What does good green and blue infrastructure policy look like: a comparative assessment of UK national planning guidance.

Abstract

This paper assesses the potential of a Green Infrastructure (GI) Policy Assessment Tool (GIPAT) to assess the efficacy of national planning guidance across all four devolved UK nations. National guidance is a key material consideration to the formulation and implementation of GI policies in statutory development plans and decision-making. Hitherto, there has been a lack of holistic assessments of GI policy in spatial planning with most attention on specific developments. GIPAT was informed by three GI initiatives; - Building with Nature, Central Scotland Green Network and Mainstreaming GI, supported by a global academic literature to address key multifunctional and mainstreaming components within 26 assessment criteria. The tool assessed, with justification, how well national guidance met the assessment criteria, together with the strength of policy wording. The results reveal a significant weakness in policy wording across all countries highlighting GI vulnerability . In terms of coverage, biodiversity and ecological networks generally score well but there are deficiencies in stewardship, blue infrastructure and mainstreaming demanding greater policy attention. There are important implications for development plan policy(ies) highlighting the need for greater integration of grey, blue and GI and improved mainstreaming as illuminated through exemplar policies. We recommend the use of Green Blue Infrastructure (GBI) to address the blue deficiency. The paper concludes with a discussion about GIPAT's wider transferability and the need for greater research into how policies are translated into development plans and decision-making.

232 words.

Key words: Green and Blue infrastructure; mainstreaming; multifunctionality; planning policy; assessment tool

1. Introduction

Green infrastructure (GI) has become established as a spatial planning concept and tool in environmental policy and practice converging in the academic literature around a diverse set of core principles and functions as illuminated in Table 1 (Monteiro et al 2020: Mell and Scott, 2023; Hislop et al, 2019; Wang and Banhaf, 2018).. Yet, there remain significant barriers to its wider mainstreaming in policy and practice outside the environment domain where it usually resides (Scott et al., 2022). Challenges associated with definitional clarity, interpretation, delivery and evaluation, together with its subservient status in planning policy and development processes persist (Johns, 2019; Matthews, Low, & Byrne, 2015; McWilliam, Brown, Eagles, & Seasons, 2015; Slatmo et al 2019; Wright, 2011). Cumulatively, these challenges raise key questions as to the efficacy of GI

36 policies in plans when economic priorities on growth seemingly dominate planning discourses in an

37 increasingly congested and rapidly changing policy arena (Mell et al., 2017).

Principle/Function	Example Author	Definition
Connected and managed network of multiple benefits	Benedict and McMahon (2002 p12);)	'an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife.'
Multifunctionality	Hansen and Pauleit (2014 p516	'The concept of multifunctionality in GI planning means that multiple ecological, social, and also economic functions shall be explicitly considered instead of being a product of chance. Multifunctionality aims at intertwining or combining different functions and thus using limited space more effectively.'
Governance	Mell et al (2017 p.333)	"….suggests that although a confluence of principles, that is, connectivity, multi-functionality, access and sustainable landscape/water management are evident between territorial interpretations, there remain explicit local variations in the structures of national and sub-national planning approaches to green infrastructure"
Integration and conflict management	Matthews et al 2015: p.157:	'The [BGI] approach thus provides a comprehensive framework to accommodate competing interests and, in practice, to engage environmental objectives and dominant economic imperatives.'
Delivery at and across Multiple scales	Tzoulas et al (2007 p.6)	'It can be considered to comprise of all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales. The concept of Green Infrastructure emphasises the quality as well as quantity of urban and peri-urban green spaces
Engineering and SMART technologies	US EPA (2013 glossary)	'…adaptable term used to describe an array of products, technologies, and practices that use natural systems – or engineered systems that mimic natural processes – to enhance overall environmental quality and provide utility services".
Public Participation	Wilker et al (2016 p.230)	'However, due to green infrastructure's considerable societal benefits, all groups of society

		should have a say in its planning and implementation to ensure that it meets their requirements.'
Social Justice and Equity	Wolch et al (2014 p.235)	'Over the past two decades, the uneven accessibility of urban green space has become recognised as an environmental justice issue as awareness of its importance to public health has become recognized.'
Narratives	Reimer and Rusche (2019 p.1558)	'In all three cases, framing and telling stories about green infrastructure play a crucial role. In the Ruhr, the term green infrastructure is directly used to stimulate regional debates on sustainability, while green infrastructure rhetoric in Manchester has been interrupted due to institutional shifts. In the Capital Region of Denmark, it is obsolete and embedded in other local discourses, i.e., climate-change adaptation.'

Table 1 Major Themes Emerging from BGI literature adapted from Mell and Scott, (2023) and Scott and Hislop (2020) The table is based on key themes from literature on GI principally from the above authors with a illustrative quote contextualising the theme.

This paper focuses on policy challenges through the design and testing of a bespoke GI policy assessment tool (GIPAT) that evaluates how far GI policies are addressing the multiple functions ascribed to GI within national planning guidance across the four devolved nations of the UK; England, Scotland, Wales and Northern Ireland. Our focus on national planning guidance is important as this dictates the policy scope and content of statutory local development plans (in a plan-led system) and thus serves as a reliable indicator of how plans at more local levels might respond to GI alongside other planning priorities. GIPAT was co-designed with academic and policy partners supporting calls by Mell et al (2017) for stronger synergies between academia and policymakers, practitioners and delivery agents to evaluate the progression and uptake of GI thinking.

The paper proceeds with an assessment of GI literature relevant to the policy challenges outlined above before describing how the GIPAT tool was co-designed and used. We then present the results

across the four devolved UK nations before considering the wider global implications and prospects for designing good GI policy and how this tool can help improve policy and decision-making processes.

1.1 Definitional Challenges for GI

Numerous definitions exist for GI but, hitherto, these have been developed through separate disciplinary/professional lenses (Mell and Scott, 2023: Table 1) leading Matsler et al (2021) to portray GI as an elusive "green chameleon". Here, flood and stormwater management (Johns, 2019); Nature based Solutions (O' Sullivan et al 2020) ecosystem services (Hansen and Pauleit, 2014); climate change (Demuzere et al 2014); green space planning (Netusil et al 2014); recreation and access (Cortinovis et al 2018); stewardship (Davies and Muro, 2023); health and well-being (Felappi et al . 2020); biodiversity (Filazzola et al 2019); biophilic design (Grace et al 2021) and green urbanism (Newman, 2010), al feature. Whilst individually they add value to the GI concept, there have been few attempts to consider the cumulative impact of how these different pieces of the GI jigsaw all fit together, if indeed they do, to help design more effective policy and practice interventions, albeit with notable exceptions by Matsler et al (2021); Wang and Banzhaf (2018); Monterio et al (2020) and Slatmo et al 2019. Slatmo's review is particularly noteworthy due to its inclusion of rural development and agriculture. Matsler's (2021) assessment of 75 GI review papers is also useful in exposing a definitional duality in the literature between a broad planning/ecological network approach versus a narrower engineering technique. Furthermore, 41% of papers refrain from using any explicit GI definition; a similar finding also evident in Grabowski's et la (2022) work in the US . Thus, it becomes important to understand if and how GI is framed and used in different spatialities and contexts.

With this diversity of GI lenses there is no universally accepted definition (Mell and Scott 2023). Indeed, Wright (2011: 1004) observes that "*searching for a single fixed definition of green*

infrastructure is problematic because the concept is evolving, divided and gravitating toward socio-economic centres". However, Wright also goes on to say (ibid: 1015) that *"It is crucial for practitioners to understand green infrastructure and how it is used and shaped in practice in order to enhance the potential of the concept through negotiation*". It is this aspect of its limited understanding and inconsistent use in plans and practice that has been illuminated in research across Europe and USA respectively (Slatmo et al 2019; Grabowski et al 2022).

From our perspective, the European Commission (2013:3) definition offers a comprehensive and informative definition with GI as *"a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation. This network of green(land) and blue (water) spaces can improve environmental conditions and therefore citizens' health and quality of life. It also supports a green economy, creates job opportunities and enhances biodiversity*". This emphasizes GI as a consciously managed network designed to deliver multifunctional benefits across multiple scales and sectors with an inbuilt mainstreaming component championing its wider societal and economic credentials.

However, such a diversity of GI definitions and differing interpretations generates its own set of tensions as identified by Lennon (2015:36). "*The concept was originally seen as a means to raise the profile of ecological issues in planning by advancing a "narrative of necessity" through association with conventional "infrastructure". However, the very associations that give the concept its currency may undermine the initial impetus for its deployment as it may result in a revaluation of nature towards development enablement at the expense of conservation".* Here the tension is between the desire to mainstream GI within wider infrastructure thinking versus the dominance of post-political neoliberalism championing market-based interventions, driven by the imperative to deregulate, liberalise, marketise, and privatise natural resources which, in itself, promotes disjointed governance

(Olesen, 2014); the very antithesis of GI thinking. The shift to neoliberalism also catalyses a market-based approach to nature which attracts strong support (e.g. Dasgupta, 2021) and criticism alike (e.g Spash and Hache 2022). Whilst progress has undoubtedly been made in conceptual pluralism for GI, there is still clear evidence that stocks of nature are being depleted at an alarming rate generating a global biodiversity emergency (IPBES, 2019).

Another key tension encountered in the literature surrounds distributional equity associated with GI (Grabowski et al 2023). Here the accessibility of GI and its attendant ecosystem services are more limited in areas of higher deprivation such as in Scott et al., (2018) study of Birmingham. Furthermore, when there is GI investment in deprived areas it can lead to gentrification and exclusion. (Grabowski et al 2023; Wolch et al., 2014). This is strongly linked with the need for all groups of society to have a stronger voice in GI planning and delivery to ensure that it meets their requirements (Wilker et al 2016).

