

Systematic Review

Thematic Imbalance in Mediterranean Climate Adaptation Research: A Systematic Review of Planning-Oriented Literature, 2015–2024

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Abstract

The Mediterranean Basin ranks among the region's most vulnerable to climate change, yet little evidence exists as to whether the scientific literature emphasises strategic planning or operational implementation. This study measures the thematic distribution of adaptation strategies in the Mediterranean adaptation literature and identifies which categories of measures remain comparatively under-researched. A systematic review following PRISMA 2020 was conducted on peer-reviewed articles indexed in the Web of Science Core Collection and published between 2015 and 2024, retrieved through a thematic query built on regional and landscape planning vocabulary. Of 89 articles retained in the qualitative synthesis, 64 reported at least one codable adaptation measure and entered the quantitative analysis, yielding 123 coded occurrences across twelve thematic categories; the remaining 25 returned a null coding vector. Chi-square goodness-of-fit testing against a maximum-entropy benchmark, with residuals corrected for article-level dependence by cluster bootstrap and for multiplicity by the Benjamini–Hochberg procedure, shows an uneven distribution (χ^2 (11, $N = 123$) = 56.02, $p < 0.001$; Cramér's $V = 0.20$; Pielou's evenness $J = 0.90$). Sustainable development and adaptation policy are over-represented; green spaces, cultivation and hydrological interventions are under-represented. An article-level analysis of register co-occurrence finds no segregation between policy-oriented and technical categories: 34.4% of coded articles engage both registers, and the two are statistically independent across the corpus (odds ratio 2.02, $p = 0.17$). The imbalance is therefore one of volume rather than of community structure. Because the unit of observation is the published article rather than the implemented intervention, and because the corpus is restricted to planning-oriented, English-language, indexed literature dominated by northern-rim EU member states, these findings characterise the orientation of a defined body of literature and cannot establish a gap in adaptation practice. The study provides a reproducible method for measuring thematic emphasis and an empirical basis for identifying under-researched categories of operational adaptation measures.



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1. Introduction

The Mediterranean Basin is recognised by the Intergovernmental Panel on Climate Change (IPCC) as one of the most climate-sensitive regions globally, classified as a hotspot for the intensification of heat waves, droughts and water deficit [1,2]. Observed data indicate an average warming of about +1.5 °C relative to the pre-industrial era, above the global trend of +1.1 °C [3]. Projections from the sixth phase of the Coupled Model Intercomparison Project (CMIP6) for 2041–2070 report a three- to five-fold increase in the frequency and intensity of heat waves, a reduction in summer rainfall of up to 30% in the southern and eastern Mediterranean, and a significant increase in the risk of meteorological, agricultural and hydrological drought [4,5]. These trends combine with high anthropogenic pressure linked to population concentration along coasts, intensification of irrigated agriculture and fragmentation of natural habitats [6].

In this context, climate adaptation is a necessary condition for preserving ecosystem functionality, economic productivity and urban liveability. Adaptation strategies range from strategic planning and multilevel governance to adaptive ecosystem management and the implementation of Nature-Based Solutions (NBS)—solutions inspired and supported by nature that simultaneously provide environmental, social and economic benefits [7,8]. Empirical evidence supports their effectiveness: urban green infrastructure, parks, green roofs and sustainable drainage systems can reduce air temperature by 1–4 °C, improve stormwater management and reduce the risk of urban flooding [9–11].

A persistent gap between the formulation of policy and its translation into action on the ground is widely reported. Moser and Ekstrom (2010) define this as a policy–action gap or implementation deficit, attributing it to institutional fragmentation, scarcity of resources, lack of technical capacity and absence of monitoring and accountability mechanisms [12]. The problem is held to be particularly acute in the Mediterranean, where administrative fragmentation and weak multilevel governance limit local implementation capacity [13,14]. Two observations frame the present study. First, adaptation planning is markedly less widespread than mitigation planning in European cities: Reckien et al. (2018), surveying 885 urban areas across the EU-28, found that 66% had a mitigation plan while only 26% had an adaptation plan, 17% had a joint plan, and 33% had no stand-alone local climate plan at all [15]. Second, where plan *content* has been assessed—a question Reckien et al. explicitly left to future research—Preston et al. (2011) report, for adaptation plans in three developed nations, that strategic objectives are elaborated more fully than implementation provisions [16].

Whether the scientific literature exhibits a comparable orientation remains an open question, and it is the question this study addresses. If the policy register predominates in published research, the resulting body of evidence may convey an impression of progress while supplying little of the operational knowledge that implementation requires. Answering it requires methods capable of mapping the dominant framing systematically and of measuring the relative weight of different strategy types. Quantitative content coding, combined with distributional analysis, offers a reproducible route from qualitative description to measurement [17–19].

Moreover, the unit of observation in this study is the published, indexed article, not the implemented intervention. The analysis can establish what a defined body of literature emphasises; it cannot establish what practitioners do. Furthermore, the corpus was retrieved by a query built on planning vocabulary (Section 2.1.2), which pre-selects for

the planning register; the measured imbalance is therefore partly endogenous to the search design and cannot be fully separated from it within this corpus. Both limits are carried through the Results and Discussion rather than confined to a limitations list.

Contextually, three research questions follow:

- **RQ1.** How are adaptation strategies thematically distributed in the planning-oriented, Web of Science-indexed Mediterranean adaptation literature published between 2015 and 2024, and which categories are over- or under-represented relative to an even distribution?
- **RQ2.** Do policy-oriented and technical/NBS categories occupy the same articles, or are they segregated across different articles?
- **RQ3.** What do the answers imply for the relationship between research supply and the operational knowledge needs of local decision-makers?

2. Methodology

The methodology is organised in four sequential phases (Table 1, Figure 1).

Table 1. Methodological workflow.

