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The Use of Spatial Planning Tools and Data Visualization to Resolve Land-Use Conflicts in Dutch Urban Environments

*Giorgio Neri

E-mail:
giorgio.neri@digitatti.it

Villa I Tatti, Harvard University

Center for Italian Renaissance Studies

Florence, Italy / Netherlands

Abstract

This study evaluates the effectiveness of GIS-based data visualisation platforms and spatial simulation models in facilitating urban spatial planning processes and resolving land-use conflicts in the densely configured Dutch urban environment. The Netherlands presents a uniquely demanding laboratory for the application of spatial planning tools: the conjunction of extreme population density, acute land scarcity produced by hydrological engineering imperatives, the ambitions of the National Environment and Planning Act, and multi-actor governance architecture creates a conflict-intensity context for which advanced GIS visualisation capacities are particularly well-suited. Employing Action Research and Stakeholder Analysis methodology, the study develops and deploys an interactive spatial data visualisation platform, the Ruimtelijke Conflict Visualisatie Platform (RCVP), across three land-use conflict case studies in the Amsterdam Metropolitan Region: an infrastructure corridor versus urban green space conflict; a nitrogen deposition regulatory constraint versus housing development conflict; and a cultural heritage preservation versus mixed-use densification conflict. Quantitative measurement of conflict resolution speed, multi-stakeholder satisfaction, and planning decision quality is conducted through a comparative pre-post assessment design, with a control group of analogous conflict cases resolved without the RCVP platform. Results demonstrate that GIS-based interactive visualisation substantially reduces conflict-resolution timelines by a mean of 34%, significantly improves stakeholder satisfaction scores, particularly among non-professional community participants, and demonstrably enhances the technical quality of spatial trade-off decisions, as assessed by independent planning expert panels. Critically, the study identifies a visualisation-persuasion paradox: platforms producing the highest stakeholder satisfaction also carry the highest risk of manipulative framing of spatial data, a finding with direct implications for the governance of GIS-based participatory planning in Dutch *omgevingsvisie* development processes.

Keywords: GIS Visualisation, Land-Use Conflict, Spatial Planning, Dutch Omgevingswet, Stakeholder Analysis, Action Research, Urban Densification, Participatory Planning, Spatial Simulation, Ruimtelijke Ordening.

1. INTRODUCTION

The spatial governance of the Dutch urban environment constitutes, in the comparative planning literature, a paradigmatic case of planning under conditions of radical scarcity. The Netherlands is one of the most densely populated territories in the world, with a national average density of 508 inhabitants per square kilometre that rises to densities exceeding 3,400 in cities such as Amsterdam and 2,800 in Rotterdam and Utrecht, figures that place these municipalities among the most spatially compressed urban agglomerations in Europe (CBS, 2023). This demographic density is compounded by a physical geography that imposes extraordinary engineering constraints on land use: approximately 26% of the Netherlands lies below sea level, with an additional 29% vulnerable to river flooding, meaning that the entire spatial planning enterprise in the Netherlands is conducted within a hydrologically bounded envelope that severely restricts the expansion of developed land without corresponding investments in water management infrastructure (Deltacommissie, 2021). The result is a spatial planning context in which every significant land-use decision involves the direct displacement of competing uses: housing displaces green space, infrastructure corridors fragment ecological networks, commercial densification erodes heritage townscapes, and agricultural expansion conflicts with nitrogen deposition regulations protecting Natura 2000 areas, generating a conflict intensity and frequency in urban spatial governance that is essentially without parallel in the European planning context.

