

# Meta-Analysis of The Impact of Land-Use Change on Urban Resilience in The Context of Urban Renewal

Wenjun Yan , Lulu Jia , \*Chung-Han Tsai 

## Abstract

Urban renewal increasingly serves as a planning approach for optimizing urban land-use change and spatial structure. Enhancing urban resilience has also become an important objective of contemporary planning. However, existing studies examining the relationship between land-use change and urban resilience are largely case-based and fragmented, limiting systematic understanding. To address this gap, this study conducts an exploratory meta-analytical synthesis using Stata, based on five independent studies and fourteen effect sizes retrieved from Web of Science, Wanfang Data, and China National Knowledge Infrastructure (CNKI). The results suggest that land-use change within urban renewal is positively associated with urban resilience. However, substantial heterogeneity exists across studies, and part of this variation appears to be related to differences in land-use change type and urban renewal mode. Given the small number of independent studies and the high level of heterogeneity, these findings should be interpreted cautiously, but they provide an initial quantitative synthesis of land-use change and urban resilience relationships in the context of urban renewal.

## Keywords:

Urban renewal; Land-use change; Urban resilience; Meta-analysis

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## Kentsel Yenileme Bağlamında Arazi Kullanım Değişikliğinin Kentsel Direnç Üzerindeki Etkisinin Meta Analizi

Kentsel yenileme, kentsel arazi kullanım değişikliğini ve mekânsal yapıyı optimize etmek için giderek daha fazla kullanılan bir planlama yaklaşımı haline gelmiştir. Kentsel direnci artırmak da çağdaş planlamanın önemli bir hedefi olmuştur. Bununla birlikte, arazi kullanım değişikliği ve kentsel direnç arasındaki ilişkiyi inceleyen mevcut çalışmalar büyük ölçüde vaka bazlı ve parçalıdır, bu da sistematik bir anlayışı sınırlamaktadır. Bu boşluğu gidermek için, bu çalışma, Web of Science, Wanfang Data ve Çin Ulusal Bilgi Altyapısı'ndan (CNKI) elde edilen beş bağımsız çalışma ve on dört etki büyüklüğüne dayanarak Stata kullanarak keşifsel bir meta-analitik sentez gerçekleştirmiştir. Sonuçlar, kentsel yenileme içindeki arazi kullanım değişikliğinin kentsel dirençle pozitif olarak ilişkili olduğunu göstermektedir. Bununla birlikte, çalışmalar arasında önemli bir heterojenlik mevcuttur ve bu varyasyonun bir kısmı, arazi kullanım değişikliği türü ve kentsel yenileme modundaki farklılıklarla ilgili görünmektedir. Bağımsız çalışma sayısının azlığı ve yüksek heterojenlik düzeyi göz önüne alındığında, bu bulgular ihtiyatlı bir şekilde yorumlanmalıdır, ancak kentsel yenileme bağlamında arazi kullanım değişikliği ve kentsel direnç ilişkilerinin ilk nicel sentezini sağlamaktadır.

## Anahtar kelimeler

Kentsel yenileme; Arazi kullanım değişikliği; Kentsel direnç; Meta-analiz

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## 1. INTRODUCTION

Rapid urbanization has brought increasing pressures on urban ecological systems, infrastructure performance, and disaster management capacity, raising concerns about the long-term stability and sustainability of cities. In response, many cities are gradually shifting from outward spatial expansion toward renewal-oriented development that emphasizes the optimization of existing urban land and built environments. Within this transition, urban renewal represents an important governance approach through which land use patterns, spatial configurations, and functional structures are reorganized. Because land use constitutes the spatial foundation of urban systems, changes in land use structure and configuration have been widely discussed in relation to urban resilience, particularly in terms of ecological regulation, infrastructure performance, and social stability. However, existing empirical studies are mostly conducted at the level of individual cities or regions and rely on different evaluation frameworks and spatial scales, which has led to fragmented evidence and inconsistent conclusions. As a result, it remains unclear whether land-use change in the context of urban renewal is generally associated with improvements in urban resilience across different empirical settings.

To address this gap, this study examines the reported relationship between land-use change and urban resilience in the context of urban renewal through a meta-analytical synthesis of existing empirical studies. Rather than testing strong causal hypotheses, this study summarizes reported patterns across available empirical studies and examines possible sources of heterogeneity across settings. Specifically, the analysis considers three research questions. First, whether land-use change is overall associated with urban resilience in studies examining urban renewal contexts. Second, whether different types of land-use change are associated with different resilience outcomes. Third, whether variation in reported associations is related to differences in urban renewal modes and resilience dimensions. This study synthesizes reported associations in observational studies and does not aim to establish a causal effect, but instead seeks to identify general tendencies and potential sources of heterogeneity across the literature.

This study contributes to the literature in three specific ways. First, it provides a quantitative synthesis of dispersed empirical findings on the relationship between land-use change and urban resilience in the context of urban renewal. Second, it explores potential sources of cross-study heterogeneity by examining differences in land use types, renewal modes, and resilience dimensions. Third, under the limitations of a small evidence base, the study offers a cautious empirical reference for resilience-oriented land use planning and urban renewal strategies.

## 2. LITERATURE REVIEW

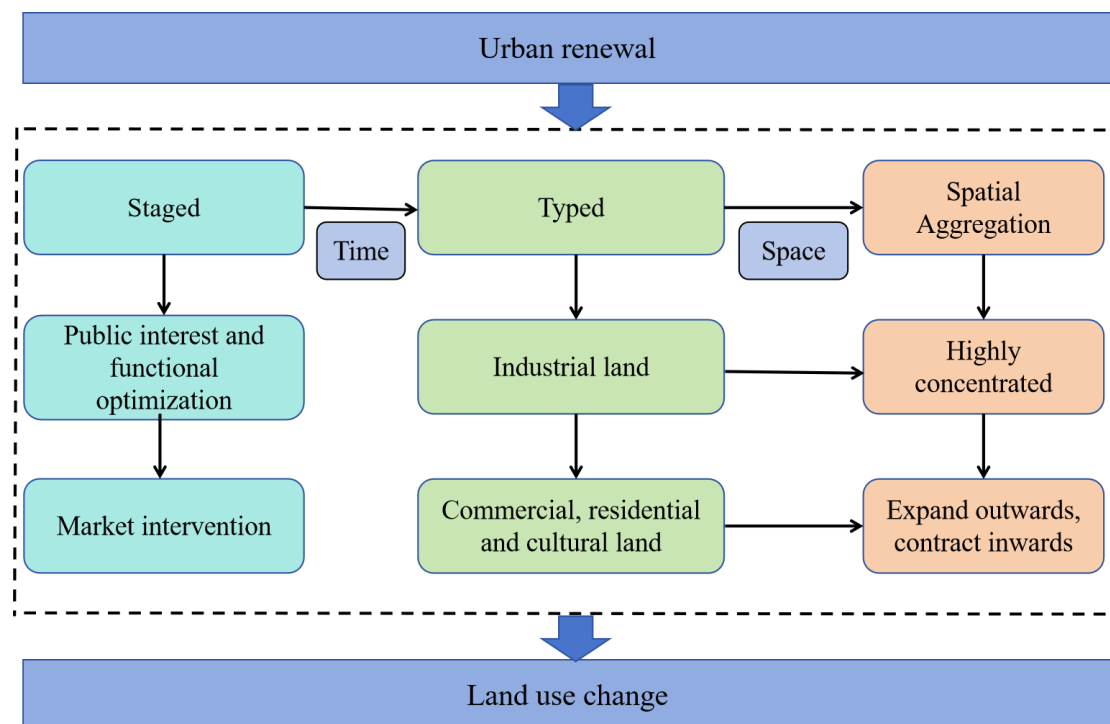
### **Urban renewal, land-use change, and multidimensional urban resilience**

Urban renewal usually refers to the improvement, reconstruction, or functional adjustment of existing built-up areas. Unlike urban expansion, which mainly relies on outward growth, urban renewal focuses on the reorganization of land and space within the existing urban area (Wu, 1991). In practice, it often includes redevelopment, renovation, rehabilitation, adaptive reuse, and infrastructure upgrading. Through these processes, urban renewal changes land-use structure, reshapes urban functions, and affects the way urban space is used.

