Landscape Architecture

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Regime Capability and Repair Priority in European Policy Portfolios for Urban Nature-Based Solutions

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Abstract

Today, nature-based solutions in urban environments need to be regarded not only as projects but also as infrastructure for adaptation, restoration, moderation, cooling, public health, and overall quality of life. However, their increasing use relies on policy portfolios that should provide more than mere regulations, funding, or guidance documents. Rather, they have to build at least some level of capability within a broad set of institutional, economic, technical, cultural, and delivery conditions within which urban infrastructure is planned, built, financed, maintained, and valued. In this article, we introduce Regime-Capability Readiness Assessments for seven European case studies: European Union, Germany, Hungary, Netherlands, Spain, Sweden, and the United Kingdom. Our approach converts policy-instrument codes into four capability states – from vacant to anchored and then combines these indicators based on three metrics: sufficiency of instrument families, capped regime saturation, and bottlenecks protection. Consequently, the developed Implementation-Readiness and Repair Index provides information on how close each portfolio is to being capable of sustaining routine nature-based implementation. The European Union demonstrates the highest score, 96.6, due to sufficiency of all instrument families and absence of any vacuum or fragility in its regime dimensions. While Germany possesses strong capacity of policy making, it suffers in its implementation readiness due to the lack of functioning industry-network and physical technology elements. The United Kingdom and Sweden find themselves in an intermediate position with their distinctive needs for repair: Sweden lacks economic and usage practice capabilities, while the United Kingdom requires financial and funding repairs. Despite retaining strong knowledge base, the Netherlands still require further development. Finally, both Spain and Hungary require further strengthening of foundational elements. It turns out that capacity assessment should always consider the issue of capability development.

Keywords: nature-based solutions; urban governance; policy portfolios; implementation readiness; regime capability; policy repair; Europe

1. Introduction

Nature-based solutions have become indispensable for climate adaptation, biodiversity recovery, flood protection, heat mitigation, public health, and liveable city-building. From green-blue corridors to wetland restoration, from tree canopy programs to sustainable drainage solutions, from green roofs to pocket parks, and from river renaturation initiatives to water-based interventions, nature-based solutions have come to be regarded not merely

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as environmental amenities but as multifunctional infrastructure that can perform crucial functions related to stormwater retention, heat alleviation, habitat connectivity, well-being, and resilience [13, 15, 18, 24]. In the process, the audience for nature-based solutions has been broadened, yet at the same time, a set of institutional challenges associated with their application has been accentuated. Even if a nature-based solution is ecologically sound and socially desirable, it can never become mainstream unless the institutional architecture prioritizing conventional grey infrastructure is addressed in any significant way.

Consequently, the challenge of mainstreaming urban nature-based solutions has little to do with the availability of projects. It is about overcoming the institutional conditions under which urban infrastructure is planned, funded, designed, monitored, insured, delivered, and maintained. As noted elsewhere, there are a number of hurdles that need to be overcome in the process: fragmented governance, unpredictable finance, insufficient knowledge, weak corporate engagement, competition over space, unclear maintenance, and insufficient communication between ecology and delivery [22, 28]. However, these hurdles are not merely problems of administration and management. They represent regime conditions under which infrastructure delivery is reproduced in certain ways [21, 26].

By definition, a policy portfolio should be able to interact with these regime conditions in order to effectuate an institutional transformation that would lead to greater use of nature-based solutions. This goal may be achieved through the strategic combination of regulatory, financial, and soft instruments that enable policy action along key regime functions, i.e., regulation, culture, knowledge, industrial organization, technology, user practices, and finance [3, 4, 31]. Each type of instrument acts on implementation through a particular mechanism: regulations create legal obligations and expectations, financing influences economic incentives, while soft measures contribute to social learning and coordination. In turn, a policy portfolio that combines them effectively will be able to facilitate mainstreaming to a much higher degree.

However, such portfolios also vary considerably in terms of instrumental composition and the extent to which they cover different regime functions. A comprehensive policy may cover too few functions with too few instruments to be capable of mainstreaming. Moreover, it might possess too many functions with only one instrument each, leaving them particularly vulnerable to external challenges. Such portfolios can hardly be considered mainstreaming-capable because of inherent structural weaknesses.

The current article is concerned with the following objective: to analyze to what extent the supra-national and national policy portfolios for urban nature-based solutions convert instrument diversity into mainstreaming-ready regime capability and thus establish which missing or fragile functions represent the highest priority. The novelty of this research lies in its focus on policy capability instead of volume. This implies an assessment of policy depth for the minimum level of instruments per regime dimension. It is important to note that the comparison is restricted to the level of minimum instrument presence. It cannot measure final outcomes since comparable cross-country evidence on the areas implemented, flood losses prevented, biodiversity performance, maintenance, investments, and well-being effects is not available.

Methodologically, this article employs a ready-to-implement approach to regime capabilities. This framework evaluates the completeness of policy instruments for minimum regime dimensions that could present implementation bottlenecks due to insufficient coverage or a low number of supporting instruments. Substantively, it identifies distinctive repair profiles for the cases of the European Union, Germany, Hungary, the Netherlands, Spain, Sweden, and the United Kingdom.

2. Literature background

2.1. Nature-based solutions in urban infrastructure policy

Nature-based solutions are generally regarded as actions involving natural and modified ecosystems for tackling societal problems and benefiting both people and biodiversity [6]. In other words, they combine the notion of ecosystem services with that of green infrastructure, ecosystem-based adaptation, and urban forestry by placing greater emphasis on the role of ecological processes as problem-solving responses to social needs [11, 12, 30].

In an urban setting, the problem-solving character of nature-based solutions becomes even more pronounced because cities tend to accumulate risks related to climate, population exposure, land competition, and infrastructural pressures [15, 25]. This means that urban nature-based solutions can deliver several benefits at once, such as flood retention, thermal regulation, quality improvement of urban spaces, habitat creation, air purification, and well-being enhancement [1, 18, 24].

Multifunctionality presents a unique challenge to urban governance because it requires infrastructure delivery to be reconfigured from a monofunctional mode of operation. While conventional urban infrastructure tends to be composed of monofunctional assets under clear sectoral budgetary responsibility and with well-established engineering criteria, nature-based solutions tend to produce distributed benefits over time and in various directions [8, 9]. A restored stream corridor may serve not only as a flood barrier but also as a biodiversity hotspot with recreational opportunities and real estate value-added for local residents. However, all these benefits may accrue to different agents responsible for installation and maintenance of a restored corridor, which creates an urgent need for instruments connecting nature-based solutions with delivery and implementation processes.