1.2 Mainstreaming GI challenges.

GI tends to be championed within its own environmental silo rather than being mainstreamed and normalised into policy and practices of other stakeholder groups and sectors (Scott et al 2022; Zuniga- Terran et al 2019). Zuniga-Teran et al (2019) identified five key GI challenges facing built environmental professionals: design standards, regulatory pathways, equity and participation, financeabilty and innovation; all dependent on political will. This all sits within a wider challenge of environmental mainstreaming highlighted by Scott et al., (2022) with additional barriers of language, governance and disintegration hindering progress in getting environmental policy embedded in other policy domains. Mell et al (2017) note significant structural changes in planning governance and sectoral myopia have hindered the mainstreaming of GI thinking and acceptability. This thinking is

132 explored further in Scott et al. (2018) mainstreaming framework which charts differing degrees of
133 mainstreaming from 4 case studies with effective mainstreaming necessitating a managed process of
134 change which requires early engagement with other publics/stakeholders (outside the environmental
135 domain) on their own terms and translating GI into their own vocabularies and priorities. It is this
136 translating function that is rarely encountered as most sectors develop and champion their own
137 technocentric vocabulary which tends to strengthen existing policy silos hindering the desired
138 integration.

139 *1.3 Political challenges*

140 The multi-scalar politics of planning play a key role in how GI is perceived and prioritised in policy
141 and decision-making, becoming a matter of political will and choice; from the day to day lived
142 experiences of individual planners operationalising governance frameworks (Inch, 2010; Trygg and
143 Wenander, 2022), to more regional scales (Beunen et al 2013; Haughton et al, 2013). For example,
144 Trygg and Wenander's (2022) Swedish study found that planners across four municipalities were
145 poorly informed of political agendas or how to prioritize conflicting objectives, set with fuzzy
146 boundaries and vague policy objectives. Here the lack of models that assess synergies and trade-offs
147 between different functions and benefits that GI provide represents a significant handicap (Lai et al
148 2019: McWilliam et al 2015), notwithstanding the contribution of Depietri (2022) review of 157
149 papers on trade-offs which found a bias towards ecosystem services' assessments whereas
150 governance and technological aspects were less evident.

151

152 Despite these barriers, surprisingly, the European Commission Green Infrastructure Strategy (from
153 2013) states that there is no need for legislation exclusively designed to enforce GI implementation;
154 rather, existing legislation, policy instruments and funding mechanisms within member states are
155 recommended for use. Consequently, we see an ad-hoc approach across the EU to GI policy and
156 delivery, fuelled by a significant research deficit on the efficacy of the different planning systems as

potential GI barriers. International planning systems vary; but are all based on the legislation and regulations that define them. These legal codes differ from country to country, and therefore generate different approaches to planning policy and in the extent to which a plan-led system (as in the UK and the Netherlands) or a development-led system (as in Finland and Sweden) is in place and the extent to which the natural environment is prioritised outside statutory environmental designations (Buitelaar et al 2011; Valtonen et al 2017).

1.4 Financial barriers

GI does not readily generate direct financial revenue to GI managers or providers (for example via taxes and donations), although considerable progress has been made with payments for ecosystem services schemes (Reed et al 2017). However, there is not yet a mature market ready to support the economic valuation of ecosystem services (Zuniga-Teran 2019). Thus, GI benefits often occur as external effects, where those paying for the provision are not necessarily those who directly benefit most, particularly when cultural and regulating services such as flood risk management and health benefits are involved. Consequently, cutting resources for GI planning, management and delivery is widespread as the benefits of GI investments are not easy to capture or to transfer. This is exacerbated by the more tangible costs of maintenance which impact negatively on budgets such as those for parks and recreation departments, perpetuating the image that GI is a cost and drain on resources. This is also evident in the delivery phases on many development schemes. When a scheme starts to exceed planned costs, GI is one of the first casualties owing to its vulnerable status as an optional extra that is not deemed essential to a development (Scott and Hislop 2019).

1.5 Planning Policy Research for Nature and GI

Hitherto, most attention in the literature for GI has focussed on case studies of projects and developments rather than evaluating the wider policy perspectives albeit with some notable

exceptions (Lennon, 2015: Ireland); (Mell et al 2017: Germany and UK); (Grabowski et al., 2022: Hoover et al., 2023 USA; (McWilliam et al., 2015: Canada). A focus on policy becomes particularly significant in countries which pursue a plan-led system where development plans and resultant policies have a statutory role as is the case in the UK and Holland (Buitelaar, Galle and Sorell,2011).

It is also important to consider the effectiveness of current tools and methods using GI that inform policies and plans. Significantly most tools are ill equipped to assess GI multifunctionality and wider mainstreaming as they are usually designed to address specific components of GI such as stormwater or natural capital (Veerkamp et al 2021; Diepetri, 2022: Jayasooriya and NG, 2014). It is also clear that efforts are made to create new tools as part of research outputs rather than adapt existing planning tools such as sustainability or impact assessments with attempts at simplicity to improve user accessibility (van Oijstaeijen et al 2020) although criticism also attacks the complexity and lack of transparency of some tools (Herman et al 2019). From the wider academic literature we have identified a simple typology based around (1) ecosystem service valuation and mapping tools; (2) certification schemes and frameworks (3) land use planning tools and (4) policy assessment tools.

ES valuation tools quantifying ES benefits dominate this literature (van Oijstaeijen et al 2020). However, the diversity and bespoke nature of tools using different methods limits their wider acceptance and use in policy and plans (Honeck et al 2020). However, it is the mapping of ecosystem services' assessments that is being used as part of evidence bases for plan formulation. However, concern reflects the bias towards relatively few ES; dependent on land use data with adequacy of proxies limiting their efficacy (Gret-Regamey et al., 2017). The absence of cultural ecosystem services is also significant (Kirby et al 2023).

Certification schemes are important tools for urban sustainability as illustrated by the global popularity of BREEAM (Kaur and Garg, 2019). However, relatively few certification schemes cover GI explicitly except in the UK Building with Nature (Jerome et al 2019) and US LEED-ND (Ameen et al 2015). Certification tools are valuable in raising regulatory standards and also have a catalysing

impact as long as the scheme is valued, trusted and well used. Here narrative based assessments are preferable to tick box exercises that can all be easily subject to gamification.

There are few dedicated land use planning tools devoted to GI but perhaps the most widespread one with global recognition and application is the green space factor (GSF) (Bush et al 2018; Juhola 2018; Ring et al 2021). It is urban-based and uses generic weighting factors for individual green /blue features in a development that cumulatively generate a score that then can be compared with development plan policies. For example, the London Assembly Plan Policy G5 recommends …. "a target score of 0.4 for developments that are predominately residential, and a target score of 0.3 for predominately commercial development". However, the GSF does not take account of the social and cultural components of GI or work well in peri-urban/rural spaces (Ring et al 2021).

GI policy assessment tools have generally used contents analyses favouring multi-criteria assessment methods. For example, McWillliam et al (2015) content analysis of Ontario's policy documents found significant deficiencies for the long-term protection of GI. Policies were narrowly focused on protecting individual GI components with inadequate tools to address the multiple impacts and trade-offs occurring at multiple scales. This was compounded by weak and vague policy wording making environmental policies more vulnerable to residential encroachment. Di Marino et al., (2019) investigated two Finnish case studies assessing the degree of integration of ecosystem services with GI. The results show that whilst national policy has embraced the two concepts, the planning strategies of the Helsinki-Uusimaa Region and the City of Järvenpää need to fully integrate GI and ES. However, a more complex picture about the difficulties in operationalising IGI and ES is provided by the planning practitioners where perceived rigid regulatory frameworks and current planning tools still represent obstacles to the effective integration of GI and ES. Grabowski et al (2022) reviewed 120 plans across 20 US cities and found 40% did not even define GI. Most GI was dominated by siting criteria dominated by stormwater challenging the multifunctionality associated

232 with GI (see also Hoover et al 2023). The plans showed significant variation in quality and extent of
233 GI raising question of understandability and use in decision making. Finally, Lai et al (2019) analysis of
234 GI in plans in Italy revealed a policy – delivery gap between what is proposed by the national and
235 regional administrations and what is actually delivered the municipalities.

236

237 **2 Methods**

238 A multi-criteria analysis was used to design GIPAT. The key consideration was that GIPAT should
239 capture all the different multi-functional components of GI together with stewardship and the extent
240 to which GI itself is mainstreamed. No tool currently assesses mainstreaming attributes and this is
241 seen as an important indicator of GIs wider impact and value outside its usual environmental policy
242 focus.

243 GIPAT's foundations were built on identifying synergies from three separate GI projects. First, Hislop
244 et al (2019) policy assessment of GI for Central Scotland local plans as part of a wider integrated
245 green infrastructure initiative for the Glasgow and Clyde Valley Green Network. Second, through
246 Building with Nature, the first UK accredited benchmark for assessing what good green infrastructure
247 policy and practice looks like (Jerome et al 2019). Finally, a Natural Environment Research Council
248 funded project on Mainstreaming Green infrastructure assessing how to improve GI mainstreaming
249 in policy (XXXX 2023)[1]. The combined outputs from these projects, together with their supporting
250 literatures allowed a draft framework to be built on 26 criteria which was then amended and tested
251 by some 30+ built environment professionals from the West of England Combined Authority in 2018-
252 2019 via three deliberative planner-led workshops using the tool in their own emerging local plan
253 policies. GIPAT was also reviewed by the UK Green Infrastructure Partnership before its finalisation.
254 GIPAT comprises seven functional themes and 26 assessment criteria (Figure 1).

