1. Introduction

In recent years, Green Infrastructure (hereinafter referred to as GI) has become an important tool for addressing climate change, maintaining sustainable development [1], alleviating air pollution [2], managing stormwater, and enhancing urban resilience [3] with significant impacts on all aspects of the environment, society, and the economy [4–6]. As it is being promoted worldwide, it has been increasingly adopted by land management policies and strategies [7]. For example, in the United States, Benedict and McMahon first published a series of papers in 2002 using contemporary terminology to describe GI [8]. As a concept that can provide multiple functions and balance development with conservation through ecological networks, it began to attract the attention of researchers [9]. In 2007, the U.S. Environmental Protection Agency (hereinafter referred to as the EPA) formally defined GI as a stormwater control practice used to comply with Clean Water Act regulations. However, since the EPA has no formal regulatory authority over land use/land cover, the concept of GI is limited to specific stormwater management technologies which have been widely used globally [10]. The significant differences between these two definitions can illustrate the diversity and potential applications of GI.

As the application of GI continues to accumulate in different countries, regions, and localities, the descriptions of GI have become increasingly diverse. Existing research indicates that the characteristics of GI largely depend on its location and scale [11]. To provide a clearer description, researchers have begun to classify and discuss GI based on differences in scale (see Figure 1). Although GI at any scale has a certain degree of multifunctionality, the problem-solving ability of GI at different scales tends to be either “Specific” predominates or “Multiple” with almost the same effect in response to today’s environmental problems. The GI with specific functional characteristics, such as the GI defined by the EPA, is mostly implemented at Site-scale, Community-scale, and Urban-scale, often in the form of rain gardens, green roofs, vegetated swales, and other features. GI that exhibits multifunctional characteristics is found in Regional-scale GI, which emphasizes the connectivity of green spaces. However, Landscape-scale GI which encompasses various expansive landscapes based on multifunctional ecological networks is the type that best demonstrates the multifunctionality of GI as Landscape-scale provides a more macroscopic perspective; not only the spatial size, but also other factors such as the morphology of the boundaries will have an impact on the GI boundaries, making it more possible [7,12–14].

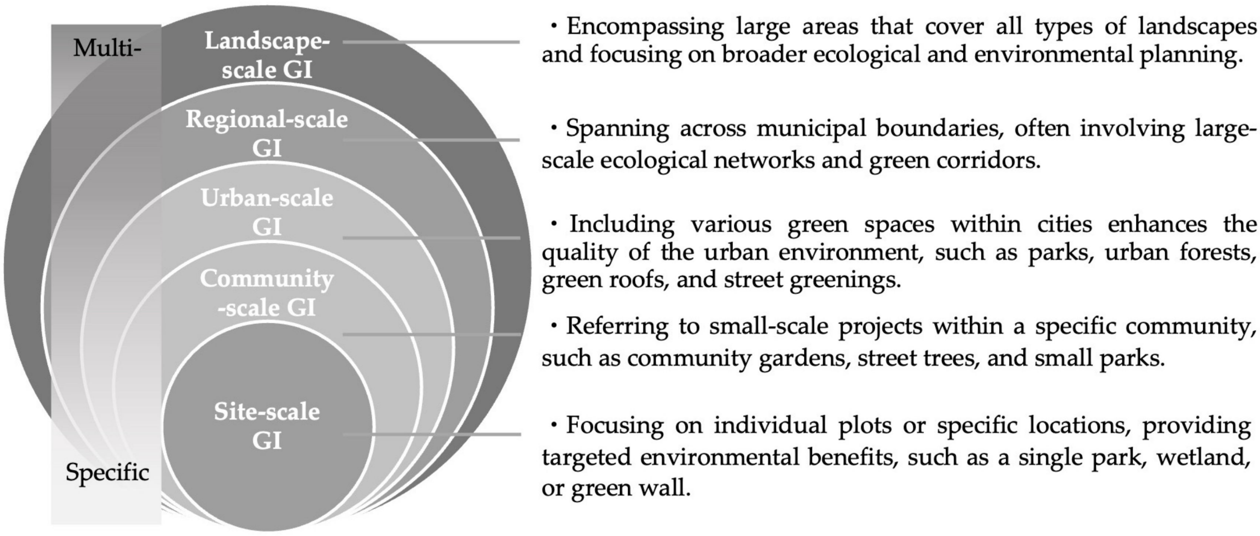

Figure 1. Different-scale GI through previous studies (summarized by author).

The initial aim of promoting GI is the focus on its multifunctionality, but the specific functions such as stormwater management have been more widely used in subsequent practices [15]. The multifunctionality of GI not only requires a Landscape-scale site involving a wider range [16] and the support of experts from multiple disciplines [17], but also makes it more difficult to manage, which also results in the infrequent and small number of Landscape-scale GI practices. Among the existing practices, there are numerous valuable cases to learn from, including those by the Conservation Fund (hereinafter referred to as the CF) over the past two decades. Actually, the summarizing practical experience is less common than theoretical research, and usually with methods like involving field observations, surveys, literature reviews, and interviews [18]. Furthermore, due to the lack of consensus among organizations regarding the understanding of GI and the limited number of organizations that have persistently engaged in Landscape-scale GI practices over extended periods, current research predominantly focuses on individual case studies and leaves significant gaps in longitudinal studies and cross-sectional analyses of developmental patterns.

The primary goal of this study is to provide a comprehensive understanding of the CF’s Landscape-scale GI practices, focusing on long-term trends, technology selection, and the broader impact of these efforts on the advancement of Landscape-scale GI. To achieve this, the study employs mixed methods research [19] and aims to bridge gaps in existing research by conducting a longitudinal and cross-sectional analysis of developmental patterns in

Landscape-scale GI. To meet this goal, the study addresses three distinct objectives, each corresponding to a specific research question:

1. What is the longitudinal trend in the CF's Landscape-scale GI practices?

We seek to understand how the CF's GI projects have evolved over the past 20 years, exploring changes in the Project Information, Purpose, GI Function and Technology/Tool application about Landscape-scale GI. By answering this question, the study will reveal patterns of development and the relevance of theory and practice.

2. What are the patterns in the CF's selection of GI technologies, and how do these choices correlate with the achievement of GI functions?

This study focuses on examining the technologies employed by the CF and how these choices align with Purpose and GI Function. This will involve a detailed assessment of how certain technologies contribute to the success of projects and their multifunctionality.

3. What is the impact of these experiences on the advancement of Landscape-scale GI?

The final objective evaluates the overall contribution of the CF's practices to the development of Landscape-scale GI, emphasizing the potential for these practices to inform future GI initiatives. By answering the third research question, the study will highlight these projects' implications for scaling up Landscape-scale GI practices.

2. Background

2.1. Disparities in the Promotion of GI

Despite the recognition of Landscape-scale GI as a critical strategy for achieving sustainable development [20], there are significant disparities in its promotion compared to other forms of GI, which are particularly evident in the regional adoption of the GI concept. For example, in Japan, GI was formally introduced into national land use and planning policies in 2015, emphasizing the use of natural functions to address social and environmental issues [21]. However, both practical and theoretical research has primarily focused on the specific GI function of stormwater management, as proposed by the EPA [22–24].

On one hand, at the Landscape-scale, the lack of information and funding, weakness of management authority, and the limitation of technical support contribute to the poor implementation of Landscape-scale GI [14]. In contrast, GI with specific functions, such as stormwater management, requires relatively less funding and land, and benefits from comprehensive guidance from theory dissemination to practical techniques [25], making its implementation more convenient. Moreover, it is challenging for different practitioners to reach a consensus on the understanding of landscape-scale GI, which is often focused on addressing specific regional issues. There are few studies that provide general experience summaries from landscape-scale GI practices, making references to the promotion of multifunctional GI scarce.

On the other hand, unlike GI with specific functions, the benefits of multifunctional GI are largely manifested in the long-term regulation of the overall macro-environment and the provision of ecosystem services [26,27]. These benefits are often difficult for residents, who are more sensitive to the micro-environment, to perceive and understand directly. Consequently, in comparison to the promotion of Landscape-scale GI, which tends to rely more on theoretical and textual descriptions, specific GI projects, such as rain gardens and green roofs which people can experience directly in their daily lives, are more likely to create a dual-coding concept that includes both imagery and textual descriptions [28]. This makes GI with specific functions more broadly acceptable to the public, leading to differing levels of effectiveness in the promotion.

2.2. Landscape-Scale GI Practice Case Study Status

A literature search in the Web of Science core database using the topic "landscape scale Green Infrastructure case study" identified a total of 42 documents explicitly focused on GI in May 2024. Analysis of these studies shows that 69% (29 papers) primarily concentrate on the practical application of GI design methodologies. The topics include regional planning applications, stormwater management, mitigation of temperature increases, GI identification, integration of GI networks and so on. Due to the emphasis of these case studies on empirical analysis of GI planning and design methods, the actual sites studied are typically limited to one to three specific areas.

Additionally, 16.7% (seven papers) of the studies are related to case evaluations. These include assessments of the effectiveness of implemented projects, empirical research validating the feasibility of evaluation methods, and studies examining the effectiveness of policies related to GI in the implementation of GI planning and design.

Finally, only 14.3% (six papers) of the studies involve summarizing practical experiences through case analyses. These include Site-scale and Community-scale summaries of practices in GI with the specific function of stormwater management, Regional-scale summaries on water resources and landscape connectivity, while only one study summarized the experience of multifunctional projects at the Landscape-scale using survey methods.

Overall, in Europe, the case studies focus on the three GI planning principles of multifunctionality, conservation, and connectivity [29], and are more numerous compared to other regions. Research on American cases tends to concentrate on stormwater management, while studies in Asian countries that have adopted GI are more inclined towards empirical research on GI planning and design methodologies. There is a relative lack of comprehensive summaries of experiences from existing Landscape-scale GI practices.