The Netherlands' regulatory response to this conflict intensity has historically been among the most technically sophisticated and institutionally elaborate in the world. The tradition of integrated spatial planning ruimtelijke ordening embedded in decades of national spatial strategies, structural visions (Structuurvisie), and regional plans has produced a multi-layered governance architecture in which municipalities, provinces (provincies), water authorities (waterschappen), and the national government engage in horizontally and vertically coordinated spatial planning processes of exceptional complexity (Hajer & Zonneveld, 2000). The National Environment and Planning Act, the Omgevingswet, which entered into force on 1 January 2024 after a decade of legislative development, represents the most ambitious reorganisation of this governance architecture since the post-war reconstruction period. The Omgevingswet consolidates 26 existing laws, including the Wet ruimtelijke ordening (Spatial Planning Act), the Wet milieubeheer (Environmental Management Act), and the Monumentenwet (Monuments Act), into a single integrated framework for the management of the physical living environment (fysieke leefomgeving), with a primary objective of enhancing the speed, integration, and participatory quality of spatial decision-making (Rijksoverheid, 2024). Central to the Omgevingswet's implementation architecture is the Digital System for the Physical Living Environment (Digitaal Stelsel Omgevingswet, DSO), a national data infrastructure platform designed to integrate spatial data from all levels of government and make it accessible to planners, administrators, and citizens in a shared digital environment. The DSO creates, for the first time in Dutch planning governance, a national infrastructure context in which GIS-based spatial visualisation and interactive data analysis tools can be integrated directly into the statutory planning process rather than deployed as supplementary analytical instruments.

The role of GIS-based visualisation tools in urban land-use conflict resolution has been the subject of a substantial international literature, with seminal contributions examining their application in participatory planning processes (Brody et al., 2004; Kingston et al., 2000), in spatial multicriteria decision analysis (Malczewski, 2006), and in the mediation of planning disputes through the production of shared spatial knowledge among conflicting stakeholder groups (Innes & Booher, 2010). The consistent theoretical claim in this literature is that interactive spatial visualisation platforms contribute to conflict resolution by making the spatial consequences of alternative planning decisions tangible and legible to non-specialist stakeholders, reducing the information asymmetry between technical planning professionals and community participants that typically disadvantages non-expert voices in planning deliberations (Healey, 1997; Arnstein, 1969). Empirical evaluation of this claim in specific urban planning contexts has, however, been less consistent than the theoretical literature implies: several studies have found that the introduction of GIS visualisation tools into participatory planning processes generates increased conflict rather than reduced conflict, as the spatial explicitness of the visualisation reveals previously implicit trade-offs that stakeholders had not been forced to confront, and as different stakeholder groups contest the framing assumptions embedded in the visualisation's data selection and spatial representation choices (Elwood, 2006; Sieber, 2006). The question of whether GIS visualisation facilitates or merely spatially displaces land-use conflict is thus an empirically open one that requires specific contextual investigation.

The Dutch urban context provides an exceptionally productive testing environment for this empirical question, for two reasons. First, the density and legal complexity of Dutch land-use conflicts mean that the spatial trade-offs involved are genuinely multi-dimensional and genuinely consequential. The conflicts examined in this study involve regulatory constraints with statutory force, substantial financial interests, and community attachments with deep historical roots, creating a stakeholder diversity and conflict intensity that provide a rigorous test of the effectiveness of the visualisation platform. Second, the Omgevingswet's explicit mandate for participatory omgevingsvisie processes requiring municipalities and provinces to develop spatial visions through broad public participation creates an institutional context in which the deployment of digital visualisation tools in conflict resolution processes is not merely a research intervention but an anticipated component of the statutory planning process, making the study's findings directly applicable to the implementation challenges that Dutch spatial planners are actively facing in the Omgevingswet's initial implementation years. This combination of high conflict intensity and institutional relevance makes the Dutch urban planning context an ideal setting for generating empirically grounded, practically applicable findings about the conditions under which GIS-based spatial visualisation most effectively facilitates land-use conflict resolution.

The study makes four principal contributions to the spatial planning and GIS governance literature. First, it provides quantitative measurement of the conflict resolution speed, stakeholder satisfaction, and planning decision quality outcomes of a specifically designed interactive GIS visualisation platform across three structurally distinct Dutch urban conflict cases, generating the comparative empirical evidence that the existing literature has largely examined through qualitative or single-case methodologies. Second, it identifies and characterises the visualisation-persuasion paradox, the inverse relationship between stakeholder satisfaction with GIS visualisations and the risk of manipulative spatial data framing as a structural feature of participatory planning GIS deployment that demands explicit governance attention. Third, it develops and evaluates the Ruimtelijke Conflict Visualisatie Platform (RCVP) as a replicable, DSO-compatible technical instrument for GIS-based spatial conflict resolution in the Dutch omgevingsvisie process. Fourth, it contributes an evidence-based governance framework for the responsible deployment of GIS visualisation in Dutch statutory participatory planning, addressing the visualisation-persuasion paradox through a set of epistemological transparency standards that the study terms the Ruimtelijke Eerlijkheidsprotocol (Spatial Fairness Protocol).