[1] Anonymous to protect author

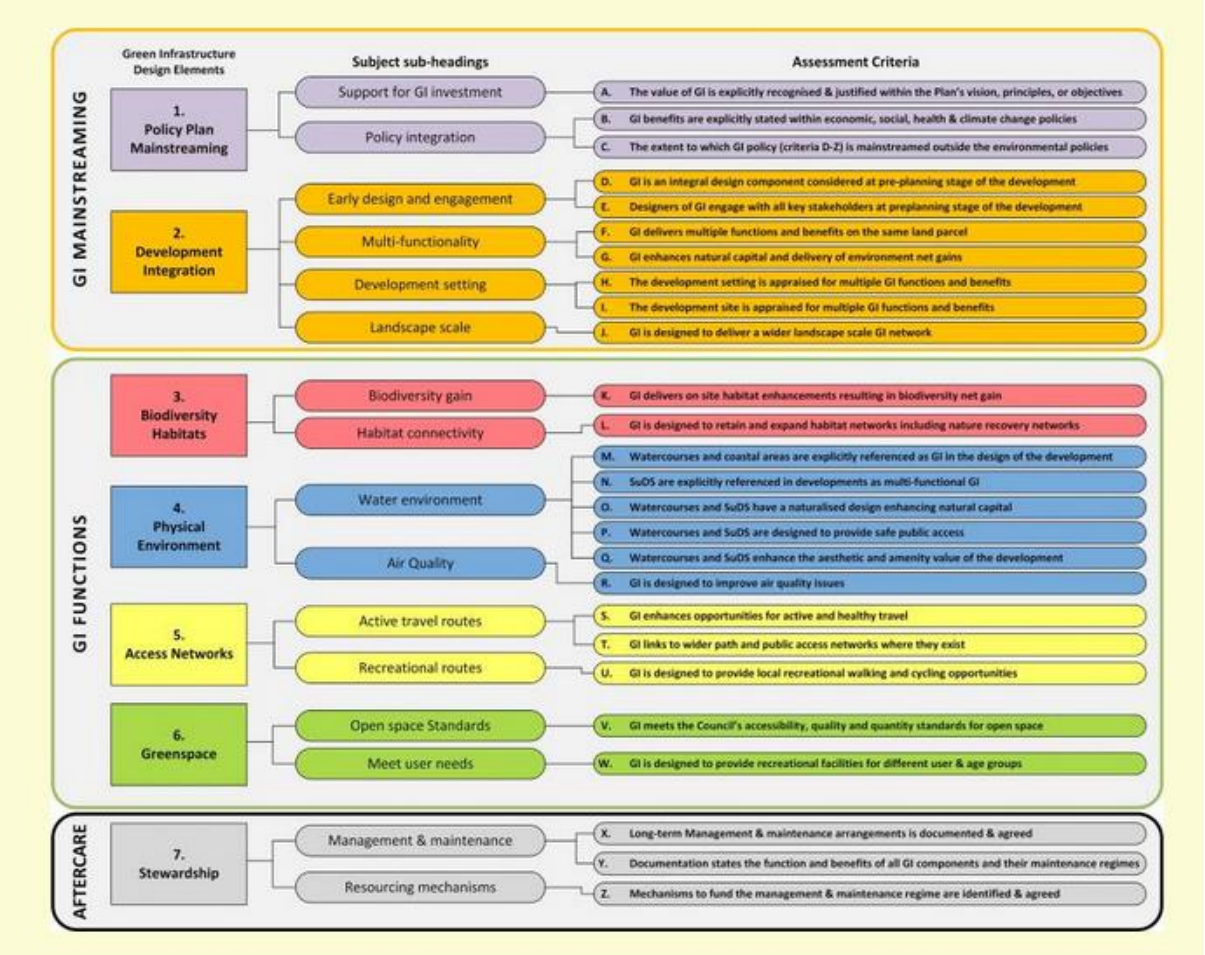

Figure 1: The GI Policy Assessment Tool Source Author 2023

The assessment process involves the following steps (Figure 2) with two assessors involved for improved triangulation and rigour.

For criteria D to Z within each plan:

- Undertake a contents analysis to capture relevant policy and supporting narratives. This involves key-word searches of the assessment criteria terms and/or suitable proxies.
- The relevant policy and any supportive text are pasted into the excel spreadsheet using the "comment/notes" function.
- This is then assessed against the assessment criteria to determine the (1) extent of coverage of that criterion; full coverage (green), mostly covered (orange), some coverage (grey) and (2) strength of the policy wording; strong wording (green), medium (orange) or weak

wording (grey). It is important to understand that the strength of policy wording can not score higher than coverage.

- The scores that are made are then justified in the comment/notes box.

For mainstreaming (Criteria A-C) a different approach is employed. Mainstreaming embeds the value of GI into other policy domains outside the environment. We have adapted this definition in GIPAT using three different but interrelated criteria ranging from strategic to specific policy areas.

- Criterion 'A' assesses the extent to which GI is recognised and valued explicitly in the introduction, vision and strategic objective aspects of a plan which collectively create a higher-level strategic/corporate environment and/or culture supportive of GI. In Figure 2 this is activated through using the "I" label for any chapter which creates a blue box thus prohibiting other scoring.
- Criterion 'B' looks at the extent to which GI benefits are recognised in climate, economy, health and social areas. This highlights national areas of policy concern and provides a measure of how well GI is seen as a way to create nature based solutions (Connop et al 2017). In this case each benefit is scored separately, with a composite score calculated, based on the highest score for each benefit.
- Criterion 'C' assesses the extent to which GI policies exist outside the environmental chapter, based on the distribution of scores across criteria D-Z. This is shown in Figure 2 by the E label which turns the box green thus eliminating the environmental chapters from analysis.

In terms of the national policy guidance assessed, each plan was read and assessed with the relevant policy sections and supporting material cut and pasted into the excel matrix using the comment function (Supplementary Evidence A-D). A recommendation and supporting justification were also inserted for improved transparency. Two assessors were involved in this process working

independently of each other. Any differences in marking were discussed with a consensus reached. The main areas where discussions took place on issues of coverage where when criteria were fully met (e.g. K L) but without the explicit mention of GI. It was agreed that results were medium at best. The other discussion point was the difference between including material as weak or rejecting it. It was agreed that there had to be more than simple recognition of the criteria. In terms of stregth of policy wording there were no differences of opinion. The results show each plan seperately (Figures 4-7) with a composite figure detailing the summary scores across the UK (Figure 3).

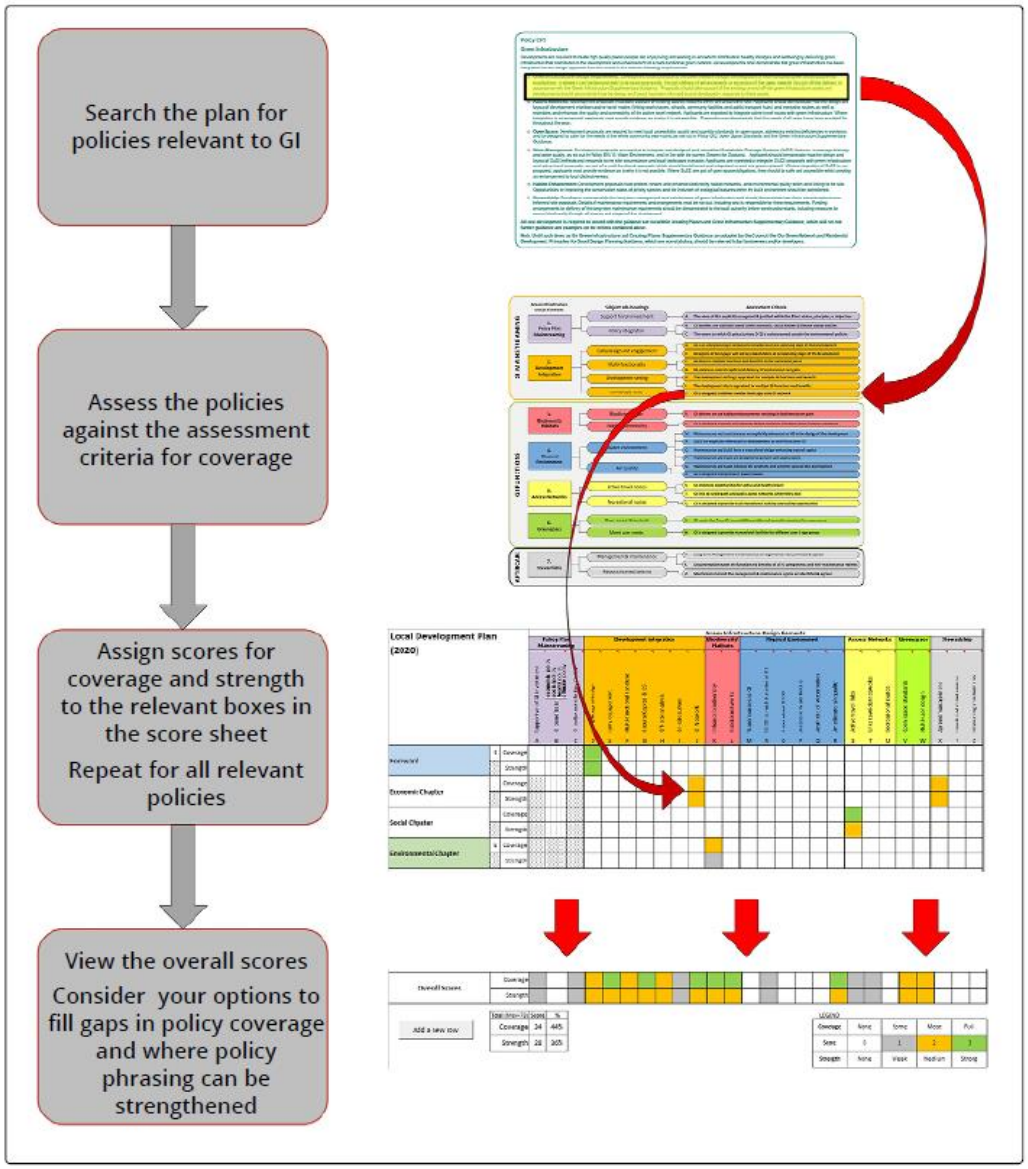

Figure 2: Method for completing a policy assessment using GIPAT tool. Source Authors.

3. Results

We first present the overall summary performance across the four countries before then considering each country separately.

Figure 3 presents the summary scores across the UK for coverage and strength of policy wording across the 26 criteria. In terms of coverage there is a good result with 83% fit. The weakest set of policies are for blue infrastructure and SuDS in the Physical Environment function of GI, with P: Access to Waterbodies completely absent. There are individual weaknesses apparent in Stewardship function (Y: Functional maintenance); Access function (U: Recreational routes) and Physical environment function (Q: Aesthetics of water bodies). Notwithstanding these weaknesses, in general, policy is collectively realizing the multifunctional components of GIGI and achieving some wider mainstreaming outside environment chapters.