As a consequence, nature-based solutions are increasingly framed as urban infrastructure rather than ornamental greenery. This is critical for policy design and implementation because urban infrastructure has a number of characteristics making it highly institutionalized in the form of regulations, standards, markets, professional routines, cultural conventions, and maintenance [21]. For the living processes to become ordinary infrastructure, it is essential to design instruments facilitating their implementation as legal entities, investment objects, construction sites, maintenance tasks, assessment items, and socially accepted solutions. Consequently, a portfolio focusing on only one function is doomed to be ineffective.

2.2. Policy portfolios and minimum institutional capacity

Environmental and sustainability transitions require complex policy portfolios due to the fact that they entail multi-actor involvement, long horizons, technological uncertainty, institutional lock-ins, and resistance from incumbents [16, 17]. A policy portfolio may fail to alter markets or standards in case of exclusive concentration on experimentation. It may trigger resistance when only regulatory instruments are relied upon and no supportive resources are allocated. It may end up being symbolic when based only on soft learning. Consequently, it is essential to have minimum institutional capacity in a form of diverse instruments covering at least two or three families.

When it comes to urban nature-based solutions, minimum capacity is particularly crucial because implementation requires addressing policy domains related to environmental planning, water management, housing, transport, public space development, climate adaptation, and biodiversity protection. Consequently, policy portfolios should be evaluated not only on the grounds of instrument diversity, but also on their ability to cover regime dimensions that are instrumental for implementation in the chosen context. Even if portfolios are characterized by abundant policies, they might suffer from structural deficiencies as they are excessively focused on soft aspects and lack delivery and finance.

2.3. Regime conditions for implementation

Socio-technical regime theory offers insight into difficulties experienced by new practices. A socio-technical regime consists of institutionalized rule structures, technologies, meaning, markets, skills, and actor constellations defining the normative practices of the period [26]. Likewise, the regime conditions of urban infrastructure are comprised of regulatory rules, technologies, expertise, utility services, land markets, funding channels, and cultural conventions associated with infrastructure reliability [21]. Nature-based solutions pose serious challenges to such regimes because of their reliance on living processes, dispersed maintenance, site-specificity, and multiple benefits.

In the process, urban nature-based solutions have emerged as an infrastructure modality, requiring policy action related to several regime functions. This paper draws on the empirical framework provided in the recent article by van der Jagt et al. The authors propose seven regime dimensions: policy and regulation, cultural values and guiding principles, knowledge and expertise, industry structure and actor network, physical infrastructures and technologies, economic mechanisms and user practices, and finance structure [27]. These are the institutional, cultural, technological, economic, and behavioral factors affecting the process of moving nature-based solutions from project status to routine delivery.

As mentioned before, a policy portfolio might appear active, but still leave one or more regime functions uncovered, i.e., contain knowledge but lack finance, have planning but not delivery coordination, provide funding but no standardization or monitoring. Such functions can be considered as repair priorities as their absence might affect implementation negatively. Therefore, the main challenge of this analysis is to detect which portfolio exhibits a sufficiently high minimum institutional capacity and what repair priorities exist in each case.

3. Materials and methods

3.1. Case material and coding structure

Seven cases were examined in the course of this study: the European Union, Germany, Hungary, the Netherlands, Spain, Sweden, and the United Kingdom. The policy counts are taken from the comparative study by van der Jagt et al. on policy portfolios for urban nature-based solutions in Europe [27]. The data was gathered through semi-structured interviews, documentary reviews, and observations with actors involved in supra-national and national policy-making, such as public agencies, NGOs, research institutions, utilities, urban developers, banks, and institutional investors.

This dataset employs the instrument classification proposed by the above-mentioned authors and distinguishing three instrument families: regulatory, financial, and soft. The first one includes regulations related to environmental and spatial planning, environment-related certifications, and technical requirements. The second family covers physical infrastructure funding, human capital funding, reduced-interest lending, tradable permits, and public procurement rules. The third one represents intermunicipal exchange platforms, competitions, education, and innovation platforms.

Table 1. Instrument counts.

Case	Regulatory	Financial	Soft	Total
European Union	5	4	3	12
Germany	3	5	6	14
Hungary	2	2	1	5
Netherlands	2	1	7	10
Spain	2	1	2	5
Sweden	4	2	1	7
United Kingdom	4	0	2	6

These counts reveal clear contrasts in policy style. Germany has the largest total portfolio, while the European Union has a more balanced distribution across the three instrument families. The Netherlands is dominated by soft instruments, and the United Kingdom has no financial instrument in the coded portfolio. These differences matter because each family supplies a different implementation route. A missing or thin family limits the ability to combine authority, resources, and learning. The country-specific profiles in Fig. 1 make this distributional contrast visible: portfolio volume, family balance, and family absence are not equivalent forms of policy capacity.

The second coding structure records how many instruments target each of the seven regime dimensions. The abbreviations used in the table are P for policy and regulation, C for cultural values and guiding principles, K for knowledge and expertise, I for industry structures and actor networks, T for physical infrastructures and technologies, E for economic mechanisms and user practices, and F for funding structures.

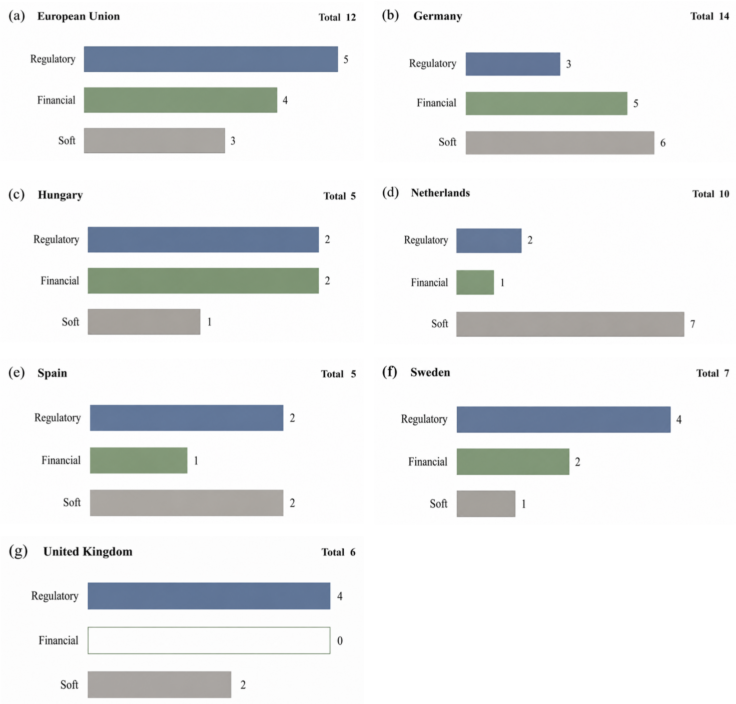

Figure 1. Policy-family composition.