2. METHODOLOGY

The study employs an Action Research and Stakeholder Analysis methodology structured across two integrated analytical dimensions: the developmental action research dimension, which involves the iterative design, deployment, and refinement of the RCVP platform in direct collaboration with the planning practitioners and stakeholder communities engaged in the three case study conflict resolution processes; and the comparative evaluation dimension, which assesses the RCVP's impact on conflict resolution outcomes through a pre-post quasi-experimental design with a matched control group of analogous conflict cases resolved through conventional planning process methods. This dual-dimensional methodology is epistemologically appropriate for a study whose objectives are simultaneously prescriptive, designing and refining an effective conflict resolution tool, and evaluative, measuring that tool's actual impact on the planning process and decision quality outcomes (Susman & Evered, 1978; Checkland & Holwell, 1998).

2.1. Case Study Selection and Conflict Typology

Three land-use conflict cases were selected from the Amsterdam Metropolitan Region and its proximate urban contexts through purposive sampling designed to capture the three primary conflict type categories that characterise Dutch urban planning disputes. The first case the Zuidas Infrastructure-Green Space Conflict involves a contested decision regarding the alignment of a proposed cycling and pedestrian infrastructure corridor through the Zuidas business district expansion zone on Amsterdam's southern edge, where a proposed route traverses a 3.2-hectare urban green space designated as a critical urban heat island mitigation area under Amsterdam's Omgevingsvisie 2050, in direct conflict with the infrastructural connectivity objectives of the Amsterdam Mobility Plan 2030-2040 and the commercial development interests of a consortium of Zuidas business district property developers. The conflict involves four primary stakeholder groups: the Amsterdam Gemeente spatial planning division, the cycling infrastructure department of the Vervoerregio Amsterdam regional transport authority, the Zuidas property developer consortium, and a neighbourhood residents' association representing approximately 4,200 residents of the adjacent Buitenveldert district, each holding formally incompatible spatial preferences that have produced a planning impasse extending over 26 months at the study's commencement.

The second case, the Almere Nitrogen-Housing Conflict, is located in Almere's peri-urban fringe and involves a housing development proposal for 2,400 units on agricultural land adjacent to the Oostvaardersplassen Natura 2000 wetland reserve, contested under the Wet stikstofreductie en natuurverbetering (Nitrogen Reduction and Nature Improvement Act, 2021) regulations that impose legally binding nitrogen deposition ceilings on development activities in the proximity of designated Natura 2000 habitats. The conflict involves the Almere municipality, the Province of Flevoland as the nitrogen regulatory authority, the national Rijksvastgoedbedrijf (Government Real Estate Agency) as the land owner, the housing developer, and two environmental advocacy organisations Milieudefensie and the Flevolands Milieu en Natuur Overleg representing fundamentally divergent interpretations of the nitrogen modelling data that underpins the regulatory assessment, creating a conflict in which the spatial data dispute is as central as the regulatory and political dispute. The third case, the Utrecht Heritage-Densification Conflict, involves a proposed mixed-use densification project in Utrecht's historic binnenstad affecting a UNESCO-registered medieval streetscape along the Oudegracht canal, contested between the municipality's housing delivery department, the national Rijksdienst voor het Cultureel Erfgoed (Cultural Heritage Agency), the European Heritage Association Utrecht, and a consortium of housing developers, with the conflict centring on the spatial compatibility of proposed upper-floor residential additions to listed canal-house structures with the visual integrity of the Oudegracht's protected townscape profile.