The policy wording profile reveals a notable decline to a 64% fit. Only in Development integration function (D: early design), biodiversity functions (K: Enhances biodiversity and L: Habitat networks) and Stewardship functions (X: Agreed management and Z: Resourcing mechanisms), were strong scores recorded. This highlights policy vulnerability facing GI when translated into development plan policies. Nevertheless, the dominance of "medium" strength policy wording is welcome.

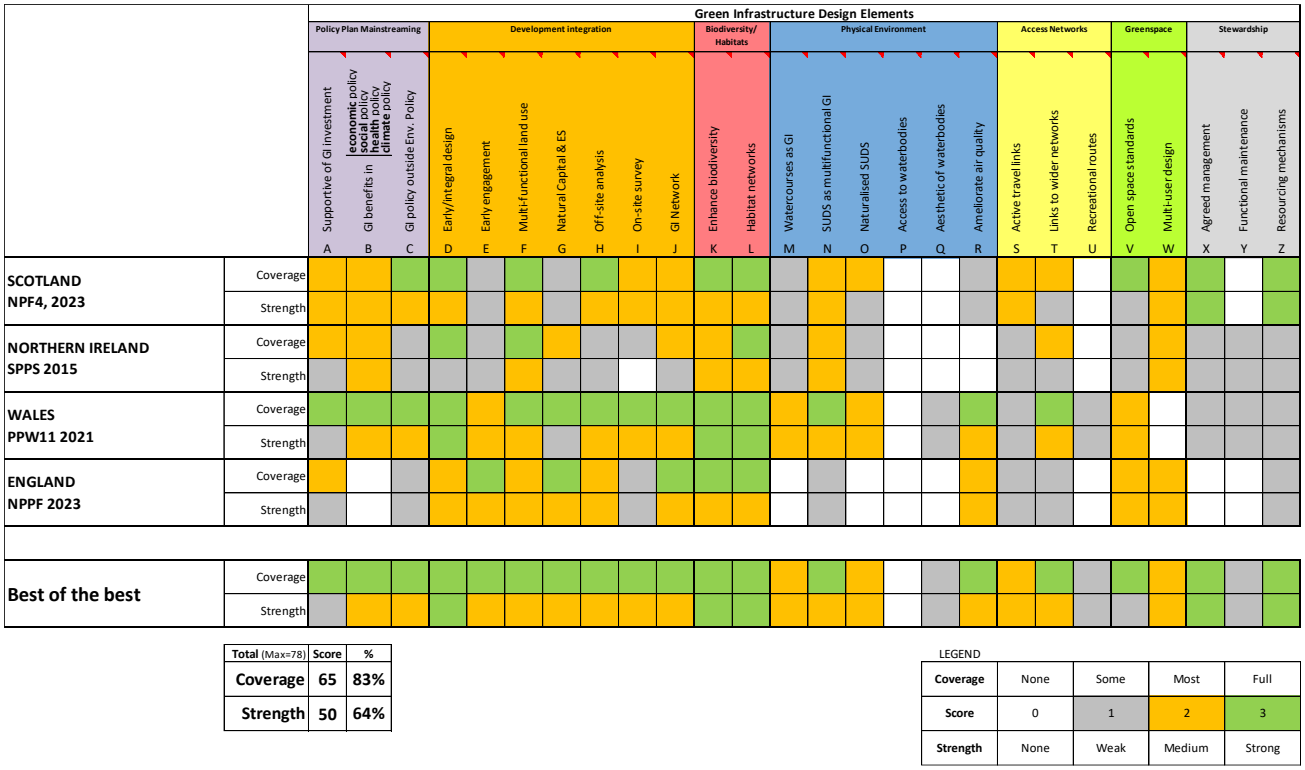

Figure 3: GIPAT policy assessment summary scores. Source Authors.

3.1 Scotland National Planning Framework 4 (NPF4) 2023 (Supplementary Information 1)

The structure of NPF4 involves 4 key themed chapters with 33 policies spread over 93 pages with detailed annexes. The scores for Scotland are revealed in Figure 4.

The results are generally good for coverage of assessment criteria (63%). NPF4 is especially strong when compared with other countries on mainstreaming function (C: GI policy outside Environment policy) and stewardship functions (X: Agreed management and Z: Resourcing mechanisms) with "full" coverage. Gaps exist in the Physical environment functions (P: Access to waterbodies and Q: Aesthetic of waterbodies), Access functions (T: Links to wider networks) and Stewardship function (Y: Functional maintenance).

The strength of policy wording profile declines to 50% fit. "Strong" scores are only evident in Stewardship functions (X: Agreed management and Z: Resourcing mechanisms). However, as no other categories score green, the overall vulnerability of GI is clear. The rest of the profile is dominated by medium scoring where the word "should" dominates.

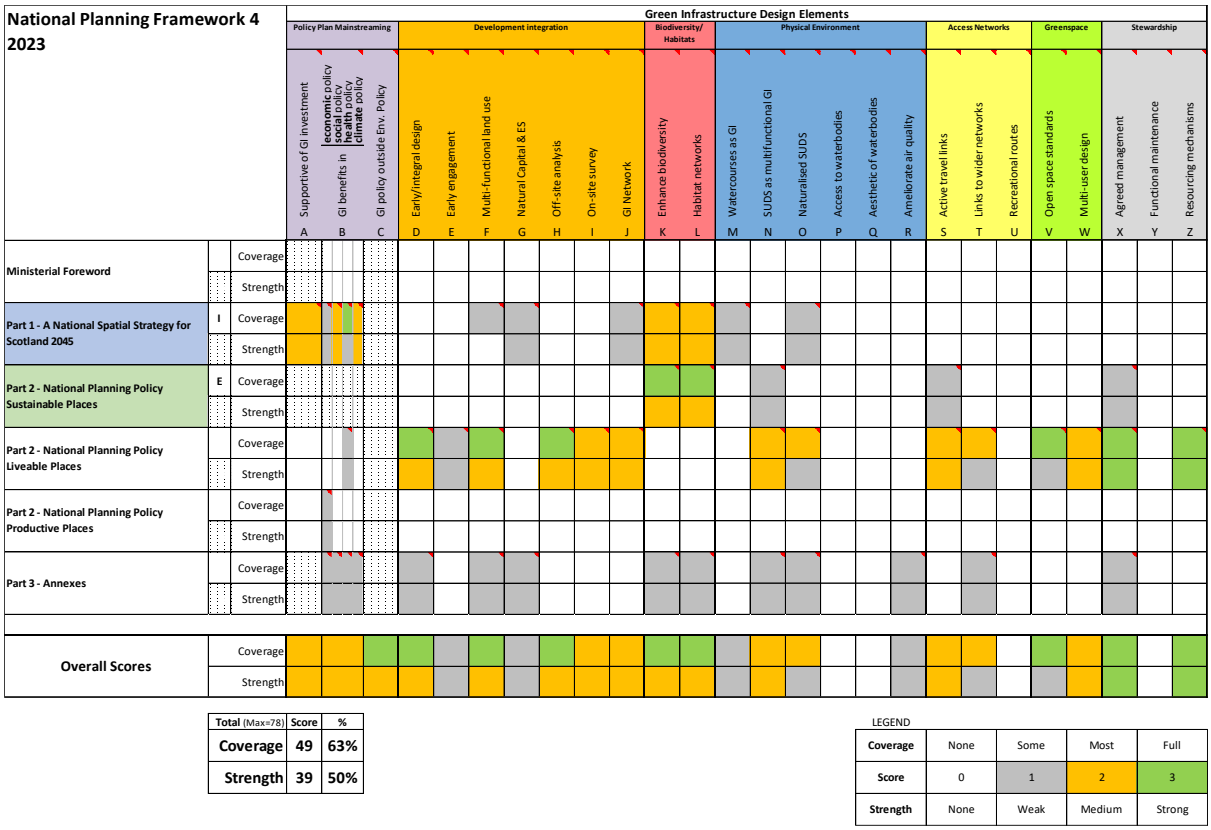

Figure 4 GIPAT policy assessment National Planning Framework NPF4, Scotland: Source Authors

3.2 Northern Ireland Strategic Planning Policy Statement SPPS (2015) (Supplementary Information 2)

The first notable point for SPPS is its 2015 publication date. This is the oldest planning guidance in existence across the devolved nations. The document has a rather unique structure with 6 chapters over 111 pages. It moves somewhat unexpectedly from policies for sustainable development and core planning policies of implementation to subject policies. Policies are clearly identified within paragraph numbers. The scores are presented in Figure 5.

The coverage score is weak with only 46% coverage across GI elements, with Physical environment functions (P: Access to waterbodies; Q: Aesthetic of waterbodies and R: Ameliorate Air Quality) and Access functions (U: Recreational routes) completely absent. However, there is full coverage on development integration functions (D: early design, F: multifunctional land use) and biodiversity function (L: habitat networks). Furthermore, the mainstreaming function performs well with (A: supportive of GI investment: B GI Benefits- climate, health, economy and social) scoring “Most” and (C: GI Policy outside environment) scoring “Some”. This stems from the documents structure where GI is present in more strategic chapters and non-environmental chapters.

For strength of policy wording the overall profile declines further to 35%; again, highlighting increased vulnerability for development plan policies.