2.3. Landscape-Scale GI Practices by the Conservation Fund

The CF has protected America's most critical lands and waters to provide greater access to nature, strengthen local economies and enhance climate resiliency in all 50 states since 1985. Benedict and McMahon, who first developed the concepts associated with the multifunctional GI network, also held key positions in the organization at the time. In the early 21st century, Landscape-scale GI projects with a national impact by the CF got GI into the limelight, encouraged more scholars to conduct research, and spurred the development of GI in America and even Europe [30]. The practice by the CF confirms that GI is not only an environmental protection tool, but also provides a comprehensive planning framework that balances the dual goals of economic growth and ecological protection in the context of sustainable development [31]. In addition, there are also scholars who use their practice as a research object to verify the relationship between GI and biodiversity [32,33], and examine the correlation between the quantity and quality of natural land and landscape connectivity [34]. The CF is the only conservation organization to design GI in three of the country's largest metro areas: Chicago, Houston and Los Angeles. They also have worked in metro areas and thought big, working with whole regions and even completing the nation's largest GI plan, across 13 states [35]. According to the official website [36], there are as many as 27 Landscape-scale GI projects that the CF has been involved in guiding from 2000 to 2022 and in these projects Landscape-scale GI was described in eight similar-meaning ways (See Table 1). But there is no study that systematically analyzes and summarizes their practical experience.

Using Landscape-scale GI practices by the CF as the case study objects has the advantage of limiting the designer while qualifying the understanding to the multifunction of Landscape-scale GI as far as possible. The rich practical experience they have accumulated over the past two decades is also available for observation to fulfill the conditions of a longitudinal study [37]. Due to this, it is easier to sort out the interplay between theory and practice over time, how people's needs for Landscape-scale GI and what technologies have changed and so on through their works. Therefore, we take the important Project Information, Purpose, GI Function, and Technology/Tool in the CF's Landscape-scale GI practices as the object of study to explore their practice patterns.

Table 1. Different definition of Landscape-scale GI in the CF projects (summarized from project reports by author).

GI Definition in the Projects by the CF	Project Name
Green infrastructure is our natural life support system—an interconnected network of forests, wetlands, waterways, floodplains, and other natural areas; including parks, greenways, farms; and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources that contribute to people's health and quality of life.	Green Infrastructure Plan for Cecil County, MD
	Kent County, Delaware Rapid Assessment of Green Infrastructure
A Green Infrastructure Network is an interconnected system of natural areas and open space that conserves ecosystem values, helps sustain clean air and water, and provides benefits to people and wildlife.	Angelina County, Texas Green Infrastructure Plan
	Green Infrastructure Plan for Central Indiana-Greening the Crossroads
Green infrastructure is defined as a strategically planned and managed network of natural lands, working landscapes, and other open spaces that conserve ecosystem functions and values and provide associated benefits to human populations.	Houston-Galveston Green Infrastructure and Ecosystem Services Assessment
	Lake County Green Infrastructure Model and Strategy
Green infrastructure refers to the services provided by open spaces. Green infrastructure includes tree-lined streets, community gardens, parks, greenways, pocket parks, farmland, forestland, waterways, and bluffs. These places, great and small, when connected, make a stronger network.	"Nashville: Naturally"
Green infrastructure—and an interconnected network of parks, rivers, and lands—to help reconnect people and wildlife to the county's lands and waters.	The Emerald Necklace Forest to Ocean Expanded Vision plan for Los Angeles County
Green infrastructure investments on a regional basis at all scales, landscape through site-specific, can provide cost-effective protection for valuable transportation, energy and water treatment infrastructure, shield homes and businesses from adverse impacts, and provide additional benefits, particularly for underserved and vulnerable populations.	Greater Baltimore Wilderness Coastal Resilience Project
Green infrastructure, a complex system of land, streams, rivers, and lakes that provide and protect critical source waters. *	Upper Neuse Clean Water Initiative
Interconnected natural areas make up the region's green infrastructure network and provide important conservation landscapes for high-quality ecosystems.	Chicago Wilderness Vision

* The definition that focus on the protection of water resources

3. Methods

This study examines all relevant practical projects conducted by the CF from 2000 to 2022. Due to the long time span, the results of the projects are subject to more external influences, and traditional research methods such as interviews and field surveys are not fully applicable. Even if all of them are the CF practice cases, their documentation of the various practices may appear in many different ways of describing the same object, thus making it difficult to use the text directly for statistical analysis and requiring further generalization. Therefore, this study combined qualitative research combined with statistical analysis and the research process was divided into three main parts: Data collection, Data analysis (including coding extraction), and Interpretation of results (See Figure 2).

The database in this study is small and textual, but relying only on the judgment and discussion of the authors may lead to omission or misjudgment. Therefore, we leverage the computer's capabilities in recording, searching, matching, and linking to enhance the efficiency and effectiveness of the data analysis process [38,39]. Currently, ATLAS.ti is one of the widely used qualitative analysis software [40,41], which has been applied in GI-related research fields [10,42]. In addition, ATLAS.ti (v23.3) can import statistical results into SPSS directly for further quantitative analysis. For these reasons, we used the coding function of ATLAS.ti [43] as the main qualitative research tool and SPSS as the statistical analysis software.

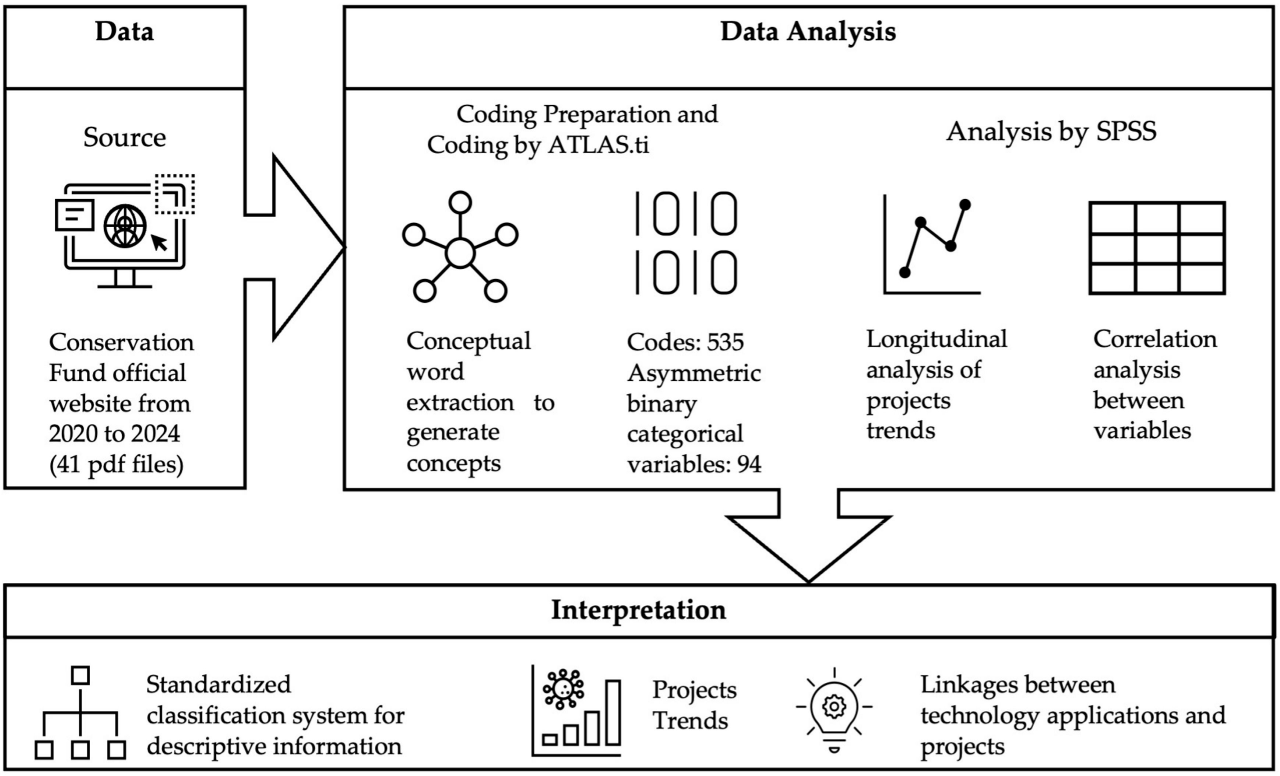

Figure 2. Research workflow (by the author).

3.1. Database Preparation

From 2000 to 2022, there were 27 Landscape-scale GI projects by the CF distributed across the United States (see Figure 3). For ease of organization, the three projects for which the exact time of implementation is unknown (links broken, etc.) are numbered as 1 to 3, and the others are in the order of the implement time (See Table 2). From the official website, there are 14 project reports and 27 website introductions. We used Adobe Acrobat DC to convert all of them into a total of 41 text-searchable PDF files to facilitate their use in the subsequent analysis.

Table 2. Projects list (ordered by the author).

No.	Project Name
01	Green Infrastructure Plan for Louisiana Wildlife Management Areas
02	Strategic Conservation Plan for Nevada
03	Green Infrastructure Plan in West Virginia
04	Greenseams®
05	Ann Arbor Greenbelt Initiative
06	Strategic Conservation for the Loxahatchee River Watershed
07	Atlanta Green Space Assessment
08	Baltimore County Land Preservation Model
09	Texas Pineywoods Experience
10	Kent County, Delaware Rapid Assessment of Green Infrastructure
11	Spartanburg Rapid Parks Assessment
12	Green Infrastructure Plan for Cecil County, MD
13	Angelina County, Texas Green Infrastructure Plan
14	Strategic Conservation for Kona, Hawai'i

Table 2. *Cont.*

No.	Project Name
15	Green Infrastructure Plan for Central Indiana-Greening the Crossroads
16	Houston-Galveston Green Infrastructure and Ecosystem Services Assessment
17	"Nashville: Naturally"
18	The Emerald Necklace Forest to Ocean Expanded Vision Plan for Los Angeles County
19	Chicago Wilderness Vision
20	Conservation Priority Mapping in West Virginia
21	Greater Baltimore Wilderness Coastal Resilience Project
22	Lake County Green Infrastructure Model and Strategy
23	Upper Neuse Clean Water Initiative
24	Finding the Flint, Flint River, Georgia
25	Green Infrastructure Vision for Cameron County, Texas
26	Mississippi River Basin/Gulf Hypoxia Initiative (MRB/GHI) Conservation Blueprint 2.0
27	Southeast Cook County Land Acquisition Plan