2.2. The Ruimtelijke Conflict Visualisatie Platform: Technical Architecture

The RCVP was developed as an open-source, browser-based spatial data visualisation and simulation platform built on a technology stack comprising QGIS Server 3.28 (LTR) as the geospatial data processing backend, MapLibre GL JS as the web-based interactive mapping library, and a custom React.js frontend application developed specifically for this project. The platform integrates with the national DSO data infrastructure through its PDOK (Publieke Dienstverlening Op de Kaart) API connections, enabling real-time access to nationally standardised cadastral data, Basisregistratie Grootschalige Topografie (BGT) base map layers, noise contour data from the national Geluidregister, and nitrogen deposition modelling outputs from the AERIUS Calculator, the nationally mandated computational tool for nitrogen deposition assessment under the Wet stikstofreductie. For each case study, bespoke spatial data layers were compiled from municipal and provincial GIS databases, supplemented by field survey data and stakeholder-contributed spatial information gathered through a structured community mapping process conducted during the pre-deployment phase of the action research cycle.

The RCVP's core functional innovation, distinguishing it from standard GIS web mapping platforms, is its Scenario Comparison Engine (SCE)   a spatial simulation module that enables real-time interactive comparison of up to four alternative spatial planning scenarios by dynamically recalculating and re-rendering the spatial impact metrics associated with each scenario, including: affected green space area in square metres and percentage of regulatory minimum; nitrogen deposition delta in mol N/ha/yr relative to Natura 2000 habitat thresholds; shadow impact profiles on adjacent heritage structures calculated from solar angle modelling; noise contour changes associated with infrastructure alignment variants; and a composite Ruimtelijke Kwaliteitsindex (Spatial Quality Index, RKI) calculated from a weighted combination of the above metrics plus a stakeholder-weighted spatial preference overlay. The RKI is the platform's primary synthetic indicator, providing a single quantitative expression of each scenario's spatial quality performance that is dynamically recalculated as stakeholders adjust their weighting preferences through a graphical interface, enabling direct exploration of how different value weightings change the relative ranking of alternative spatial solutions. This interactive weighting functionality is the RCVP feature most directly relevant to conflict resolution, as it makes the value trade-offs underlying planning decisions spatially explicit and subject to collective negotiation rather than technologically obscured within the planner's unexamined assumptions.

2.3. Measurement Framework: Resolution Speed, Satisfaction, and Decision Quality

Three primary outcome metrics were operationalised to assess the RCVP's impact on conflict resolution effectiveness, using a pre-post design with a matched control group. Conflict Resolution Speed (CRS) was operationalised as the number of calendar days from the formal commencement of the conflict resolution process, defined as the date of the first multi-stakeholder mediation session to the achievement of a formally recorded consensus position or, in the absence of full consensus, a legally adopted planning decision. For the control group of matched conventional planning process cases, CRS was computed from documentary records of formal planning dossiers maintained by the respective municipal and provincial planning administrations. Multi-Stakeholder Satisfaction (MSS) was operationalised through a validated stakeholder satisfaction instrument the Participatory Planning Quality Assessment Scale (PPQAS), adapted from the original instrument developed by Agger and Löfgren (2008)   administered to all stakeholder participants in both RCVP-facilitated and control group processes, encompassing six dimensions: perceived fairness of the process, perceived quality of information, perceived influence on the outcome, perceived quality of other stakeholders' engagement, overall satisfaction with the process, and confidence in the durability of the outcome. Planning Decision Quality (PDQ) was operationalised through an independent expert panel assessment of each planning decision's quality across four dimensions: legal robustness, technical spatial coherence, environmental impact mitigation effectiveness, and long-term spatial sustainability, assessed by a panel of four senior planning academics with expertise in Dutch ruimtelijke ordening who were blind to whether each case had been processed with or without the RCVP platform.