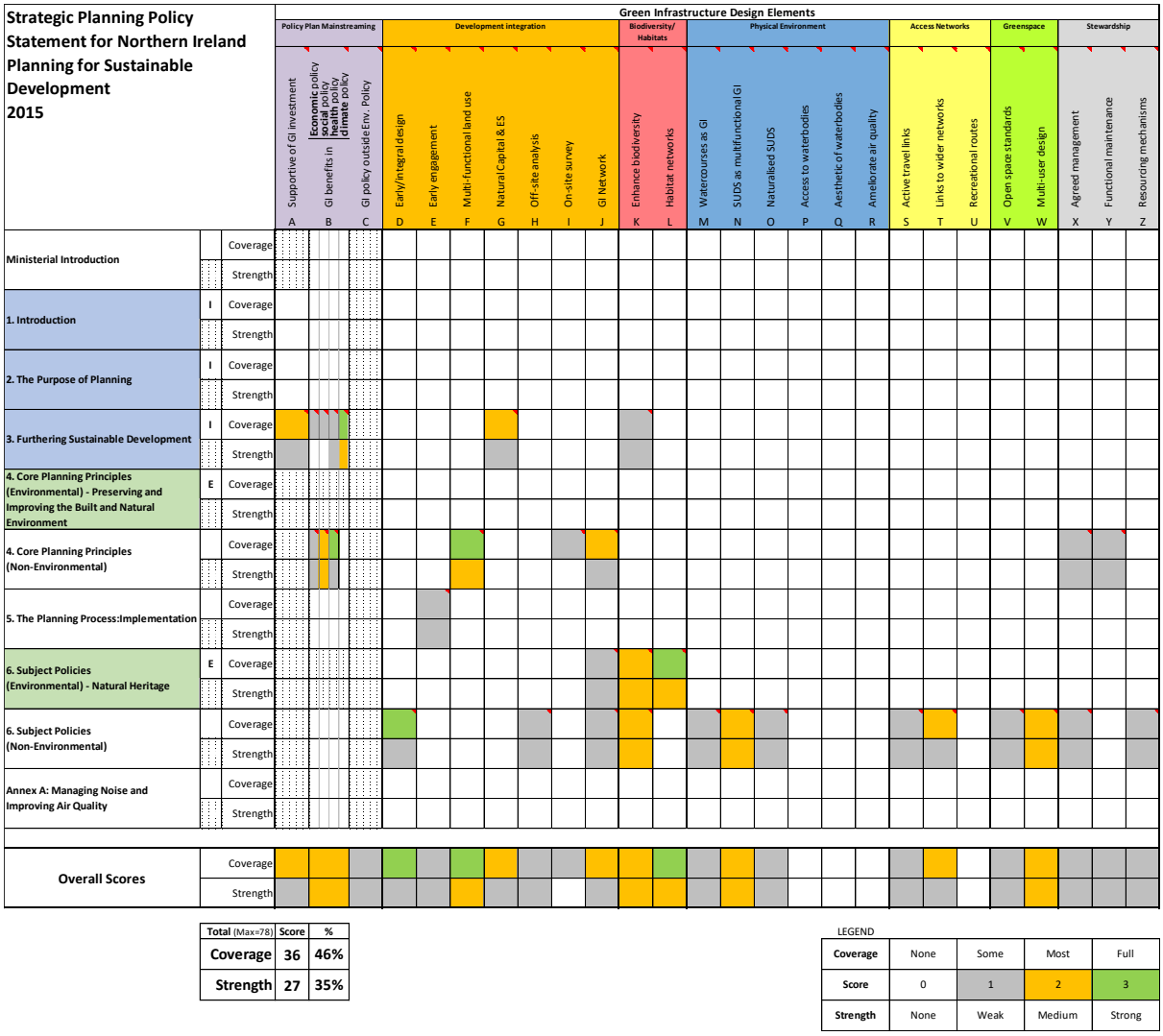

Figure 5: GIPAT policy assessment: Strategic Planning Policy Statement (SPPS), Northern Ireland: Source Authors

3.3 England National Planning Policy Framework NPPF (2023) (Supplementary Information 3)

The NPPF document involves 17 chapters spread over 76 pages with clear policy and/or justification contained in each paragraph. The NPPF has the largest number of chapters but is also the shortest document. The scores are presented in Figure 6. In terms of policy coverage England scores 44%, the lowest of all the devolved nations. There are notable policy gaps in the physical environment functions affecting blue infrastructure (M: Watercourses as GI; O: Naturalised SuDS; P: Access to waterbodies and Q: Aesthetic of waterbodies) and stewardship functions (X agreed management and Y: functional maintenance). There is also a notable gap in the mainstreaming function (B: GI benefits) covering health, climate, economic and social priorities and only "Some" wider mainstreaming present across other chapters (C: GI policy outside environment. Nevertheless, there are full coverage scores in development integration functions (E: Early engagement; G; natural capital and ES; J: GIGI network) and biodiversity function (L: ecological networks).

The strength of policy wording score declines further to 37% with no strong scores achieved across the whole profile. This emphasizes GIGI significant policy vulnerability.

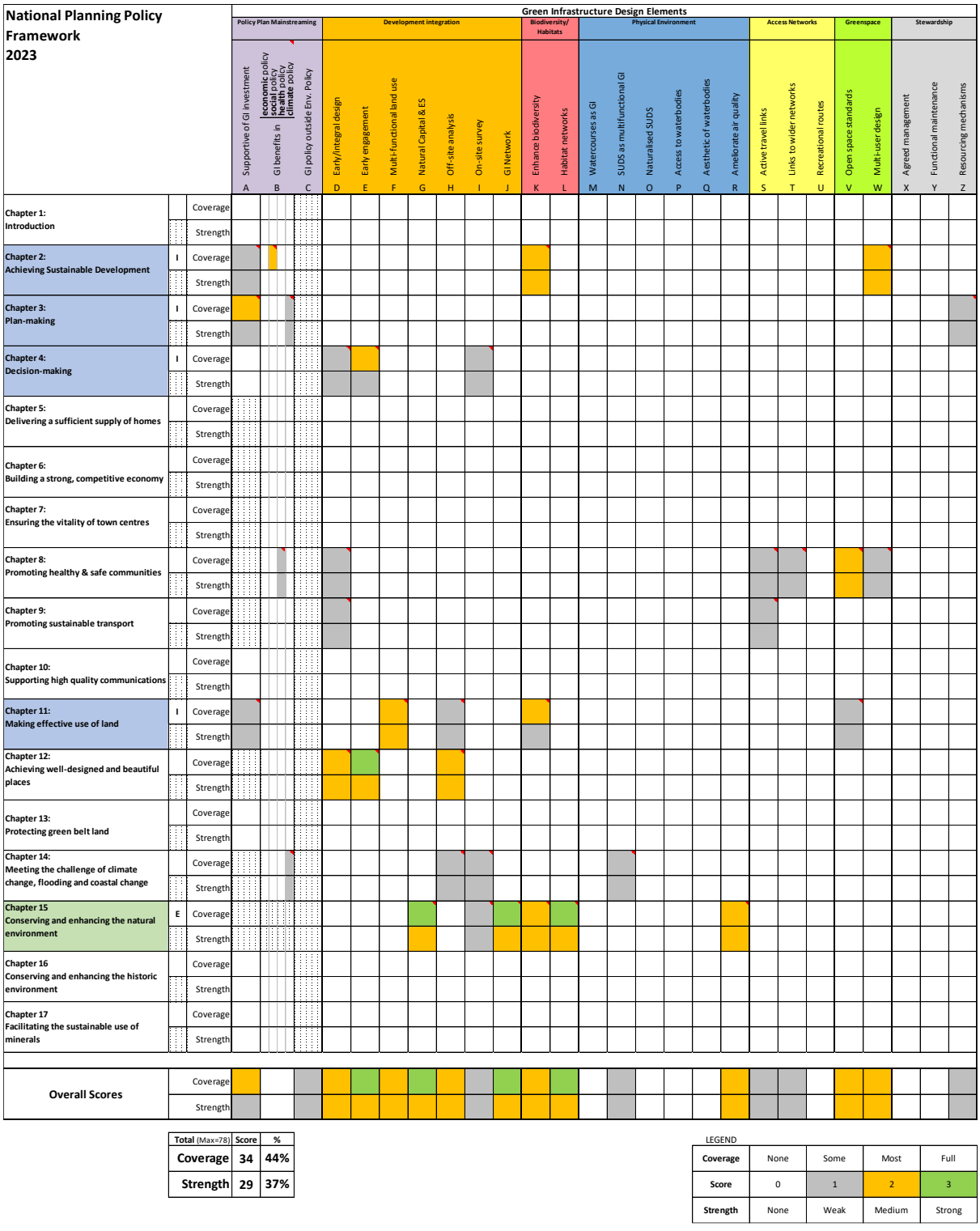

Figure 6 GIPAT policy assessment: National Planning Policy Framework (NPPF), England: Source Authors

3.4 Planning Policy Wales PPW11 (2021) (Supplementary Information 4)

PPW11 is the longest document with 168 pages. It is structured around a placemaking set of headings rather than conventional chapters which aids mainstreaming. Policies are implicit within paragraphs but not clearly identified from statements. The scores are presented in Figure 7. In terms of policy coverage, it scores 72% the highest of the devolved nations with mainstreaming functions scoring full coverage in all categories (A, B, C); the only country to achieve this. It also scores fully in the development integration functions (D Early integral design; F: Multifunctional land Use; G: Natural capital and ES; H: Off-site analysis; I: On site survey and J: GI network) and biodiversity functions (K: Enhance biodiversity and L: Habitat Networks). On individual criteria full scores are also recorded for N: multifunctional SuDS and T: links to wider networks. The only area of weakness is the stewardship function which only has some coverage (X: Agreed management; Y: functional maintenance and Z Resourcing mechanisms).

The strength of policy wording declines to 55% in line with all other countries, but represents the highest score. Here, only D: Early design, K: Enhanced biodiversity and L: Habitat networks have "strong" policy wording. The rest of the profile highlights potential GI policy vulnerability.