Table 2. Regime counts.

Case	P	C	K	I	T	E	F
European Union	6	5	5	4	3	2	2
Germany	3	4	6	0	0	2	3
Hungary	3	1	0	0	0	1	3
Netherlands	1	1	6	3	1	0	1
Spain	0	2	3	0	0	1	0
Sweden	3	1	3	2	3	0	1
United Kingdom	4	2	3	2	1	2	0

The regime counts reveal a different pattern from instrument totals. The European Union is the only case with positive counts in every regime dimension. Every national portfolio contains at least one unserved dimension. Germany combines strong knowledge and cultural guidance with no coded instruments in industry structures or physical technologies. The Netherlands has substantial knowledge depth but only one instrument in several other dimensions. Spain has the narrowest regime profile. The regime-depth panels in Fig. 2 show why the assessment must distinguish deep capability from shallow or absent support rather than relying on aggregate instrument totals.

3.2. Capability-state scoring

Each regime-target count is reclassified into a capability state. A count of zero is coded as vacant because no instrument addresses that regime function. A count of one is coded as fragile because implementation depends on a single route. Counts of two or three are coded as active because several instruments are present. Counts of four or more are coded as anchored because multiple instruments reinforce that function. This classification does not imply that a high-count dimension is automatically effective. It indicates that the dimension has more policy depth and less single-instrument dependence.

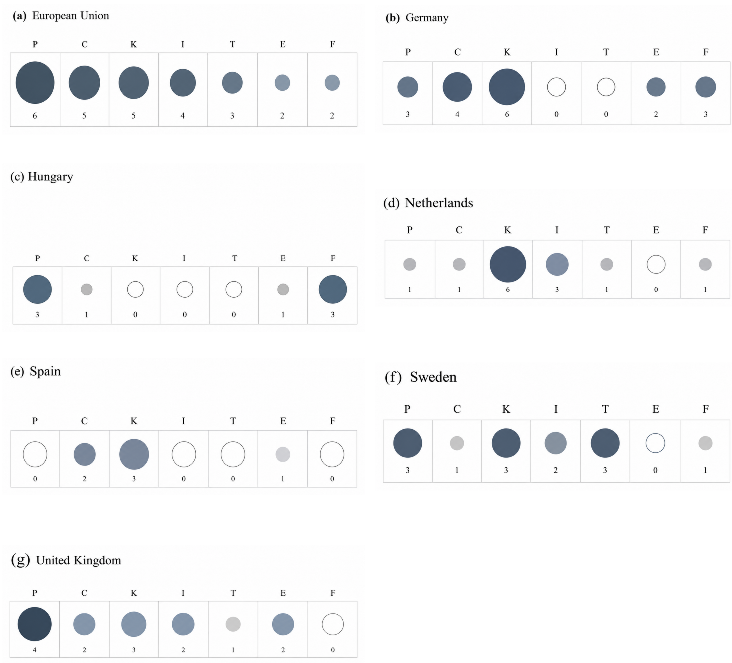

Figure 2. Regime-function depth.

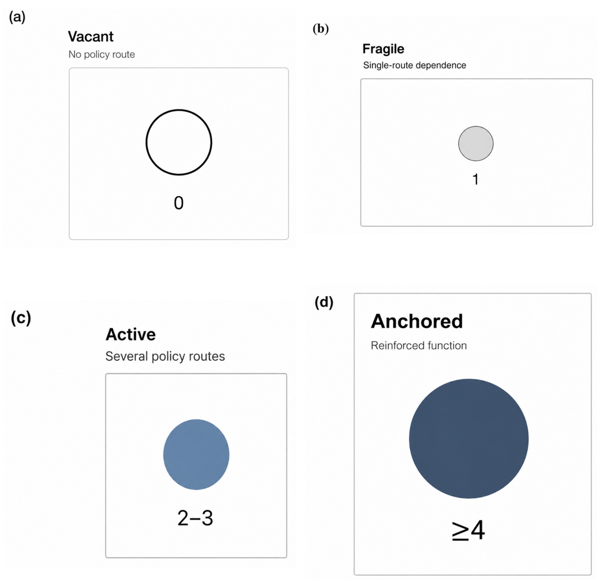

Figure 3. Capability-state thresholds.

The thresholds applied to the number of instruments, result in an implementation diagnosis. It distinguishes a case where there is only one instrument in a dimension from one where there is a cluster of instruments in the same dimension, despite a similarly high maturity level. It also clarifies priorities. Vacant dimensions require priority one repairs. Fragile dimensions have to be strengthened because a single route cannot be sufficient to change practices, behavior, or deliveries.

3.3. Readiness Components

The first component evaluates the minimum policy family floor. Let us define n_{it} as the number of instruments belonging to family t, where t can be any of the three types of instruments – regulatory, financial, or soft. The family-floor score is

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$$F_i = \frac{1}{3}\sum_{t=1}^{3}\frac{\min(n_{it}, 2)}{2}. \quad (1)$$

The threshold of two instruments per family is applied here because we evaluate the presence of families rather than their sizes. Two instruments are the minimum that allows the family to be considered as reaching the floor. One instrument provides some degree of coverage and earns partial points, whereas no instrument earns no points. This construction prevents a portfolio from being overrepresented in terms of family-floor when adding instruments to one family that is already represented.

The second component evaluates regime saturation. In case i, x_{ir} denotes the number of instruments targeting regime dimension r. The regime saturation is then computed as

$$S_i = \frac{1}{7}\sum_{r=1}^{7}\frac{\min(x_{ir}, 3)}{3}. \quad (2)$$

This component takes a threshold of three instruments into account due to the understanding that, in the context of readiness, what really matters is not five versus six instruments but zero versus one instruments. Therefore, saturation rewards broadness and a moderate level of depth without giving way to dominance by one particular dimension, especially knowledge and regulatory ones. An effective way to maximize this component consists in reinforcing under-developed dimensions.