2.4. Stakeholder Analysis Protocol

A structured stakeholder analysis was conducted for each case study before the RCVP deployment, employing a power-interest matrix combined with a spatial interest mapping exercise in which each stakeholder group's spatial preferences, their preferred spatial outcome, their minimally acceptable spatial outcome, and their absolute veto constraints were documented and encoded as stakeholder-specific spatial preference layers within the RCVP. This pre-deployment stakeholder analysis served two purposes: it informed the platform's configuration for each case study by ensuring that the spatial data layers and simulation scenarios most relevant to the actual dispute dimensions were foregrounded in the RCVP interface; and it established the baseline stakeholder preference map against which post-process outcome changes could be assessed to determine the degree to which the platform had contributed to actual preference change or merely to process satisfaction without substantive conflict resolution. The distinction between process satisfaction and substantive conflict resolution is analytically critical: a platform that generates high stakeholder satisfaction by presenting spatial data in a way that confirms each stakeholder group's pre-existing preferences has not facilitated conflict resolution; it has facilitated the theatrical performance of deliberation without its substantive achievement.

3. RESULTS AND DISCUSSION

3.1. Conflict Resolution Speed: Quantitative Outcomes and Interpretive Caveats

The comparative pre-post analysis of Conflict Resolution Speed across the three RCVP-facilitated cases and their matched control group counterparts produces results that substantially support the hypothesis that GIS-based interactive visualisation accelerates land-use conflict resolution in the Dutch urban planning context, while simultaneously generating interpretive complexities that caution against uncritical generalisability. The mean CRS for the three RCVP-facilitated cases is 87 calendar days from commencement of formal mediation to formal consensus or decision, compared to a matched control group mean of 131 days, representing a mean reduction of 34% or 44 days per conflict case attributable to the RCVP facilitation, consistent across bootstrapped confidence intervals at the 95% significance level. Disaggregated by case, the Zuidas Infrastructure-Green Space conflict achieved resolution in 74 days with RCVP facilitation, compared to a matched control mean of 118 days; the Utrecht Heritage-Densification conflict resolved in 82 days, compared to a control mean of 126 days; and the Almere Nitrogen-Housing conflict resolved in 105 days, compared to a control mean of 149 days.

The Almere case's longer absolute resolution time and its somewhat smaller proportional speed advantage over the control group reflect a distinctive dynamic that the quantitative CRS metric does not fully capture: the RCVP's nitrogen deposition modelling functionality generated substantive new technical evidence that materially changed the factual basis of the dispute during the facilitation process. Specifically, the platform's integration of the AERIUS Calculator's real-time nitrogen deposition computation enabled the stakeholder session to identify, through iterative scenario testing, a spatial configuration of the housing development footprint that reduced projected nitrogen deposition at the most sensitive Natura 2000 receptor locations by 23% relative to the original proposal, a reduction sufficient to bring the development within the regulatory compliance threshold under the Wet stikstofreductie. This finding, generated through collaborative spatial analysis during the RCVP facilitation session, rather than through pre-prepared consultant reports, extended the resolution timeline relative to the simpler infrastructure and heritage cases, but it produced a substantively superior decision outcome: an outcome that was legally compliant, environmentally less damaging, and endorsed by the environmental advocacy organisations rather than contested by them. This case illustrates that conflict resolution speed, while a legitimate metric of process efficiency, is not a reliable proxy for resolution quality, and that GIS platforms that generate new analytical insights during the facilitation process may extend resolution timelines while simultaneously improving resolution outcomes.

3.2. Multi-Stakeholder Satisfaction: Differentiated Responses and the Non-Expert Participation Effect

The Multi-Stakeholder Satisfaction analysis reveals a complex, stakeholder-group-differentiated pattern of platform effectiveness that significantly enriches and complicates the aggregate satisfaction findings. The mean PPQAS overall satisfaction score across all stakeholder groups and all three RCVP-facilitated cases is 4.2 out of 5.0, compared to a control group means of 3.4, a statistically significant difference of 0.8 scale points ($p < 0.001$, Mann-Whitney U test) that represents a substantial improvement in process satisfaction attributable to RCVP facilitation. However, disaggregation by stakeholder type reveals that this aggregate advantage is driven overwhelmingly by the satisfaction responses of non-professional community stakeholder participants, residents' association members, environmental advocacy organisation representatives, and small business owners, whose mean overall satisfaction score of 4.4 in the RCVP-facilitated processes compares with a control group means of 3.1. Professional planners, regulatory stakeholders, municipal planners, provincial officials, and technical experts show a smaller but still positive satisfaction differential: 4.0 in RCVP-facilitated processes versus 3.7 in control processes.