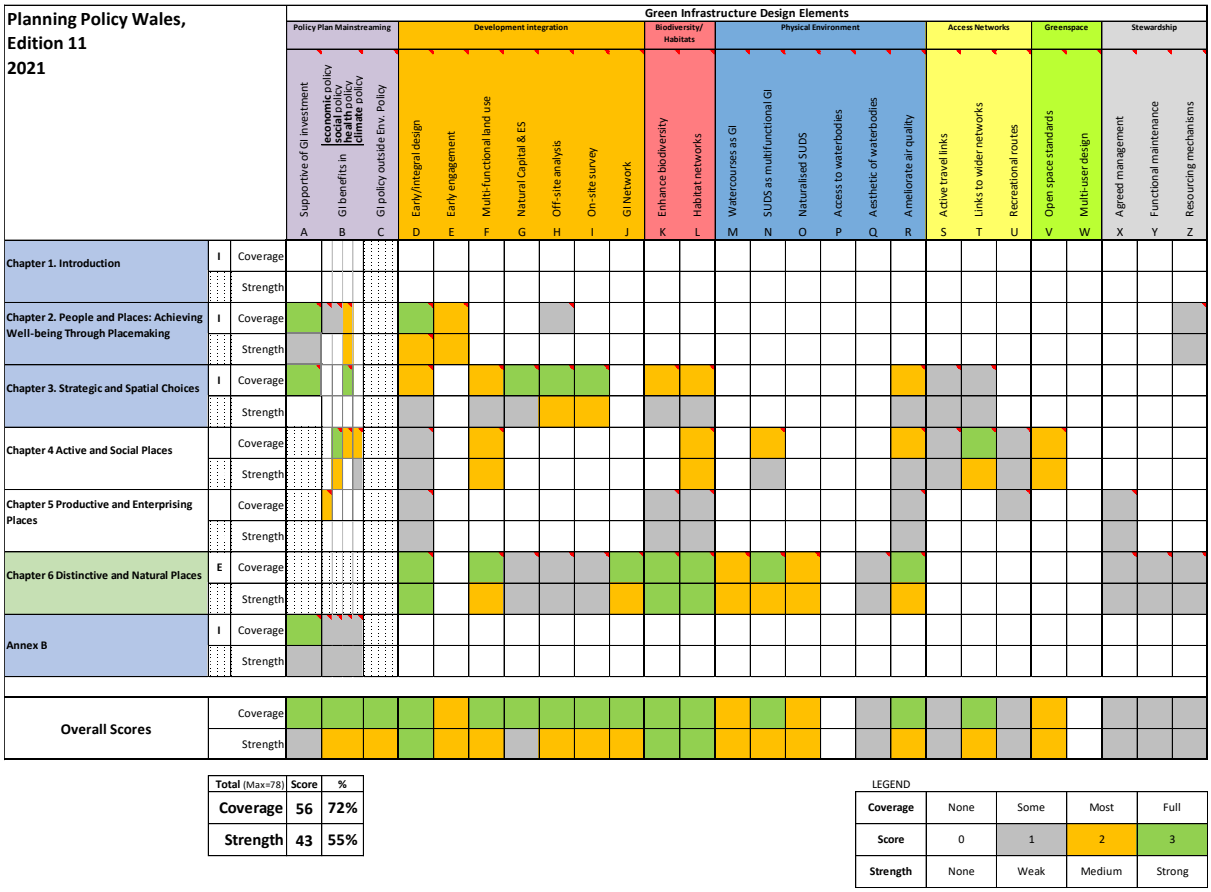

Figure 7: GIPAT policy assessment Planning Policy Wales (PPW11), Wales: source Authors

4. Discussion

4.1 Mind the gaps in GI guidance .

The use of the GIPAT tool confirms that all UK national planning policy guidance endorses GI as a multifunctional resource (Figure 2. This is an important and positive finding, confirming the growing maturity and acceptability of GI across UK spatial planning policy (Fisher et al 2023; Mell, 2020;). There are, however, notable functional gaps apparent affecting blue infrastructure, access and open space and stewardship. Blue infrastructure remains overlooked in GI policy with SuDS not sufficiently recognised as GI or designed as multifunctional assets. This mirrors findings by Wilczyńska et al (2021) in blue infrastructure assessments in Poland and specialized work on stormwater (Jayasooriya and Ng, 2014). GIPAT categorization (M-P: Figure 2) also requires integration between blue and green infrastructure to ensure policy is not siloed. We contend that the hidden nature of blue in GI more generally requires a shift in nomenclature to Green and Blue Infrastructure (GBI). Thus, we now use GBI in this paper in recognition of this.

It is also important to recognize the opportunities for integration with grey infrastructure or "silver-green" as Grace et al (2021) prefer. Thus, features such as green roofs/walls and active travel routes critically depend on integration with grey infrastructure.

Stewardship scores weakly across all UK nations when compared to other criteria, reflecting a planning policy focus on placemaking functions at the expense of placekeeping (Dempsey and Burton, 2010). Stewardship as a concept is evolving and contested; going beyond long-term management of GBI with increasing importance given now to ethical responsibility, cooperation and community involvement (Davies and Muro, 2023). This has a knock-on effect with mainstreaming as all too often GBI is perceived as a cost to development, resulting in short term management regimes pursuing lower maintenance costs at the expense of optimized GI multifunctionality. This compares unfavorably with the way maintenance budgets are used for grey infrastructure (Mell and Scott 2023).

4.2 How vulnerable is GI planning policy?

GIPAT scores reveal across all UK nations that the strength of policy wording is weaker than the coverage scores with few strong scores evident anywhere (Figures 2-5). This suggests significant GBI vulnerability for local plan policy formulation and decision-making when confronted with other policy priorities like economic growth and housing which readily trump GBI. The signal to developers and local authorities alike is that GBI is not a priority matter for action. This aligns with findings of McWilliam et al (2015) in Ontario where weak and vague policy wording led to significant loss of GBI.

Whilst there is a place for vague policy wording; for example, Buhler et al (2021) work on French transport plans, national guidance identifies policy priorities and actions through use of words such as “must”, “should” or “consider”; and the absence of must is significant. If GBI had stronger policy wording across all its functions (C-Z), then this would bring GBI into active consideration alongside other priorities from project inception with trade-offs then being made based on material considerations relevant to the specific project. Initiatives like the UK Building with Nature have tried to address this gap by explicitly seeking to raise the bar of national policy with the establishment and then refinement of the first UK accredited benchmark for what good green infrastructure looks like (Jerome et al., 2019).

The functions performing strongly in policy wording are in well-established policy domains where statutory regulations apply; consultation (E) and biodiversity (K, L) categories. However, work by Hislop et al (2019) in Scotland, revealed examples of strong policy wording responses at local authority level across non statutory criteria that are significantly stronger than national guidance, as well as policies that are weaker. This variation from national guidance is evident in findings of Cortinovis and Geneletti (2018) in their assessment of plans across 22 Italian cities and Grabowski et al (2022) and Hoover et al 2023 across US cities. In both cases plans showed significant variation in quality and extent of GBI. . The reasons for this are unclear but suggest the importance of micropolitics (Inch 2010); issues of individual character of the policy drafter, their confidence in the policy subject; GBI, motivation, training and leadership all being relevant (Scott et al., 2018). These potential drivers provide important future research pathways.

4.3 Improving the integration and mainstreaming of GBI.

In a UK context the two most established areas of planning legislation and policy are nature conservation and Green Belt (Kirby and Scott, 2023); both embedded in regulation and policy since the late 40s and early 50s where they have largely evolved in their policy silos. GBI came into the policy arena in early 2000 where it has struggled to be mainstreamed both within and outside the “environment domain” (Mell et al 2017). Consequently, we tend to see GBI policy developed in isolation (dis)integrated from other environmental policies (Scott et al., 2022). This is evident in local authority planning policy where GI is often presented as one policy rather than a suite of policies to optimize its multifunctional characteristics across other policy domains. This lack of integration is clearly exposed in green belt, where despite it being an essential component of GBI where it exists, it does not explicitly feature in any of the justification policy material (Supplementary Information 1-4). Equally, in the green belt sections or chapters there is no mention of GBI. This hinders both biodiversity and multifunctionality objectives for GI and green belt itself as identified by Kirby and

Scott (2023) in their green belt policy analysis. This policy (dis)integration is further evident in the way that climate change, equity and health and well-being considerations; all emerging areas of planning policy also do not fully integrate GI as reflected in low scoring B: GI benefits profiles (Figures 4-7).

4.4 GIPAT as a transferable tool with global application.

We now turn our attention to how transferable GIPAT is outside the UK. GIPAT has significant transferability as it was built from three separate research projects; two with their supporting global academic literatures; Jerome et al (2017) and Author (2019). Specifically, GIPAT was built to encompass all the identified GI themes and functions in Table 1 with no attempt to build a bespoke UK tool. The assessment criteria were designed for generic use rather than focusing on a particular national approach. Indeed, GIPAT has been used and adapted for use in New Zealand with a pilor project on Tasman District also incorporating Te Aranga Principles Taiao and Mauri Tū . The adaptation to include Māori cultural perspectives was particularly significant (Ransom and Scott, 2020). It has also been embedded in two EU Interreg GBI projects: PERFECT (2017-2021) involving eight partners through a dedicated expert policy paper (********[2]) and GIFT (2023-) (Green Infrastructure for Forests and Trees) to assess multiple GI plans across the 8 European partners. It has also been adapted as a green belt policy assessment matrix tool (Kirby and Scott 2023). However, it is important to note that the tool itself has been purposively designed to enable users to adapt criteria to a local context as appropriate whether in a UK or global north setting where it is perhaps most applicable.

Another dimension of GIPATS wider transferability is through the development of exemplar "model" GI policies for each of the key GIPAT design elements (Figure 1). Box 1 captures the highest scoring policy examples based on all 4 UK nations which is dominated by Scottish and Welsh examples. It should be noted that the policy wording has not been changed but we have in brackets indicated how policy wording could be strengthened.

[2] Reference not cited due to author confidentiality

Mainstreaming functions

Landscape and green infrastructure considerations are an integral part of the design process. Integrating green infrastructure is not limited to focusing on landscape and ecology, rather, consideration *should* (must) be given to all features of the natural environment and how these function together to contribute toward the quality of places. This embraces the principles of 'ecosystems services' and sustainable management of natural resources where multiple benefits solution become an integral part of good design. (PPW11)

Stewardship functions

Development proposals that include new or enhanced blue and/or green infrastructure will provide effective management and maintenance plans covering the funding arrangements for their long-term delivery and upkeep, and the party or parties responsible for these (NPF4).