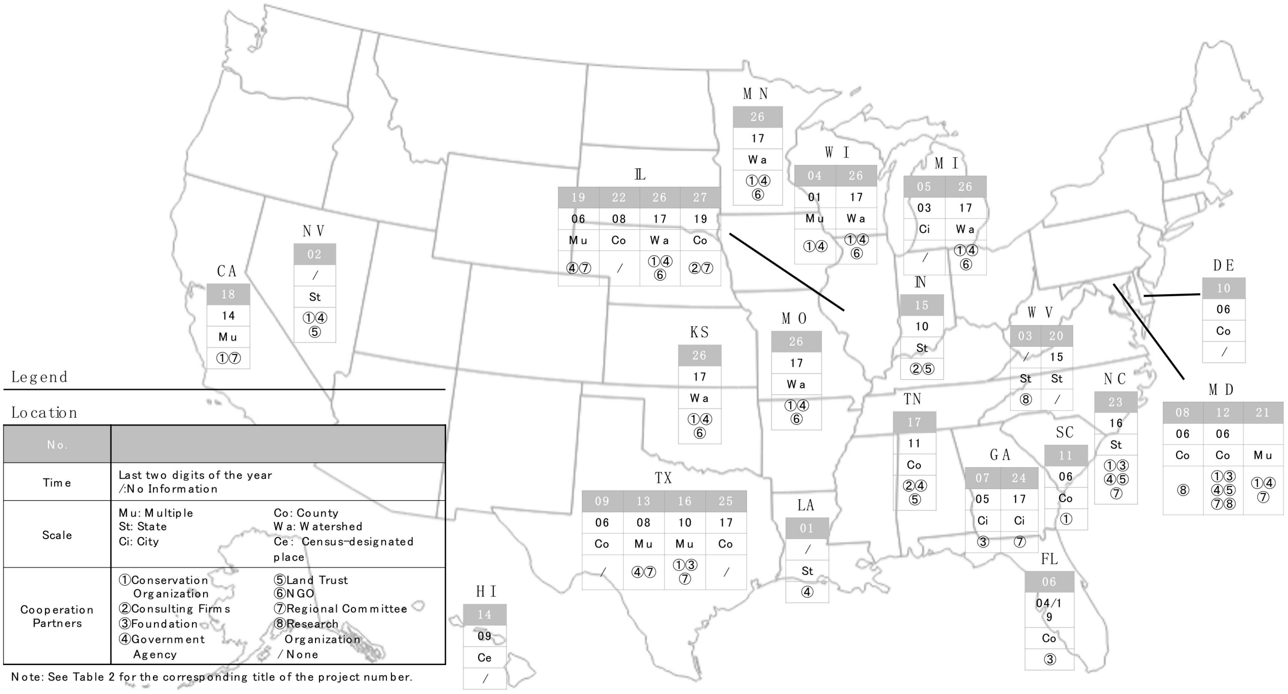

Figure 3. Projects Distribution in America (by the author).

3.2. Data Analysis

3.2.1. Determination of "Standardized Classification System for Descriptive Information" and Coding

To standardize the descriptions of the four research subjects—Project Information, Purpose, GI Function, and Technology/Tool—across different sources, in this study, we initially used ATLAS.ti (v23.3) to conduct an unsupervised machine learning analysis, which involved preliminary coding of relevant paragraphs, sentences, and graphics in the 41 project documents. In further defining the standardized descriptions based on above, there are three main treatments:

1. Standardized Project Information description. We mainly extracted Location/Scope, Cooperation Partner, and Land use/Land; these cover three aspects of Project Information, which may have constraints on the implementation of different projects. The Location/Scope classifications are consistent with the criteria used in the delineation of site boundaries, the Cooperation Partner is directly based on their own work char-

acteristics, and the Land Use/Land Cover is described in further detail using the Land Use and Land Cover Classification System [44] as a baseline.

2. Standardized Purpose and GI Function description. Unlike Project Information, there are no directly usable classification criteria for Purpose and GI Function, so we used the conceptual function in ATLAS.ti (v23.3) [45] based on the preliminary coding result to extract concept words and count the frequency of occurrence. However, the extracted concept words do not directly reflect the specific purposes and functions, so we discussed and summarized the standardized Purposes and GI Function based on the lexical nature of the concept words, the frequency of their occurrence, and the context of the original descriptions in the projects (See Tables A1 and A2).
3. Standardized Technology/Tool description. The official website discloses some of the main technologies the CF used in the GI projects [46], which are used as parts of the standardized description in this study. Other documented technologies also have been added using the same treatment as in "2".

In conclusion, under the premise of consensus reached by all authors, we proposed "Standardized Classification System for Descriptive Information (hereafter as SCSDI)" (see Table 3) and ensured that the system could fully cover the differentiated information of the 27 projects. It is worth mentioning that although the concept words "water resources" belong to the same nature and ecosystem in terms of context, the frequency of their separate occurrence is much higher than others in the same context, and there are projects that focus on the protection of water resources in the definition of GI (Table 3 with *), so "Water Resource" is discussed as a separate category of GI Function.

Table 3. Standardized Classification System for Descriptive Information Projects list (by the author).

Items	Category	Subcategory	
Project Information	Location/Scope	Census-designated place	Multiple
		City	State
		County	Watershed
	Cooperation Partners	Conservation Organization	Land Trust
		Consulting Firms	NGO
		Foundation	Regional Committee
		Government Agency	Research Organization
	Land Use and Land Cover Description	Border Area	Lake/Pond
		Coastal Area	Open Space
		Farmland	Park and Preserve
		Forest/Woodland	River/Stream
		Full Administrative Scope Area	Urban Developed Area
		Grassland	Water and Watershed
		Green Space	Wetland
Purpose	View of Development	People–Nature Connection	Preservation and Addition of City Parks/Parkland
		Economy Development	Promote Sectoral Cooperation
		Farmland Protection and Support Food Supply	Raise Environmental Awareness
		Improve People Living Environment	Stormwater/Flood Management
		Land Acquisition and Management	Use Nature Resource for Tourism
	View of Protection	Addition of Protected Area	Curb the Negative Effects of Development and Urban Sprawl
		Build Site Resilience	Nature and Resource Restoration

Table 3. *Cont.*

Items	Category	Subcategory	
Purpose	View of Protection	Conservation of Wildlife Living Environment	Priority of Nature Environment and Resource Protection
		Construct of GI Network for Conservation	Protection and Supply of Ecosystem Service
	Others	Environment Assessment	
GI Function	Nature and Ecosystem	Build Site Resilience	Determine the Minimum Area to be Protected/Utilized
		Build GI Networks	Identification of Priority Areas for Protection
		Conservation of Nature Resources	Identification of Regional Capacities/Potentials
		Conservation of Species and Habitats	Keep Balance of Protection and Utilization in Land Use
		Conservation/Addition of Nature Land	Purification of Air
		Conservation/Support of Ecosystem Service	Restoration of Natural Environment
		Curb the Negative Effects of Development and Urban Sprawl	
	People Society Activities	Build Parks and Connecting to Nature	Protection of Infrastructure
		Develop Recreation by Natural Landscapes Finance of Funds	Raise Civic Awareness and Encouraging Public Participation
		Improve People Living Environment and Public Health	Resist Disasters and Reducing the Cost of Disaster Prevention
		Preservation of Cultural Heritage	Support Economy Development
		Protection of Agricultural	Support Stabilization of Food Supply
		Communities/Agricultural Landscapes	
	Planning and Implementation	Assess Protection Ability	Provide Technical Support for the Future
		Assistance in Program/Strategy/Development	Sensitive Land Acquisition
		Guide the Future	Systematic Integration of Conservation/Restoration/ Development
	Water Resource	Protection and Purification of Water Quantity/Quality	Stormwater Management
		Protection of Waters Area	
Technology /Tool *	/	**Ecosystem Service Valuation**	Public Involvement and Cooperation Enhanced
		GIS Decision Support Tools and Map Services	**Rapid Open Space Assessments**
		Green Infrastructure Networks/Landscape Design	**Regional Conservation Visions**
		Implementation/Acquisition Targeting	Review of Previous Planning and Conservation
		Implementation Quilt	**Strategic conservation guidance**
		Leadership Forum	**Structured Decision Tools Using the Logic Scoring of Preference Method**
		Optimization Models for Cost-effective Decision-making	Travel Planning

* The technology/tools marked in bold are from the official website of the CF, and the rest are compiled from this study.

3.2.2. Coding and Characterization of Variables

Based on the SCSDI, 41 documents from 27 projects were recoded using ATLAS.ti (v23.3) to recount the occurrence of different Project Information, Purpose, GI Function, and Technology/Tool in each project.

In SCSDI, there are 94 binary variables that have only two categories of "presence" and "absence". Furthermore, project similarity is greater when the same descriptive information is "presence" compared to when it is "absence". Consequently, the variables in this study were analyzed as asymmetric binary variables. During the secondary coding process using Atlas.Ti (v23.3), the software assigns binary values 0 to indicate the "absence" or 1 to "presence" of descriptive information corresponding to each code across the 27 projects. This step does not require data normalization and all 27 projects were included in the overall characteristics analysis, with no need to remove outliers.

3.2.3. Selection of Analytical Methods and Statistical Analysis

Given the relatively small sample size of this study (27 projects), the analysis employs Chi-square tests and Fisher's exact tests to examine the correlations between variables while Phi (φ) coefficients were used to assess the strength of these correlations as they are asymmetric binary variables and do not distinguish between independent and dependent variables. The specific steps include:

1. Descriptive Statistics: SPSS is used to perform descriptive statistical analysis on the collected data. This analysis provides insights into changes in Project Information, Purpose, GI Function, and Technology/Tool over time and can also summarize the overall characteristics.
2. Correlation Analysis: The correlation between various items within SCSDI is examined by using SPSS. The primary focus is on exploring the relationships between Technology/Tool and Project Information, Purpose, and GI Function.
3. Trend and Pattern Analysis: Based on the results of the aforementioned analyses, the overall trends in Landscape-scale GI practices by the CF and the characteristic patterns in technical applications are summarized.

4. Results

Due to some projects having multiple descriptive files or duplicate descriptive information, the data exported from ATLAS.ti (v23.3) contained instances where the same code appeared multiple times for the same project. In order to avoid the impact of the above on the quantitative analysis, we corrected all instances where the same code appeared two or more times to a single occurrence, resulting in a total of 535 coded instances.