Land use refers to the way land is allocated and used for different economic, social, and ecological purposes (Wang et al., 1999). In the context of urban renewal, land-use change is mainly reflected in the conversion of inefficient or obsolete land, the adjustment of industrial, commercial, residential, and public-service land, and the reconfiguration of spatial functions within the existing urban fabric (Chen & Zhang, 2005; Zhou et al., 2018). For example, former industrial land may be transformed into

residential or commercial land, and old urban districts may be renewed through mixed-use development or public-space improvement (Miao et al., 2020). These changes are not only physical adjustments but also reflect broader economic and governance transformation.

Urban resilience is commonly understood as the ability of a city to absorb shocks, adapt to change, and recover from disturbances (Zhao et al., 2020). It usually includes ecological, social, economic, and infrastructural dimensions. Ecological resilience concerns environmental capacity and ecosystem stability; social resilience concerns community adaptability, public services, and social inclusion; economic resilience concerns the ability to maintain or restore economic functions; infrastructural resilience concerns the stability and recovery capacity of transport, energy, water, and other urban systems. Because urban resilience is multidimensional, the effects of land-use change cannot be assumed to be the same across all dimensions. A change that improves ecological conditions may not necessarily improve social or economic resilience. For this reason, the relationship between land-use change and urban resilience should be examined in a differentiated way rather than treated as a single uniform effect. See Figure 1.



**Figure 1.** Typical patterns of land-use change under urban renewal

Source: Prepared by the authors based on the literature review.

### Existing studies on land-use change and urban resilience

Existing research has paid increasing attention to the relationship between land-use change and urban resilience, but the findings remain scattered. One group of studies focuses on ecological and environmental outcomes. These studies usually show that changes in land cover, surface materials, green space, and ecological corridors influence urban heat, runoff, biodiversity, and environmental risk. In particular, excessive impervious expansion and functional homogenization may weaken ecological resilience, while ecological restoration and green-space improvement may help strengthen environmental capacity (Parmeggiani et al., 2024; Hwang et al., 2020). However, these studies often use different indicators and are strongly shaped by local environmental conditions, making direct comparison difficult.

A second group of studies focuses on spatial structure and infrastructure. These studies examine brownfield redevelopment, land recycling, stock-based renewal, and infrastructure upgrading. The common view is that better land allocation and more efficient reuse of existing urban land may improve accessibility, reduce land waste, and support more stable infrastructure systems (Mecca et al., 2019). Research on urban villages, old industrial areas, and self-built neighborhoods also suggests that renewal may improve structural safety, service provision, and local governance capacity (Dong et al., 2023). At the same time, the scale of intervention, the condition of existing infrastructure, and the institutional setting often shape the results, which means that the reported effects vary considerably across cases.

A third group of studies pays attention to social and economic consequences. These studies point out that land-use adjustment may improve land-use efficiency and urban functions, but may also produce uneven social effects. High-density redevelopment and functional upgrading can sometimes increase housing pressure, displacement, exclusion, or unequal access to public resources. Research has shown that socially vulnerable groups may face higher environmental burdens and weaker recovery capacity under certain forms of land-use change (Shen et al., 2024). Post-pandemic studies also suggest that neighborhood structure, land-use density, and spatial accessibility are closely related to social recovery and everyday resilience (Zhao et al., 2024). These findings show that the social and economic implications of land-use change are complex and cannot be reduced to a simple positive or negative judgment.

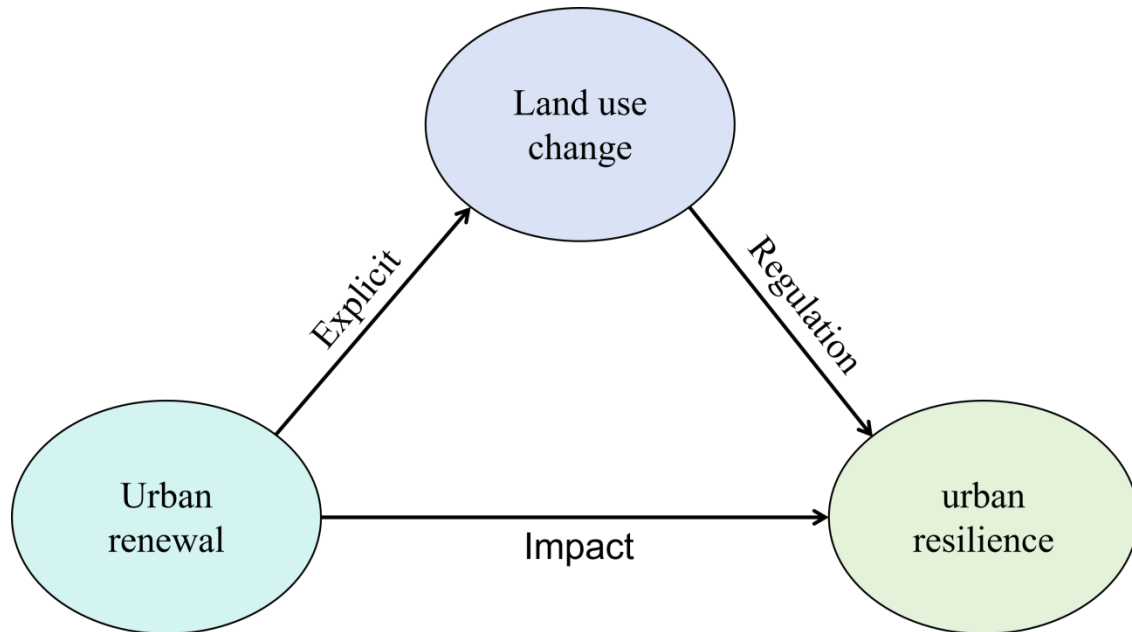
Overall, the current literature suggests that land-use change is closely related to urban resilience, but the reported results are far from consistent. The reasons are not difficult to understand. First, different studies use different measures of resilience. Second, different types of land-use change may lead to different outcomes. Third, urban renewal itself includes different modes, such as redevelopment, renovation, adaptive reuse, and comprehensive improvement, and these modes may influence resilience in different ways. As a result, the existing literature provides important case-based evidence, but it does not yet offer a clear overall picture.

### **Research gap and framework of analysis**

Although research on urban renewal, land-use change, and urban resilience has grown rapidly, several gaps remain. First, most existing studies are case-based. They provide valuable evidence for specific cities, districts, or neighborhoods, but it is still difficult to judge whether the reported relationships can be observed more broadly across different contexts. A quantitative synthesis is therefore needed to summarize the available empirical results. Second, the current literature has not sufficiently explained why findings differ from one study to another. Differences in land-use categories, renewal modes, resilience dimensions, research scale, and measurement methods may all affect the reported results. However, these possible sources of variation have rarely been examined together in a systematic way. Third, urban resilience is often treated too broadly in literature. Because resilience includes ecological, social, economic, and infrastructural dimensions, it is necessary to examine whether land-use change affects these dimensions in the same way or not. Without such distinction, the relationship between land-use change and resilience may be overstated or oversimplified.