The third component evaluates bottleneck protection. Let us define V_i as the number of vacant regime dimensions and L_i as the number of fragile (one-instrument) regime dimensions. Bottleneck protection is then computed as

$$B_i = 1 - \frac{V_i + 0.5L_i}{7}. \quad (3)$$

A vacant dimension receives a full penalty because its presence means that there is no policy route addressing this particular regime function. A fragile dimension gets a half penalty since although some effort was made to mainstream, there might be problems with the particular instrument's scope, enforcement, discontinuation, or uptake. This construction reflects the logic of thinking about bottleneck as the weak part of the whole portfolio.

The total implementation-readiness and repair index IRRI is the harmonic mean of the three components:

$$IRRI_i = 100 \times \frac{3}{F_i^{-1} + S_i^{-1} + B_i^{-1}}. \quad (4)$$

In order to construct a readiness and repair index, the harmonic mean is used because it is highly sensitive to low values. This choice is logical in the context of implementation-readiness, as a portfolio cannot be ready when it does well in one component but poorly in others. A good distribution of regime dimensions combined with a lack of financial family cannot be considered a comprehensive policy portfolio, neither can a good family balance together with vacant dimensions. And yet, a relatively saturated portfolio, which contains many fragile cells, still requires some reinforcements. Thus, this index should be interpreted as structural readiness rather than actual implementation success.

3.4. Repair Sequencing

Repair prioritization is performed in two steps. First of all, we identify missing and thin instrument families. If a portfolio is missing a certain family, we assume it needs repair; if it has only one instrument from a particular family, we assume it needs reinforcement. The second step identifies vacant and fragile regime dimensions. Among those, vacancy takes priority because it means a complete absence of policy attention, whereas fragility calls for reinforcement if it corresponds to functions that are difficult to implement via one instrument only, including funding, industry coordination, technical standards, incentives, or user practice.

Figure 4. Readiness calculation.

The calculation structure in Fig. 4 links the three readiness components to policy interpretation. A high score indicates that a portfolio has a sufficient family floor, moderate-to-high regime depth, and limited bottleneck exposure. A low score identifies whether the weakness lies in missing policy families, shallow regime targeting, or fragile implementation functions. This distinction matters because the policy response differs by weakness. A finance omission requires a different repair route from a technical-standard omission, and knowledge over-concentration requires a different response from a vacant industry-network dimension.

4. Results

4.1. Cross-case readiness profiles

The readiness results, summarized numerically in Table 3 and visually in Fig. 5, produce a hierarchy that differs from a simple instrument count. The European Union has the strongest implementation-readiness profile. Germany ranks second because of its high family-floor capacity and strong depth in several dimensions, even though two delivery-related functions remain vacant. Sweden and the United Kingdom form an intermediate group. The Netherlands, Hungary, and Spain are more repair-intensive because their portfolios contain knowledge concentration, many fragile functions, or multiple vacancies.

Table 3. Readiness scores.

Case	F_i	S_i	B_i	Vacant	Fragile	IRRI
European Union	1.000	0.905	1.000	0	0	96.6
Germany	1.000	0.667	0.714	2	0	76.9
Sweden	0.833	0.619	0.714	1	2	71.2
United Kingdom	0.667	0.619	0.786	1	1	68.4
Netherlands	0.833	0.476	0.571	1	4	59.4
Hungary	0.833	0.381	0.429	3	2	48.7
Spain	0.833	0.286	0.357	4	1	40.0

The ranked score profile in Fig. 5 separates a near-complete supra-national portfolio from national portfolios with targeted or foundational repair needs. The figure also shows that the middle group is not defined by total instrument volume, but by whether family-floor capacity, saturation, and bottleneck protection remain simultaneously adequate.

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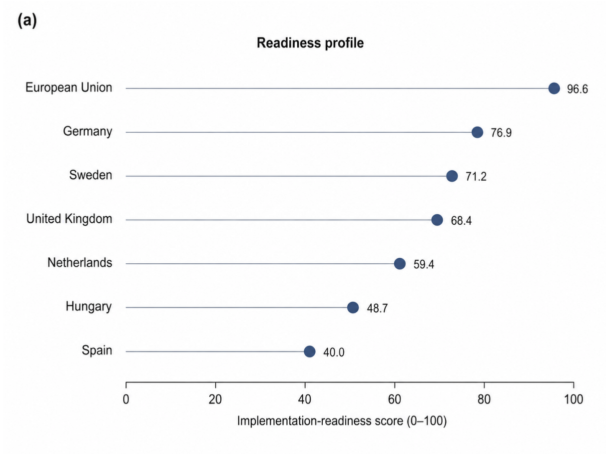

Figure 5. Readiness profile.

For instance, the EU result is very close to saturation because the portfolio does not lack any regime dimension, while three family-floors exceed the minimum requirement. However, this portfolio is still below saturation because the economic mechanisms and funding structures are not sufficiently saturated compared to other families. Still, since the number of bottlenecks equals zero, this portfolio offers several possible entry points for nature-based solutions in regulation, finance, learning, markets, technology delivery, and funding.

Despite having the highest instrument total and family-floor capacity, Germany's portfolio does not have sufficient saturation scores, meaning that some actors are still unrepresented by the existing portfolio. In particular, the lack of coverage relates to industry networks and physical technologies, meaning that instruments may need to reach those networks in order to ensure routine nature-based solution delivery.

Sweden has a good performance relative to the total number of instruments used by the country. In this case, seven instruments enable reaching six regime dimensions and achieving the same saturation level as that of the United Kingdom. As for the weaknesses, the portfolio lacks the economic/user-practice dimension and has fragile cultural and funding regimes.

As mentioned earlier, the UK regime lacks the family related to finance and the funding structure. Nevertheless, the portfolio achieves high protection from bottlenecks thanks to a lower number of fragile dimensions. In turn, the portfolio shows poor family-floor capacity owing to missing instruments that relate to financing.

The Netherlands regime is limited by the dominance of knowledge in terms of its distribution among regime dimensions. Although this regime includes ten instruments, only one of them is hard while the remaining ones are soft, resulting in a total count of six instruments in the knowledge dimension. Four dimensions appear to be fragile while the economic mechanisms/user practices dimension is vacant.