4.1. Descriptive Statistics

We counted the occurrence of each item of descriptive information according to the time of implementation, and the trends exhibited based on the time are as follows.

4.1.1. Project Information Descriptive Statistics

First, in terms of Location/Scope, County coded 11 is the most common, followed by Multiple (6) and State (5) that stretch across administrative boundaries. Except for the Ann Arbor Greenbelt Initiative (2003) and Strategic Conservation for Kona, Hawai'i (2009), which were completed independently, the CF works in partnership with other organizations and the most frequent cooperators are Government Agency (10), Conservation Organization (9) and Regional Committee (9). Meanwhile, Land Use and Land Cover Description is also dominated by Full Administrative Scope (11), while various types of water-related areas (13 in total), green open spaces like parks (7 in total), Farmland (5), and the concurrent appearance of Forest/Woodland and Grassland (3) are the major types. Woodland and Grassland (3) are the main land cover types covered (See Figure 4).

Overall, Landscape-scale GI often involves a huge range of sites, not only covering the administrative boundaries of a particular region, but also crossing multiple administrative boundaries, which makes the Land Use and Land Cover Description of the project even more diverse and makes multi-party collaborations the best option for considering all aspects of planning and design management. Among the many partners, Government Agency, Regional Committee, Conservation Organization, and resource providers are in the forefront.

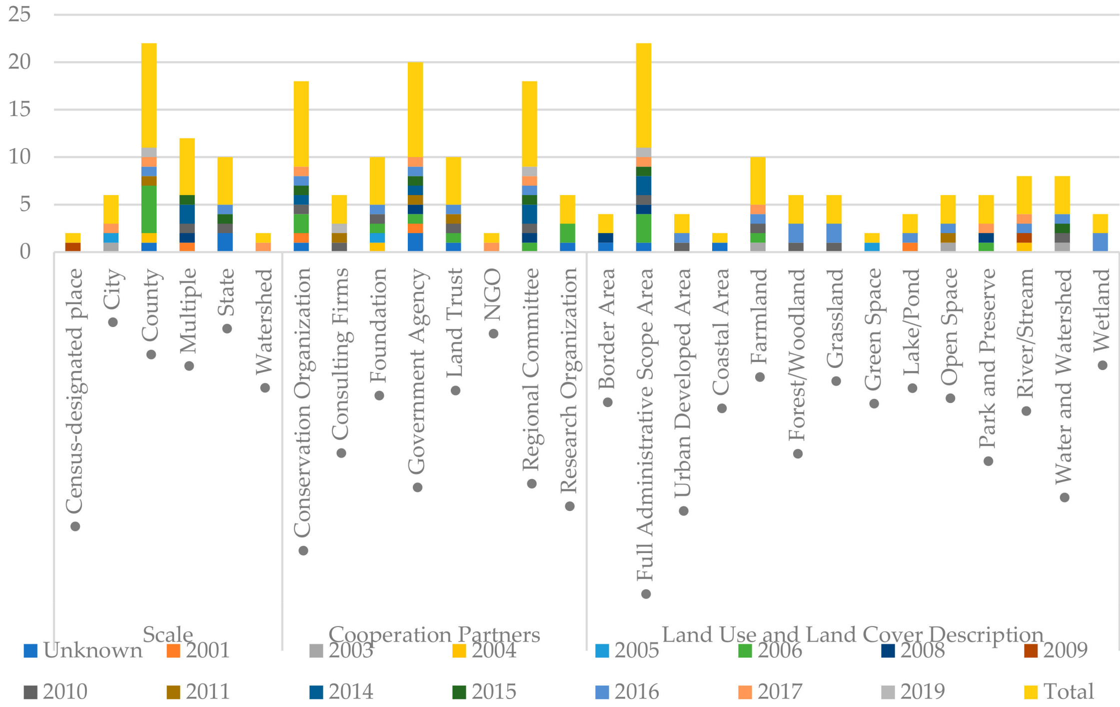

Figure 4. Stacked bar charts based on Temporal distribution of Project Information by Location/Scope, Cooperation Partners and Land Use and Land Cover Description (by the author).

4.1.2. Purpose and GI Function Descriptive Statistics

According to the results of the standardization of descriptive information, Purpose can be divided into two main categories: View of Development and View of Protection, which have almost always appeared simultaneously and in balance from the beginning until now. Although there are some projects with only one type of purpose or an imbalance between the two, conservation-oriented projects are still the majority (see Figure 5).

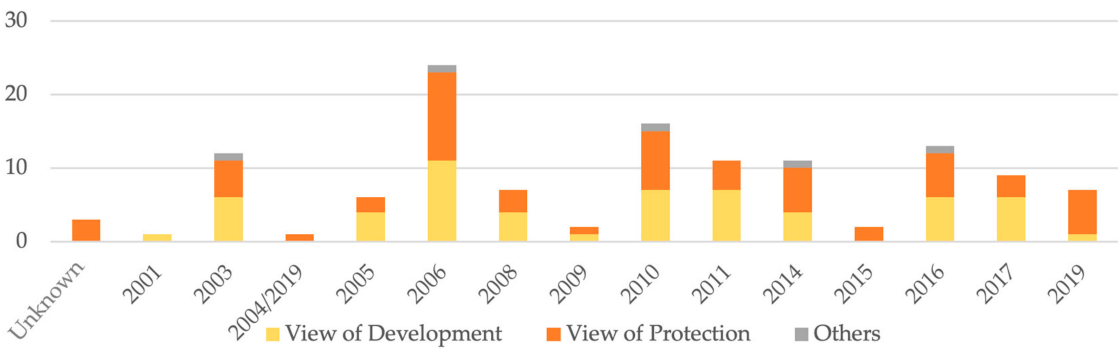

Figure 5. Stacked bar charts based on Temporal distribution of Project Purpose by Development and Protection (by the author).

In addition, the four GI Function categories of Nature and Ecosystem, People Society Activities, Planning and Implementation, and Water Resource are almost always present in a balanced manner at all stages. This demonstrates that the CF has remained true to its original concept of coexistence of development and conservation (see Figure 6).

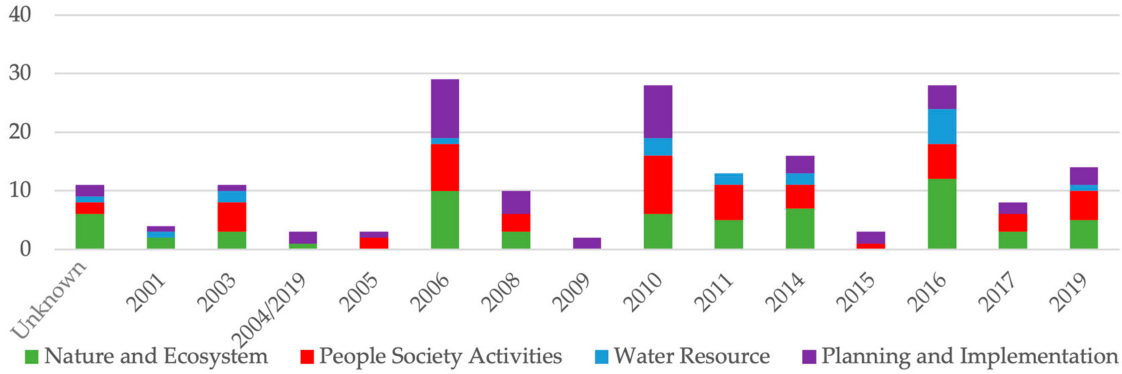

Figure 6. Stacked bar charts based on Temporal distribution of Function by Nature and Ecosystem, People Society Activities, Planning and Implementation, and Water Resource (by the author).

4.1.3. Technology/Tool Descriptive Statistics

GIS decision support tools and map services permeate all the CF practices and Strategic conservation guidance (14), Implementation/acquisition targeting (12), Structured decision tools using the Logic Scoring of Preference method (11) and Green infrastructure networks/landscape design (9) were also the main technologies used (see Figure 7). Considering the large scope and complexity of sites, it is difficult for traditional survey and analysis methods to produce ideal results in a short period of time, so the application of GIS technology and the Logic Scoring of Preference method is an inevitable choice to provide a relevant basis for decision-making. Similarly, compared with the specific design scheme, the formulation of the regional development direction, guidance for more rational land use, or the construction of GI network to constrain and control the region as a whole is also more appropriate. Other technologies adopted by the CF are also centered on the above themes.

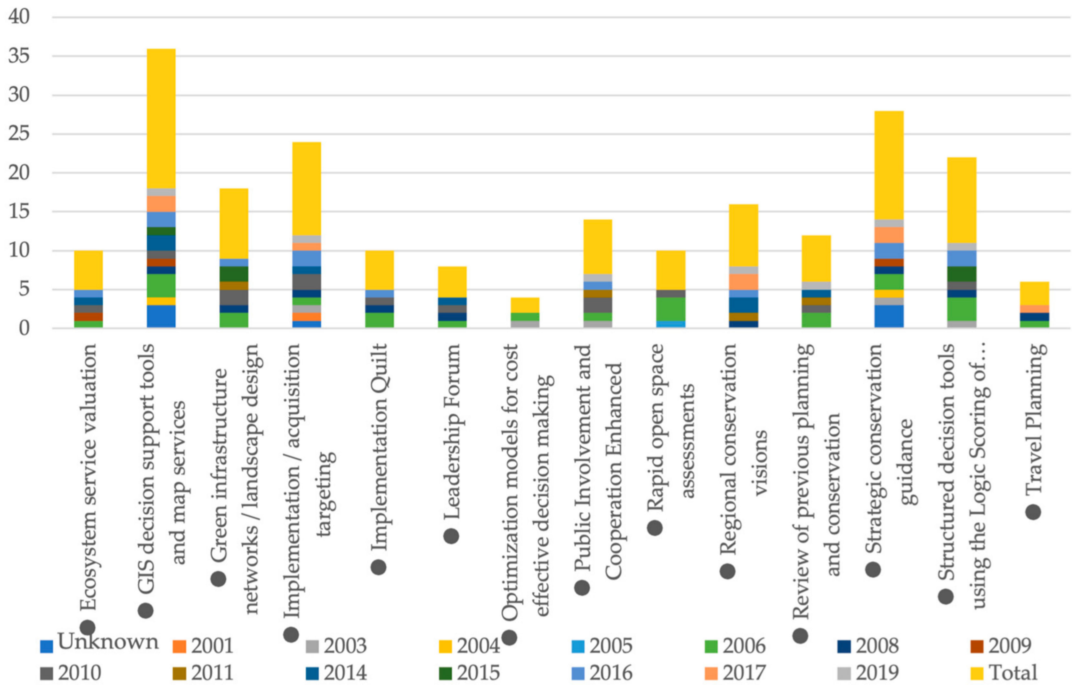

Figure 7. Stacked bar charts based on Temporal distribution of Technology/Tool (by the author).