Considering these gaps, the study uses a simple analytical framework to guide empirical synthesis. Urban renewal is treated as the broader context in which land-use change takes place. Land-use change is the central variable discussed in literature. Urban resilience is treated as the

outcome, but not as a single undivided concept. Instead, it is understood as a multidimensional outcome that may respond differently under different land-use conditions and renewal modes. This framework provides the basis for empirical analysis in the following sections and helps explain why heterogeneity should be expected in the reported relationship between land-use change and urban resilience. (See Fig2)



**Figure 2.** Analytical framework of the relationship among urban renewal, land-use change, and urban resilience

Source: Prepared by the authors based on the literature review.

### 3. RESEARCH METHODS

Given the very limited number of eligible studies, the present analysis is framed as an exploratory synthesis of reported associations rather than a basis for strong meta-analytic generalization. The objective is therefore to systematically compile existing empirical evidence and examine patterns in the reported relationships between land-use change and urban resilience within the context of urban renewal.

#### Search strategy and inclusion criteria

To systematically assess the effects of land-use change on urban resilience in the context of urban renewal, a structured literature search was conducted across three major databases: Web of Science, China National Knowledge Infrastructure (CNKI), and Wanfang Data. The search covered the period from database inception to 1 November 2025, with no restrictions on publication language. For the Web of Science, the search was performed in the Topic (TS) field, which includes titles, abstracts, and author keywords, using the following query: TS = (("urban renewal" OR "urban redevelopment" OR "urban regeneration") AND ("land-use change") AND ("resilience" OR "vulnerability")). For CNKI, the search was conducted in the subject and keyword fields, using the following Chinese terms: ("城市更新" urban renewal) AND ("土地利用变化" land-use change) AND ("城市韧性" urban resilience). For Wanfang Data, an equivalent search strategy was applied in the title, abstract, and keyword fields, using the same Chinese and English keywords as those applied in the CNKI search. All searches were completed on 1 November 2025. All retrieved records were imported into Endnote for automatic and manual duplicate removal. Following de-duplication, the remaining studies were screened through a two-stage selection process (title, abstract and full-text eligibility assessment). Both stages of screening were performed

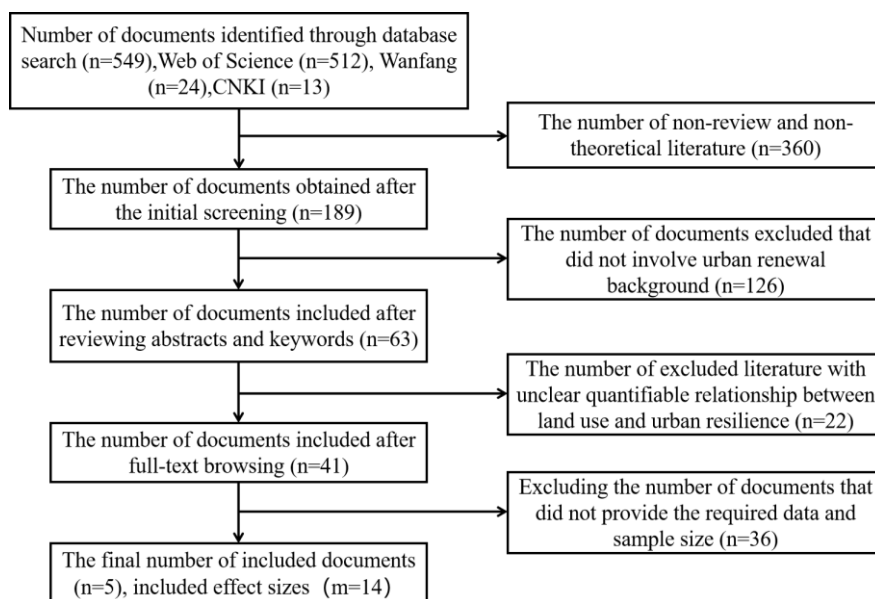
independently by two reviewers following predefined inclusion and exclusion criteria. Disagreements were resolved through discussion and consensus, ensuring the reliability of the study selection procedure. See Appendix A.

**Inclusion criteria:** empirical studies; study context involving urban renewal projects; explicitly reporting a quantitative relationship between land-use change and at least one urban resilience indicator; and providing data from which effect sizes could be calculated. Grey literature, including doctoral and master's theses, was intentionally considered eligible for this review. In the field of urban and planning research, high-quality empirical studies—particularly those involving detailed land-use measurements, GIS analyses, and spatial modeling—are often reported in thesis form and may not appear in peer-reviewed journals. Excluding these sources could introduce publication bias and limit the comprehensiveness of evidence synthesis. To maintain methodological rigor, grey literature was subjected to the same inclusion and quality assessment criteria as peer-reviewed publications. Specifically, only papers meeting the following criteria will be included: reported clear and reproducible data sources, clearly defined land-use change and urban resilience measures, and the use of transparent empirical or modeling methodologies.

**Exclusion criteria:** reviews, commentaries, purely theoretical or qualitative studies; incomplete or non-extractable data; studies without extractable statistical information; and duplicate publications.

### Data extraction and coding

**Study Selection Process:** The initial search identified 549 records. After removing reviews and purely theoretical work, 189 empirical studies remained. Screening for explicit urban-renewal contexts yielded 63 studies. Of these, 41 quantified land-use change in relation to at least one resilience dimension, and 14 partially dependent effect sizes derived from 5 independent studies were included in the final synthesis. See Figure 3. The final number of eligible studies was small because the inclusion criteria required both conceptual relevance and sufficient quantitative information for standardized effect-size extraction. This small evidence base limits the strength of generalization and requires cautious interpretation throughout the analysis.



**Figure 3.** Literature Screening Process and Results

Source: Prepared by the authors based on the screening results.

Table 1 reports the basic information for the 14 extracted effect sizes derived from 5 studies, including author, year, sample size, urban renewal mode, land-use type, resilience dimension, and effect size values in Fisher’s z metric. For ease of interpretation, pooled results are discussed in back-transformed r values where appropriate.

**Table 1.** Data Extraction Table

Number	Author	Year	Sample Size	Urban Renewal Mode (Code)	Land Use Type (Code)	Urban Resilience Dimension (Code)	Effect size	Data source
1	Tang, Y.	2023	286	A2	B1	C1	0.121	
2	Tang, Y.	2023	286	A2	B2	C2	0.214	(Tang, 2023)
3	Tang, Y.	2023	286	A2	B3	C4	0.149	
4	Tang, Y.	2023	286	A2	B4	C3	0.14	
5	Wang, H.	2023	192	A2	B3	C2	0.1724	
6	Wang, H.	2023	192	A2	B3	C3	0.1894	(Wang, 2023)
7	Wang, H.	2023	192	A2	B3	C4	0.3763	
8	Jia, S.	2023	153	A1	B2	C1	0.854	(Jia, 2023)
9	Jia, S.	2023	153	A1	B2	C2	0.827	
10	Jia, S.	2023	153	A1	B2	C4	0.932	
11	Fu, Y. , et al.	2022	200	A2	B1	C1	0.1437	
12	Fu, Y. , et al.	2022	200	A1	B4	C3	0.0479	(Fu et al., 2022)
13	Fu, Y. , et al.	2022	200	A3	B3	C2	0.0702	
14	Feng, S., et al.	2024	65	A2	B1	C1	0.79	(Feng et al., 2024)

Note: Urban renewal mode coding (A1 = Redevelopment, A2 = Comprehensive Renovation, A3 = Protective Renewal), land-use type coding (B1 = Increase in Green Space, B2 = Building Densification, B3 = Functional Mixing, B4 = Industrial Land Transformation), urban resilience dimension coding (C1 = Ecological, C2 = Social, C3 = Economic, C4 = Infrastructure), Effect Size = Fisher's z (back-transformed r shown in text)