Phase	Objective	Main Output	Question Addressed
1. PRISMA systematic review	Identify and select primary studies	Corpus of 89 articles (2015–2024)	corpus definition
2. Coding and classification	Classify adaptation strategies into thematic categories	89 × 12 matrix; 123 occurrences from 64 articles	—
3. Distribution analysis	Test evenness; identify deviations	χ^2 with cluster-bootstrap and FDR correction; concentration measures	RQ1
4. Co-occurrence analysis	Test whether the two registers occupy the same articles	Article-level cross-tabulation; Fisher’s exact test	RQ2

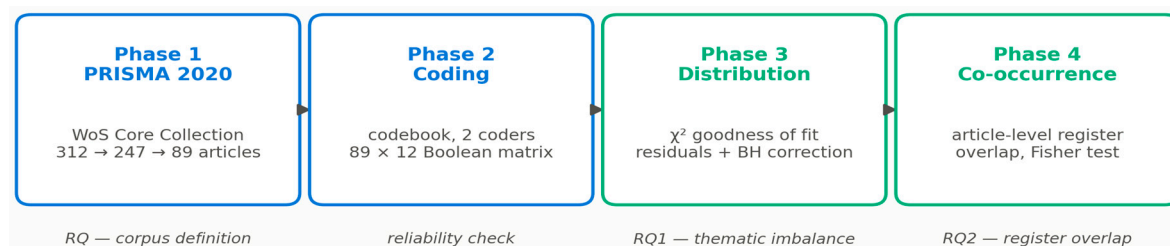


Figure 1. Schematic of the four-phase workflow.

2.1. Phase 1: Systematic Review Following PRISMA 2020

2.1.1. Protocol and Eligibility Framework

A protocol was drawn up before the search specifying the population of interest (studies on the Mediterranean), the intervention (adaptation strategies), the outcome (type and frequency of strategies) and the study design (empirical, review, policy analysis), following a PICOS structure to reduce the risk of post hoc deviation. The systematic review was conducted following PRISMA 2020; the completed PRISMA 2020 checklist is provided in File S5.

2.1.2. Search Strategy, Its Rationale and Its Limits

The Web of Science Core Collection was queried on 20 September 2024 with the following thematic string:

(TS = (“Regional Planning”) OR TS = (“Landscape Planning”))
AND TS = (“adaptation to climate change”)

Filters were applied for document type (article, review), language (English) and publication window (2014–2024); the years present in the final corpus span 2015–2024, and this range is used throughout. The query returned 312 records.

The Mediterranean restriction was applied at Level 1 screening (Section 2.1.3), not at retrieval.

The Web of Science Core Collection was selected for the consistency of its indexed keyword fields (Keywords Plus), on which the coding procedure in Section 2.2 depends; the stability of its TS = field-tag syntax, which makes the query exactly reproducible; and its controlled document-type filter. These are considerations of reproducibility rather than of coverage.

The design excludes journals indexed only in Scopus or in regional platforms such as SciELO, together with national planning and engineering journals in Mediterranean countries; work published in Arabic, Turkish, Greek, Hebrew, Croatian and other languages of the Basin; and grey literature—local adaptation plans, LIFE and Interreg deliverables, agency technical reports—which is the principal repository of operational information on NBS [20] and which database searching is known to reach poorly [21]. None of these exclusions is neutral with respect to the outcome under study: operational and locally published work is disproportionately absent from an English-language indexed corpus, so such a corpus will overstate the relative weight of the policy and planning register.

A more fundamental limitation also applies. Because the string required “Regional Planning” or “Landscape Planning” in the topic field, Mediterranean adaptation research framed in the vocabulary of agronomy, hydrology, coastal engineering or public health was not retrieved at all and post hoc geographic screening cannot recover articles a thematic query never returned. Part of the imbalance reported in Section 3.1 is therefore attributable to the vocabulary of the search string itself. Testing whether the imbalance survives a register-neutral design requires a query built on adaptation-measure vocabulary with an explicit geographic block, for example:

```
TS = ("nature-based solution*" OR "green infrastructure" OR "urban green*"
OR "water reuse" OR "managed aquifer recharge" OR "sustainable drainage"
OR "agroforestry" OR "coastal protection")
AND TS = ("climate change adaptation" OR "climate adaptation")
AND TS = (Mediterranean OR Italy OR Spain OR France OR Greece OR Türkiye
OR Turkey OR Morocco OR Tunisia OR Algeria OR Egypt OR Israel
OR Lebanon OR Cyprus OR Malta OR Croatia OR Slovenia OR Albania
OR Montenegro OR "Bosnia and Herzegovina" OR Libya OR Syria
OR Palestine OR Monaco)
```

Accordingly, the object of study is stated throughout as the planning-oriented, English-language, Web of Science-indexed Mediterranean adaptation literature, and not the Mediterranean adaptation literature.

2.1.3. Screening and Eligibility

After automatic and manual duplicate removal in Rayyan, 247 unique records remained. Two independent researchers assessed each record at Level 1 (title/abstract) against predefined criteria, with discrepancies resolved by discussion or by a third assessor; the 89 records passing Level 1 were read in full at Level 2.

Geographic inclusion criterion. An article was retained when its analysis was relevant to the Mediterranean context. This included (i) studies whose study area lay wholly or partly within the Mediterranean Basin, defined by the riparian states and the Mediterranean bioclimatic region; (ii) basin-wide or multi-country studies encompassing Mediterranean territory; and (iii) global, European or comparative studies whose analysis encompassed Mediterranean territory or Mediterranean riparian states. An article was excluded only when the reported study area lay outside the Basin, and the analysis made no reference to the Mediterranean context. Accordingly, the corpus characteristics reported below classify

articles by the study area they actually report, rather than by the criterion under which they were eligible.

Thematic inclusion criteria. Empirical studies, policy analyses or reviews reporting adaptation strategies implemented or proposed in the Mediterranean Basin, describing at least one operational or strategic measure, with full text available.

Exclusion criteria. Purely modelling studies without local application; opinion articles; editorials; non-peer-reviewed book chapters (Tables 2 and 3).

The 89 studies retained in the qualitative synthesis constitute the primary-study corpus of this systematic review. For bibliographic transparency, all included studies are now cited in the main manuscript and listed individually in the main reference list [22–110], in the same article order used in Files S1, S3 and S4. These primary-study references are distinct from the 44 contextual, methodological and interpretive references cited elsewhere in the manuscript.

Table 2. PRISMA 2020 flow.

Stage	Records
Records identified	312
Duplicates removed	65
Records screened	247
Excluded at title/abstract, of which:	158
Geographic scope	62
Thematic irrelevance	54
Ineligible publication type	42
Full-text assessed for eligibility	89
Excluded after full-text review	0
Included in qualitative synthesis	89
Excluded from quantitative analysis (null coding vector)	25
Included in quantitative analysis	64

Table 3. (a) Publication year of the included studies ($n = 89$). (b) Spatial scale, sector and geographic distribution ($n = 89$).

