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What Is the Future of the Bush Capital? A Socio-Ecological Approach to Enhancing Canberra's Green Infrastructure

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Abstract: Canberra, a city known as a "garden city" that emerged in the early twentieth century, is developing at a speedy rate. The compact city vision for Canberra was announced in ACT Planning Strategy 2018 while the city encounters climate change impacts. Although urban compaction has its own benefits, it is considered a challenge for maintaining and developing the quality and quantity of urban green spaces. Canberra owns a unique urban design legacy and is known for its bush capital/garden city character, which has intertwined the social and ecological layers of the city. The concern around urban compaction and densification calls for holistic green infrastructure (GI) planning to balance the built and non-built infrastructure. To do so, it is necessary to understand the underlying social-cultural and ecological layers of Canberra's green spaces and the Ecosystem Services (ESS) they offer. The application of multiple ESS in the current GI planning and governance practices is another issue that needs to be examined to inform future development. Thus, this qualitative research seeks to understand the ESS discourses in Canberra's GI and the challenges in applying these ESS in planning and governance. We used a socio-ecological approach to design the research and understand the multidimensional values and benefits of Canberra's green spaces. We adopted semi-structured interviews with twelve experts from relevant disciplines with specific knowledge of Canberra's urban landscape and green spaces to find out the socio-ecological synopsis of Canberra's GI and green spaces governance. We found that it is necessary to mainstream multiple ESS in Canberra's GI to amplify the existing socio-ecological values. The abundance of green spaces in Canberra can be better used to make a multifunctional landscape that serves multiple ESS. However, we identified the maintenance and budget issues as the main challenges that can be addressed by improving community engagement. To design an effective GI network and mainstream ESS in green spaces, the planning and governance system should employ a transdisciplinary, multi-object and multi-scale approach and state-of-the-art technologies. Moreover, this research underlined the importance of a protocol and guidelines that monitor the landscape projects' design and delivery correspondence to the high-level policies.

Keywords: green infrastructure; green space; socio-ecological thinking; green infrastructure governance; Canberra

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1. Introduction

Urban compaction is known as an effective strategy to control urban sprawl and urban development's destructive impact on natural elements [1,2]. However, it is a potential threat to the quality and quantity of urban green spaces (UGS) [3]. In addition, there is an increasing concern regarding the climate change crisis, which has drawn decision-makers' attention to the importance of green spaces for increasing urban resilience [4–7]. Rapid urbanisation, urban compaction, and the climate change crisis have resulted in a growing interest in UGS and developing approaches to integrate UGS in urban planning to benefit people and environment [8–11].

One of the tools to enhance the human environment and conserve nature is Green Infrastructure (GI). GI was introduced as a strategic planning network of interconnected

patches of various green spaces (natural, semi-natural, informal and human-made) [12,13]. GI planning is considered a socio-ecological phenomenon where human needs, ecosystem functions and green spaces are overlaid [14]. The urban GI concept contributes to a better inclusion of services offered by UGS in the spatial planning and design policies and guidelines [15,16]. UGS includes any type of green space within the urban footprint boundary. It can be designed parks, street verges, nature reserves (which usually are green patches that survive in and around the urban fabric), and spontaneous (informal) green spaces. UGS is identified as a critical element of an urban landscape for enhancing cities' aesthetics, health, and ecological function [17]. In recent decades, the global interest in "re-naturing" or "re-wilding" cities has increased [10,18], drawing attention to the role of UGS in improving biodiversity and nature appreciation values. Green space benefits were defined as ecosystem services (ESS) in the 1970s [19] which means material, goods, and services such as food and clean air, and non-material services such as aesthetic values that a healthy ecosystem provides to people [20,21]. The ESS concept was further developed in the following decades. In 2005, in the Millennium Ecosystem Assessment report, ESS was classified into four broad categories: regulating (e.g. air and water quality, flood control, and wastewater treatment), supporting (e.g. biodiversity values, habitat for fauna and soil quality), provisioning (any natural products obtained from ecosystems such as fibre, food and fuel), and cultural (non-material and spiritual benefits and values such as recreation, aesthetic etc.) [22]. Although the ESS classification paved the way towards better inclusion of multiple greenspace benefits, the provision of ESS within urban GI is very complex and intertwined with the level of community engagement and the complexity of consideration of multiple ESS and different ownerships [23]. Hence, researchers argue that a socio-ecological analysis of the site helps to identify the values and benefits that UGS offer and reveals the gaps in the inclusion of multiple ESS in GI planning and delivery [17,24,25]. Studies emphasised the importance of interrogating urban GI planning from both socio-cultural and ecological aspects to design a more inclusive GI that can serve people better and function ecologically [17,26–28].

In Australian cities, green spaces are significant components of the urban landscape. Australian cities still contain many remnants of native vegetation, while in most cities in other countries, original landscapes have disappeared [29]. However, considering the existing native remnants within the urban footprint and ample UGS in Australian cities, urban densification can be regarded as an ongoing threat. A growing body of research is discussing the urgency of the protection of native remnants against urban development [30–32] and increasing the quality and quantity of UGS to mitigate climate change challenges [33,34].

GI planning that respects and considers the local characteristics and features of Australian cities is a developing field of study, and all the state governments are trying to incorporate the GI concept in developing high-level policies [35]. For example, urban forestry strategies aim to increase tree canopy cover, and water sensitive urban design (WSUD) targets managing water resources by designing site-specific green spaces such as rain gardens and bio-swales. Even green roofs and wall design considers the principles of managing urban water cycles in sustainable ways [36]. However, GI planning is unique in the context of Canberra, a city that was designed and constructed in the 20th century to function as the national capital of Australia. Canberra's urban design is based on the concept of landscape as the national identity. Accordingly, compared to other Australian cities, numerous green spaces (planted native/exotic, native revegetation, and remnant native vegetation) are spread within the urban environment. In 2012, a more compact and efficient city vision was announced for the future of Canberra with the target of 70% of urban development to be focused within the existing built environment, aiming to control the spread of the urban footprint on the surrounding natural green spaces [37]. While it is an effective strategy to protect the surrounding natural landscape and minimise urban footprint, there is a concern about how Canberra's green character, urban GI network and quantity and quality of UGS should be conserved and promoted [33].