### Effect-size transformation

To ensure comparability across studies, the core reported statistics were harmonized prior to meta-analytic synthesis. Pearson or Spearman correlation coefficients ( $r$ ) between land-use change and urban resilience were extracted when available. For studies reporting alternative metrics, such as weighted indices or composite scores reflecting land use–resilience relationships, these statistics were converted to the  $r$  metric when sufficiently reported and when transparent transformation was possible, allowing approximate representation of association strength while maintaining consistency in effect direction. For meta-analytic estimation, all correlation coefficients were transformed using Fisher's  $Z$  to stabilize variance and satisfy normality assumptions, following standard meta-analytic procedures. Pooled effect sizes and subgroup estimates were calculated in the  $Z$  metric, after which the results were back-transformed to  $r$  using the inverse Fisher transformation  $r = \tanh(Z)$  to facilitate intuitive interpretation. This approach ensures that effect sizes are comparable across heterogeneous measurement scales while preserving statistical validity in aggregation (Borenstein et al., 2010). Correlation coefficients were transformed into Fisher's  $z$  values using standard meta-analytic procedures. For interpretation, pooled  $z$  values were back-transformed into correlation coefficients using the inverse Fisher transformation:

$$r = \frac{e^{2Z} - 1}{e^{2Z} + 1} \quad (\text{I})$$

$$Z = \frac{1}{2} \ln \left( \frac{1+r}{1-r} \right) \quad (\text{II})$$

Where  $r$  denotes the original correlation coefficient and  $Z$  represents the transformed effect size.

Under a sample size of  $n$ , the variance of Fisher's  $Z$  is:

$$\text{Var}(Z) = \frac{1}{n-3} \quad (\text{III})$$

The corresponding standard error is:

$$SE_Z = \sqrt{\frac{1}{n-3}} \quad (\text{IV})$$

Several primary studies contributed more than one effect size by reporting results for different land-use types, resilience dimensions, or model specifications. As a result, effect sizes were not statistically independent but nested within studies. To address this dependency, effect sizes were coded with study-level identifiers, and all inferential statements were interpreted with caution regarding non-independence. Rather than treating each effect size as representing an independent study, the meta-analysis focused on estimating an average association while allowing for substantial between-study heterogeneity. The implications of effect-size dependency were explicitly considered when interpreting statistical significance and heterogeneity, and subsequent subgroup and meta-regression analyses were treated as exploratory.

### Analytical strategy and limitations

Meta-analysis is a quantitative synthesis approach that aggregates reported effect sizes across empirical studies to identify general patterns and explore heterogeneity through subgroup and meta-regression analyses. Systematic reviews provide structured summaries of empirical evidence, support transparent synthesis of findings, and help identify gaps and directions for future research (Hutton et al., 2015). Guidelines such as QUOROM (Moher et al., 1999) and PRISMA (Moher et al., 2009) have been developed to improve the reporting quality of systematic reviews and meta-analyses across disciplines.

Since the beginning of the 21st century, scholars have systematically summarized methods for effect size pooling, heterogeneity testing, and model selection, facilitating the expansion of meta-analysis from medicine and psychology to fields such as economics, social sciences, and urban and regional studies. Empirical research in urban and planning studies does not rely on a universally established quality appraisal or risk-of-bias tool, particularly in meta-analyses synthesizing observational and spatial studies. Given the diversity of data sources, analytical approaches, and spatial scales in land-use and urban resilience research, this study applied a domain-specific quality assessment framework to characterize the methodological rigor of the included studies.

The assessment was intended to support transparent interpretation of the evidence base rather than to exclude studies or to infer causal validity. Based on commonly accepted methodological considerations in urban and spatial empirical research, five dimensions were evaluated: (i) Measurement consistency, referring to the clarity and reproducibility of land-use and urban resilience indicators; (ii) Model identification, assessing whether analytical models and variable roles were explicitly specified; (iii) Adequacy of control variables, examining whether major contextual confounders were reasonably accounted for; (iv) Spatial scale appropriateness, evaluating the suitability and comparability of spatial units of analysis; (v) Data transparency, concerning the reporting of data sources, temporal coverage, and preprocessing procedures.

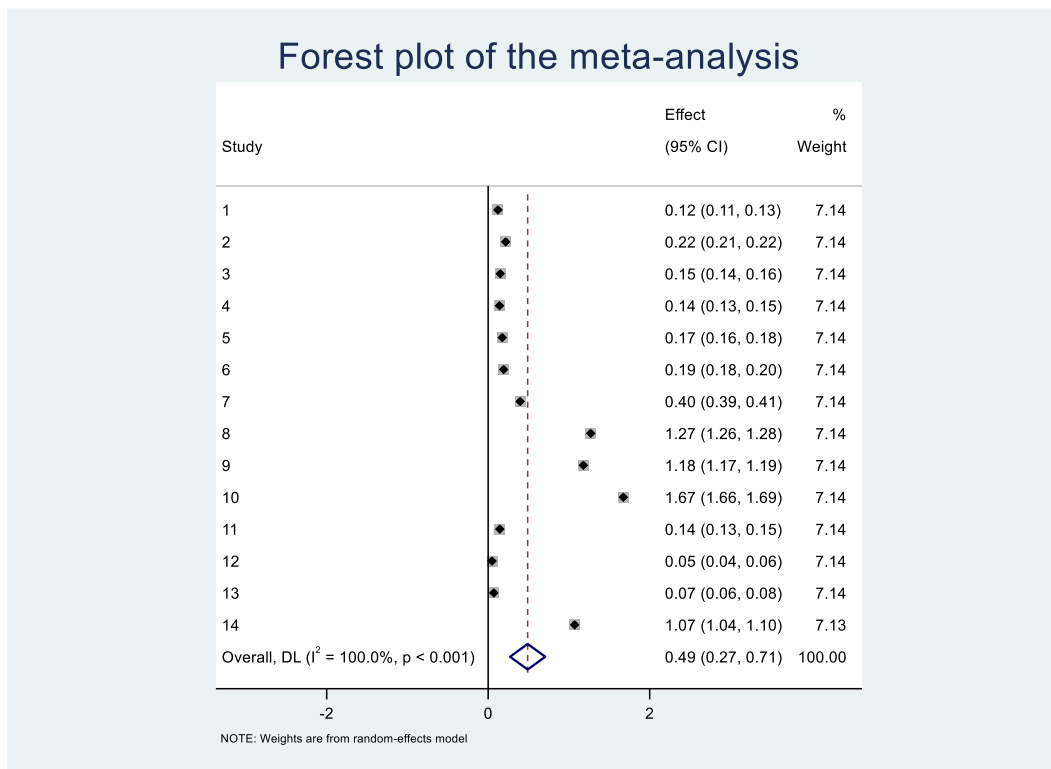
Each dimension was rated on a three-level scale (low, moderate, high). Assessments were conducted independently by two reviewers, with discrepancies resolved through discussion. Quality profiles were used descriptively to contextualize observed heterogeneity and the robustness of findings. No study was excluded or weighted based on quality, ensuring that pooled estimates reflect the full range of available empirical evidence.

Publication bias was not formally assessed because the number of independent studies was too small to support a meaningful evaluation.

## **4. RESULTS**

### **Overall Effect**

Based on 14 extracted effect sizes, the random-effects meta-analysis estimated a positive pooled association between land-use change and urban resilience in the context of urban renewal. The random-effects framework was selected not only to account for differences between studies, but also to accommodate contextual diversity, measurement heterogeneity, and varying operationalization of resilience and land-use change across studies. However, the model does not eliminate the interpretive limitations posed by the very small number of independent studies. See Figure 4.



**Figure 4.** Forest plot of the meta-analysis on the impact of land-use change on urban resilience in the context of urban renewal

The pooled effect size of land use on urban resilience was estimated at  $r = 0.489$ , with a 95% confidence interval of [0.271, 0.708] ( $P < 0.001$ ), indicating a positive association. However, these 14 extracted effect sizes were derived from only five independent studies, heterogeneity was extremely high, and several effect sizes came from the same primary study.