4.2. Correlation Test

In order to find out the patterns of the CF technology application in practice, we focused on whether there are correlations and the strength between Technology/Tool and Project Information, Purpose, and GI Function. Since without distinguishing between independent and dependent variables, Cross Tabulation in SPSS was utilized to perform a 2 × 2 Fisher's exact test and a chi-square test to obtain the probability value (hereafter as p) and Phi (φ) (the sample size is less than 40). As a criterion for judging, when $p < 0.05$ it indicates that there is a correlation between the two variables, while Phi (φ) between 0.3–0.6 indicates a strong correlation and Phi (φ) > 0.6 indicates an extremely strong correlation [47,48].

We separately counted the category and subcategory variables being applied in these 27 projects and conducted correlation tests. Since the sample size for conducting the correlation test for each category is greater than 40, and the sample for testing each subcategory is 27 less than 40, the Pearson was used to determine the correlation for each category and the Fisher's exact test was used for each subcategory.

4.2.1. Technology/Tool and Project Information Correlation

From the results that realized a significant relationship (See Table 4), the Location/Scope did not influence the CF's choice of Technology/Tool. In terms of Cooperation Patterner, the probability of applying Public Involvement and Cooperation Enhanced is higher for projects with Consulting Firms and Land Trust. Sites within Full Administrative Scope require Review of previous planning and conservation more frequently; Implementation Quilt is more likely to be applied when Urban Developed is involved; Optimization models for cost-effective decision-making were chosen more often when there was Farmland on the site; and the probability of applying Public Involvement and Cooperation Enhanced was higher when there was Open Space and Water and Watershed. The most special feature is that Park and Preserve only appears together with Travel Planning, and it can be basically judged that the CF regards Travel Planning as an important technology to deal with Park and Preserve sites.

Table 4. Relevant Technology/Tool and Project Information correlation analysis results (by the author).

Technology/Tool	Cooperation Partners		Land Use and Land Cover Description					
	Consulting Firms	**Land Trust**	**Full Administrative Scope**	**Urban Developed**	**Farmland**	**Open Space**	**Park and Preserve**	**Water and Watershed**
Implementation Quilt		$p = 0.030$ Phi (φ) = 0.509		$p = 0.028$ Phi (φ) = 0.593				
Optimization Models for Cost-effective Decision-making					$p = 0.028$ Phi (φ) = 0.593			
Public Involvement and Cooperation Enhanced	$p = 0.012$ Phi (φ) = 0.598	$p = 0.009$ Phi (φ) = 0.588				$p = 0.012$ Phi (φ) = 0.598		$p = 0.042$ Phi (φ) = 0.467
Review of Previous Planning and Conservation			$p = 0.027$ Phi (φ) = 0.463					
Travel Planning							$p \leq 0.001$ Phi (φ) = 1.000	

Blank indicates that the correlation is not significant.

4.2.2. Technology/Tool and Purpose Correlation

Other Purpose: Environmental Assessment, with Green infrastructure networks/landscape design ($p = 0.011$, Phi (φ) = 0.533) and Rapid open space assessments ($p = 0.006$, Phi (φ) = 0.575) have some correlation, and other correlation tests are as follows:

1. Technology/Tool and View of Development Purpose (See Table 5). The six Technology/Tool as Ecosystem service valuation, GIS decision support tools and map services, Green infrastructure networks/landscape design, Implementation/acquisition targeting, Public Involvement and Cooperation Enhanced, and Regional conservation visions showed a statistically significant relationship between Technology/Tool and View of Development Purpose, but in terms of subcategory of these purposes, Raising Environmental Awareness had four Technology/Tool with relevance, Using Nature Resource for Tourism had three, and Stormwater/Flood Management had none. The remaining purposes all have 1–2 relevant Technology/Tool.

Table 5. Relevant Technology/Tool and View of Development Purpose correlation analysis results (by the author).

	View of Development									
Technology/Tool	**Category Total**	**Addition of People-Nature Connection**	**Economy Development**	**Farmland Protection and Support Food Supply**	**Improve People Living Environment**	**Land Acquisition and Management**	**Preservation and Addition of City Parks/ Parkland**	**Promoting Sectoral Cooperation**	**Raising Environmental Awareness**	**Using Nature Resource for Tourism**
Ecosystem Service Valuation	$p = 0.022$ Phi (φ) = 0.145		$p = 0.030$ Phi (φ) = 0.472							
GIS Decision Support Tools and Map Services	$p \leq 0.001$ Phi(φ) = −0.261				$p = 0.030$ Phi(φ) = −0.472					
Green Infrastructure Networks/ Landscape Design	$p \leq 0.001$ Phi (φ) = 0.223							$p = 0.008$ Phi (φ) = 0.567	$p = 0.023$ Phi (φ) = 0.478	
Implementation Quilt	$p = 0.037$ Phi (φ) = 0.131								$p = 0.024$ Phi (φ) = 0.491	
Leadership Forum									$p = 0.042$ Phi (φ) = 0.467	
Optimization Models for Cost-effective Decision-making				$p = 0.017$ Phi (φ) = 0.678						
Public Involvement and Cooperation Enhanced	$p \leq 0.001$ Phi (φ) = 0.267	$p = 0.050$ Phi (φ) = 0.421				$p = 0.042$ Phi (φ) = 0.467		$p = 0.024$ Phi(φ) = 0.497	$p = 0.050$ Phi (φ) = 0.421	
Rapid Open Space Assessments						$p = 0.013$ Phi (φ) = 0.606				
Regional Conservation Visions	$p = 0.002$ Phi (φ) = 0.194									$p = 0.027$ Phi (φ) = 0.467
Review of Previous Planning and Conservation							$p = 0.043$ Phi (φ) = 0.529			
Structured Decision Tools Using the Logic Scoring of Preference Method										$p = 0.004$ Phi (φ) = 0.197
Travel Planning			$p = 0.029$ Phi (φ) = 0.500							$p = 0.019$ Phi (φ) = 0.545

Blank indicates that the correlation is not significant.

2. Technology/Tool and View of Protection Purpose (See Table 6). Seven of the Technology/Tool as Ecosystem service valuation, Green infrastructure networks/landscape design, Implementation/acquisition targeting, Public Involvement and Cooperation Enhanced, Regional conservation visions, Review of previous planning and conservation and Structured decision tools using the Logic Scoring of Preference method showed a statistical correlation with View of Protection Purpose. However, only two Technology/Tool: Ecosystem service valuation and Public Involvement and Cooperation Enhanced, showed relevance to the subcategory purposes, and Public Involvement and Cooperation Enhanced was the Technology/Tool with the highest number of correlations.

Table 6. Relevant Technology/Tool and View of Protection Purpose correlation analysis results (by the author).

Technology/Tool	**View of Protection**				
	Category Total	**Construct of GI Network for Conservation**	**Curb the Negative Effects of Development and Urban Sprawl**	**Priority of Nature Environment and Resource Protection**	**Protection and Supply of Ecosystem Service**
Ecosystem Service Valuation	$p = 0.004$ Phi (φ) = 0.207			$p = 0.016$ Phi (φ) = 0.495	$p = 0.030$ Phi (φ) = 0.509
Green Infrastructure Networks/Landscape Design	$p = 0.008$ Phi (φ) = 0.187				
Implementation Quilt	$p = 0.013$ Phi (φ) = 0.172				
Public Involvement and Cooperation Enhanced	$p \leq 0.001$ Phi (φ) = 0.349	$p = 0.023$ Phi (φ) = 0.478	$p = 0.009$ Phi (φ) = 0.588	$p = 0.033$ Phi (φ) = 0.445	
Regional Conservation Visions	$p = 0.017$ Phi (φ) = 0.171				
Review of Previous Planning and Conservation	$p = 0.024$ Phi (φ) = 0.167				
Structured Decision Tools Using the Logic Scoring of Preference Method	$p = 0.004$ Phi (φ) = 0.197				

Blank indicates that the correlation is not significant.

4.2.3. Technology/Tool and GI Function Correlation

1. Technology/Tool and Nature and Ecosystem Function (see Table 7). We found that there are as many as seven Technology/Tool that have relevance to Nature and Ecosystem Function, but only five subcategory functions (less than half) have relevance to one or two Technology/Tool. In terms of Technology/Tool, the most relevance to various Nature and Ecosystem Function are Public Involvement and Cooperation Enhanced and Regional conservation visions. In addition, Green infrastructure networks/landscape design is only relevant to one subcategory function, Implementation Quilt, Review of previous planning and conservation and Structured decision-making tools using the Logic Scoring of the Preference method are relevant for the whole category only.

2. Technology/Tool and People Society Activities Function (see Table 8). There are seven subcategory of People Society Activities Function that have at least two Technology/Tool with relevance; Support Economy Development has relevance with as many as four Technology/Tool, followed by Improve People Living Environment and Public Health with three. In terms of Technology/Tool, except Ecosystem service valuation, Optimization models for cost-effective decision-making, and Strategic conservation guidance, as many as 11 were associated with this category and only Green infrastructure networks/landscape design did not have a subcategory function

associated with it while Implementation Quilt, Leadership Forum, Rapid open space assessment and Travel Planning in contrast did.

Table 7. Relevant Technology/Tool and Nature and Ecosystem Function correlation analysis results (by the author).