Canberra's green character is a unique combination of nature and culture [38], and the necessity of understanding the socio-ecological dimensions attached to its green spaces is fundamental to making the city socially and ecologically resilient while it is developing and densifying [5,39]. Currently, there is a knowledge gap in the research on the mechanism for conserving and improving UGS against urban densification. Moreover, the delivery of planning and governance practices needs to be examined to discover the hindrance as well as potential approaches towards mainstreaming ESS in Canberra's GI network while implementing urban compaction. Our recent study [38] identified the opportunities and constraints for Canberra's future GI planning. We highlighted the opportunity to develop and enhance the urban GI network based on the socio-cultural and ecological potentials identified in policy documents and the governance system.It includes the diversity of UGS types, the heritage values associated with the existing trees, the regulations in effect to protect existing trees, and the current community engagement.

Accordingly, this research aims to identify the complex interrelations of socio-cultural and ecological values and the gaps in the existing practices of Canberra's GI planning and governance. This socio-ecological knowledge can shed light on better integration of GI planning in the future development of this city by incorporating multiple ESS. To investigate these values and benefits and add to existing knowledge, we adopted a qualitative method of semi-structured interviews with experts who are knowledgeable and experienced in GI planning in Australia with specific study practices on Canberra's landscape. In this research, we aimed to answer the following research questions:

(1) What are the socio-cultural and ecological values and perspectives regarding Canberra's green spaces from the perspective of relevant experts?
(2) What are the perceived opportunities and challenges associated with GI planning and green space design practice in Canberra from experts' perspectives?
(3) How can socio-ecological benefits and concerns regarding Canberra's existing green spaces be articulated better in future GI planning and governance?

2. Methods

2.1. Case Study

Canberra (located in the Australian Capital Territory) is the largest Australian inland city. It was designed by an American couple (Walter Burley Griffin and Marion Mahoney Griffin) in 1912 and officially established in 1913. Canberra is distinct from other Australian cities because it is purposely designed from the ground up as the seat of the Australian government. The city was designed based on a landscape vision, and its urban design and planning were inspired by the Garden City and the City Beautiful movements [40]. The extensive planting of native and exotic trees on the treeless plain (named Yass Canberra) eventually represented the city's character as a garden city. By the mid of 20th century, Canberra was dominated by green spaces with vistas of forested mountains, resulting from the idea of a city that is respectfully located in its natural setting [41]. However, Canberra was developing rapidly after the 1950s and an urban development strategy was required to guide future development. The key strategic plan adopted for Canberra's development (Y plan) in 1967 was a multi-centred urban form of a series of towns with open spaces such as parklands and green corridors in between [42]. The model committed to the Griffin plan and targeted the preservation of hills, ridges and native forested mountains; however, it resulted in a scattered urban form (Figure 1) [43]. In the same decade, the construction of the key elements of Griffin's plan, such as Lake Burley Griffin, led to the introduction of nationally significant spaces that should be preserved in future urban development.

With the increased global attention to environmental values after the mid-20th century, the values of native vegetation in Australia were spotlighted, which led to the planting of more native trees within the urban environment. Accordingly, the value of natural landscapes and the importance of their conservation were better perceived. In Canberra, this momentum raised concern regarding the scattered and rapid urban development that might impact the natural landscape within and around the city.

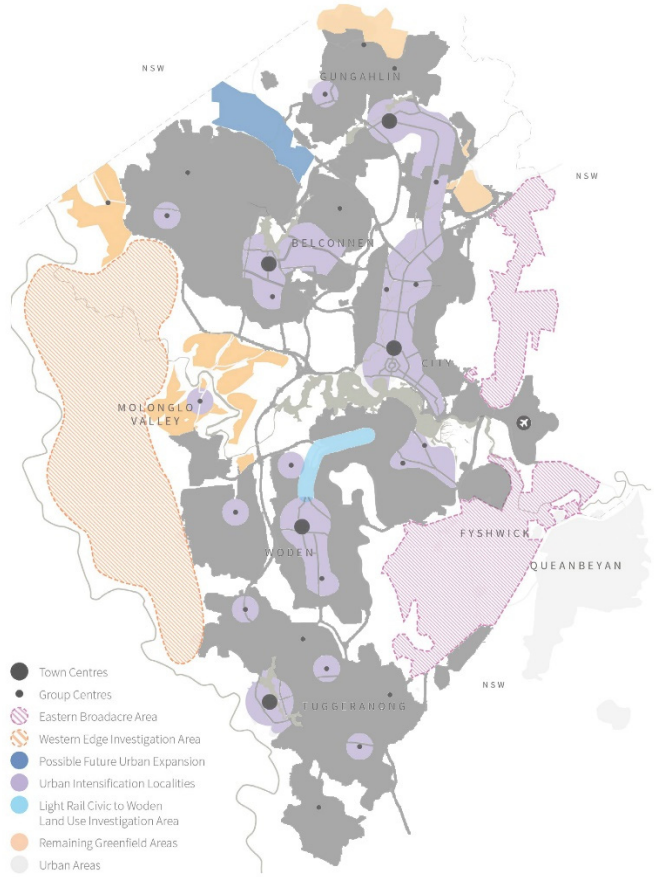

Figure 1. The dark grey colour shows the scattered urban form and the purple colour shows the urban intensification localities. Adapted from Figure L4: Current and future urban growth in the ACT, with permission from Office of the Commissioner for Sustainability and the Environment (2019). Licensed under a Creative Commons Attribution (CC BY 3.0) licence.