Physical Environment functions (including blue infrastructure)

LDPs *should* (will) strengthen community resilience to the current and future impacts of climate change, by avoiding development in areas at flood risk as a first principle. Resilience should also be supported by managing the need to bring previously used sites in built up areas into positive use; planning for adaptation measures; and identifying opportunities to implement improvements to the water environment through natural flood risk management and blue green infrastructure. Development proposals which create, expand or enhance opportunities for natural flood risk management, including blue and green infrastructure, will be supported (NPF4).

Biodiversity functions

a) Development proposals will contribute to the enhancement of biodiversity, including where relevant, restoring degraded habitats and building and strengthening nature networks and the connections between them. Proposals should also integrate nature-based solutions, where possible. d) Any potential adverse impacts, including cumulative impacts, of development proposals on biodiversity, nature networks and the natural environment will be minimised through careful planning and design. This *will take into account* (necessitates) the need to reverse biodiversity loss, safeguard the ecosystem services that the natural environment provides, and build resilience by enhancing nature networks and maximising the potential for restoration. (NPF4)

Development integration functions

Site and context analysis *should* (must) be used to determine the appropriateness of a development proposal in responding to its surroundings. This process will ensure that a development is well integrated into the fabric of the existing built environment. The analysis process will highlight constraints and opportunities presented by existing settlement structure and uses, landscape, biodiversity, water environment, movement, infrastructure, materials and resources, soundscape and built form which will need to be considered when formulating proposals. (PPW11)

Blue and green infrastructure are an integral part of early design and development processes; are designed to deliver multiple functions including climate mitigation, nature restoration, biodiversity enhancement, flood prevention and water management (NPF4)

Plans should plan for the enhancement of natural capital at a catchment or landscape scale across local authority boundaries (NPPF).

Access functions

New development *should* (will) be integrated with active travel networks and contribute to their expansion and improvement, through the inclusion of well-designed routes and facilities as part of the schemes and financial contributions to pay for off-site connections. Planning authorities should also seek to assist in the completion of the national cycle network and key links to and from the network. These measures should, where appropriate, be aligned with approaches to secure green infrastructure. (PPW11)

LDPs *should* (will) safeguard access rights and core paths, including active travel routes, and encourage new and enhanced opportunities for access linked to wider networks. (NPF4)

Green Space functions

Development proposals for incorporating new or enhanced blue and/or green infrastructure will be supported. Where appropriate, this will be an integral element of the design that responds to local circumstances. Design will *take account* (assess) of existing provision, new requirements and network connections (identified in relevant strategies such as the Open Space Strategies) to ensure the proposed blue and/or green infrastructure is of an appropriate type(s), quantity, quality and accessibility and is designed to be multi functional and well integrated into the overall proposals. (PPW11)

LDPs *should* (must) identify sites for sports, play and outdoor recreation for people of all ages. This *should* (will) be based on an understanding of the needs and demand in the community and informed by the planning authority's Play Sufficiency Assessment and Open Space Strategy. These spaces can be incorporated as part of enhancing and expanding blue and green infrastructure, taking account of relevant agencies' plans or policy frameworks, such as flood risk and/or water management plans (PPW11).

Box 1 ***Selected policy extracts bracketed words include authors suggestions for improved policy wording from those words in italics .***

5. Conclusions

This paper has provided the first GI assessment of contemporary planning policy across all 4 devolved nations of the UK. The results reveal that GI is increasingly recognized as a multifunctional asset albeit with notable gaps in the areas of blue infrastructure and access. Green belt is also notable by its absence as a GI asset within the GIPAT matrix policy material. Furthermore, stewardship is an area demanding more policy attention redressing the balance of policy emphasis between placemaking and placekeeping functions as well including retrofitting GI in areas of GI deficit as part of a wider equity agendas. The stand-out finding is the lack of strong policy wording

for GI at a national level which signals significant policy vulnerability. To address this we have amalgamated the highest scoring policies to create a suite of policies that could be used in development plans and to improve existing national planning policy. This is particularly important in Northern Ireland with its now outdated SPPS(2015). The GIPAT tool provides a transferable tool which can be used to help the development and evaluation of GI policy at a range of spatial scales. Its value lies in the design process that integrated academic and policy and practice perspectives utilizing co-production processes. The results here will hopefully provide a new strand of GI research to improve not only policies at national and local level but also how decision-making processes can best use these to tackle key societal challenges.

6. References

Benedict M.A. and McMahon E.T. (2002) Green Infrastructure: Smart Conservation for the 21st Century, *Renewable Resources Journal* 20 (3) 12-17

Beunen, R., K. Van Assche, and M. Duineveld. (2013). Performing failure in conservation policy: The implementation of European Union directives in the Netherlands. *Land Use Policy* 31: 280–288. https://doi.org/10.1016/j.landusepol.2012.07.009.

Buhler, T. (2021) When vagueness is a strategic resource for planning actors, *Planning Theory*, 20 (4) 325-349

Buitelaar, E., Galle, M. and Sorel, N. (2011) Plan-led planning systems in development-led practices: An empirical analysis into the (lack of) institutionalisation of planning law. *Environment & Planning A: Economy & Space*, 2011, Vol. 43(4), 928-41).

Building with Nature (2022) The Building with Standards Framework 2.0 https://www.buildingwithnature.org.uk/standards-form [accessed 19 February 2024]

Bush, J., Ashley, G., Foster, B. and Hall. G. (2021) Integrating Green Infrastructure into Urban Planning: Developing Melbourne's Green Factor Tool, Urban Planning, 6 (1) https://doi.org/10.17645/up.v6i1.3515

Connop S, Vandergert P, Eisenberg B *et al.* (2016) Renaturing cities using a regionally-focused biodiversity-led multifunctional benefits approach to urban green infrastructure. *Environmental Science & Policy* **62**: 99–111, 10.1016/j.envsci.2016.01.013

Cortinovis, C. and Geneletti, D. (2018) Ecosystem services in urban plans: What is there, and what is still needed for better decisions, *Land Use Policy*, 70, 298-312, https://doi.org/10.1016/j.landusepol.2017.10.017.

595 Cortinovis, C., Zulian, G. and Geneletti, D. (2018) Assessing Nature-Based Recreation to Support
596 Urban Green Infrastructure Planning in Trento (Italy) Land *7*(4), 112;
597 https://doi.org/10.3390/land7040112

598 Dasgupta, P. 2021. *The economics of biodiversity*: The Dasgupta review. HM Treasury: London

599 Davies, C. and Muro, R.S.T (2023) Stewardship and green infrastructure in England. Planning
600 perspectives informed through an investigation of urban green infrastructure, Journal of
601 Environmental Planning and Management, DOI: 10.1080/09640568.2023.2197557

602 Dempsey, N. and Burton, M. (2012) Defining place-keeping: The long-term management of public
603 spaces*, Urban Forestry & Urban Greening,*11(1), 11-20, https://doi.org/10.1016/j.ufug.2011.09.005.

604 Demuzere M, Orru K, Heidrich O, Olazabal E, Geneletti D, Orru H, Bhave A, Mittal N, Feliu E, Faehnle
605 M. (2014) Mitigating and adapting to climate change: multi-functional and multi-scale assessment of
606 green urban infrastructures. *Journal of Environmental Management*, 146, 107-115

607 Depietri, Y. (2022) Planning for urban green infrastructure: addressing tradeoffs and synergies
608 *Current Opinion in Environmental Sustainability,* 54 Article 101148

609 Di Marino, M.; Tiitu, M.; Lapintie, K.; Viinikka, A.; Kopperoinen, L. (2019) Integrating Green
610 Infrastructure and Ecosystem Services in Land Use Planning. Results from Two Finnish Case Studies.
611 *Land Use Policy*, 82, 643–656.

612 EU Commission (2013) *Communication from the Commission to the European Parliament, the Council,*
613 *the European Economic and Social Committee and the Committee of the Regions. Green Infrastructure*
614 *(GI) – Enhancing Europe's Natural Capital*. Green Infrastructure Strategy. COM (2013) 249 final.
615 European Commission, May 2013, p3. **https://eur-lex.europa.eu/legal-**
616 **content/EN/TXT/?uri=CELEX:52013DC0249**

617 Felappi, J.F., Sommer, J.H., Falkenberg, T., Terlau, W and Kötter, T. (2020) Green infrastructure
618 through the lens of "One Health": A systematic review and integrative framework uncovering
619 synergies and trade-offs between mental health and wildlife support in cities, *Science of The Total*
620 *Environment,*748,141589, https://doi.org/10.1016/j.scitotenv.2020.141589.

621 Fisher, D., Blackstock, K. & Irvine, K. (2021) It's on the 'nice to have' pile: Potential principles to
622 improve the implementation of socially inclusive Green Infrastructure. *Ambio* **50**, 1574–1586 .
623 https://doi.org/10.1007/s13280-020-01372-2

624 Grabowski, Z.J., McPhearson, A.T., Matsler, M., Groffman, P. and Pickett, S.T.A (2022) What is green
625 infrastructure? A study of definitions in US City Planning *Frontiers in Ecology and the Environment*,
626 10.1002/fee.2445

627 Grabowski, Z. J., McPhearson, T. & Pickett, S. T. A. (2023) Transforming US urban green infrastructure
628 planning to address equity. *Landscape and Urban Planning.* **229**, 104591 (2023).

629 Grace, M., Scott, A.J., Sadler, J.P., Proverbs, D.J. and Grayson N. (2020) Exploring the smart-natural
630 city interface; re-imagining and re-integrating urban planning and governance Emerald Open Res, 2,
631 7, 10.35241/emeraldopenres.13226.1

632 Hansen R and Pauleit S (2014) From multifunctionality to multiple ecosystem services? A conceptual
633 framework for multifunctionality in green infrastructure planning for urban areas. *Ambio* **43(4)**: 516–
634 529.