Similarly to Hungary, Spain's regime profile shows the lowest readiness value owing to the existence of several vacant regime dimensions. In this case, the policy and funding structures are operational, while knowledge, industry networks, and physical technologies are vacant. The Spanish regime shows active knowledge and cultural dimensions but misses other dimensions needed for successful nature-based solution deployment.

4.2. Regime capability states

The regime dimensions' counts can be converted into the corresponding states to reveal whether an organization has anchored, active, fragile, and/or vacant regimes. From this standpoint, the number of instruments does not necessarily reflect portfolio capabilities. For example, although Germany and the Netherlands have large volumes of instruments, they are anchored in completely different sets of regimes.

Table 4. Capability profile.

Case	P	C	K	I	T	E	F
European Union	Anchored	Anchored	Anchored	Anchored	Active	Active	Active
Germany	Active	Anchored	Anchored	Vacant	Vacant	Active	Active
Hungary	Active	Fragile	Vacant	Vacant	Vacant	Fragile	Active
Netherlands	Fragile	Fragile	Anchored	Active	Fragile	Vacant	Fragile
Spain	Vacant	Active	Active	Vacant	Vacant	Fragile	Vacant
Sweden	Active	Fragile	Active	Active	Active	Vacant	Fragile
United Kingdom	Anchored	Active	Active	Active	Fragile	Active	Vacant

Notes: P = policy and regulation; C = cultural values and guiding principles; K = knowledge and expertise; I = industry structures and actor networks; T = physical infrastructures and technologies; E = economic mechanisms and user practices; F = funding structures.

The bottleneck atlas in Fig. 6 presents the same regime information as exposure rather than abundance. Empty and fragile functions become visible as implementation risks, especially where financial, technical, industry-network, or user-practice capacity is missing.

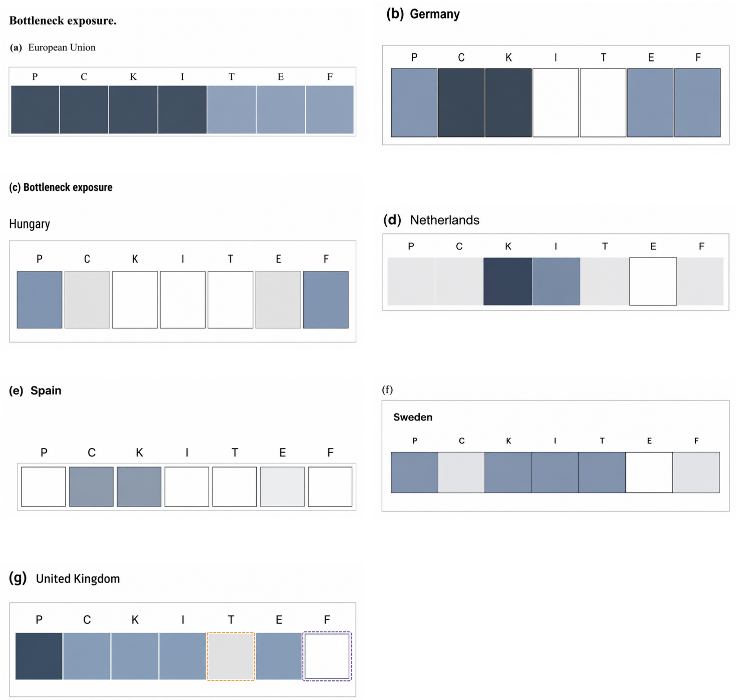

Figure 6. Bottleneck exposure.

Strongest cross-case pattern is the presence of knowledge and policy/regulatory activities. Knowledge activities are anchored in EU, Germany and NL and active in Spain, Sweden and the UK. Policy/regulation activities are present in five cases. On the other hand, economic mechanism, financial structures, industry networks and physical technology functions tend to emerge as either vacant or fragile. These functions are clearly linked with implementation. A portfolio can produce strategies, learning tools and guidelines without altering the delivery system, it can set planning expectations without providing financing, purchasing, technical specifications or adoption incentives.

The EU is the sole case which lacks any vacancies or fragilities. The combination of coverage shows more than mere policy symbolism since the portfolio has achieved coverage in all the functional areas with an active level of achievement. Two important omissions are observed in Germany, but its other dimensions are both active and anchored. Sweden's functional coverage is relatively balanced, but its economic/user practice vacuum along with fragile cultural and financial areas highlight the unfinished socialization and financial processes. The UK exhibits

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a solid regime profile but a financial vacuum suggesting that the financial challenge is critical rather than the conceptual.

The Netherlands, Hungary and Spain illustrate the various kinds of fragility. While the Netherlands has one anchored and one active industry network knowledge activity but has four fragilities and a single vacancy. Hungary is an example of an active policy/funding but no learning/technical delivery dimension. Spain is another case of active cultural and knowledge but has no policy/industry network, technical and funding dimensions. These profiles clearly demonstrate that instrument quantity does not imply readiness in itself.

4.3. Instrument family sufficiency

It becomes clear how the concept of readiness differs from quantity of policy instruments due to the family-floor value. If any case includes two or more instruments for all three instrument families, then it receives the total family floor score. Only EU and Germany are able to meet the criteria for full family-floors. Hungary, Netherlands, Spain and Sweden have a single family with a solitary instrument. United Kingdom lacks the whole financial family.

Table 5. Family floor.

Case	Regulatory	Financial	Soft	Interpretation
European Union	Full	Full	Full	All families have minimum capacity.
Germany	Full	Full	Full	Large and family-complete portfolio.
Hungary	Full	Full	Partial	Soft capacity is thin.
Netherlands	Full	Partial	Full	Financial capacity is thin despite many soft instruments.
Spain	Full	Partial	Full	Financial capacity is thin in a small portfolio.
Sweden	Full	Full	Partial	Soft capacity is thin in a compact portfolio.
United Kingdom	Full	Missing	Full	Financial mechanism is absent.

The family-floor configuration provides a new perspective on several cases. The Netherlands has more instruments than the other two developed countries (Sweden and the UK), but has a poor financial family with an emphasis on soft instruments. The UK covers many regime functions but lacks a financial family, which means a completely different weakness. In the case of Hungary and Spain, although the three families exist, their regime capability is low. This indicates that it is necessary to differentiate between the presence and effectiveness of the policy families.

Policy abundance is important only if it makes contributions to minimum floors and under-represented regime functions. This point can be explained by using Germany, where the policy abundance creates great capacity and saturation, while no instruments involve industry networks and physical technologies. In the case of the Netherlands, there are too many instruments in one regime dimension and in one family. Therefore, it is advisable that each additional instrument be analyzed to identify whether or not it contributes to a deficient family or function.