Consequently, in the 1970s, the National Capital Open Space System (NCOSS) was introduced to conserve and protect the native remnant green spaces and the Lake against urban development and human interventions. NCOSS is Canberra's most enduring element [44], which goes through and around the suburbs and defines the urban form. With the increased attention to Canberra's remnant native habitats (woodlands and grasslands) in recent years, Canberra's "garden city" character has morphed into a "bush capital". Currently, both unique characters of the garden city (which is mostly based on an Anglo-American vision and exotic tree species) and the bush capital, with an emphasis on native vegetation, coexist in Canberra. Accordingly, future developments should carefully consider the historic and existing green character, environmental challenges, and landscape-sensitive design legacy in the decision-making process.

2.2. Methodology

The socio-ecological approach has been getting more attention since the past decade in the research relevant to urban greening [45,46]. This approach is developed based on ESS categories introduced in Millennium Ecosystem Assessment 2005 [22] and considers both societal context (human well-being, cultural and spiritual values) and natural conditions (biodiversity, ecosystem health and heat mitigation) values and concerns [23,45]. However, a successful GI implementation that considers the socio-ecological benefits and values needs careful planning and ongoing long-term governance. The degree to which socio-ecological knowledge can be effective and useful depends on to what extent we are able to apply this knowledge in GI planning and sustain it in governance [20].

We adopted (a) ESS knowledge, (b) planning and (c) governance as a central framework for our research investigation to discover the challenges of consideration and application of multiple ESS in Canberra's GI planning and governance practices (Figure 2).

Figure 2. The framework of the study. Source: Authors.

To better understand the experts' perspectives on socio-ecological benefits and values associated with Canberra's GI and the challenges to mainstream ESS in current urban GI planning and governance practice a survey strategy was adopted. This strategy is suitable for qualitative descriptive research with the aim "to observe (gather information on) certain phenomena, typically at a single point in time" [47] (p. 261). Therefore, a semi-structured interview with experts was selected to collect the primary data. Semi-structured interviews provide the opportunity to ask open questions and make a more in-depth conversation and examine the question from multiple perspectives through follow-up responses [48].

The experts were selected by a mix of purposeful sampling and snowball sampling to identify and select information-rich participants. This method is mostly used for qualitative research [49]. Purposeful sampling is based on identifying and selecting people with special knowledge about the research area. Snowball sampling is a sampling technique used to recruit interviewees among their acquaintances, meaning that suitable cases would be suggested by the interviewed people [49,50]. Therefore, the first potential participants (n = 18) were determined by adopting purposeful sampling and were selected by reading publications on Canberra's "urban landscape", "green space", "open space", and "green infrastructure" in which participants were involved as an author. However, only nine selected interviewees were responsive to the invitation. Due to the COVID-19 pandemic and lockdown, some potential interviewees were not able to participate. Six interviewees were identified by snowball sampling and were invited by emai; however, three experts agreed to be interviewed. A total of twelve semi-structured interviews were carried out between March 2021 and April 2022. The conducted interviews reflect perspectives expressed by experts from the relevant disciplines such as urban design, urban planning, urban ecology, urban forestry, and landscape architecture who had research as well as practical experience and knowledge of Canberra's green spaces (Table 1).

Table 1. List of participants and their expertise.

Participants (P)	Expertise
P1	Landscape Architecture
P2	Urban Ecology
P3	Urban Design
P4	Town and Regional Planning and Urban Governance
P5	Urban ecology and Botany
P6	Urban planning
P7	Urban Forestry
P8	Urban Forestry and environmental science
P9	Urban design
P10	Urban Planning
P11	Landscape Architecture and urban design
P12	Landscape Architecture
Total	12

Eleven interviews were conducted virtually and one in a face-to-face meeting. A formal email was sent to the selected people and provided information about the research, including the participant information form (PIF) and participant consent form (PCF). The anticipated interview time was 40 min, but the duration varied from 30 min to 1.5 h with the participant's consent and willingness to continue the discussion. The interviews were audio-recorded, and a transcription of all interviews was prepared.

Directed content analysis was adopted as a method to develop the initial themes and codes using NVivo software version 12 plus (Figure 3). A direct approach to content analysis seeks to validate or extend conceptually a theoretical framework or theory. "It can provide predictions about the variables of interest or the relationships among variables, thus helping to determine the initial coding scheme or relationships between codes." [51] (p. 1281). The analysis of interviewees' responses to the open-ended questions (Table 2) and expectations that are in common among academics and experts aimed to identify the discourse on the ESS, the consideration of these ESS, and the challenges in planning and practice.