### Heterogeneity Test

**Table 2.** Heterogeneity Test

Measure	Value	df	p-value
Cochran's Q	96981.13	13	0
			-[95% Conf. Interval]-
H	86.372	49.227	123.604
$I^2$ (%)	100.00%	100.00%	100.00%

Heterogeneity diagnostics indicated an extremely high level of variability across the included effect sizes. This extreme heterogeneity indicates that the pooled effect should not be interpreted as a uniform effect size and materially limits the interpretability of the overall estimate. Because multiple effect sizes were extracted from the same studies, the analyses do not fully satisfy the assumption of independence required for stable moderator estimation. Consequently, subgroup analyses and meta-regression were conducted only as exploratory analyses to probe potential sources of effect variation. Results are indicative only and should not be interpreted as strong causal evidence. This level of heterogeneity suggests that the underlying studies are likely capturing substantively different empirical relationships rather than repeated estimates of the same association.

The estimated between-effect variance ( $\tau^2=0.1739$ ) indicates a considerable dispersion of true effects across studies and effect sizes, while not suggesting unbounded divergence. A random-effects model was applied to estimate the overall association, reflecting contextual diversity, measurement heterogeneity, and varying operationalization of land-use change and urban resilience across studies. However, this model does not eliminate interpretive limitations posed by the small number of independent studies and the non-independence of multiple effect sizes from the same studies.

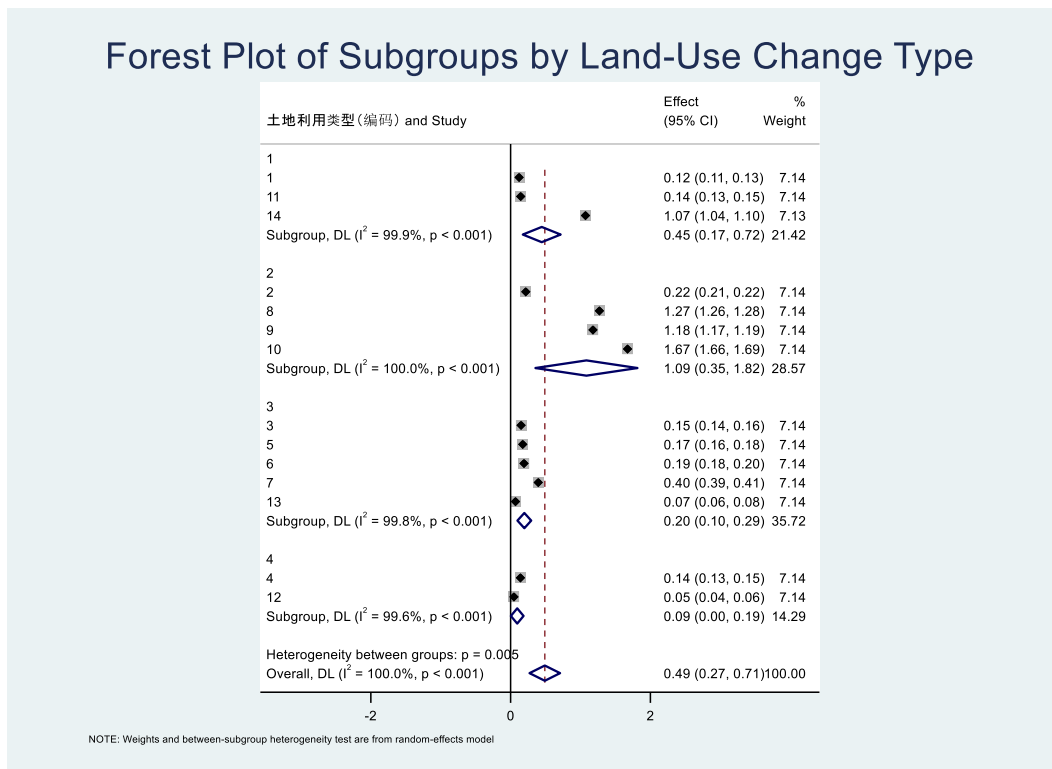
From a substantive perspective, the pronounced heterogeneity is likely associated with contextual differences across studies, including variations in urban development stage and governance capacity, alternative operationalizations of land-use change, heterogeneity in the construction of urban resilience indicators, and differences in urban renewal strategies. Given the magnitude of heterogeneity and dependent effect sizes, subgroup analyses and meta-regression were conducted only as exploratory analyses, intended to probe potential sources of effect variation rather than establish definitive causal hierarchies. Results are indicative only and should be interpreted with caution.

Therefore, the pooled estimate should be interpreted as an average summary across highly diverse contexts rather than as evidence of a single common effect.

### Exploratory subgroup patterns

Unless otherwise stated, the subgroup estimates reported below are pooled Fisher’s z values. To explore potential sources of heterogeneity, subgroup analyses were conducted descriptively by land-use change type, resilience dimension, and urban renewal mode (Figures 5–7). Across subgroup specifications, residual heterogeneity remained substantial, suggesting that contextual conditions and measurement choices continue to contribute to between-effect variability beyond the moderators considered.

### Subgroup Analysis of Land-Use Change Types

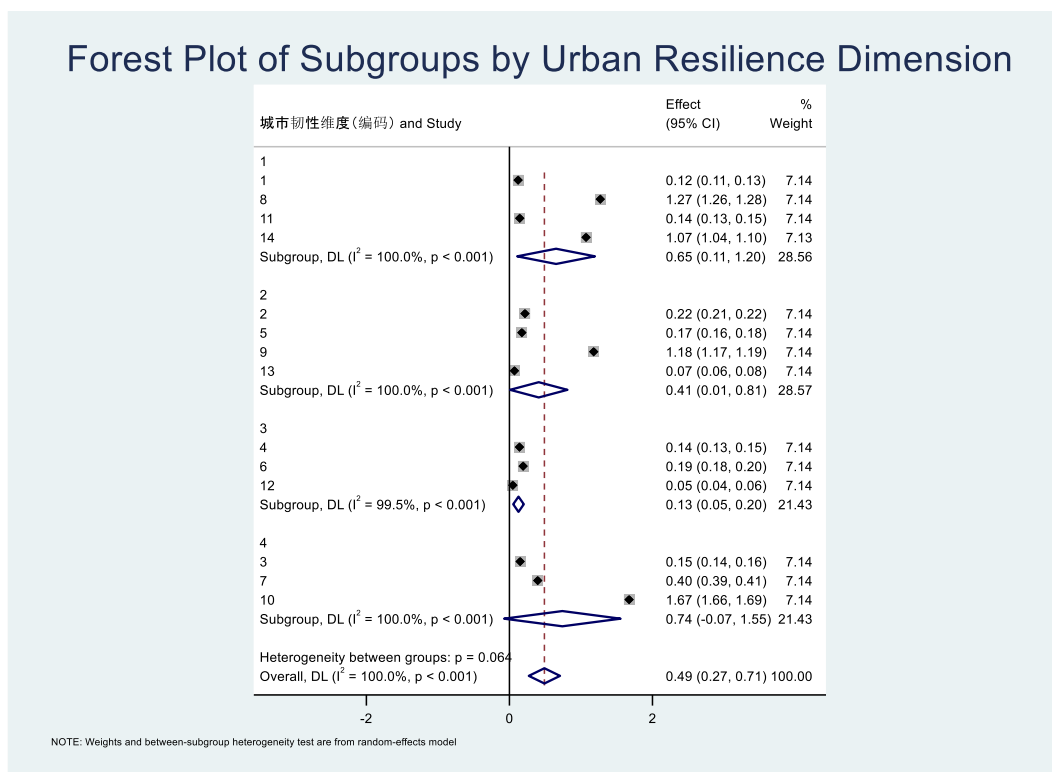


**Figure 5.** Forest Plot of Subgroups by Land-Use Change Type

Pooled effect sizes appeared to differ across land-use change types (Figure 5). Type 2 tended to show a larger pooled estimate (1.085), whereas Type 3 (0.196) and Type 4 (0.095) showed comparatively smaller pooled effects. These patterns suggest descriptive variation in the magnitude of land-use–resilience associations by type of land-use adjustment; however, high within-subgroup heterogeneity indicates that additional, unmodeled factors likely condition these estimates. These subgroup contrasts are descriptive and should not be interpreted as definitive evidence of between-group differences, given the small and uneven distribution of studies across categories.