4.4. Repair priorities

Repair priority refers to the minimal changes in order to make improvements toward implementation readiness. There is the need for an addition to the regime dimension at the first priority level. A vulnerable regime dimension supporting an important implementation function constitutes the second priority. At the third place, there are either a thin or an absent instrument family.

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Table 6. Repair priorities.

Case	Immediate repair	Reinforcement need	Policy meaning
European Union	None	Economic and funding depth	Portfolio is structurally complete but could deepen market and finance functions.
Germany	Industry networks; physical technologies	None among covered cells	Strong portfolio requires delivery-chain and technical-standard repair.
Hungary	Knowledge; industry networks; physical technologies	Culture and user practice	Learning and physical implementation functions need to be created.
Netherlands	Economic mechanisms and user practices	Policy, culture, physical technologies, funding	Knowledge capacity must be converted into demand, finance, and technical adoption.
Spain	Policy, industry networks, physical technologies, funding	User practice	Broad foundational repair is required before mainstreaming can be expected.
Sweden	Economic mechanisms and user practices	Culture and funding	Compact portfolio needs user-demand and market-normalization repair.
United Kingdom	Funding structures	Physical technologies	Financial capacity is the main missing implementation route.

The country repair cards in Fig. 7 translate the numerical diagnosis into case-specific policy needs. They distinguish portfolios requiring no structural repair, targeted delivery repair, demand-side repair, financial repair, and broad foundational strengthening.

In this way, the policy interpretation follows from the specific structural repair priorities. Structural repair of nature-based solution instruments is not required by the European Union under this classification, although it can deepen the economy and financial dimensions because they remain active rather than anchored. In the case of Germany, a new knowledge instrument is not the right choice either. The missing dimensions are delivery mechanisms and physical technologies, meaning that Germany will need instruments that facilitate the connection of knowledge to construction, engineering, standards, monitoring, and infrastructure procurement processes. Hungary will need a more fundamental capability development path because of the absence of knowledge, industry network functions, and physical technology dimensions altogether.

The Netherlands should consider initiating economic mechanisms and user practice as its starting point. Otherwise, without such capability, even a knowledge-rich portfolio runs the risk of creating instruments and tools that do not translate to adoption change. Financial reinforcement is also necessary since the family-floor capacity is insufficiently high. Spain will need comprehensive and deep foundational repair, including policy, industry, and physical technology dimensions and financing functions. The introduction of only one new instrument will not help in this situation. Sweden will need to translate its relatively balanced regime profile into the areas of economic demand and user practice. The United Kingdom will need funding structure reinforcement and repair in addition to introducing a missing financial family.

4.5. Volume and readiness

Under the volume criterion, the rankings will place Germany above the European Union and the Netherlands. On the other hand, the readiness ranking shows a completely different picture. First, the European Union takes the top place due to the absence of any structural bottleneck in its portfolio. Second, Germany takes the second place, but not because of the high number of its instruments. Instead, this is determined by the fact that it has very high family capacity and several active and anchored regime dimensions. Third, the Netherlands come below Sweden and the United Kingdom in terms of implementation-readiness because many of their regime dimensions are fragile or vacant even though there is a relatively high number of instruments.

The field illustrated in Fig. 8 highlights the discrepancy between policy volume and implementation readiness. As it can be seen, Germany and the Netherlands are examples showing that it is possible to have high numbers of instruments without delivery void or knowledge concentration, whereas Sweden illustrates that a relatively small portfolio may outperform a larger portfolio that is unevenly converted into capabilities.