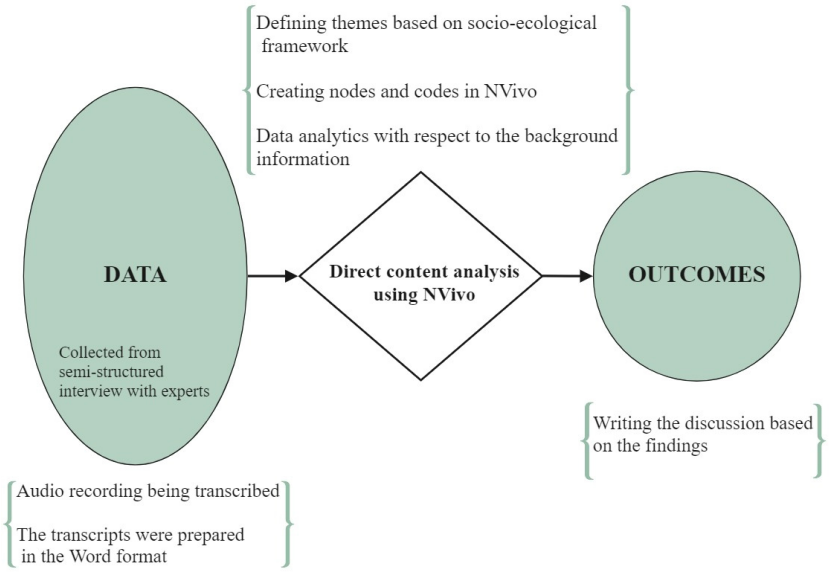

Figure 3. Direct content analysis method using NVivo. Authors.

Table 2. Open-ended questions designed for the interviews.

•	Background information
1	Includes education, academic position, research focus, and study experience on the urban green spaces and GI (in Canberra and Australia)
•	Ecology and Environmental perspectives
2	Which type of green space, in your opinion, is more vulnerable to climate-related challenges and urban development pressure in Canberra? (Why? Which factors do they contain that make them more vulnerable?)
3	Which type of green space, in your opinion, is more resilient? (Why? Which factors do they contain that make them resilient?)
•	Social perspective
4	Which type of green space in Canberra is more associated with socio-cultural values?
5	How can we involve socio-cultural values in urban GI planning?
6	What is the contribution of native and exotic trees in creating green spaces' cultural and social values?
•	Planning and governance perspective
7	Which types of UGS are more important in the planning of Australian cities and particularly in Canberra? Please explain why you think they are more important (e.g., culturaland ecological significance, national significance, etc.)
8	What are the strengths and challenges in GI planning practice in Australia? What about Canberra? What are the research gaps in GI planning?
9	How can the government use community resources to better manage and maintain green spaces?
10	What steps are necessary for GI planning for sustainable development patterns (implications for policymakers, community groups, etc.)?

3. Results

3.1. Ecological Perspective

Responses to the questions regarding the vulnerability and resiliency of green spaces to climate change include the following four themes: (a) consideration of Canberra's urban form and the residential suburbs, (b) fire threat for houses close to natural green spaces, (c) flood and WSUD, (d) urban heat island effect (UHI) and the importance of street trees.

Canberra's scattered urban form was argued by interviewers from two different perspectives. One perspective spotlighted the built environment footprint, and the other focused mainly on the benefits of the open spaces between residential suburbs. For example, P3 addressed the negative impact of the sprawling suburban model of the city that increases car dependency and CO2 emissions. However, P12 argued that, despite many ongoing discussions about the unsustainability of the suburban sprawl model, this model increases the resiliency of the city to climate change (as a result of heat mitigation and flood control) as well as the social resilience in the face of pandemics (easy access to open spaces). P1 acknowledged the function of open corridors between suburbs and natural resources in terms of heat mitigation. Nevertheless, as stated by the interviewees, living in proximity to nature reserves and natural grasslands and woodlands carries a fire risk and the challenge of making a buffer zone to keep the communities safe.

UHI was noted as a growing problem and underscores the necessity of providing adequate shade to make the city habitable for people. The road network and wide streets in Canberra (the influence of the Garden City and the City Beautiful movements) were addressed by experts as a plus to the city since they are capable of embedding large trees which can provide good canopy cover and mitigate the urban heat temperature in the face of climate change. The urban heat was addressed as a challenge not only in the urban

open spaces but also in native grasslands located within the urban environment. Although these areas are highly valued in terms of native biodiversity, they get much hotter than woodlands since they lack canopy cover.

Ten out of twelve interviewees addressed the impact of long droughts caused by climate change on the trees. Accordingly, P2 pointed out the necessity to search for plants that can effectively cope with urban heat. In this respect, the difference in the level of native and exotic plants' adaption to climate change was addressed. Some experts mentioned native trees are more resilient to droughts in Canberra's urban environment. While the native flora is an important element in Australian cities, an urban ecologist and urban governance expert stated it is crucial to have a mix of native and exotic trees. P12 supports this argument by highlighting the importance of planting more conifers and evergreen trees densely and the use of irrigated grass for mitigating the climate change impact. The urban ecologist believed that we need "an open mind" for a good mix of native and exotic patches or mosaics of green space in a way that caters for a range of ESS. Although experts believed that exotic trees provide shade and mitigate UHI effect, they mentioned that it is important to use more native trees with an appropriate canopy cover. P2: "I think using only native trees might not be possible, and yet, it is a lot more possible than what people claim or state. I think it is possible to use a lot more native trees than what we do, because there are native species that can provide a good amount of shade".

The native grasslands located within the urban footprint were addressed as valuable green spaces that contain a significant area of remnant vegetation and provide important habitats for fauna. Moreover, NCOSS was mentioned multiple times by interviewees. Experts highlighted that NCOSS has high biodiversity and has been well-managed.

> P1: "NCOSS has a high biodiversity value and a high level of volunteers."
>
> P4: "Many cities are trying to retrofit their cities to have such a thing. NCOSS is a great asset and valued by the community and by the governments."

Street trees and urban forests in Canberra were also mentioned for their value as bird habitats (Figure 4). However, the experts believed that while Canberra celebrates the provision of green spaces and high biodiversity, urban development could dramatically impact Canberra's biological communities by reducing the habitat provision. For example, the urban forestry expert shared concerns regarding the loss of old trees and large hollow-bearing trees within the urban footprint, which reduces bird habitats.

Figure 4. Bird habitat on the street trees and verges in a residential suburb in Canberra. Photos: F. Mofrad, 2022.