(a)			
Year	n	Year	n
2015	5	2020	11
2016	6	2021	14
2017	2	2022	11
2018	8	2023	19
2019	6	2024	7
(b)			
Characteristic	Category	n	%
Spatial scale	Urban	41	46.1
	Regional or national	28	31.5
	Basin-wide	20	22.5
Main sector	Urban planning	28	31.5
	Water management	19	21.3
	Agriculture and forestry	16	18.0
	Ecosystem services	12	13.5

Table 3. *Cont.*

		Biodiversity	3	3.4
		Cross-sectoral or not determinable	11	12.4
Study area	Northern rim (IT 15, PT 7, ES 4, GR 2, FR 2, HR 2, CY 1, MT 1)		33	37.1
		Basin-wide or multi-country	20	22.5
		Eastern rim (TR 3)	3	3.4
		Southern rim (MA 1)	1	1.1
		Outside the Mediterranean Basin	10	11.2
		Not determinable	22	24.7

Note: The spatial scale was extracted during the screening phase. The main sector and study area were assigned based on the title and indexed keywords of each record; where neither identifies a study area, the record is classified as not determinable. Country codes follow ISO 3166-1 alpha-2 [111]. An article referring to study areas across multiple Mediterranean shores is classified as basin-wide or multi-country rather than assigned to a single country. Percentages are calculated based on $n = 89$. The per-article classification and assignment information underlying these corpus characteristics is provided in File S4.

Exclusion reasons at title/abstract are mutually exclusive, each record being assigned its first applicable reason in the order shown. The null-vector exclusion is an analytical rather than an eligibility exclusion and is shown as a separate downstream step.

2.1.4. Characteristics of the Corpus

Aggregated, this gives 21 articles (23.6%) for 2015–2018, 31 (34.8%) for 2019–2021 and 37 (41.6%) for 2022–2024.

The same information is presented graphically in Figure 2. Of the 67 articles whose study area is identifiable from the title or the indexed keywords, 33 (37.1%) lie on the northern rim, three on the eastern rim and one on the southern rim; a further 20 (22.5%) are basin-wide or multi-country. The implications are discussed in Section 4.5.

2.1.5. Risk of Bias

The Critical Appraisal Skills Programme (CASP) checklists were used as a qualitative appraisal aid [112]. However, the archived materials retain only the reconciled coding matrix and do not preserve sufficiently detailed item-level appraisal records to support a reproducible per-article risk-of-bias table. We therefore do not present a retrospective quantitative risk-of-bias classification. This limitation is stated explicitly in Section 4.7 and is considered when interpreting the synthesis.

2.2. Phase 2: Coding and Thematic Classification

2.2.1. Construction of the Category Scheme

The twelve categories derive from the Keywords Plus field of the retrieved records and were consolidated iteratively until further merging would have collapsed distinct measure types. Geneletti and Zardo (2016) [113] and Kabisch et al. (2016) [114] informed the consolidation but did not supply the categories.

The twelve categories are **C1** sustainable development; **C2** adaptation policy; **C3** ecosystem services; **C4** plans; **C5** land use; **C6** public participation; **C7** biodiversity; **C8** green infrastructure; **C9** strategic environmental assessment (SEA); **C10** hydrological interventions and water-system measures; **C11** cultivation; **C12** green spaces.

These are thematic categories of adaptation discourse at heterogeneous levels of abstraction, not twelve comparable strategies. “Sustainable development” is a policy frame; “plans” is an instrument type; “green spaces” is a physical intervention. The coding framework classifies each category by level—policy frame, planning instrument,

governance process, ecological concept, or physical intervention. The coding manual (File S2) documents each category by level—policy frame, planning instrument, governance process, ecological concept, or physical intervention—with an operational definition, an inclusion rule, an exclusion rule for borderline cases, the register assignment used in Section 3.2, the number of coded occurrences, and the indexed keywords most distinctive of that category in the coded corpus. The heterogeneity is consequential and is revisited in Section 4.4: the most frequent categories are frames and instruments, the least frequent are physical interventions, and part of the measured imbalance may reflect the general tendency of academic text to mention abstract categories more often than specific ones.