### Subgroup Analysis by Resilience Dimension

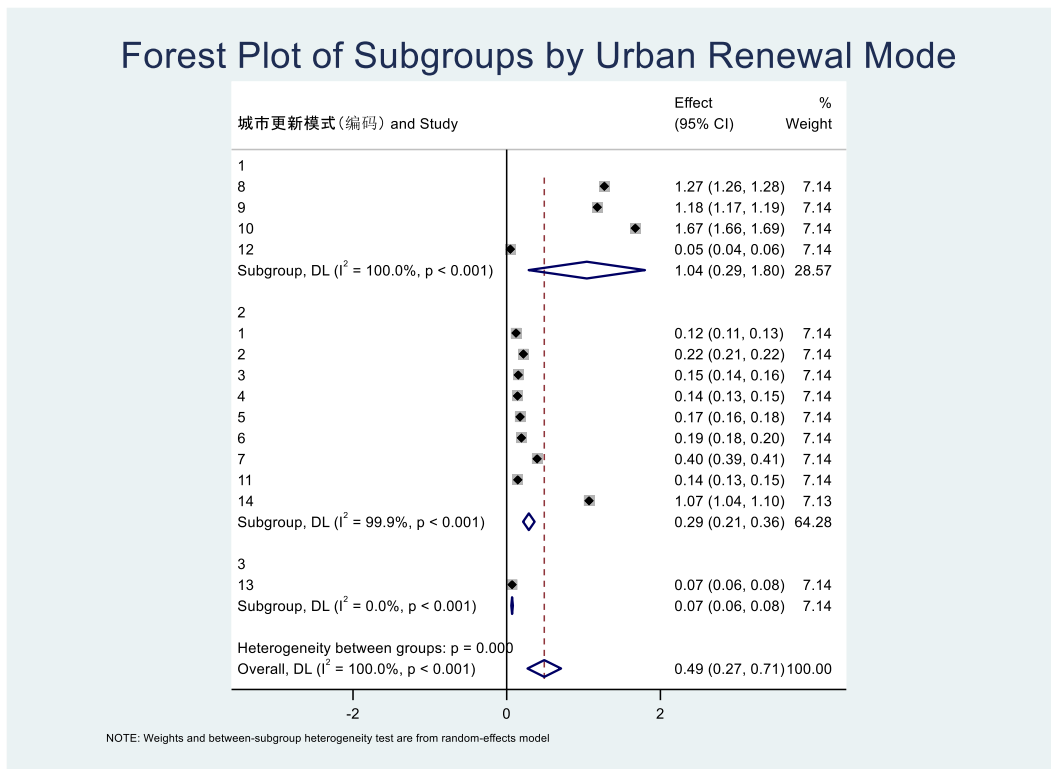
Urban resilience is widely recognized as a multidimensional concept encompassing ecological, social, economic, and infrastructure dimensions. To account for potential differences across these dimensions, the present study coded resilience outcomes according to their specific dimension and incorporated this variable as a moderator in the meta-regression analysis rather than assuming equivalence among different resilience dimensions.



**Figure 6.** Forest Plot of Subgroups by Urban Resilience Dimension

Across resilience dimensions, pooled effects appeared to range from 0.127 to 0.740, with largely overlapping confidence intervals (Figure 6). The between-group Q test was only marginally significant ( $p = 0.064$ ), suggesting that resilience dimension may explain only a small portion of the observed heterogeneity. These patterns should be interpreted descriptively and not as definitive evidence of between-dimension differences.

### Subgroup Analysis by Urban Renewal Mode



**Figure 7.** Forest Plot of Subgroups by Urban Renewal Mode

Pooled effects appeared to vary by urban renewal mode (Figure 7). Redevelopment (Mode 1) tended to show a larger pooled effect (1.043), followed by Comprehensive Renovation (Mode 2) and Preservation-oriented Renewal (Mode 3). The between-group Q test was statistically significant ( $Q = 38.04$ ,  $p < 0.001$ ), suggesting that renewal mode may account for a portion of between-effect variability. These subgroup contrasts are descriptive and should not be interpreted as definitive evidence of superior strategies or causal moderation.

Interpretation note. Given the substantial within-subgroup heterogeneity and the limited and uneven distribution of included studies and effect sizes, subgroup patterns should be interpreted as descriptive and exploratory, rather than as definitive evidence of causal moderation.

### Exploratory Meta-Regression Patterns

An exploratory meta-regression was conducted using three coded variables—land-use type, urban renewal mode, and urban resilience dimension—as predictors. The analysis is limited by the low number of independent studies and the non-independence of multiple effect sizes from the same studies. (see Table 3). The resilience dimension variable was included to explore potential differences in effect sizes across different components of urban resilience. Coefficients appeared to vary descriptively, reflecting the multidimensional nature of resilience rather than implying uniform or causal effects. These results should be interpreted as exploratory patterns.

**Table 3.** Meta-Regression Analysis

z	Coefficient	Std. err.	t	P> t	[95% conf. interval]	
Land use type code	-.2983019	.147091	-2.03	0.070	-.626041	.0294372
Urban renewal model code	-.5576043	.1977408	-2.82	0.018	-.9981981	-.1170104
Urban resilience dimension code	.1271141	.1305735	0.97	0.353	-.1638218	.41805
_cons	1.909678	.465171	4.11	0.002	.8732125	2.946144

It should be noted that land use type, renewal mode, and resilience dimension are categorical constructs. The meta-regression coefficients therefore reflect between-category differences associated with the chosen coding scheme, rather than linear, ordinal, or monotonic effects. Accordingly, the results are interpreted as exploratory evidence of heterogeneity associated with different categories, rather than as directional or causal relationships.

An exploratory meta-regression was conducted as a supplementary analysis to examine whether part of the observed heterogeneity might be related to coded study characteristics. The exploratory model produced an overall F statistic of 4.66 (df = 3, 10; p = 0.0276),but this result should be interpreted with caution. Because the evidence base is very small and the extracted effect sizes are not fully independent, this result is reported only for descriptive reference.

For renewal mode, the coefficient (−0.5576, 95% CI: −0.9982 to −0.1170) suggested some differences across coded categories. However, because the categories were introduced through a simplified coding scheme and the evidence base is small, this result should not be interpreted as a stable moderator effect.

The coefficient for land-use type (−0.2983, 95% CI: −0.6260 to 0.0294)showed some variation across coded categories, although the estimate remains uncertain and should be interpreted cautiously..

For resilience dimension, the coefficient (0.1271, 95% CI: −0.1638 to 0.4181) did not show clear differences across coded categories in this exploratory model. This result should not be interpreted as evidence that all dimensions respond in the same way.

The intercept remained statistically significant (coefficient = 1.9097, p = 0.002), indicating a positive baseline association after accounting for the included coded variables. Despite the inclusion of these variables, substantial residual heterogeneity persisted, implying that a large share of variability remains unexplained. This residual heterogeneity likely reflects unobserved contextual and methodological differences across studies, such as variations in urban contexts, indicator construction, spatial scales, model specifications, and data quality. Given the very limited number of independent studies and the non-independence of multiple effect sizes from the same studies, the meta-regression results are reported only as tentative, exploratory patterns and are not used as a basis for strong inference.