> P7: " . . . the beautiful bird life we have in Canberra is because we've got trees for those birds to live in . . . although there are plantings of eucalyptus in some of the public open spaces along creeks and parks as a proportion of the overall area, I don't think that's sufficient to maintain the biodiversity values that people also appreciate."

3.2. The Social Perspective

The natural landscape was noted as a very popular space with aesthetic values, and Canberra's residents have easy access to these areas. These green spaces are very well-used by residents for physical activities such as walking, running, bike riding, and dog walking. The interviewees highlighted that there is a strong level of community appreciation on a macro scale to NCOSS, including hills, ridges, and buffers. Conversely, the parklands within the suburbs were addressed as green spaces that do not provide high cultural ESS and are considered less socially valuable green spaces. For example, P1 noted that "We have a lot of low-quality open space in Canberra, and it is redundant and doesn't meet the needs of the communities. So, we have natural barriers". The interviewed landscape architects believed that, although parkland serves other ESS, such as temperature mitigation or habitat for fauna, they are underutilised by the community.

Lake Burley Griffin, creek corridors, sports ovals and playgrounds were addressed in the discussion that revolved around recreational activities. The parks around Lake Burley Griffin were noted as green spaces that were well-used by the community. The symbolic open spaces (for instance, the National Triangle, the War Memorial and Anzac Parade, the national galleries around the Lake, and the Floriade display of spring bulbs in Commonwealth Park) were also assigned to cultural ESS for the urban design legacy, historical values and tourism (Figure 5).

Figure 5. The photos show some of the valuable green spaces from the socio-cultural ESS perspective. Photos: Authors.

The green spaces on the neighbourhood scale were noted as of high importance for residents. For example, the experts specifically addressed the value of local parks and streetscapes during the COVID-19 pandemic, since people could easily access the neighbourhood green spaces to have fresh air and participate in community-driven activities such as community gardens. P3 observed that " . . . In the pandemic, people were discovering their neighbourhood . . . " and P12 stated that "Canberra's system of open space has never been better used . . . the amenity, provided by suburban gardens, and generous streets with street trees and parks and sidewalk tracks and pocket parks have really been a boon for those of us who live in Canberra versus Sydney or Melbourne or any of the other more urban centres of Australia's population. Because we have had the space. We have had the opportunity to go for a walk and get some fresh air".

Moreover, the value of native trees was strongly addressed by the interviewed experts. Some of the interviewees mentioned that Canberra's residents appreciate the native landscape and are aware of the values and the necessity of its conservation. For example, P7 noted, "people appreciate remnant trees that predate the establishment of Canberra" and as P4 addressed " . . . indigenous trees are incredibly important for biodiversity and indigenous heritage". Moreover, P2 added, " . . . native trees pin down the connection with the natural environment . . . ". However, one of the interviewees mentioned that not all the residents are interested in planting native trees and that people complain about Eucalyptus trees because they drop bark and branches and thus are "messy".

Another topic that was addressed in the interviews was the community's interest in growing food and attending community gardens. For example, P6 and P12 stated that there is a strong revival of the idea of local food production. They believed this potential can be used as an opportunity in Canberra to cultivate plants and produce food rather than amenity horticulture, especially on valley floors and more fertile flood plains. The interviewees' observation was that the community's interest in private gardening increased during the onset of the COVID-19 pandemic. In contrast, the farming lands located on the west side of Canberra near Majura were mentioned as the green space types that have received less attention. P1 mentioned, "The farming land is just waiting to be turned into urban areas, which is unfortunate. Urban ecology is serving tourism and development!"

Another type of green space in Canberra that was mentioned for the provisioning of ESS was the forest plantations of exotic conifers, *Pinus radiata* in particular. These industrial tree plantations have been historically a feature of a self-sufficient community, following the Garden City movement principles and examples.

3.3. GI Planning: Opportunities and Challenges

The potential of linear corridors, such as creek lines, to serve both wildlife and humans was underlined in the conversations with the interviewees. Moreover, NCOSS was unanimously mentioned by all the interviewees as a strength of Canberra's GI, which connects the ecologically valuable green spaces. However, as was demonstrated by P4, the current challenge is to better link the large open spaces with small open spaces for people and to provide wildlife corridors. This challenge was discussed from a different angle by P7, addressing the difficulty of consideration of the potential of private land uses (due to the ownership status) in GI planning to strengthen GI connectivity. Moreover, the interviewees thought that not all the green space types and land uses have been considered in GI planning. P4 mentioned, " . . . so the small [green space] you have, it doesn't prompt people to think we have to use those places, there is not a sense of urgency . . . It is important to have a typology that speaks more accurately of place and recognises the diversity of urban green spaces that are in the city". This discussion was supported by the example of industrial lands in Canberra, which at the moment are not included in GI planning and are not valued for the ESS they can offer.

NCOSS was addressed not only for its significant ecological values and cultural ESS but also for integrating with other infrastructures such as power lines and telecommunications (Figure 6). The integrity of GI with other social infrastructures was another factor discussed

by landscape architects and urban planning experts. A balance of social mobilisation and technical issues of GI planning and also the ecological system with the urban densification were other challenges that demand a search for a more integrated GI.

Figure 6. The powerline in bushland on Mount Ainslie in Canberra is an example of the integration of GI with other infrastructures. Photo: F. Mofrad, 2022.