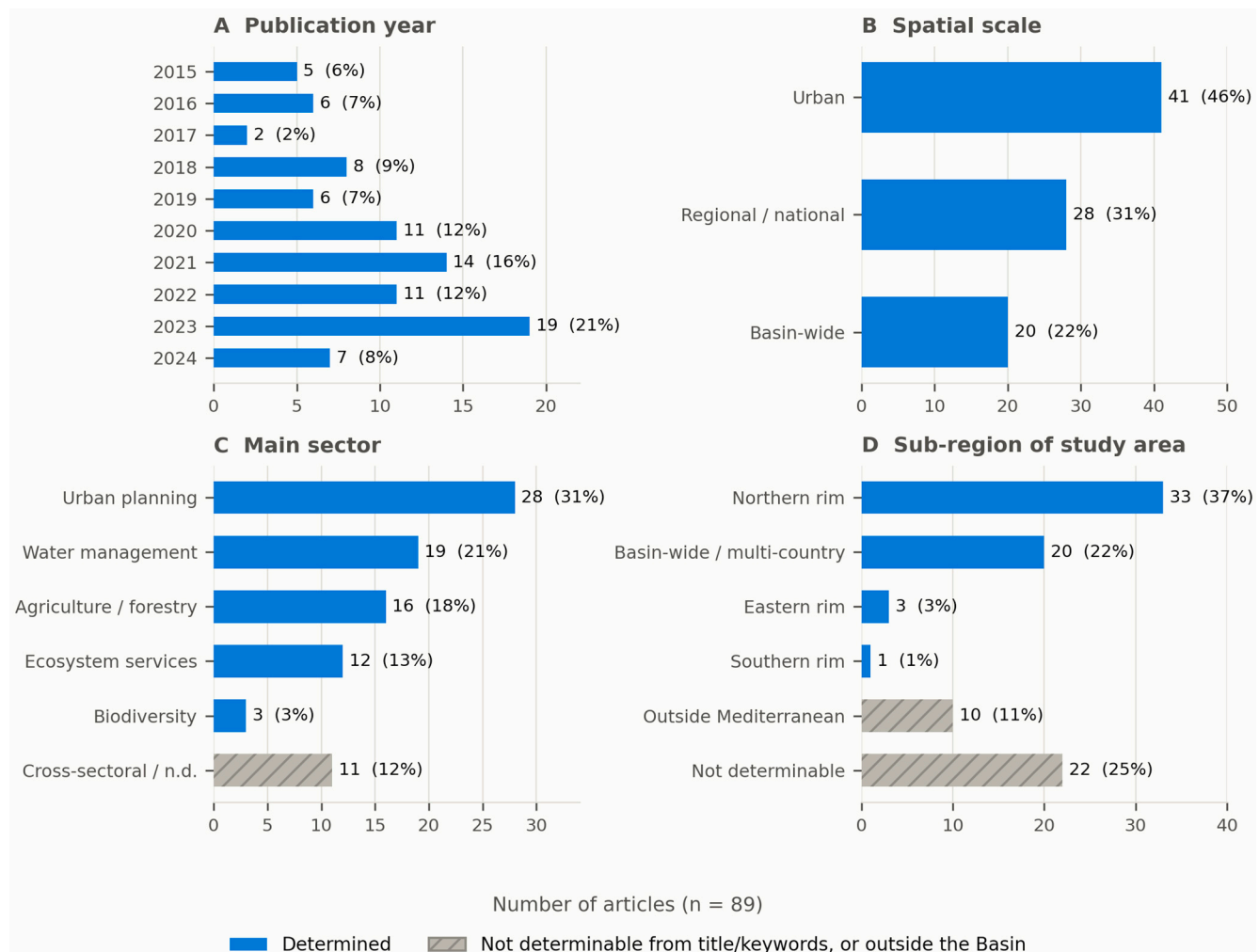


Figure 2. Characteristics of the corpus ($n = 89$): (A) publication year, (B) spatial scale, (C) main sector, and (D) country of study. Panels (C,D) use the disaggregated categories of Table 3b. Percentages are calculated from the 89 included articles and may not sum to 100 owing to rounding.

Two registers are distinguished for the analysis in Section 3.2. The policy register comprises C1, C2, C4, C5 and C6—governance and planning instruments. The technical/NBS register comprises C3, C7, C8, C9, C10, C11 and C12—physical, ecological and assessment measures.

2.2.2. Coding Procedure and Its Limits

Two researchers read each article and recorded explicit mentions of adaptation strategies. A mention was valid only if it referred to a specific measure, policy or intervention; generic references to climate change were excluded. Each occurrence was assigned to a single category based on the dominant theme in the sentence, and disagreements were resolved by discussion.

No formal inter-coder agreement statistic was computed, and none is recoverable from the archived materials, which retain only the reconciled consensus matrix. This is a limitation of the study and is stated as such in Section 4.7. A recoding protocol for a random subsample of the corpus, with Krippendorff's α [17,115] and a bootstrap confidence interval reported separately for the two registers, is set out in Section 4.8 as the first item of future work.

Coding was recorded as occurrence counts in the article-level coding matrix (File S1). Of the 1068 cells in the 89×12 matrix, all but one take the value 0 or 1; one article records two ecosystem service occurrences, giving a total of $N = 123$. A strictly Boolean recoding gives $N = 122$, $\chi^2(11) = 55.25$, $p = 7.0 \times 10^{-8}$, and changes no substantive conclusion. Twenty-five articles returned a null vector across all twelve categories (File S3) and were excluded from the quantitative analysis, leaving 64 articles contributing a mean of 1.92 occurrences each (range 1–5).

2.3. Phase 3: Distribution Analysis

Reference distribution: No external distribution of adaptation-strategy prevalence exists against which this corpus could be compared, and there is no theoretical basis for expecting equal frequencies across twelve heterogeneous categories. Uniformity is therefore adopted not as a substantive hypothesis but as a maximum-entropy reference benchmark: rejecting it establishes only that attention is unevenly distributed. Pearson's chi-square goodness-of-fit test was computed against an expected frequency of $123/12 = 10.25$ per category [116].

Concentration without a null model: Because the benchmark carries no theoretical content, the concentration of the distribution is additionally characterised by measures requiring no null: Pielou's evenness J [117], the Gini coefficient, the Herfindahl index and the share of the four largest categories. Effect size is reported as Cramér's V ; Cohen's w is reported alongside its attainable maximum for a $1 \times k$ table, $\sqrt{(k-1)} = 3.317$, since the conventional benchmarks for w are not calibrated for $k = 12$ [118].

Dependence: The 123 occurrences arise from 64 articles and are not independent. A cluster bootstrap resampling of articles rather than occurrences (20,000 replicates; seed 20,260,817) was used to estimate the design effect for each category proportion [119], and a first-order Rao–Scott correction was applied to the goodness-of-fit statistic [120].

Multiplicity: Standardised residuals $r = (O - E)/\sqrt{E}$ were rescaled by the square root of the mean design effect and converted to two-sided p -values, which were adjusted across the twelve categories by the Benjamini–Hochberg procedure controlling the false discovery rate at 0.05 [121]. Holm-adjusted values are reported alongside for readers preferring familywise control [122].

2.4. Phase 4: Co-Occurrence Analysis

For each of the 89 articles, the number of coded categories in each register was counted; articles were cross-classified by the presence of each register, and independence was tested by Fisher's exact test, with Spearman's rank correlation between the two register counts reported as a continuous complement.

2.5. Software and Reproducibility

Screening and duplicate removal were carried out in Rayyan; coding was performed in Microsoft Excel. All statistical analyses and figures were produced in Python 3.11 with NumPy [123], SciPy [124], pandas and Matplotlib [125]. The cluster bootstrap used seed 20,260,817. The article-level coding matrix (File S1), coding manual/codebook (File S2), null-vector records (File S3), per-article classification and assignment information (File S4), and completed PRISMA 2020 checklist (File S5) are supplied as Supplementary Materials. Data and analysis scripts are intended for deposit in a public repository; the persistent link must be inserted before resubmission.

3. Results

3.1. Thematic Distribution (RQ1)

The distribution of the 123 occurrences across the twelve categories departs from evenness: $\chi^2(11, N = 123) = 56.02, p = 5.0 \times 10^{-8}$. Correcting for article-level dependence, the mean design effect is 0.877—below 1, indicating that clustering slightly *reduces* rather than inflates the variance of the category proportions, because articles code few categories each and within-article composition induces mild negative dependence. The Rao–Scott corrected statistic is $\chi^2_{RS} = 63.90, p = 1.7 \times 10^{-9}$. Per-category design effects ranged from 0.72 to 1.02.

Cohen’s $w = 0.675$, but the maximum attainable value for $k = 12$ is 3.317, so the observed value is about 20% of its maximum; Cramér’s $V = 0.203$ indicates a small-to-moderate departure, and the null-free concentration measures agree (Table 4). Accordingly, the effect is interpreted here as a small-to-moderate departure rather than against the conventional Cohen benchmark, which is not calibrated for a $1 \times k$ table with twelve categories (Table 5).