## 5. DISCUSSION

Based on the available evidence, land-use change under urban renewal appears to be positively associated with urban resilience in the included studies, but not all land-use changes are necessarily beneficial. The observed association may reflect contextual factors, planning practices, or governance capacity, and may partly result from structural or functional improvements in urban systems. At the

same time, resilience gains may be uneven across dimensions, land-use types, and social groups, highlighting the conditional nature of these relationships.

### **Resilience Effects of Land-Use Changes in Urban Renewal**

Overall, the meta-analytic results indicate that land-use changes induced by urban renewal are positively associated with urban resilience, with no statistically significant negative pooled effects observed across the included studies. However, the magnitude of these effects varies substantially by land-use change type, suggesting that resilience gains are highly uneven and structurally differentiated rather than uniform outcomes of land-use adjustment.

Among the examined land-use categories, building densification appeared to show larger pooled effects on urban resilience compared with green space expansion, functional mixing, and industrial land transformation. These descriptive differences may partly reflect structural transformations involving intensified land use and higher functional integration, but the magnitude and direction of effects are likely contingent upon local baseline land conditions, governance capacity, planning priorities, and measurement frameworks. From a mechanistic perspective, densification-oriented renewal could be related to changes in spatial form, infrastructure networks, and functional coupling, which may enhance accessibility, service efficiency, and resource allocation under certain conditions. However, these patterns should not be interpreted as evidence that densification constitutes a universally optimal pathway to resilience, as outcomes may vary across environmental, spatial, and governance contexts.

Importantly, the resilience outcomes of densification are closely mediated by planning and governance capacity. Cities with integrated land-use and infrastructure planning, effective environmental regulation, and stronger implementation capacity may be more likely to translate density increases into resilience gains under certain conditions. Conversely, in contexts characterized by fragmented governance, limited regulatory enforcement, or uneven access to public amenities, densification may intensify existing vulnerabilities rather than mitigate them. This conditionality helps explain part of the observed heterogeneity across studies and underscores the need to interpret pooled effects in relation to their institutional and spatial contexts.

In the context of stock-based urban renewal, densification is therefore more likely to yield comprehensive resilience benefits in areas where land-use efficiency is low, functional structures are rigid, and transformation potential is relatively high. In contrast, in areas with complex property rights, intact historical fabrics, dense social networks, or already high population concentrations, incremental and adaptive renewal strategies—such as micro-renewal, functional infill, infrastructure upgrading, and heritage-sensitive redevelopment—may offer more sustainable pathways for resilience enhancement. These approaches prioritize gradual improvement and social continuity over rapid structural transformation, aligning resilience gains with local spatial and social conditions.

Taken together, the findings suggest that land-use change under urban renewal should not be understood as a uniform driver of resilience, but as a context-dependent process shaped by differences across resilience dimensions and urban conditions.

### **Moderating Effects of Control Variables**

The exploratory analyses suggest that differences in study characteristics may be related to part of the observed variation in reported associations. Rather than producing uniform effects, land-use adjustments appear to operate under different planning and governance conditions, which may help explain the heterogeneous patterns reported across studies.

Among the examined study characteristics, urban renewal mode appeared to be associated with part of the observed variation, although this pattern remains tentative. The exploratory results are consistent with the possibility that differences in intervention form and implementation context are related to variation in reported resilience effects. However, this pattern should not be interpreted as evidence of a universally superior renewal strategy. Instead, it indicates that the resilience implications of land-use change are contingent upon how renewal is implemented, including the scope of physical transformation, institutional coordination, and governance capacity. In practice, these exploratory findings may provide a cautious reference for policymakers when considering how land-use interventions are aligned with local implementation conditions.

Land-use change type also appears to play a conditional role, although its moderating influence is less pronounced. This suggests that the substantive content of land-use transformation matters, but its effects are likely mediated by complementary factors such as infrastructure provision, environmental design, and socio-spatial context. Consequently, land-use adjustments alone should not be expected to generate resilience gains unless they are embedded within integrated planning frameworks that address environmental, social, and infrastructural dimensions simultaneously.

In contrast, evidence regarding resilience dimensions appeared weak, as no statistically distinct subgroup patterns were observed across dimensions. The lack of distinct patterns should not be interpreted as evidence that all dimensions respond uniformly to land-use change. This may partly result from the limited number of available studies, overlapping or inconsistent indicators, and mixed operationalization of resilience across the literature. Consequently, observed effects may reflect integrated system-level responses rather than clearly separable dimensional mechanisms, but these interpretations remain tentative and descriptive. The multidimensional nature of urban resilience underscores the importance of future research with larger and more consistent datasets to examine how different resilience dimensions may differentially respond to land-use changes under urban renewal.

Taken together, these moderating effects point to a central conclusion: land-use change can contribute to urban resilience, but its effectiveness is conditional rather than universal. Resilience gains are more likely to materialize under specific combinations of renewal mode, land-use strategy, and governance context.

### **Policy implications under contextual constraints**

The findings of this study suggest that the resilience implications of land-use change under urban renewal should be understood in relation to specific urban contexts rather than assumed to be universal. Although the pooled evidence indicates a generally positive association between land-use change and urban resilience, the substantial heterogeneity across studies implies that similar land-use interventions may produce different outcomes depending on local institutional capacity, spatial structure, redevelopment intensity, and the way resilience is defined and measured. Therefore, policy interpretation should avoid assuming that any specific urban renewal strategy will automatically generate resilience gains across settings.

First, land-use restructuring in urban renewal should be aligned with the dominant resilience needs of the local urban system. In areas facing ecological stress, greater attention may need to be given to green space restoration, ecological connectivity, and environmental buffering capacity. In densely built-up districts with aging infrastructure, resilience-oriented renewal may depend more on the coordination between land-use adjustment and infrastructure upgrading, public service accessibility, and emergency response capacity. In socially vulnerable neighborhoods, planners should also consider whether redevelopment-induced land-use change may generate uneven social consequences, such as displacement, exclusion, or reduced affordability, which could weaken resilience in broader social terms.

These differences suggest that land-use change should not be evaluated only by its intensity or efficiency, but by how well it corresponds to the specific resilience priorities of a given urban context.

Second, the results imply that policy design should pay closer attention to the implementation conditions of different renewal modes. The exploratory analyses suggest that land-use outcomes may vary across redevelopment, renovation, adaptive reuse, and other renewal approaches. This does not mean that one mode is inherently superior to another, but rather that the resilience consequences of land-use change are likely to depend on how intervention scale, functional transformation, institutional coordination, and community adaptation interact in practice. Accordingly, urban renewal policies should avoid standardized replication of land-use models and instead emphasize flexible planning frameworks that can respond to local development constraints and resilience objectives.

Third, a resilience-oriented land-use strategy requires more integrated governance and evaluation mechanisms. Because urban resilience is multidimensional, policy assessment should not rely on a single outcome indicator or assume that positive effects in one dimension necessarily extend to others. Land-use policies that improve ecological or infrastructural resilience may not automatically enhance social or economic resilience, and may in some cases create trade-offs across dimensions. For this reason, urban renewal governance would benefit from more comprehensive monitoring systems that combine spatial, environmental, infrastructural, and social indicators, so that policy adjustments can be made in response to uneven or unintended consequences over time.

At the same time, these policy implications should be interpreted with caution. The evidence synthesized in this study remains limited in size, highly heterogeneous, and based on observational research rather than causal identification. Therefore, the implications offered here are best understood as conditional lessons derived from currently available empirical patterns, rather than as prescriptive rules for universal application. Future policy design should continue to be informed by place-based evidence, comparative evaluation, and more robust empirical research on how specific forms of land-use adjustment operate under different urban renewal conditions.

### **Limitations and future research**

This study provides an exploratory synthesis indicating that land-use change under urban renewal is often associated with higher reported levels of urban resilience across the included studies. However, this conclusion should be interpreted cautiously because the evidence base includes only a small number of independent studies, exhibits extremely high heterogeneity, and relies primarily on observational research with partially dependent effect sizes.