Technology/Tool	Nature and Ecosystem					
	Category Total	**Build Site Resilience**	**Building GI Networks**	**Conservation of Nature Resources**	**Conservation of Species and Habitats**	**Purification of Air**
Green Infrastructure Networks/Landscape Design				$p = 0.007$ Phi (φ) = 0.590		
Implementation/ Acquisition Targeting	$p < 0.001$ Phi (φ) = 0.239	$p = 0.003$ Phi (φ) = 0.598				
Implementation Quilt	$p = 0.031$ Phi (φ) = 0.121					
Public Involvement and Cooperation Enhanced	$p < 0.001$ Phi (φ) = 0.198	$p = 0.024$ Phi (φ) = 0.497		$p = 0.042$ Phi (φ) = 0.467		$p = 0.024$ Phi (φ) = 0.497
Regional Conservation Visions	$p < 0.001$ Phi (φ) = 0.184		$p = 0.011$ Phi (φ) = 0.542		$p = 0.008$ Phi (φ) = 0.562	$p = 0.044$ Phi (φ) = 0.434
Review of Previous Planning and Conservation	$p = 0.004$ Phi (φ) = 0.161					
Structured Decision Tools Using the Logic Scoring of Preference Method	$p = 0.047$ Phi (φ) = 0.111					

Blank indicates that the correlation is not significant.

Table 8. Relevant Technology/Tool and People Society Activities Function correlation analysis results (by the author).

Technology/Tool	People Society Activities							
	Category Total	**Build Parks and Connecting to Nature**	**Develop Recreation by Natural Landscapes**	**Improve People Living Environment and Public Health**	**Raise Civic Awareness and Encouraging Public Participation**	**Resist Disasters and Reducing the Cost of Disaster Prevention**	**Support Economy Development**	**Support Stabilization of Food Supply**
GIS Decision Support Tools and Map Services	$p = 0.018$ Phi (φ) = −0.141							$p = 0.029$ Phi (φ) = −0.500
Green Infrastructure Networks/Landscape Design	$p = 0.007$ Phi (φ) = 0.159							
Implementation/ Acquisition Targeting	$p < 0.001$ Phi (φ) = 0.219						$p = 0.024$ Phi (φ) = 0.491	
Implementation Quilt					$p = 0.013$ Phi (φ) = 0.606			
Leadership Forum							$p = 0.042$ Phi (φ) = 0.467	
Public Involvement and Cooperation Enhanced	$p < 0.001$ Phi (φ) = 0.371	$p = 0.024$ Phi (φ) = 0.497		$p = 0.002$ Phi (φ) = 0.657	$p = 0.042$ Phi (φ) = 0.467	$p = 0.001$ Phi (φ) = 0.700	$p = 0.050$ Phi (φ) = 0.421	$p = 0.012$ Phi (φ) = 0.598
Rapid Open Space Assessments				$p = 0.030$ Phi (φ) = 0.472				

Table 8. *Cont.*

Technology/Tool	People Society Activities							
	Category Total	Build Parks and Connecting to Nature	Develop Recreation by Natural Landscapes	Improve People Living Environment and Public Health	Raise Civic Awareness and Encouraging Public Participation	Resist Disasters and Reducing the Cost of Disaster Prevention	Support Economy Development	Support Stabilization of Food Supply
Regional Conservation Visions	$p = 0.014$ Phi (φ) = 0.146		$p \leq 0.001$ Phi (φ) = 0.746				$p = 0.011$ Phi (φ) = 0.542	
Review of Previous Planning and Conservation	$p < 0.001$ Phi (φ) = 0.204			$p = 0.008$ Phi (φ) = 0.567				
Structured Decision Tools Using the Logic Scoring of Preference Method	$p = 0.010$ Phi (φ) = 0.152	$p = 0.027$ Phi (φ) = 0.463				$p = 0.027$ Phi (φ) = 0.463		
Travel Planning			$p = 0.029$ Phi (φ) = 0.500					

Blank indicates that the correlation is not significant.

3. Technology/Tool and Planning and Implementation Function (see Table 9). Half of the Planning and Implementation Function subcategories had relevance to one or two Technology/Tool, with as many as four Technology/Tool having relevance to Guiding the Future. On the other hand, fewer than half of Technology/Tool had relevance to this category or subcategories, and none of them had more than two.

Table 9. Relevant Technology/Tool and Planning and Implementation Function correlation analysis results (by author).

Technology/Tool	Planning and Implementation			
	Category Total	Guiding the Future	Providing Technical Support for the Future	Systematic Integration of Conservation/ Restoration/ Development
Ecosystem Service Valuation	$p = 0.006$ Phi (φ) = 0.228	$p = 0.017$ Phi (φ) = 0.526		
Green Infrastructure Networks/Landscape Design	$p = 0.006$ Phi (φ) = 0.223		$p = 0.023$ Phi (φ) = 0.478	
Implementation/ Acquisition Targeting	$p = 0.024$ Phi (φ) = 0.181			
Implementation Quilt	$p = 0.001$ Phi (φ) = 0.264	$p = 0.017$ Phi (φ) = 0.526		
Leadership Forum			$p = 0.042$ Phi (φ) = 0.467	
Public Involvement and Cooperation Enhanced	$p = 0.006$ Phi (φ) = 0.221	$p = 0.011$ Phi (φ) = 0.542		$p = 0.050$ Phi (φ) = 0.421
Structured Decision Tools Using the Logic Scoring of Preference Method	$p = 0.004$ Phi (φ) = 0.230	$p = 0.033$ Phi (φ) = 0.452		

Blank indicates that the correlation is not significant.

4. Technology/Tool and Water Resource Function (see Table 10). Although there are not many subcategories of Water Resource Function, each of them has one or two Technology/Tool associated with, which are Implementation/acquisition targeting, Public Involvement and Cooperation Enhanced and Review of previous planning and conservation.

Table 10. Relevant Technology/Tool and Water Resource Function correlation analysis results (by the author).

Technology/Tool	**Water Resource**			
	Category Total	**Protection and Purification of Water Quantity/Quality**	**Protection of Waters Area**	**Stormwater Management**
Implementation/ Acquisition Targeting	$p < 0.001$ Phi (φ) = 0.384	$p = 0.024$ Phi (φ) = 0.491		
Public Involvement and Cooperation Enhanced	$p < 0.001$ Phi (φ) = 0.470		$p = 0.042$ Phi (φ) = 0.467	$p \leq 0.001$ Phi (φ) = 0.727
Review of Previous Planning and Conservation				$p = 0.044$ Phi (φ) = 0.434

Blank indicates that the correlation is not significant.

5. Discussion

5.1. Selection and Expansion of Technology/Tool

Over the past two decades since the concept of GI was introduced, its theoretical development and applications have expanded across various fields. Landscape-scale GI is integral to people's lives and affects the overall macro-scale ecological environment [49]. The diverse development requires more support for implementation, as seen in the CF's projects, which rely on collaborations for land, technology, funding, and management.

As the forms of Landscape-scale GI practices continue to diversify, the technologies applied by the CF are also increasing. In addition to the nine technologies officially provided by the CF, we have identified five additional technologies from project documents. Among these, the Leadership Forum and Implementation Quilt frequently co-occur with GI network design. The Implementation Quilt refers to tools recommended for their potential application during project implementation, which align with specific aspects of the GI network design process. Additionally, Travel Planning is a specialized technology predominantly applied in recreation-related projects. On the other hand, in these five additional technologies, Public Involvement and Cooperation Enhanced and Review of Previous Planning and Conservation appear more frequently compared to the other three technologies.

5.2. Interaction between Technology/Tool and Project Information

It appears that aside from recreational use when the CF is handling Park and Preserve projects, there is no strong correlation between other objective project conditions and the technological applications. This is consistent with other research findings, as parks not only provide green spaces for local residents but are also often part of visitors' itineraries, especially when the parks and preserves are well-known tourist attractions [50].

Furthermore, some of these projects are commissioned by other organizations. Although collaborators are one of the objective conditions of the projects, as commissioning parties, they have subjective intentions to participate. The site scope and land type are influenced by the will of the commissioning parties, which means that the project description information is not entirely based on the CF's independent judgment. Therefore, we contend that these correlations do not necessarily indicate that these relevant technologies will always be applied when these Cooperation Partners are involved or when these types of land are being managed.

5.3. Experience of the CF Technology/Tool Applications

Each Technology/Tool performs different roles in projects by the CF. In terms of Purpose and GI Function, the analysis results revealed the following three situations (see Table 11):

Table 11. Technology/Tool Performance with Purpose and GI Function (by the author).

Technology/Tool	Adopted Times	Situation Type for Purpose Relevance *			Situation Type for GI Function Relevance **			
		VD	VP	O	NE	PSA	PI	WR
Implementation/Acquisition Targeting	12	S(3)	S(2)		S(3)	S(3)	S(2)	S(3)
Public Involvement and Cooperation Enhanced	7	S(3)	S(3)		S(3)	S(3)	S(3)	S(3)
Green Infrastructure Networks/Landscape Design	9	S(3)	S(2)		S(1)	S(2)	S(3)	S(1)
Review of Previous Planning and Conservation	6	S(1)	S(2)		S(2)	S(3)		
Structured Decision Tools Using the Logic Scoring of Preference Method	11	S(1)	S(2)		S(2)	S(3)	S(3)	
Regional Conservation Visions	8	S(3)	S(2)		S(3)	S(3)		
Ecosystem Service Valuation	5	S(3)	S(3)				S(3)	
GIS Decision Support Tools and Map Services	18	S(3)				S(3)		
Implementation Quilt	5				S(2)	S(1)	S(3)	
Travel Planning	3	S(1)				S(1)		
Leadership Forum	4	S(1)					S(1)	
Rapid Open Space Assessments	5	S(1)				S(1)		
Optimization Models for Cost-effective -Decision-making	2	S(1)						
Strategic Conservation Guidance	14							

* S(1)–(3): Situation (1)–(3); VD: View of Development Purpose; VP: View of Protection Purpose; O: Other Purpose; ** S(1)–(3): Situation (1)–(3); NE: Natural and Ecosystem Function; PSA: People Society Activities Function; PI: Planning and Implementation Function; WR: Water Resource Function.

- Situation (1): The Technology/Tool is correlated with a subcategory Purpose/GI Function but not with the general category it belongs to. This indicates that the CF prioritizes this Technology/Tool for achieving a particular Purpose/GI Function. However, it may not be applicable to another Purpose/GI Function within the same category.
- Situation (2): The Technology/Tool is correlated with a category of Purpose/GI Function but not with any subcategory. This situation is not uncommon, suggesting that while the Technology/Tool may have weaker specificity, it provides support across the entire category of Purpose/GI Function.
- Situation (3): The Technology/Tool is correlated with a subcategory Purpose/GI Function and also with the category it belongs to. This indicates that the Technology/Tool not only has a targeted effect on a particular Purpose/GI Function but also provides support for others within the same category.