Table 4. Test statistics and concentration measures.

Statistic	Value	Reference
χ^2 (uncorrected)	56.02	$df = 11, p = 5.0 \times 10^{-8}$
χ^2 (Rao–Scott, design-corrected)	63.90	$df = 11, p = 1.7 \times 10^{-9}$
Mean design effect	0.877	1.0 under independence
Cramér’s V	0.203	Small-to-moderate
Cohen’s w	0.675	Maximum for $k = 12$ is 3.317
Pielou’s evenness J	0.903	1.0 = perfectly even
Gini coefficient	0.375	0 = perfectly even
Herfindahl index	0.121	0.083 = perfectly even
Share of four largest categories	60.2%	33.3% = perfectly even

Table 5. Observed frequencies, residuals and adjusted significance for all twelve categories.

Category	Register	O	%	r	r Adj.	BH q	Holm
Sustainable development	Policy	21	17.1	+3.36	+3.59	0.004 **	0.004 **
Adaptation policy	Policy	19	15.4	+2.73	+2.92	0.021 *	0.039 *
Ecosystem services	Technical	17	13.8	+2.11	+2.25	0.042 *	0.170 ns
Plans	Policy	17	13.8	+2.11	+2.25	0.042 *	0.170 ns
Land use	Policy	16	13.0	+1.80	+1.92	0.074 ns	0.220 ns
Public participation	Policy	10	8.1	−0.08	−0.08	0.934 ns	0.934 ns
Biodiversity	Technical	6	4.9	−1.33	−1.42	0.171 ns	0.313 ns
Green infrastructure	Technical	5	4.1	−1.64	−1.75	0.096 ns	0.240 ns
Strategic environmental assessment	Technical	4	3.3	−1.95	−2.08	0.056 ns	0.185 ns
Hydrological interventions	Technical	3	2.4	−2.26	−2.42	0.037 *	0.140 ns
Cultivation	Technical	3	2.4	−2.26	−2.42	0.037 *	0.140 ns
Green spaces	Technical	2	1.6	−2.58	−2.75	0.024 *	0.059 ns
Total		123	100				

Note: Expected frequency $E = 10.25$ per category. Standardised residual $r = (O - E) / \sqrt{E}$; r adj. rescaled by the square root of the mean design effect (0.877). BH q = Benjamini–Hochberg adjusted p -value controlling the false discovery rate at 0.05; Holm = Holm-adjusted p -value controlling the familywise error rate. * $q < 0.05$; ** $q < 0.01$; ns = not significant at the 0.05 level.

Under false discovery rate control, sustainable development and adaptation policy are over-represented, ecosystem services and plans are over-represented at the 0.05 level, and hydrological interventions, cultivation and green spaces are under-represented. Under the stricter familywise criterion, only sustainable development and adaptation policy survive, with green spaces marginal ($p = 0.059$). The individual under-representation results should therefore be read as FDR-level findings, not as independently established for each category. The distribution is shown in Figure 3.

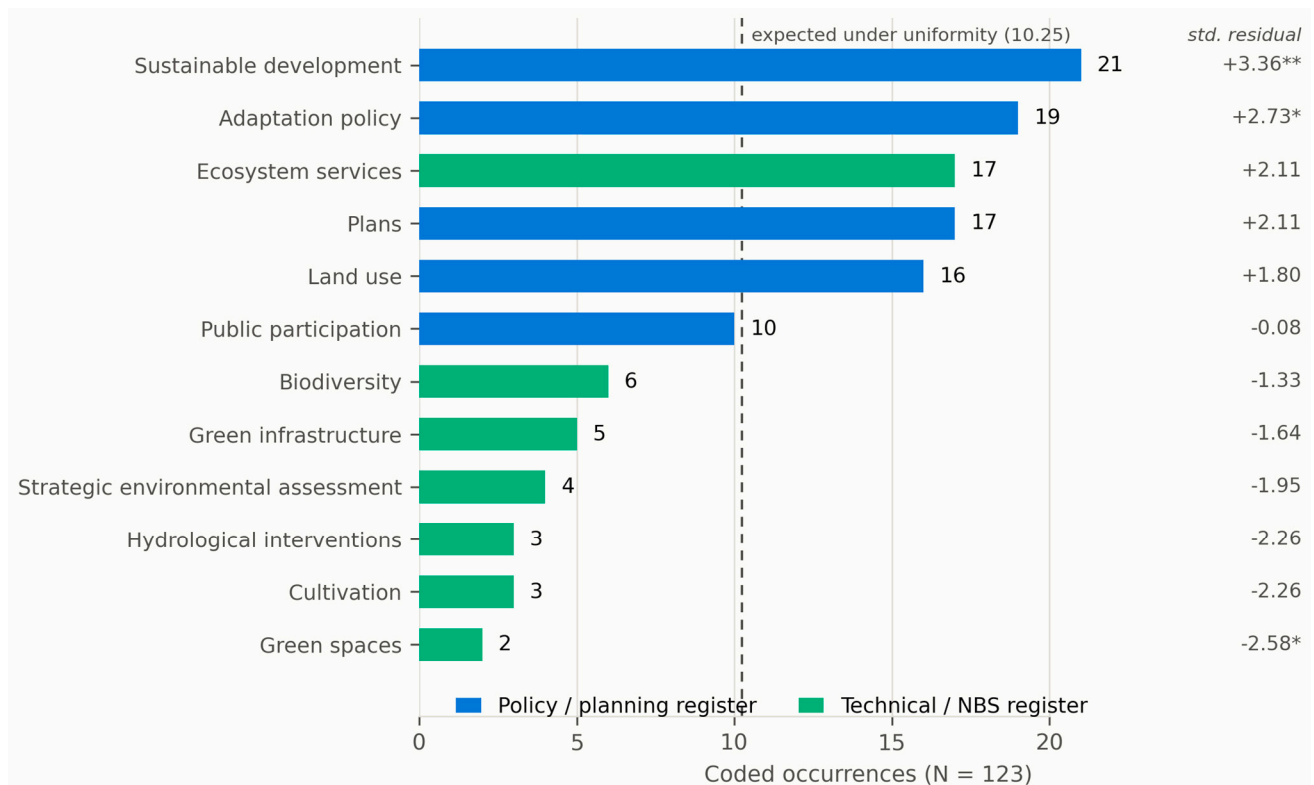


Figure 3. Coded occurrences by category, ordered by frequency, with the expected frequency under evenness (10.25) shown as a reference line and standardised residuals in the right-hand column. Bar colour distinguishes the two registers. * $p < 0.05$; ** $p < 0.01$.