The findings highlight that heterogeneity plays a central role in shaping the observed relationships, and that land-use change types, renewal modes, and resilience dimensions should not be collapsed into a single uniform effect. Instead, the relationship between land-use change and urban resilience appears to vary across contexts, measurement frameworks, and governance conditions.

Future research would benefit from a larger number of independent empirical studies, more consistent operationalization of urban resilience indicators, and stronger causal research designs, in order to clarify the conditions under which land-use adjustments may contribute to resilience outcomes in the context of urban renewal.

Taken together, the present study should therefore be viewed as an initial synthesis highlighting possible patterns and sources of heterogeneity, rather than as definitive evidence of a single causal relationship between land-use change and urban resilience.

## 6. CONCLUSION

This study presents a meta-analytic synthesis of the reported relationship between land-use change and urban resilience in the context of urban renewal. Based on five independent studies and fourteen extracted effect sizes, the results suggest that land-use change is, on average, positively associated with urban resilience, although the evidence remains limited. However, the reported associations are highly heterogeneous and should not be interpreted as evidence of a single common effect or of a causal relationship.

The subgroup and supplementary moderator analyses indicate that part of the observed variation may be related to differences in land-use type, urban renewal mode, and resilience dimension. At the same time, the small number of independent studies and the partial dependence among effect sizes limit the strength of inference. Therefore, the findings of this study should be understood as an initial quantitative summary of a fragmented body of literature. Future research should expand the empirical base, improve the consistency of resilience measurement, and adopt stronger research designs in order to clarify the conditions under which land-use change may be associated with urban resilience in different urban renewal settings.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## AUTHOR CONTRIBUTIONS

Conceptualization: Wenjun Yan; Methodology: Wenjun Yan, Lulu Jia; Writing – original draft: Wenjun Yan; Writing – review and editing: Chung-Han Tsai.

## REFERENCES

- Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2010). A basic introduction to fixed-effect and random-effects models for meta-analysis. *Research Synthesis Methods*, 1(2), 97–111.
- Chen, Y., & Zhang, A. (2005). Intensive land use during urban renewal: a case study of Wuhan. *Agric Econ*, (4), 9–11.
- Dong, W., Gao, X., Han, W., & Wang, J. (2023). Renewal Framework for Self-Built Houses in “Village-to-Community” Areas with a Focus on Safety and Resilience. *Buildings*, 13(12), 3003. <https://doi.org/10.3390/buildings13123003>
- Feng, S., Chen, Y., Kou, X., et al. (2024). Temporal updating of informal green spaces to improve urban park equity: a case study of Gulou District, Xuzhou. *Acta Ecol Sin*, 44(20), 9173–9182.
- Fu, Y., Guo, B., Wang, M., & Qin, X. (2022). Spatial resilience evolution of green space from a social-ecological system adaptive governance perspective: a case study of urban renewal in Guangzhou, China. *J Nat Resour*, 37(8), 2118–2136.

- Hutton, B., Salanti, G., Caldwell, D. M., et al. (2015). The PRISMA extension statement for reporting of systematic reviews incorporating network meta-analyses of health care interventions: checklist and explanations. *Ann Intern Med*, 162(11), 777–784.
- Hwang, K., Schuetze, T., & Amoruso, F. M. (2020). Flood resilient and sustainable urban regeneration using the example of an industrial compound conversion in Seoul, South Korea. *Sustainability*, 12(3), 918.
- Jia, S. (2023). Landscape renewal strategies of old communities from the perspective of flood resilience: a case study of Xihu District, Nanchang [Master's thesis]. Jiangxi University of Finance and Economics.
- Liberati, A., Altman, D. G., Tetzlaff, J., et al. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies evaluating health care interventions: explanation and elaboration. *Ann Intern Med*, 151(4), W65–W94.
- Mecca, U., Piantanida, P., Prizzon, F., & Rebaudengo, M. (2019). Impact of brownfield sites on local energy production as resilient response to land contamination: A case study in Italy. *Sustainability*, 11(8), 2328.
- Moher, D., Cook, D. J., Eastwood, S., et al. (1999). Improving the quality of reports of meta-analyses of randomized controlled trials: the QUOROM statement. *Lancet*, 354(9193), 1896–1900.
- Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med*, 151(4), 264–269.
- Miao, Y., Dai, W., Chen, X., et al. (2020). Landscape spatial pattern changes in historical and cultural blocks under urban renewal: a case study of Shangxiaohang Street, Fuzhou. *Urban Hous*, 27(6), 173–174, 176.
- Parmeggiani, D., Despini, F., Costanzini, S., Silvestri, M., Rabuffi, F., Teggi, S., & Ghermandi, G. (2024). Assessing Satellite Data's Role in Substituting Ground Measurements for Urban Surfaces Characterization: A Step towards UHI Mitigation. *Atmosphere*, 15(5), 551.
- Peng, X., Liao, L., Tan, X., Yu, R., & Zhang, K. (2024). City health assessment: urbanization and eco-environment dynamics using coupling coordination analysis and flus model—a case study of the Pearl River delta urban agglomeration. *Land*, 14(1), 46.
- Shen, J., Wang, S., & Wang, Y. (2024). Environmental inequality in peri-urban areas: a case study of Huangpu District, Guangzhou City. *Land*, 13(5), 703.
- Tang, Y. (2023). Evolution and scenario simulation of integrated land carrying capacity in the Ha-Chang urban agglomeration from the perspective of urban renewal [Dissertation]. Dalian University of Technology.
- Wang, H. (2023). Evaluation and planning of underground space in Nanping Street area, Kunming, from an urban renewal perspective [Master's thesis]. Kunming University of Science and Technology.
- Wang, X., & Bao, Y. (1999). Discussion on research methods for dynamic land-use changes. *Prog Geogr*, (1), 83–89.
- Wu, L. (1991). From “organic renewal” to a new “organic order”: Approaches to the rehabilitation of residential areas in the old city of Beijing (II). *Architectural Journal*, (2), 7–13.
- Zhao, M., Liu, N., Chen, J., Wang, D., Li, P., Yang, D., & Zhou, P. (2024). Navigating post-COVID-19 social-spatial inequity: unravelling the nexus between community conditions, social perception, and spatial differentiation. *Land*, 13(4), 563.
- Zhao, R. (2019). Urban land-use change and impact mechanism under the combined effect of incremental development and stock land renewal [Dissertation]. Chongqing University.
- Zhao, R., Fang, C., & Liu, H. (2020). Progress and prospects of urban resilience research. *Prog Geogr*, 39(10), 1717–1731.
- Zhou, T., & Wu, N. (2018). Land-use change patterns in urban renewal areas: a case study of Yuzhong District, Chongqing. *China Land Sci*, 32(4), 67–73.

**Appendix A: Literature Search Strategy**

Database	Search Terms	Fields/Limiters	Search Date	Deduplication Method
Web of Science	("urban renewal" OR "urban redevelopment" OR "urban regeneration") AND ("land-use change") AND ("resilience" OR "vulnerability")	Topic (TS); no language restriction	Up to 1 Nov 2025	Records exported to EndNote X9; duplicates removed using EndNote's "Find Duplicates" function
CNKI	("城市更新" urban renewal)	Title, Abstract, Keywords; no language restriction		Duplicates manually checked and removed; EndNote used for record management
Wanfang	AND ("土地利用变化" land-use change ) AND ("城市韧性" urban resilience)			

Notes: All searches were conducted independently by two reviewers. And disagreements were resolved through discussion. Grey literature (e.g., master's and doctoral theses) was included to reduce potential publication bias, provided that quality criteria—measurement consistency, model identification, adequacy of control variables, and spatial scale comparability—were satisfied.