5.3.1. According to Purpose

It is clear that Public Involvement and Cooperation Enhanced holds a crucial position in achieving various Landscape-scale GI purposes. Additionally, the correlation between Technology/Tool and different Purpose varies. Specifically:

- In View of Development Purpose: There are six of Technology/Tool in Situation (1), none in Situation (2), and six in Situation (3). Moreover, nearly all nine subcategories of View of Development Purpose are associated with one or two related Technology/Tool.

- In View of Protection Purpose: There are no Technology/Tool in Situation (1), five in Situation (2), and two in Situation (3). Additionally, only four subcategories of View of Protection Purpose are associated with one or two related Technology/Tool.

The reason for these differences is that development-oriented purposes have a degree of independence in their technological requirements, while conservation-oriented purposes share a stronger commonality. This also indicates that the Technology/Tool adopted by the CF have a stronger correspondence with development-oriented purposes, while they exhibit broader applicability when addressing conservation-oriented purposes, enabling them to meet various natural environmental needs.

5.3.2. According to GI Function

Public Involvement and Cooperation Enhanced also holds a significant position and the correlation between Technology/Tool and GI Function varies across different subcategories:

- In Natural and Ecosystem Function: There is one of Technology/Tool in Situation (1), three in Situation (2), and three in Situation (3). Only half of the subcategories have associated Technology/Tool.
- In People Society Activities Function: There are four of Technology/Tool in Situation (1), one in Situation (2), and six in Situation (3). Seven subcategories have at least two associated Technology/Tool.
- In Planning and Implementation Function: There is one of Technology/Tool in Situation (1), one in Situation (2), and five in Situation (3). Half of the subcategories have associated Technology/Tool.
- In Water Resource Function: There is one of Technology/Tool in Situation (1), none in Situation (2), and two in Situation (3). Each subcategory has at least one associated Technology/Tool.

Comparing the correlation analysis results between Purpose and Technology/Tool reveals that the distribution trends of People Society Activities Function and View of Development Purpose, as well as Natural and Ecosystem Function and View of Protection Purpose, are highly consistent. This indicates that the Technology/Tool adopted by the CF exhibit a certain degree of independence in their social functions, while natural functions are more interconnected. This also indirectly validates the correspondence between purposes and functions proposed in the SCSDI of this study, aligning with the general consensus. Additionally, the correlation analysis results for Planning and Implementation Function and Water Resource Function are primarily in Situation (3), indicating that the Technology/Tool/Tool used by the CF possess universality.

5.3.3. Performance of the CF Technology/Tool Applications

From the statistical perspective, Implementation/Acquisition Targeting, Public Involvement and Cooperation Enhanced, Green Infrastructure Networks/Landscape Design, Review of Previous Planning and Conservation, and Structured Decision Tools Using the Logic Scoring of Preference (hereafter as LSP) Method provide strong support across various aspects of the CF's practices.

- "Implementation/Acquisition Targeting", as an officially endorsed method by the CF, characterized by clear target positioning, serves as a foundational tool for project implementation. It has been applied 12 times, highlighting its widespread use.
- "Green Infrastructure Networks/Landscape Design", another officially recognized method, exhibits clear correlations with various types of projects, empirically validating the widely accepted theoretical connection between multifunctional GI at the Landscape-scale and interconnected spatial networks [51–54]. However, it is noteworthy that this technology was applied only nine times across 27 projects, indicating that while network form and landscape design are key mediators in achieving GI multifunctionality, other forms of Landscape-scale GI may also be viable.

- "Structured Decision Tools Using the LSP Method", also publicly available from the CF, is a Multi-Criteria Evaluation (hereafter MCE) method designed for the assessment and comparison of complex systems [55]. It encompasses every measurable attribute relevant to Landscape-scale GI [56], with criteria tailored to the reasonable needs of different stakeholders [57]. This approach assists decision-makers in comprehensively considering various factors to make scientifically informed and optimal choices [58].
- "Public Involvement and Cooperation Enhanced", as identified in this study through document analysis, has been similarly validated in GI practices in other regions, particularly within the European Union. Public involvement is widely recognized as a means to ensure that planning decisions reflect public interests, better understand local conditions, and foster a mutual understanding between stakeholders and designers regarding the design proposals, which contribute to the long-term, high-quality maintenance of GI spaces in turn [59]. However, the effectiveness of participation can vary depending on the project stage and the identity of the participants. While research indicates that the involvement of government, business, academia, and civil society is crucial and indispensable, issues such as incomplete coverage of participant identities and low participation rates still persist [60,61].
- "Review of Previous Planning and Conservation" aids participants in gaining a better understanding of the local context, identifying the strengths and weaknesses of past planning and conservation efforts, and making targeted improvements in new GI projects. Although related planning policies often reference GI concepts, they may differ in the depth of their considerations compared to actual GI projects. Drawing on experiences from GI practice, recommendations can be made to optimize planning policies, reducing restrictions on GI and maximizing the benefits for both planning and GI outcomes [62].

Compared to the previously mentioned Technology/Tool, Regional Conservation Visions, Ecosystem Service Valuation, GIS Decision Support Tools and Map Services, and Implementation Quilt have a somewhat narrower scope of application but still provide strong support in their respective areas. These tools and approaches, while more focused in their application, are crucial in aiding the effective implementation and optimization of GI projects, particularly in conservation planning, spatial analysis, and valuation of ecosystem services.

- "Regional Conservation Visions" go beyond simple ecological restoration by identifying and designating areas of conservation value, offering a more advanced approach to protection [63].
- "GIS Decision Support Tools and Map Services" is the most frequently employed computational aid in this identification process. Since the 1990s, GIS has proven to be a valuable tool for spatially presenting and analyzing information layers, offering decision-makers accessible and manageable data [64]. GIS-based decision support systems facilitate communication between researchers and decision-makers and provide a platform for multidisciplinary studies.
- "Ecosystem Service Valuation" and other tools like it are still being refined; they enable the calculation of the added value generated by GI investments, providing developers with a basis for assessment and helping to mitigate potential obstacles in GI project investments [65].
- "Implementation Quilt", as summarized in reports, alongside tools designed for specific objectives such as Optimization Models for Cost-Effective Decision Making and Rapid Open Space Assessments, serve similar roles, offering targeted support for specialized goals.

The supporting role of the more specific Strategic conservation guidance is also not to be underestimated. Although not statistically correlated with Purpose and GI Function alone, it was used 14 times, second only to GIS decision support tools and map services, which were used 18 times. The supportive role is also not to be underestimated.

5.4. Classification of Technology/Tool Used by the CF

Based on the Situation (1)–(3) relationships of each Technology/Tool corresponding to the Purpose and GI Function (See Table A3), and considering the small number of samples and the fact that the variables are all asymmetric binary variables, we utilize Hierarchical clustering in SPSS and select the Jaccard measure to classify the Technology/Tools used by the CF (See Figure 8), which can be broadly classified into the following two categories (See Table 12).

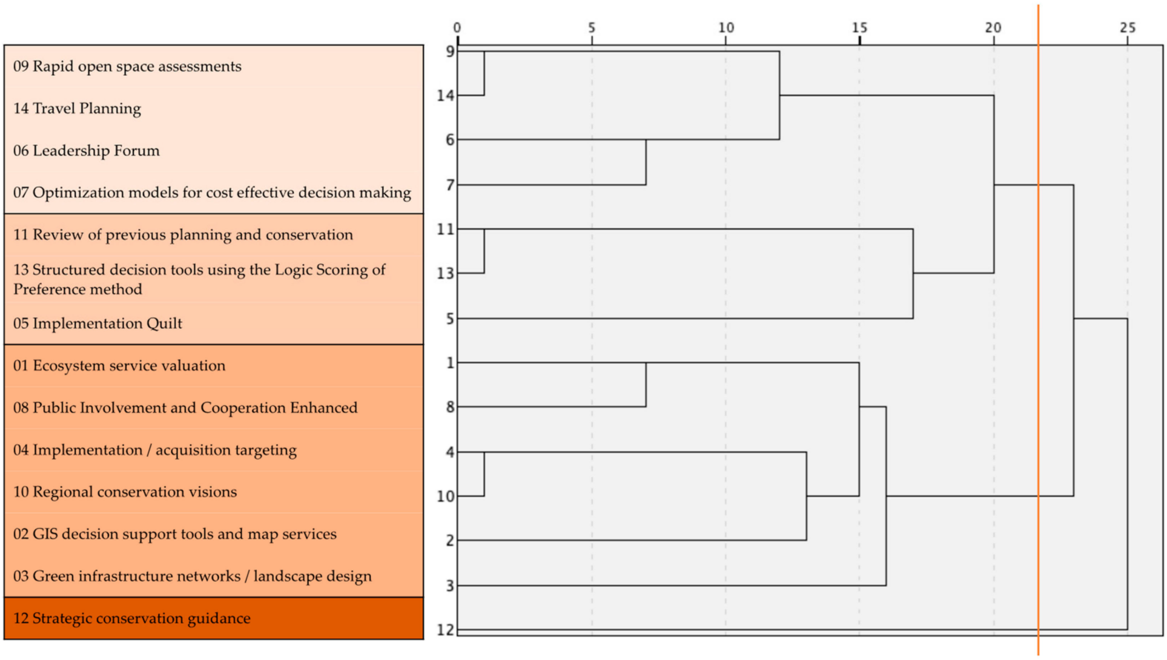

Figure 8. Dendrogram of Technology/Tool (from SPSS by the author).

Table 12. Technology/Tool Classification (by the author).

Classification	Technology/Tool		Adopted Times
Core Technology/Tool	12	Strategic Conservation Guidance	14
	01	Ecosystem Service Valuation	5
	02	GIS Decision Support Tools and Map Services	18
	03	Green Infrastructure Networks/Landscape Design	9
	04	Implementation/Acquisition Targeting	12
	08	Public Involvement and Cooperation Enhanced	7
	10	Regional Conservation Visions	8
	05	Implementation Quilt	5
Specialized Technology/Tool	11	Review of Previous Planning and Conservation	6
	13	Structured Decision Tools using the Logic Scoring of Preference Method	11
	06	Leadership Forum	4
	07	Optimization Models for Cost-effective Decision-making	2
	09	Rapid Open Space Assessments	5
	14	Travel Planning	3

Core Technology/Tool:

In the practice by the CF, this category of technologies has demonstrated the ability to address the objectives from different perspectives, meeting the demands of most GI projects.