3.2. Register Co-Occurrence (RQ2)

Across the 123 occurrences, 83 fall in policy categories and 40 in technical/NBS categories. At the article level, the two registers are not segregated (Table 6, Figure 4).

Table 6. Article-level register composition.

Composition	<i>n</i>	% of Coded Articles
Policy register only	34	53.1
Both registers	22	34.4
Technical/NBS register only	8	12.5
Total coded articles	64	100

Cross-classifying all 89 articles by the presence of each register gives an odds ratio of 2.02 (Fisher's exact test, $p = 0.17$), and the rank correlation between the number of policy and technical categories within an article is -0.075 (Spearman, $p = 0.56$). Neither indicates that the registers avoid one another. Articles engaging the policy register are not less likely to engage the technical register, and a third of coded articles engage both. The imbalance

documented in Section 3.1 is therefore one of volume—policy categories are mentioned more often—and not one of community structure.

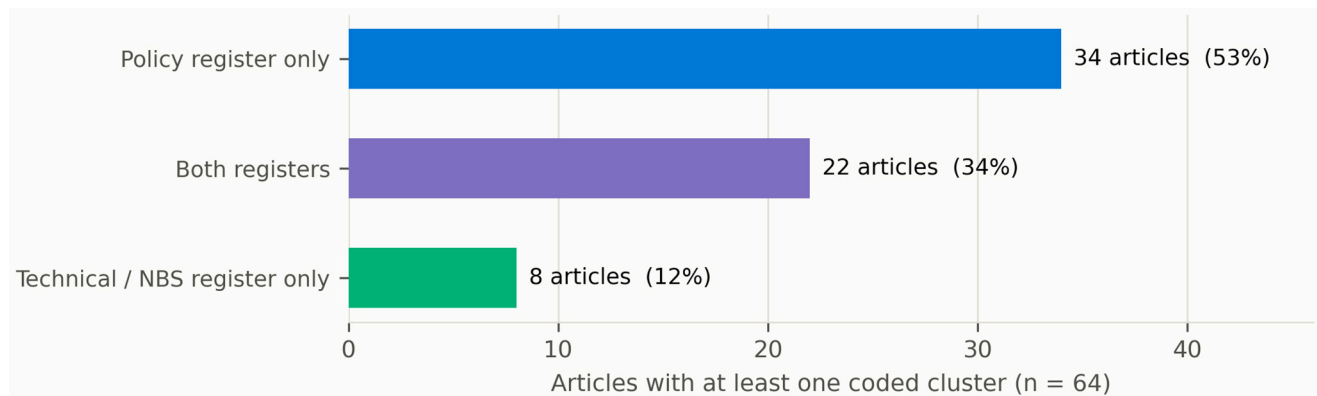


Figure 4. Article-level register composition ($n = 64$ coded articles).

3.3. Sensitivity Analyses

Three decisions in the analysis could have been taken otherwise: whether to code occurrence counts or strict presence/absence (Section 2.2.2), whether to correct the goodness-of-fit statistic for article-level dependence (Section 2.3), and whether to control the false discovery rate or the familywise error rate across the twelve residuals (Section 2.3). Table 7 reports the results under each alternative.

Table 7. Sensitivity of the distributional result to coding, dependence and multiplicity decisions.

Specification	N	χ^2	p	V	d	χ^2 RS	BH	Holm
Occurrence counts (primary)	123	56.02	5.0×10^{-8}	0.203	0.877	63.90	7	2
Strict Boolean recoding	122	55.25	7.0×10^{-8}	0.203	0.858	64.42	6	2

Note: V = Cramér's V; d = mean design effect from a cluster bootstrap over articles (20,000 replicates, seed 20,260,817); χ^2 RS = Rao–Scott statistic corrected by d. BH and Holm give the number of clusters, out of twelve, whose standardised residual remains significant at 0.05 after adjustment by the Benjamini–Hochberg and Holm procedures, respectively. The risk-of-bias exclusion specification is not reported because sufficiently detailed item-level appraisal records were not retained for reproducible retrospective classification (Sections 2.1.5 and 4.7).

The omnibus conclusion is insensitive to all three decisions: every specification rejects evenness at $p < 10^{-7}$, and the effect size is unchanged at $V = 0.20$. The cluster-level conclusions are less stable. Strict Boolean recoding removes **ecosystem services** from the BH-significant set, leaving six clusters rather than seven, because the single article contributing two ecosystem services occurrences is counted once; under familywise control, only sustainable development and adaptation policy survive in either coding. We therefore report the cluster-level results as FDR-level findings throughout and note that the over-representation of ecosystem services is the one cluster-level claim that does not survive a change of coding convention.

3.4. Sensitivity to the Geographic Criterion

Condition (iii) of the geographic criterion (Section 2.1.3) admits global, European and comparative studies whose reported study area is not itself Mediterranean. Ten articles in the corpus are of this kind, and a further 22 report no identifiable study area (Table 3b). Because the composition of the corpus itself is one of the findings, the distributional analysis was re-run under two stricter definitions: retaining only articles whose reported study area lies inside the Basin, and retaining only those with an identifiable Mediterranean study area (Table 8).

Table 8. Sensitivity of the distributional result to the geographic criterion.

Specification	Articles	Coded	N	χ^2	p	V	J
Full corpus (primary)	89	64	123	56.02	5.0×10^{-8}	0.203	0.903
Reported study area inside the Basin	79	59	115	56.23	4.6×10^{-8}	0.211	0.897
Identifiable Mediterranean study area	57	41	80	47.20	2.0×10^{-6}	0.232	0.872

Note: Chi-square goodness-of-fit against a maximum-entropy benchmark, $df = 11$ in every specification. V = Cramér's V; J = Pielou's evenness. Ten articles report a study area outside the Basin and 22 report none identifiable (Table 3b).

The omnibus result is unaffected by the criterion. Removing the ten articles whose reported study area lies outside the Basin leaves the statistic and its significance essentially unchanged ($\chi^2 = 56.23$ against 56.02) and raises the effect size marginally ($V = 0.211$ against 0.203). Under the strictest definition, the corpus falls to 57 articles and 80 coded occurrences, and evenness is still rejected at $p = 2.0 \times 10^{-6}$ with a slightly larger effect ($V = 0.232$); the only category-level change is that strategic environmental assessment falls to zero observations, which is a consequence of the reduced sample rather than a reversal. The measured imbalance is therefore a property of the corpus and not of the geographic criterion.