Another key principle of GI is multifunctionality which is highly important in providing cultural ESS. Such an approach gives the community motivation and an opportunity to be involved in the management and maintenance of green spaces. The necessity of designing and redeveloping a multifunctional landscape was highlighted by the interviewees. Accordingly, it was stated that multifunctionality calls for flexible governance. For example, the historical plantations of exotic trees (e.g., *Pinus radiata*) were addressed by P6 as a green space type that can be turned into a park that can be used more actively by residents. Another green space that was particularly addressed by interviewees is Haig Park. It is a historical manmade green space that from the very beginning functioned as a wind shelter and is now registered as a cultural heritage (Figure 7). P1 believed that Haig Park does not meet the needs of the residents. Likewise, IR8 discussed the safety issues of Haig Park. For example, it was mentioned that people are not comfortable walking through dense vegetation in this park where lighting is insufficient. However, P11 addressed the short-term interventions by the City Renewal Authority (by placing lighting, a nature play area, a community centre, and a village market) called the "Haig Park experiment", carried out to change people's perception of a space to a more positive mode.

Figure 7. Haig Park in Canberra was established in 1921 and consists of exotic pine trees (such as *Cedrus deodara* and *Pinus radiata*). Right photo shows a part of the interventions to make it multifunctional by providing some amenities. Photos: F. Mofrad, 2022.

A multifunctional green space can facilitate the management of the urban landscape for the government since it increases people's engagement in a space that is meaningful for them. As P1 noted, "If we want somebody to spend resources looking after something it's got to be meaningful to them".

The community's engagement in GI planning was discussed with consideration of activities such as community gardens and local food production. Several experts believed that urban agriculture should be seriously considered in the GI planning policy. Moreover, understanding people's perceptions and expectations for the development or redevelopment of space was pointed out in the discussions, meaning that the approach should be site-specific, and the landscape design should fit the common users' expectations.

3.4. GI Governance

Canberra has many open spaces, and it was explicitly mentioned by the interviewees that the government cannot look after all these green spaces. Therefore, as elaborated by P1, P7 and P12, the government seeks low-maintenance green spaces, while high-quality designs usually need a high level of maintenance. For example, some of the wetland systems can be high maintenance. Moreover, the interviewees reflected on the community's concern regarding the level of government investment in managing the street trees in their neighbourhood and the public realm, and the existing trees' resilience in the face of climate change. As mentioned by P7 and P12, the budget allocated to public open space management is lower than other infrastructures such as roads, health, and education. The same issue was addressed regarding the management of street trees. P7 stated, " . . . the ACT government doesn't have committing resources to support maintenance and renewal and green infrastructure at the level that is required . . . there's quite a problem with the street trees because the ACT government doesn't have enough money to manage them properly. The same is probably true for the NCA, although they've got fewer trees.". This challenge draws our attention to the community partnership in green space management. P12 addressed that the newer suburbs and those under development should be enhanced by green spaces, and residents need to invest sufficiently in the quality of the urban open space to meet their expectations. Likewise, P11 stated that community engagement makes a landscape more resilient, giving examples of the parks and green spaces across Sullivan's Creek, where the community participates in managing and maintaining those parks. P12 believed "community engagement is happening but it's a small scale and community-driven".

To answer the question of how the government can use this potential to better manage and maintain green spaces, two approaches were addressed. The first is with "education" and "cultural change". For example, it is important to educate people about how to look after the surrounding environment and to tackle the impact of climate change by doing more frequent fuel reduction burning and being educated to develop an understanding of the local landscape. As P6, an urban planner specialist, noted "The people of Canberra must start to develop and institutionalise positive relationships with their trees and their parks". The second suggested way is by building relationships with the community and adopting a structured bottom-up approach. As argued by P2, the decision-makers should listen to what matters for different groups of people, including the majority group of people, minorities, and traditional custodians of the land. However, P6 argued that to integrate socio-cultural values with the planning process and consider residents' proposals, the decision-makers need to be more flexible by adopting an "experiment or innovation framework" and allowing for more experimentation. Likewise, P3 mentioned it is important to "give people more space to express themselves in a more practical sense to create more human-centred spaces".

Implementation of the policies was another challenge that was clearly addressed by experts. For example, P11 mentioned, "when it comes to implementation, it's really hard to get the asset managers to accept the high-quality design ideas unless it's in the city centre where it's maintained differently." Another expert also was concerned with the constraints that are put on a design by asset managers such as minimum maintenance and irrigation.

Moreover, the high-quality designs by landscape architects in many cases are not complied with by the developers and builders. This problem, however, is strongly interwoven with the ongoing maintenance issue. As one of the experts said, "no one's making the builder accountable for what they're doing, so, it's constructed, and I could see that within a year they're going to have serious maintenance problems".

The concerns with the impact of higher-density cities and loss of green spaces were mostly regarding the execution and implementation of the policy. All the discussions addressed the importance of not only careful and high-quality design in the private realm but also the imperatives to having high-quality construction and continuous upkeeping of the green space. P12 said, " . . . the issue for me with the densification is quality, not quality only of construction, quality of maintenance and ongoing care, and how you get a financial model to make it pay". Therefore, the governance of the private realm is another challenge. Some of the experts shared their concerns regarding the loss of trees on private lands because of urban densification. P7 "There's been some discussion around schemes for offsetting, or other ways of encouraging developers to retain praise [existing trees], but they haven't come to a conclusion and in the meantime, that process of losing many of those trees continues. It's not been solved very well in Canberra.". The urban forestry expert commented that the Tree Protection Act legislation captures trees that are over a certain size, while we also need to have a long-term vision and protect smaller trees which will later be big ones. The necessity of a long-term landscape plan that includes both public and private lands was mentioned by a landscape architect. P12 stated " . . . there is a lack of landscape-driven strategy decision-making . . . the national capital, the Garden City, the Bush capital, has no landscape architects as a public servant, there are in the NCA. The NCA has them integrated throughout their teams. But the ACT government does not".