- Implementation/Acquisition Targeting ensures that clear objectives are set before the project begins.
- Green Infrastructure Networks/Landscape Design control the spatial form of GI.
- GIS Decision Support Tools and Map Services provide an objective and comprehensive assessment of the overall environment.
- Ecosystem Service Valuation and Regional Conservation Visions deepen the focus of GI-specific practices.
- Public Involvement and Cooperation Enhanced ensure that projects are effectively implemented throughout their lifecycle.

These core technologies are crucial for the successful execution of GI projects, offering comprehensive support from planning and design to implementation and evaluation.

Specialized Technology/Tool:

Compared to the balanced nature of Core Technology/Tool, this category exhibits a stronger focus on specific functions or purposes. Implementation Quilt, Review of Previous Planning and Conservation, and Structured Decision Tools using the Logic Scoring of Preference (LSP) Method support natural, social, and planning functions. Additionally, the latter two technologies are correlated with certain purposes from both development and conservation perspectives. When there are clear economic development and planning needs, the CF tends to adopt more targeted technologies such as Leadership Forum, Optimization Models for Cost-effective Decision-making, Rapid Open Space Assessments, and Travel Planning.

These specialized technologies are applied selectively based on the specific requirements of a project, providing tailored solutions that address particular aspects of GI initiatives.

6. Conclusions

This study conducted both qualitative and quantitative analyses of 27 Landscape-scale GI practices by the CF, proposing a standardized classification system for descriptive information. It summarizes the trends and experiences of Landscape-scale GI practices over the past two decades and explores the patterns of the CF's technological applications. This research marks the first attempt to integrate qualitative and quantitative analyses through a unified descriptive information framework to conduct a case study of Landscape-scale GI. It is also the first longitudinal study of Landscape-scale GI cases spanning over 20 years. The results indicate that the CF's practices have consistently aimed to balance development and conservation, perpetuating the theoretical foundations of Landscape-scale GI. The practice sites are predominantly at the county level or across administrative boundaries, with collaborators mainly being government entities or regional managers providing management assistance and organizations offering financial or land resources. Based on the correlation analysis of various Purpose and GI Function, the 14 technologies employed by the CF can be categorized into Core Technology/Tool applicable to a wide range of projects and Specialized Technology/Tool that are more targeted towards specific objectives. The correlation analysis further validated the feasibility of these Landscape-scale GI technologies from a practical perspective, clarified the contexts in which these technologies are applicable, and highlighted the potential of Landscape-scale GI.

From the perspective of promoting Landscape-scale GI, this study verifies the feasibility of the theory of GI balancing development and conservation in practice through the longitudinal analysis of CF cases, which is conducive to enhancing the credibility of promoting landscape-scale GI. In addition, the results of identifying the applicable environments and categorizing for the 14 technologies can help establish a technology roadmap for Landscape-scale GI in the promotion process, assisting new projects in selecting the most applicable technologies according to their goals and other objectives, and improving the success rate of the practice. Meanwhile, the conclusions can provide data support for the relevant departments to help formulate more scientific and reasonable Landscape-scale GI promotion policies.

There are some potential limitations in this study. To control variables, this research primarily focuses on longitudinal studies targeting a single subject, which may introduce limitations in the definition and understanding of Landscape-scale GI. While this study has verified the feasibility of this case study method, it remains to be seen whether the standardized results for descriptive information will still be effective when the number of cases increases and the cases are not just concentrated in the same country. Future research will include longitudinal studies of Landscape-scale GI practices by other organizations and countries for comparison, aiming for a more detailed and comprehensive exploration of Landscape-scale GI and refinement of this research method. In addition, if conditions permit, we consider conducting a long-term tracking study of multiple organizations to observe their application and adaptation of GI techniques and strategies at different stages to further understand the sustainability and long-term effects of these approaches. Although this study has summarized the technologies used in Landscape-scale GI practices, the actual application of these technologies requires interdisciplinary support. The core theories and more detailed application guidelines of each technology are crucial in the specific practice. It is hoped that this study will attract researchers from various fields to collaboratively improve the guidelines for Landscape-scale GI practices, thereby facilitating the better promotion of Landscape-scale GI.

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Appendix A

The data obtained through analysis using Concept in Atlas.Ti (v23.3).

Table A1. Standardization of the Purpose Concepts.

Objective Objects *			Interests *			Main Thrust of the Operation *			Practical Approach *		
**Category ** **	**Concept**	**Freq.**	**Category ** **	**Concept**	**Freq.**	**Category ** **	**Concept**	**Freq.**	**Category ** **	**Concept**	**Freq.**
Biotype	wildlife	9	All	opportunity	14	Utilization	Development	21	Planning Type	plan/planning	15/9
	people	5		benefit	11		use	9		project	9
Natural and Ecological Resources	land	34		need	8		tourism	6		strategy	8
	water	24		quality	6	Conservation	conservation	13		program	6
	resource	21		additional	5		protection	9		vision	6
	forest	8		impact	5		preservation	5		policy	4
	ecosystem	6		change	4		support	5		framework	3
	nature	6		effect	4				Operation	process	8
	source	6		growth	4					management	8
	landscape	5		future	3					information	5
	stream	4		value	3					Acquisition	4
	tree	4	View of Nature	priority	8					assessment	4
	river	3		forest preserves	5					decision	4
Spatial Morphology	network	22		restoration	5					implementation	4
	corridor	8		no loss	4					issue	4
	system	6	View of Human	health	6				Limitation	year	8
	trail	6		recreation	6						
	greenway	4		enjoyment	4						
Site	area	21		ecosystem service	4						
	County	18		supply	4						
	Acre	16		economy	3						
	Region	14		food	3						
	community	13									
	city	11									
	state	8									
	downtown	6									
Land type	park/parkland	13/3									
	habitat	10									
	asset	5									
	farm/farmland	3/3									
Disaster	flood	5									
	stormwater	5									

* Classification Based on the Parts of Speech of Conceptual Words; ** Classification Based on the Context of Conceptual Words.

Table A2. Standardization of the GI Function Concepts.

Objective Objects *			Interests *			Main Thrust of the Operation *			Practical Approach *		
Category **	**Concept**	**Freq.**	**Category ****	**Concept**	**Freq.**	**Category ****	**Concept**	**Freq.**	**Category ****	**Concept**	**Freq.**
Natural and Ecological Resources	Land	53	All	Quality	27	Utilization	Development	19	Planning Type	Plan/Planning	26/10
	Ecosystem	25		Benefit	19		Use	10		Study	13
	Air	19		Value	19	Conservation	Conservation	30		Strategy	10
	Specie	17		Opportunity	18		Protection	14		Program	8
	Climate	17		Impact	10		Support	11		Vision	6
	Soil	16		Change	9				Operation	Assessment	17
	Resource	16		Future	7					Project	17
	Forest	14		Addition	7					Effort	14
	Plant	13	View of Nature	Restoration	10					Management	10
	Carbon	12		Priority	9					Investment	10
	Vegetation	9	View of Human	Recreation	19					Process	9
	life	9		Ecosystem service	18					Decision	8
	Bird	7		Cost	17				Limitation	Year	15
	Tree	7		Health	16					Level	10
	Animal	6		Production	11					Term	7
Water Resources and Water Management	Water	49		Food	10						
	Wetland	20		Treatment	8						
	Flood/Flooding	14/13		Economy	7						
	Stormwater	13		Emission	7						
	River	10		Property	7						
	Lake	9									
	Runoff	8									
	Groundwater	8									
	Watershed	7									
	Stream	7									
	Sediment	7									
Spatial Morphology	Space	22									
	System	21									
	Network	19									
	Trail	13									
Disaster	Greenway	10									
	Greenbelt	8									
Wild live Survival	Wildlife	26									
	Parcel	10									
	Habitat	20									
	Corridor	15									
People Society Activities	Resident	15									
	Activity	10									
	People	9									
	Visitor	8									
	Business	8									
	Agency	7									
	Pollutant	6									

Table A2. *Cont.*

Objective Objects *			Interests *			Main Thrust of the Operation *			Practical Approach *		
**Category ** **	**Concept**	**Freq.**	**Category ** **	**Concept**	**Freq.**	**Category ** **	**Concept**	**Freq.**	**Category ** **	**Concept**	**Freq.**
Site	Area	41									
	Community	40									
	Park/Parkland	30/7									
	County	22									
	Acre	21									
	Region	20									
	State	13									
	Site	12									
	City	8									

* Classification Based on the Parts of Speech of Conceptual Words; ** Classification Based on the Context of Conceptual Words.

Appendix B

The data obtained through analysis using SPSS (v29.0.1.0).

Table A3. Situation (1)–(3) relationships of each Technology/Tool corresponding to the Purpose and GI Function (by the author) *.

Technology/Tool	**Development**			**Protection**			**Other**	**Nature**			**Society**			**Planning**			**Water**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Ecosystem Service Valuation	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
GIS Decision Support Tools and Map Services	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
Green Infrastructure Networks/Landscape Design	1	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	0	0	0
Implementation/ Acquisition Targeting	1	0	0	0	1	0	0	1	0	0	1	0	0	0	1	0	1	0	0
Implementation Quilt	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0
Leadership Forum	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Optimization Models for Cost-effective Decision-making	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public Involvement and Cooperation Enhanced	1	0	0	1	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0
Rapid Open Space Assessments	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
Regional Conservation Visions	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Review of Previous Planning and Conservation	0	0	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1
Strategic Conservation Guidance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A3. *Cont.*

Technology/Tool	Development			Protection			Other	Nature			Society			Planning			Water		
	S1	S2	S3	S1	S2	S3	S	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
Structured Decision Tools Using the Logic Scoring of Preference Method	0	0	1	0	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0
Travel Planning	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

* S(1)–(3): Situation (1)–(3); The value 1 indicates the presence of a relationship, while the value 0 indicates the absence of a relationship.

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