3.5. Summary

(1) The distribution across categories is uneven, and the omnibus result is robust to correction for article-level dependence; the magnitude of the departure is small to moderate (Cramér's $V = 0.20$; Pielou's $J = 0.90$), not large; (2) over-representation of sustainable development and adaptation policy holds under familywise control; the remaining over- and under-representation results hold under false discovery rate control only; (3) the two registers co-occur rather than segregate; there is no evidence for distinct epistemic profiles within this corpus; (4) part of the measured imbalance is endogenous to a search string built on planning vocabulary and cannot be separated from it within this corpus.

4. Discussion

4.1. What the Distribution Shows

The categories most frequently coded are sustainable development, adaptation policy, ecosystem services and plans; the least frequent are green spaces, cultivation and hydrological interventions. The prominence of sustainable development and adaptation policy is consistent with the influence of post-2015 international frameworks, in particular the Paris Agreement and the 2030 Agenda, and with evidence that adaptation plans can elaborate strategic objectives more fully than implementation provisions, as reported by Preston et al. (2011) [16]. Biesbroek et al. (2015) caution, in this connection, that adaptation decision-making cannot be read off documents alone and that functionalist accounts of it are poorly supported [126]—a caution that applies to our own corpus, which consists of documents.

The scarcity of published evidence on measures acting directly on the urban microclimate and the water cycle matters because such measures are effective where they have been studied. Oliveira et al. (2011) in Lisbon, Emmanuel and Loconsole (2015) in Glasgow, and Zölch et al. (2016) in Germany report that small-scale NBS can reduce air temperature by 1.5–3 °C, lower physiological equivalent temperature (PET) by 4–6 °C and decrease surface runoff by 20–40% [9,10,127]. The marginality of these categories in the indexed literature suggests a misalignment between the operational knowledge sought by local decision-makers and the output of academic research, as noted by Kabisch et al. (2016) [114].

4.2. Registers Coexist Rather than Segregate

The co-occurrence analysis (Section 3.2) yields a result that qualifies a common framing in this literature. Geneletti and Zardo (2016) and Olazabal et al. (2019) distinguish a “policy discourse” from an “implementation discourse” in climate governance [113,128], and it would be natural to read our distributional result as evidence that the two occupy separate scholarly communities. A third of coded articles engage both registers, and the presence of one is statistically independent of the presence of the other. The non-circular article-level analysis therefore does not support segregation between the two registers.

The practical implication is more encouraging than a segregation account would be. The difficulty is not that researchers who write about governance are unable or unwilling to write about physical measures; many do both. It is a matter of relative volume, which points towards incentives and data availability rather than towards disciplinary boundaries—the subject of the next subsection. Laforzezza et al. (2018) [129] reach a compatible conclusion in assessing the European potential of NBS for urban adaptation.

4.3. Why the Funding Structure Favours the Policy Register

Nesshöver et al. (2017) observe that European research programmes have prioritised governance, co-creation and mainstreaming over the technical monitoring of implemented measures [130]. Comparing the terms of reference of the two instruments that dominate Mediterranean adaptation funding identifies structural reasons for the imbalance that do not require attributing an intention to funders.

The EU Mission “Adaptation to Climate Change” under Horizon Europe sets three objectives, of which the first two—supporting regions to understand and manage climate risk, and working with “at least 150 regions and communities” on transformation pathways—are governance and capacity-building objectives, while the third commits to “at least 75 large-scale demonstrations of systemic transformations” [131]. Its build-up phase (2021–2023) carried approximately €368 million, and research and innovation actions and coordination and support actions are funded at up to 100% of eligible costs. The LIFE Climate Change Adaptation sub-programme (Standard Action Projects), by contrast, sets a maximum EU co-financing rate of 60%, with mandatory reporting against the LIFE Project Indicators and an explicit replication requirement [132].

Three asymmetries follow. First, co-financing: a municipality implementing and monitoring a physical intervention under LIFE must raise 40% of the cost from its own budget, while a university consortium producing a governance framework under Horizon Europe faces no such requirement. The barrier falls on the actors best placed to generate operational evidence and weighs most on the least well-resourced administrations. Second, measurability within a funding cycle: a governance deliverable is complete when the document is complete, whereas the performance of a physical intervention—canopy cooling, runoff attenuation, planting survival—is a multi-year quantity not observable within a typical reporting period. A programme obliged to demonstrate results within its own cycle is structurally biased towards deliverables whose completion is contemporaneous with the funding; this operates even at equal cost, though physical interventions are also generally more expensive. Third, where the output lands, LIFE beneficiaries discharge their obligations through indicator reports and project deliverables, not journal articles, whereas Horizon Europe consortia are academic institutions whose incentive is publication. Much of the operational evidence therefore exists but is not in the databases a review of the indexed literature can reach—closing a loop with Section 2.1.2 and with Pauleit et al. (2019), who report that more than 60% of local practices in Italy and Spain are not published in scientific journals [20]. These are documented features of the two instruments and our

interpretation of their consequences; they are not demonstrated causes of the distribution reported in Section 3.1.

4.4. *Heterogeneity of the Categories*

The twelve categories are not comparable units (Section 2.2.1), and this qualifies the headline result in a specific direction. The four most frequently coded categories are policy frames and planning instruments; the least frequent are physical interventions. Abstract categories are mentioned more often than specific ones in academic text generally, and some of the measured imbalance may reflect that tendency rather than anything particular to adaptation. A category scheme designed for comparability—restricted, for instance, to measure-level categories—would be a better instrument for this research question, and constructing one is a natural next step.

4.5. *Geographic Coverage and the Northern-Mediterranean Bias*

The corpus is not geographically representative of the Basin, and the imbalance is more marked than the submitted version reported. Of the 67 articles whose study area is identifiable from the title or the indexed keywords, 33 lie on the northern rim, three on the eastern rim (all in Türkiye) and one on the southern rim (Tetouan, Morocco); a total of 20 studies (22.5%) are basin-wide or multi-country, and 22 report no identifiable study area. No study of Algeria, Egypt, Libya, Tunisia, Israel, Lebanon, Syria or Palestine appears in the corpus. Three mechanisms, all consequences of the review design, plausibly produce this skew: the English language and indexing criteria filter against southern- and eastern-rim output; European research funding is concentrated in member-state institutions; and adaptation work on the southern and eastern rims is more often carried out within donor-funded programmes whose outputs are technical reports rather than indexed articles. The category scheme derives from keywords in a corpus dominated by northern-rim studies, and several category labels—strategic environmental assessment, plans, public participation—correspond to instruments of EU environmental regulation. A corpus of this composition will register these instruments readily, while adaptation practice organised around other instruments is under-registered by construction. The over-representation of the policy register is thus partly a property of the coding frame's European origin.