4. Discussion

The semi-structured interview with experts on Canberra's green spaces and GI planning revealed the socio-ecological trade-offs and the interrelated challenges in planning, implementation and governance (Figure 8). In this section, we discuss these challenges, the interrelations, and the existing potential to mainstream ESS in planning and governance.

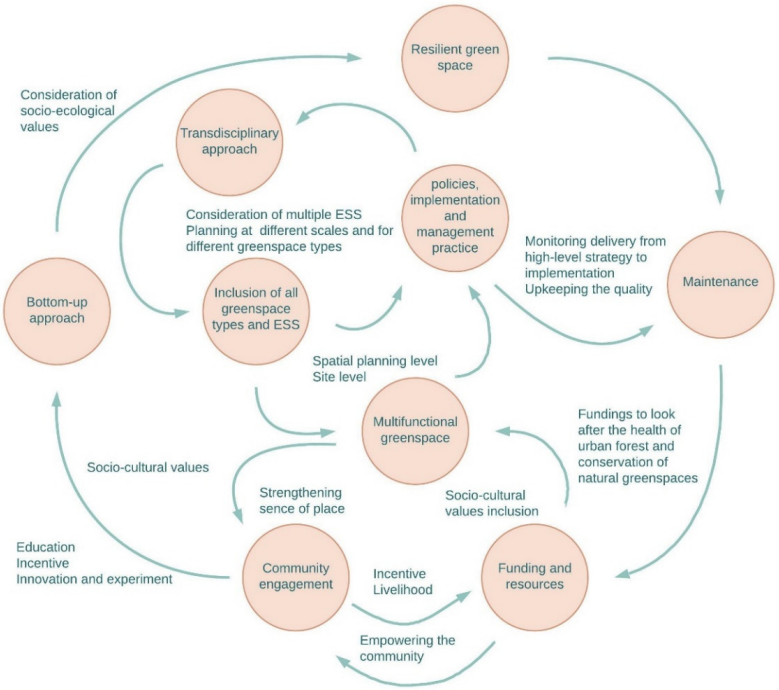

Figure 8. Systems mapping diagram illustrates the identified trade-offs to increase landscape resiliency and sustainability. Source: Authors.

4.1. Abundance of Green Spaces and Maintenance Challenges

The form and structure of urban development significantly impact the way residents interact with nature and green spaces [52]. It is proved that the closer connection of people to nature makes a healthier society (physical and mental health) [53–55]. Our study shows that experts believed Canberra's urban form enhances the connection of people with green spaces and provides an urban environment where people and nature cohabitate. However, the maintenance of abundant green space in Canberra needs enough committed resources and high capacity to achieve proper management and make the urban landscape resilient. Providing enough resources to sustain the ESS and the values attached to GI is still an ongoing challenge [25]. Maintenance includes "proactive tree planting and species replacement" using high-tolerant and evergreen trees that cope better with warmer weather [34], weeding as well as irrigation when it is required.

The necessity of stakeholders' contribution to green space planning and maintenance has been cited by many academics [56–58]. The residents' partnership has relied on the sense of responsibility of the people in building their environment and community, and the governance system to work closely with the community, adopting a bottom-up approach to encourage the community to be engaged [59]. For example, in Canberra, the existing community councils and communities that are interested in Landcare (a not-for-profit organisation that involves a local group of volunteers for the maintenance and restoration of the natural environment) can be more empowered and widely used for the maintenance of green spaces and educating residents to look after the neighbourhood green spaces. This can be promoted by working and investing in activities that can strengthen the residents' connection and sense of responsibility to the natural landscape as well as UGS [58]. For example, providing more urban settings where people can socialise and be engaged such as community gardens for food production and growing ornamental or native plants is proven to be effective not only for social benefits and other cultural ESS but also for the environment and economy [60,61].

Currently, urban agriculture is receiving more attention in Australia [40,41] and Canberra is no exception. Urban agriculture is effective in enhancing people's knowledge about the ecological process as well as green space maintenance [62]. According to Artmann and Sartison (2018) [60], the most significant ESS offered by urban agriculture is food supply, but it also has a substantial contribution to the enhancement of education, recreation and human health which potentially inform adults and children and make them more responsible for the maintenance of their environment. This practice is also influential in microclimate regulation and enhancing soil fertility and pollination. One of the residents-led approaches to community gardens and urban agriculture that have been suggested in Australian cities is verge gardening (or nature strip gardening) [45,63,64] which can work well with the form of Canberra's suburbs and the wide verge structure. Native verge gardening (planting native species instead of lawns) not only serves cultural ESS and mitigates the UHI effect but also makes a habitat for local fauna and strengthens the ecological corridor. Native plants are a key element of the Australian urban landscape that connects the cities to the local identity [65] and can cultivate a sense of place and foster volunteer activities for green space maintenance [66]. Moreover, the provision of biodiversity in UGS is an effective response to adapt the cities to climate change impacts [67,68]. The biodiversity aspects of urban design were discussed by [69] who suggested the use of more diverse native understorey vegetation and native biodiversity-focussed parks. Their suggestion also expanded further than tree canopy and native gardens and included native green links in between various precincts and parks and also green spaces in and around residential blocks. While, as stated by the experts in our research, people appreciate the native biodiversity, not all residents are interested in having native trees within residential suburbs. Moreover, the potential to have a better mix of native and exotic plants was pointed out. Studies addressed that some of Australia's native plant species are significantly resilient, even outperforming introduced species in some cases [70]. One solution might be to change the guidelines for the common green spaces by adopting a transdisciplinary approach

and suggesting or offering suitable plant species that could be more resilient to climate change. Design of regulations and guidelines adaptive to changes along with incentives can enhance residents' engagement. Moreover, increasing community knowledge and raising awareness of the native biodiversity can help to have stronger community involvement. The "living lab" and "learning-by-doing" approaches were suggested by researchers and adopted in Europe as an influential practice in exchanging knowledge and promoting civic engagement and collaboration [26,71,72].