635 Haughton, G., P. Allmendinger, and S. Oosterlynck. 2013. Spaces of neoliberal experimentation: Soft
636 spaces, postpolitics, and neoliberal governmentality. *Environment and Planning a: Economy and*
637 *Space* 45: 217–234. https://doi.org/10.1068/a45121

638 Honeck, E., Sanguet, A., Schlaepfer, M.A. (2020) Methods for identifying green infrastructure. *SN*
639 *Applied Sciences* **2**, 1916 (2020). https://doi.org/10.1007/s42452-020-03575-4

640 Hoover, F.A., Meerow, S., Coleman, E., Grabowski, Z. and McPhearson, T. (2023) Why go green?
641 Comparing rationales and planning criteria for green infrastructure in U.S. city plans, *Landscape and*
642 *Urban Planning* 237 10.1016/j.landurbplan.2023.104781

643 Inch A (2010) Culture change as identity regulation: The micro-politics of producing spatial planners
644 in England. *Planning Theory and Practice*, 11(3), 359-374

645 IPBES. (2019). *Global assessment report on biodiversity and ecosystem services.* IPBES, 60.

646 Jaligot, R. and Chenal, J. (2019) Integration of ecosystem services in regional spatial plans in Western
647 Switzerland, *Sustainability,* 11 10.3390/su11020313

648 Jayasooriya, V.M. and Ng, A.W.M. (2014) Tools for Modeling of Stormwater Management and
649 Economics of Green Infrastructure Practices: a Review, *Water, Air, Soil Pollution,* 225:2055 DOI
650 10.1007/s11270-014-2055-1

651 Jerome G, Sinnett D, Burgess S, Calvert T and Mortlock R (2019) A framework for assessing the quality
652 of green infrastructure in the built environment in the UK. *Urban Forestry & Urban Greening* 40: 174–
653 182, 10.1016/j.ufug.2019.04.001

654 Johns, C.M. (2019) Understanding barriers to green infrastructure policy and stormwater
655 management in the City of Toronto: a shift from grey to green or policy layering and conversion?,
656 Journal of Environmental Planning and Management, 62:8, 1377-1401, DOI:
657 10.1080/09640568.2018.1496072

658 Juhola, S. (2018) Planning for a green city: the green factor tool, *Urban Forestry and Urban Greening*,
659 34, 254-258, 10.1016/j.ufug.2018.07.019

660 Kaur, H. and Garg, P. (2019) Urban sustainability assessment tools: a review, *Journal of Cleaner*
661 *Production*, 210, 146-158, 10.1016/j.jclepro.2018.11.009

662 Lai, S., Leone, F. and Zoppi, C (2019) Assessment of Municipal Masterplans Aimed at Identifying and
663 Fostering Green Infrastructure: A Study Concerning Three Towns of the Metropolitan Area of Cagliari,
664 Italy Sustainability, 11, p. 1470, 10.3390/su11051470

665 Lennon, M. Green infrastructure and planning policy: A critical assessment. *Local Environment*. **2015**,
666 20, 957–980

667 McWilliam, W., Brown, R., Eagles, P., & Seasons, M. (2015). Evaluation of planning policy for
668 protecting green infrastructure from loss and degradation due to residential encroachment. *Land Use*
669 *Policy*, *47*, 459–467.

670 Matsler, A.M., Meerow, S., Mell, I.C. and Pavao-Zuckerman, M.A. (2021) A 'green' chameleon:
671 Exploring the many disciplinary definitions, goals, and forms of "green infrastructure", *Landscape and*
672 *Urban Planning*, 214

673 Matthews T, Lo AY and Byrne JA (2015) Reconceptualizing green infrastructure for climate change
674 adaptation: barriers to adoption and drivers for uptake by spatial planners. *Landscape and Urban*
675 *Planning* **138**: 155–163

676 Mell I, Allin S, Reimer M and Wilker J (2017) Strategic green infrastructure planning in Germany and
677 the UK: a transnational evaluation of the evolution of urban greening policy and practice.
678 *International Planning Studies* 22(4): 333–349, 10.1080/13563475.2017.1291334

679 Mell, I. (2020) What Future for Green Infrastructure Planning? Evaluating the Changing Environment
680 for Green Infrastructure Planning Following the Revocation of Regional Planning Policy in England,
681 Planning Practice & Research, 35:1, 18-50, DOI: 10.1080/02697459.2020.1714271

682 Mell, I.; Scott, A. Definitions and context of blue-green infrastructure. In ICE Manual of Blue-Green
683 Infrastructure; Washbourne, C.-L., Wansbury, C., Eds.; ICE Manuals; ICE Publishing: London, UK, 2023;
684 pp. 3–22. ISBN 978-0-7277-6542-0

685 Monterio, R., Ferriera, JC and Antunes P (2020) Green Infrastructure Planning Principles: An
686 Integrated Literature Review, Land *9*(12), 525; https://doi.org/10.3390/land9120525

687 Natural England (2023) Green Infrastructure Framework: Principles and Standards for England.
688 https://designatedsites.naturalengland.org.uk/GreenInfrastructure/Home.aspx [accessed 16
689 February 2024]

690 Netusil NR, Levin Z, Shandas V and Hart T (2014) Valuing green infrastructure in Portland, Oregon.
691 *Landscape and Urban Planning* **124**: 14–21, 10.1016/j.landurbplan.2014.01.002

692 Newman P (2010) Green urbanism and its application to Singapore. *Environment and Urbanization*
693 *ASIA* **1(2)**: 149–170, 10.1177/097542531000100204

694 O'Sullivan F, Mell I and Clement S (2020) Novel solutions or rebranded approaches: evaluating the use
695 of nature-based solutions (NBS) in Europe. *Frontiers in Sustainable Cities* **2**: 572527,
696 10.3389/frsc.2020.572527.

697 Reed MS, Allen K, Attlee A, Dougill AJ, Evans KL, Kenter JO, et al. A place-based approach to payments
698 for ecosystem services. *Global Environmental Change*. 2017; 43:92–106.

699 Ring, Z., Damyanovic, D. and Reinwald, F. (2021). Green and Open Space Factor Vienna: a steering and
700 evaluation tool for urban green infrastructure. *Urban Forestry & Urban Greening*. 62. 127131.
701 10.1016/j.ufug.2021.127131.

702 Scott AJ, Holtby R, East H and Lannin A (2022) Mainstreaming the environment: exploring pathways
703 and narratives to improve policy and decision-making. *People and Nature* 4(1): 201–217,
704 10.1002/pan3.10276.

705 Scott, AJ; Carter C.,Hardman, M.,Grayson, N.&Slaney T (2018) Mainstreaming ecosystem science in
706 spatial planning practice: exploiting a hybrid opportunity space, *Land Use Policy* 70, 232-246

707 Scott AJ, Bader, E. and Dempsey N (2023) Case studies of blue-green infrastructure in spatial planning
708 The ICE Manual of Blue Green Infrastructure. Washbourne, C. & Wansbury, C. (eds.). London: ICE
709 Publishing, Chapter 16, 287-301

710 Slatmo, E., Nilsson, K. and Turunen, E (2019) Implementing Green Infrastructure in Spatial Planning in
711 Europe*, Land* https://doi.org/10.3390/land8040062

712 Spash, C.L. and Hache F (2022) The Dasgupta Review deconstructed: an exposé of biodiversity
713 economics, Globalizations, 19:5, 653-676, DOI: 10.1080/14747731.2021.1929007

714 Trygg, K., and H. Wenander. 2022. Strategic spatial planning for sustainable development—Swedish
715 planners' institutional capacity. European Planning Studies 30: 1985–2001.
716 https://doi.org/10.1080/09654313.2021.2001792

717 Tzoulas K, Korpela K, Venn S *et al.* (2007) Promoting ecosystem and human health in urban areas
718 using green infrastructure: a literature review. *Landscape and Urban Planning* **81**: 167–178.

719 Valtonen, E., Falkenbach, H. and Viitanen, K. (2017) Development-led planning practices in a plan-led
720 planning system: empirical evidence from Finland. *European Planning Studies*, 2017, Vol. 25(6), 1053-
721 75)

722 Valtonen, E., Falkenbach, H., Viitanen, K., 2017. Development-led planning practices in a plan-led
723 planning system: empirical evidence from Finland. European Planning Studies 25 (6),1053–1075

724 Van Oijstaeijen W, Van Passel S, Cools J. Urban green infrastructure: A review on valuation toolkits
725 from an urban planning perspective. *Journal of Environmental Management*. 267:110603. doi:
726 10.1016/j.jenvman.2020.110603.

727 Veerkamp, C.J., Schipper, A.M., Hedlund, K., Lazarova, T., Nordin, A. and Hanson, H.I. (2021) A
728 review of studies assessing ecosystem services provided by urban green and blue infrastructure,
729 *Ecosystem Services*, 52 Article 101367 https://doi.org/10.1016/j.ecoser.2021.101367

730 Wang J and Banzhaf E (2018) Towards a better understanding of green infrastructure: a critical review.
731 *Ecological Indicators* **85**: 758–772, 10.1016/J.ECOLIND.2017.09.018

732 Wilker J, Rusche K and Rymsa-Fitschen C (2016) Improving participation in green infrastructure
733 planning. *Planning Practice & Research* **31(3)**: 229–249, 10.1080/02697459.2016.1158065

734 Wilczyńska, A., Myszka, I., Bell, S., Slapińska, M., Janatian, N. and Schwerk, A. (2021) Exploring the
735 spatial potential of neglected or unmanaged blue spaces in the city of Warsaw, Poland, *Urban*
736 *Forestry & Urban Greening*, 64,https://doi.org/10.1016/j.ufug.2021.127252.

737 Wolch JR, Byrne J and Newell JP (2014) Urban green space, public health, and environmental justice:
738 the challenge of making cities 'just green enough'. *Landscape and Urban Planning* **135**:224–234

739 Wright H (2011) Understanding green infrastructure: the development of a contested concept in
740 England. *Local Environment* **16(10)**: 37–41.

741 Zuniga-Teran AA, Staddon C, de Vito L *et al.* (2020) Challenges of mainstreaming green infrastructure
742 in built environment professions. *Journal of Environmental Planning and Management* **63(4)**: 710–
743 732, 10.1080/09640568.2019.1605890

744

745

746