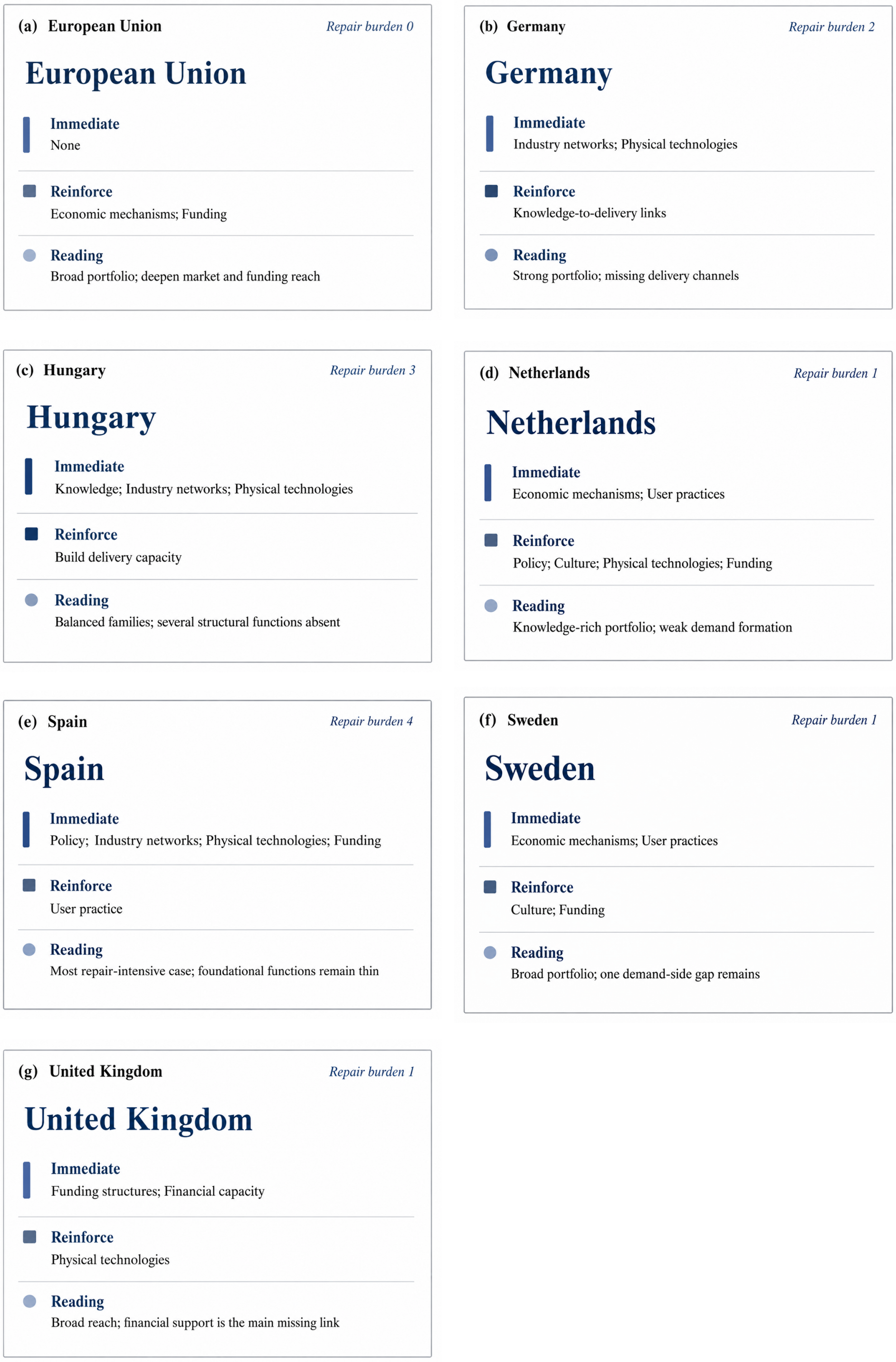

Figure 7. Repair priorities.

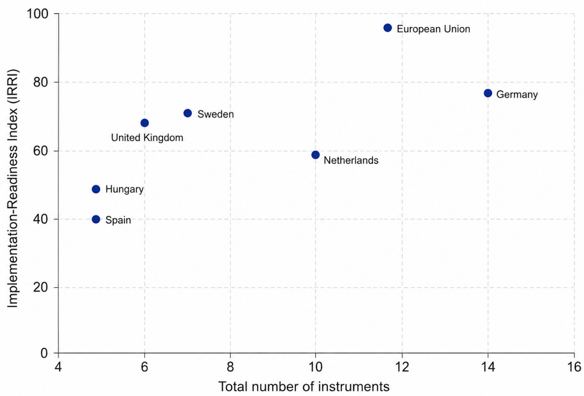

Figure 8. Volume-readiness divergence.

The results of score grouping confirm the core finding in a clearer way: implementation readiness is a feature of capability conversion of a policy mix. Thus, Germany has a high number of instruments but needs to develop technical and industry network functions. In turn, the Netherlands have relatively many instruments but lack economic and funding depths, which means that the knowledge depth cannot guarantee automatic development of the whole portfolio. Finally, even though the United Kingdom has a smaller portfolio, its regime profile is not as shallow as one might expect considering the vacancy of its financial family.

5. Discussion

5.1. Interpreting implementation readiness

In general, the readiness approach transforms the key question for the researcher from "how many instruments are there?" to "what kind of implementation capabilities is it supporting?" The answer to the latter question is crucial for understanding the success or failure of policies related to nature-based solutions. For example, it is possible for a country to have many policies and instruments about nature-based solutions but still encounter obstacles in the areas of finance, maintenance, procurement, adoption, and performance standards. However, even a relatively small portfolio may be strategically valuable due to its capability development in several regimes.

As illustrated in Fig. 9, each of the seven portfolios considered is located within specific readiness zones. More specifically, the European Union, Germany, Sweden, the United Kingdom, the Netherlands, Hungary, and Spain represent quite distinguishable zones of implementation readiness of nature-based solution policy mixes.

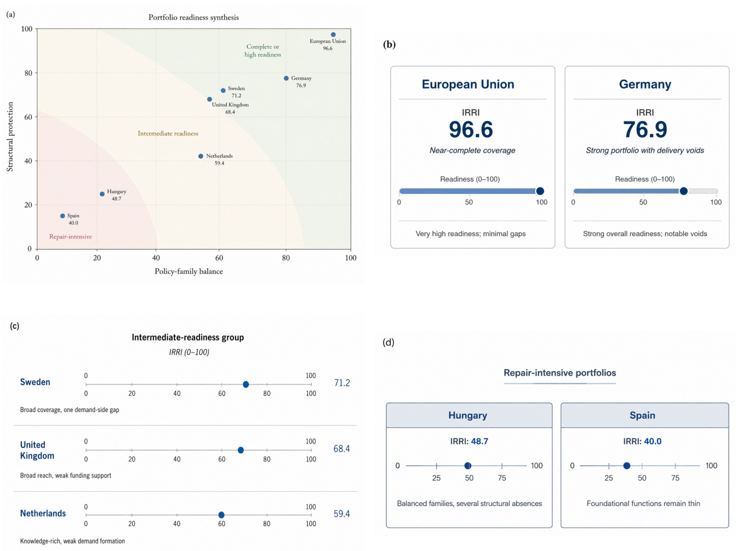

Figure 9. Portfolio-readiness synthesis.

In the given case, the best readiness profile is characteristic of the European Union. It is expected because the institution operates at a supranational level, providing a regulatory capacity, finance, research, certification, and learning platforms for nature-based solutions. However, the critical fact is that these resources are spread throughout all regime dimensions, giving it a much better chance of success than a mere large number of instruments. In other words, the structural brittleness of the portfolio is minimized. What remains to be done, however, is further saturation in economy and funding dimensions.

For Germany, it is the opposite story. Even though its portfolio has a high family floor and sufficient saturation in several dimensions, the absence of industry network and physical technology dimensions shows that there are some gaps in delivery. As a consequence, even though knowledge and finance may contribute greatly, their presence does not necessarily mean that the policies will be mainstreamed because other instruments need to ensure coordination,

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procurement, and technical support. For these purposes, Germany will have to translate knowledge into action using standards, alliances, accreditation, construction sector partnerships, and monitoring infrastructure.

Similarly, Sweden can serve as an example of relative implementation readiness of a relatively compact portfolio due to its lack of excessive concentration. Even though its portfolio covers several regime dimensions with active support, the missing economic/user practice function proves that it lacks a particular logic. Thus, the adoption of nature-based solutions is likely to depend on the involvement of municipalities, developers, landowners, residents, and service providers in the process. Consequently, it will rely more on the leading role of public institutions than on market normalization.

As for the United Kingdom, a more balanced regime coverage is observed, but the fact that there is no financial family reduces its implementation capacity. A portfolio may seem relatively well-structured on the surface but lack a crucial mechanism of implementation, thus requiring an urgent addition. However, this addition should not take the form of a policy strategy, vision, or guiding statement. Instead, the addition is more likely to be a financial route for making nature-based solutions profitable, procurable, and sustainable. This could involve green infrastructure funds, blended finance, incentives, or performance-based finance linked to delivery.