The three sub-regions differ in ways that would plausibly produce different thematic profiles: EU regulatory instruments dominate on the northern rim; water scarcity, irrigation efficiency and agricultural resilience on the southern rim; transboundary water governance, conflict and displacement on the eastern rim. We do not report a statistical comparison across sub-regions: with the southern and eastern strata at their present size, expected cell frequencies would fall far below the validity threshold, and any difference obtained would reflect sampling variation. The comparison requires a corpus built for the purpose.

4.6. *Consequences of a Persistent Imbalance for Mediterranean Territories*

If the imbalance is not reduced, four consequences follow for Mediterranean territories, each tied to a documented condition rather than asserted generally.

First, funding access. Competitive calls require a business case with costs, expected performance and monitoring provisions. Where local performance data do not exist, that case cannot be built, which compounds the co-financing barrier identified in Section 4.3 and reproduces the imbalance in the next funding cycle.

Second, unsafe transfer of evidence. Absent before-and-after evidence from Mediterranean climates, interventions validated in temperate northern Europe are transferred on the assumption that their performance carries over. That assumption has not been established for a summer-drought regime, in which irrigation demand, species survival

and substrate behaviour differ fundamentally. A green roof specification that performs in Munich is not thereby a specification for Seville.

Third, pilots that do not scale. Geneletti and Zardo (2016) find that standardised monitoring protocols raise the probability that a pilot is scaled to city level [113]. In the absence of monitored precedents in comparable contexts, that condition remains unmet, and pilot projects remain pilots.

Fourth, unequal distribution of the burden. Administrations with in-house technical capacity can generate their own evidence; those without depend on published evidence that does not exist. The gap therefore widens between well-resourced cities and the smaller, more exposed municipalities that Adger et al. (2009) identify as most dependent on external knowledge [133]. This is the equity consequence of an imbalance at the level of the literature, and it constitutes the strongest practical reason to correct it.

These are reasoned implications of our findings rather than findings in their own right.

4.7. Limitations

The study measures the frequency of coded concepts in published articles. It does not assess implemented projects, budgets, responsibilities, completion, monitoring or adaptation outcomes, and cannot establish that planning outpaces implementation in practice. Its relationship to the implementation deficit reported by Preston et al. (2011) [16] is one of consistency, not confirmation; the evidence bases differ.

The corpus is drawn from a single database, in one language, through a query built on planning vocabulary (Section 2.1.2). The measured imbalance is partly endogenous to that design.

The twelve categories sit at heterogeneous levels of abstraction (Section 4.4).

No agreement statistic was computed for the original coding (Section 2.2.2). This is a material limitation for a study whose measurements rest on subjective classification.

A linear discriminant analysis was not retained because class labels derived from the same category counts used as predictors would make the separation circular. Section 3.2 therefore uses a non-circular article-level co-occurrence analysis.

4.8. Future Work

In order of priority, replication with a register-neutral, multi-database, multilingual query including a grey-literature stratum (OpenAIRE, Climate-ADAPT); construction of a comparability-controlled, measure-level category scheme with double coding and a reported agreement statistic; a sub-regional comparison on a corpus built for that purpose; and longitudinal case studies quantifying the costs, benefits and trade-offs of measures such as rain gardens, green corridors and de-paving in Mediterranean contexts, integrated with microclimatic and hydrological models (ENVI-met, SWMM).

5. Conclusions

Within the planning-oriented, English-language, Web of Science-indexed Mediterranean adaptation literature published between 2015 and 2024, 123 occurrences were coded from 64 of 89 eligible articles across twelve thematic categories.

The distribution is uneven, and the omnibus result is robust to correction for article-level dependence ($\chi^2_{RS} = 63.90$, $p = 1.7 \times 10^{-9}$). The magnitude of the departure from evenness is small-to-moderate (Cramér's $V = 0.20$; Pielou's $J = 0.90$), and the four largest categories account for 60.2% of occurrences against 33.3% under evenness. Sustainable development and adaptation policy are over-represented under familywise control; ecosystem services, plans, hydrological interventions, cultivation and green spaces reach significance under false discovery rate control only.

The policy and technical/NBS registers are not segregated. A third of coded articles engage both, and the presence of one is independent of the presence of the other (odds ratio 2.02, $p = 0.17$). The imbalance is one of volume, not of community structure.

The categories least often addressed are those closest to implementable measures—green spaces, cultivation and hydrological interventions. This imbalance in the literature is consistent with, but does not demonstrate, the implementation deficit documented by Preston et al. (2011) in adaptation plans [16]. Its direct implication concerns the research agenda: where the literature does not supply evidence on the feasibility, cost and performance of local NBS, decision-makers lack the operational references needed to justify investment.

Four measures, each with an identified actor. *Funders* should attach a monitoring and reporting condition to adaptation funding, with a minimum indicator set and a post-completion reporting window extending beyond the project period. *Programme authorities* should require that LIFE and Interreg MED deliverables be deposited in an open repository indexed by OpenAIRE and Climate-ADAPT, so that existing operational evidence becomes discoverable. *Journals* should open registered-report and data-availability routes for implementation studies, whose results are less publishable because they are often null or incremental. *The research community* should adopt Mediterranean-specific reporting minima for NBS performance studies—climate normals, irrigation regime, species and substrate, monitoring duration—without which transfer between Mediterranean contexts cannot be assessed. The first step within our own control is the public deposit of this study's materials, which accompanies this paper.

A reproducible method for measuring thematic emphasis in an adaptation corpus, and applied to a defined body of literature, yields a specific and modest finding: policy and planning categories are mentioned more often than physical-intervention categories; the two registers coexist rather than segregate; and the categories least often mentioned are those closest to implementable measures. Whether adaptation practice is similarly weighted is a question about interventions, and answering it would require evidence of a kind this study does not contain.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su18189361/s1>, File S1: article-level coding matrix for the 89 studies included in the systematic review, covering the twelve thematic categories; File S2: coding manual/codebook for the twelve thematic categories, including operational definitions and coding rules; File S3: records returning a null coding vector across the twelve categories; File S4: per-article classification and assignment information; File S5: completed PRISMA 2020 checklist [19].

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