In recent years, technological approaches towards the management of green spaces and encouraging community engagement have been developed. For example, a research-based practice conducted by (Wellmann et al., 2022) [68] in Leipzig, Germany suggested a social-ecological-and technological (SET) approach for managing urban forests in the face of drought and heat stresses. Globally, there is a call for the improvement of governance, delivery of projects, and the development of innovative maintenance approaches.

4.2. Green Space Connectivity and Multifunctionality for People and the Environment's Sake

The connectivity of green space patches is one of the key principles of an effective GI that can support wildlife and serve human activities [73,74]. The green space connectivity reinforces multiple ESS, for example, temperature regulation, recreation, habitat support and connectivity. Hence, the existing green spaces and green corridors in Canberra such as parklands can be retrofitted into more multifunctional spaces for example by providing cycling pathways. Such an approach will make a more active and inclusive urban landscape that serves multiple ESS [75].

Multifunctionality needs to be considered in both the planning and site-specific level of decision-making processes (spatially and temporally) by working with the community [76]. To consider multifunctionality in site-level design it is necessary to work with a community panel to draw out a design brief for the proposed space. However, the results of a study [68] indicated that apart from place-based approaches and the inclusion of local knowledge, feedback is also important. It means that the community should be acknowledged for their contribution. A direct link between the community and the implementation process should be established and fostered.

The integration of GI with the built environment helps to design a multilayer, multi-functional urban GI and create a green active transport link. GI integration can be achieved through the integration of private green spaces, public parks and gardens, cycling networks and utility infrastructures. An integrated model of GI planning that uses existing green spaces in Canberra (such as remnant natural landscape on the city edge, nature reserves within the city and UGS) yet needs to be developed to reinforce the links between vegetation patches and the grey infrastructure (hard surfaces such as road layout and buildings). A state-of-art approach that is developing in recent years is Digital Twin which can pave the way towards resolving the complexities of GI planning as a multi-object network. For example, (Gholami et al., 2022) [77] argue the potential of using Digital Twin for enhancing green corridors and multifunctional networks. In another study on the case of Helsinki city, Digital Twin proved to be an effective tool for monitoring and managing the dynamics of urban development with respect to social and ecological aspects [78].

To strengthen the GI network considering social and ecological factors we need to adopt a comprehensive approach that recognises all types of green spaces and considers multiple ESS. It means that it is necessary to include different land-uses and land ownership, for example, private properties, industrial and post-industrial landscapes [79]. Accordingly, all potential green spaces at different scales with cultural values and environmental benefits should be identified to delineate a robust GI plan. Different types of nature (designed, native and informal) and the nativeness potentials in GI planning and governance need further research [35,80]. For instance, the potential of private land-uses in GI planning can be incorporated into GI planning by developing policies and guidelines [57].

4.3. From Drawing Strategy to Design and Implementation

Careful GI planning and governance are necessary from high-level policies to the delivery of policies and landscape design implementation. Key detailed strategies and plans are defined for Canberra's GI planning such as Climate Change Plan [81], Living Infrastructure Plan [82], and Water Sensitive Urban Design guideline [83]. However, it is essential to have a framework and guidelines that can be followed by all developers. There should be better control of the construction and redevelopment projects to make sure that policies are complied with developers. The ideal development happens when the developers follow policies to build a curated space of activities and then they couple it with maintenance of the place.

Researchers have addressed the necessity of a critical review and examination of the urban greening policy and practice in Australian cities [35]. For example, more research is required regarding the implementation of nativeness within the urban environment and finding a balance between the ornamental character of UGS and the biodiversity conservation goals [19,84]. For more effective GI planning and governance, it is crucial to adopt the transdisciplinary approach where the urban environment is researched by different disciplines in collaboration with local communities [26,71]. Professionals in different relevant disciplines such as landscape architecture, urban forestry, urban planning, civil engineering, botany and urban design are required to work collaboratively and make a balanced connection between buildings and open spaces, people and the environment.

5. Conclusions

Canberra has been developing quickly in recent decades and the urban compaction and densification vision calls for more precise and careful GI planning. This issue is getting more critical as Canberra tackles the impact of climate change including drought, fire and flood. Hence, the imperative to retrofit the GI structure in Canberra in a changing and evolving urban landscape should be pursued meticulously. The semi-structured interview with experts revealed the synergies and trade-offs between multiple ESS and their consideration in GI planning, green space implementation and upkeep and governance. The research highlighted that, to make a resilient landscape and develop a robust GI, we need to consider carefully the socio-cultural values which can add to the management and maintenance capacities. Understanding ESS and maintaining their functions are necessary to satisfy human needs and survival. The planners and decision-makers can use the potential of the provision of green spaces and transform the low-valued green spaces into spaces that not only can benefit the environment but also provide direct services for the community. The human-nature connection and physical activities such as walking, cycling and enjoying the green spaces can be strengthened by increasing the green space connectivity and making multifunctional green spaces by adopting a bottom-up approach and working closely with the community. To enhance ecological connectivity and social infrastructure and to plan for a resilient GI, a transdisciplinary team working together is required. Further research needs to discover innovative approaches to overcome the complexities of GI planning that also include socio-ecological layers, using state-of-art technologies. An important step towards protecting the existing UGS against urban compaction isdetailed research of all existing UGS with respect to the provision of social and ecological services. This information could help planners and decision-makers and can become a common ground for transdisciplinary collaboration and coordination of GI policy and practice.

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