Finally, the portfolio of the Netherlands demonstrates the limitations of knowledge-centric approaches. The fact is that a wide range of tools for supporting knowledge development (learning platforms, innovation deals, etc.) is helpful for building the corresponding competence and enhancing legitimacy. Nonetheless, knowledge alone does not mean much in terms of development, procurement, user adoption, and technical performance. In turn, the vacancy or fragility of some functions in Hungary and Spain makes these countries' profiles similar to each other because of the direct impact of the concerned dimensions on implementation capacity.

5.2. Policy design implications

First of all, governments should recognize the potential risks implied by the existence of vacant regime dimensions. For example, if the dimension of a funding structure is vacant, nature-based solutions will be subject to grants, discretionary funding, or political considerations. If the physical technology dimension is vacant, the design and performance standards may not be defined and properly enforced. If the industry network dimension is missing, the development organizations may not rearrange their activities. In each of these cases, the capacity of nature-based solutions may be undermined.

Secondly, one-instrument dimensions cannot be neglected. Fragile dimensions, although not vacant, still indicate dependence on one particular route of development. Such fragility could become a problem if the environment was characterized by political instability or budget constraints because such dependence could be risky. In order to avoid the problem, it is reasonable to reinforce those dimensions which are critical in implementation: funding, economic/user practice, and physical technology.

Thirdly, instrument-family and regime repair should be interconnected. For example, adding a financial instrument would help more when the funding and economic dimensions are fragile. Adding a soft instrument would benefit knowledge, legitimacy, and actor coordination, while the addition of a regulatory instrument would help solve problems with formal authority and standards. Hence, portfolio design should not follow the common habit of choosing familiar instruments but instead focus on the most appropriate instrument family.

Fourthly, knowledge should always be supplemented with delivery mechanisms. Guidance, innovation deals, and learning platforms are indispensable in the area of nature-based solutions whose effectiveness largely depends on performance. However, their contribution would be limited without procurement criteria, standards, and financial instruments for development. Therefore, it is necessary to go beyond the stage of information generation and start developing implementation connections.

5.3. Analytical contribution

On a methodological level, this approach is an addition to the traditional policy-mix assessment approaches in which instrument diversity, coherence, and comprehensiveness play a significant role [5, 14, 23]. The presented approach adds to them the idea of minimum capability required for the policy to become operational and structurally sound. As a result, it helps evaluate policy mixes when there is an abundance of instrument counts, but no comparative evidence of their effects.

The family-floor factor prevents the total dominance of one family over others because it implies that the former is able to compensate for the latter's vacancy. Meanwhile, the regime saturation factor ensures that very high saturation levels do not obscure the weaknesses of other regime dimensions. Furthermore, the regime bottlenecks factor allows evaluating the importance of vacant and fragile dimensions explicitly, and the harmonic mean combines all these factors logically. The result is the capability-readiness index that is interpretable, reproducible, and transparent.

The priority of structural repair is another critical element of the approach because otherwise, the ranking will be meaningless. In order to interpret the ranking meaningfully, researchers will need to know what repairs are necessary for improvement. Thus, a country with low scores will need to make extensive repairs while a country with high scores may require only one particular correction. Moreover, in terms of implementation readiness, instrument quantity is irrelevant. Some countries will have to repair technical and network dimensions despite having many instruments, while others will have to introduce financial instruments despite having fewer policies.

5.4. Methodological constraints

On the one hand, the study has been significantly constrained by the quality of instrument counts. For example, they do not reflect legal strength, budget magnitude, effectiveness of enforcement, territorial relevance, instrument duration, or outcome evidence. One national strategy and one document with guidance for practice will be counted as two separate instruments. Future research may try to supplement the data with information on instrument characteristics and evidence of actual effects.

On the other hand, the capability-state thresholds used in the study are quite straightforward. Zero stands for vacant, while one stands for fragile regime capability. Still, this distinction could be questioned in terms of particular thresholds, i.e., a higher threshold (such as three) may be relevant in certain contexts and vice versa. Similarly, the threshold for active capability can be discussed by applying sensitivity analysis to alternative values.

Furthermore, the procedure proposed in this paper ignores interactions among instruments in the portfolio. Although they could complement each other, they could also compete, contradict each other, or fail to interact effectively. Thus, a funding instrument may prove to be quite effective if it is coupled with standards and planning. Alternatively, the same funding instrument may be inefficient and ineffective because it is separated from other policy dimensions. The future research might consider instrument interactions in addition to readiness.

Moreover, this paper analyzes a static portfolio. Since the mainstreaming of nature-based solutions is a process, this static snapshot is unlikely to provide adequate evidence about policy development trends. To capture this dynamic phenomenon, it would be necessary to analyze a portfolio over time and track changes in instrument composition and effects.

6. Conclusion

In summary, this paper examines the degree of readiness to implement policies for nature-based solutions in seven countries and highlights the major structural barriers that require repair. It concludes that implementation-readiness depends on three conditions, including the presence of a minimum instrument family floor, adequate regime saturation, and the absence of vacant and fragile regime dimensions. Thus, a portfolio is not ready just because it has many instruments or because it touches several policy areas. It is prepared for implementation if different families of instruments are coordinated with the regime structures determining the development of urban nature-based solutions.

As can be seen, the most developed portfolio is found in the European Union because of its completeness in terms of family floor, high regime saturation, and lack of vacancies and fragility. Meanwhile, Germany has high instrument capability, but it faces particular problems with industry networks and physical technologies, meaning that the technical gap must be closed. Sweden and the United Kingdom have medium profiles, but for entirely different reasons: while the former needs economic and user practice capabilities, the latter needs financial and funding capabilities. The portfolio of the Netherlands suffers from knowledge concentration and several fragilities, suggesting the need for closer coupling of learning and economic incentives and standards. As for Hungary and Spain, there is a greater need for foundation in order to fill vacant dimensions and make them more robust.

From a policy perspective, it is crucial that governments see the nature-based solution portfolio not as an instrument collection but as an interdependent system. Namely, each additional instrument should be selected not based on administrative preferences and portfolio expansion goals but on regime vulnerability and instrument-family deficiency. The overall goal of nature-based solution portfolio design is to minimize the necessity of repair by filling in vacant regime dimensions, reinforcing weak dimensions, linking knowledge with delivery mechanisms, and aligning finance with planning and user demand.

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