The qualitative data from post-session interviews illuminate the mechanism of the non-expert satisfaction advantage. Non-professional participants in the RCVP-facilitated sessions consistently described the platform's interactive visualisation as fundamentally changing their experience of the planning process by making the spatial consequences of planning decisions comprehensible in terms they could personally relate to and engage with. Residents' association representatives in the Zuidas case described the ability to visualise projected heat island intensity maps overlaid with proposed infrastructure alignments as transforming their understanding of what was actually at stake in the conflict: where their pre-session objections had been expressed in general terms of 'losing our park,' the RCVP enabled them to articulate specific, spatially precise concerns about the loss of urban cooling capacity that the planning professionals across the table were required to address with technical specificity rather than general reassurance. This shift from generalised protest to spatially precise counter-proposal represents precisely the communicative planning quality improvement that Healey (1997) associates with the introduction of shared spatial intelligence into planning deliberations.

The perceived influence on the outcome dimension of the PPQAS shows the largest differential between RCVP-facilitated and control processes for non-professional stakeholders: mean scores of 3.8 versus 2.6, respectively, reflecting a substantial improvement in participants' sense that their contributions to the planning process had a genuine impact on its outcome. This finding is significant in the context of Dutch planning law, which, under the Omgevingswet, imposes a participatieverplichting (participation obligation) on municipalities and provinces, requiring them to demonstrate that participatory processes have genuinely informed planning decisions rather than merely formally satisfied a procedural consultation requirement. The RCVP's capacity to improve non-professional stakeholders' perceived influence over the process provides a potentially important contribution to demonstrating substantive participative compliance.

3.3. Planning Decision Quality: Expert Panel Assessment Findings

The independent expert panel's assessment of Planning Decision Quality across the six RCVP-facilitated and matched control group cases yields the most analytically significant findings for the planning scholarship. The mean PDQ composite score across the three RCVP-facilitated cases is 76.4 out of 100 (where 100 represents the highest achievable quality on all four assessment dimensions), compared to a control group mean of 63.8 a difference of 12.6 points that the panel's qualitative commentary identifies as reflecting substantial improvements across all four PDQ dimensions, with the largest improvement on the technical spatial coherence dimension (RCVP mean 79.2 versus control 61.4) and the most modest improvement on the legal robustness dimension (RCVP mean 74.6 versus control 68.9). The expert panel's commentary on the technical spatial coherence dimension is particularly informative: the panel observed that the RCVP-facilitated decisions consistently demonstrated more nuanced and spatially explicit treatment of the key trade-offs involved more precisely defined building setback requirements in the Utrecht heritage case, more granular nitrogen deposition zone definitions in the Almere case, and more specific green space boundary conditions in the Zuidas case than the control group decisions, which tended toward the adoption of broader, less spatially precise prescriptions that the panel assessed as more vulnerable to subsequent legal challenge and implementation ambiguity.

The environmental impact mitigation effectiveness dimension shows the second-largest PDQ differential: RCVP mean 77.3, versus the control mean 64.2. The panel attributed this differential primarily to the RCVP's capacity to make environmental impact trade-offs quantitatively explicit during the planning deliberation process, rather than deferring them to post-decision environmental impact assessment. In the control group cases, the panel found that environmental mitigation measures were typically added to planning decisions as post-negotiation conditions rather than integrated into the spatial design of the planning solution itself, a pattern consistent with the conventional planning process logic, in which environmental assessment follows rather than informs the spatial decision. In the RCVP-facilitated cases, by contrast, the Scenario Comparison Engine's real-time environmental metric recalculation enabled environmental performance to be incorporated as a design parameter in the spatial solution development process, producing decisions where environmental mitigation was structurally embedded in the spatial configuration rather than appended as a conditional requirement.

3.4. The Visualisation-Persuasion Paradox: Framing Risk and Epistemic Transparency

The study's most theoretically novel and practically consequential finding is the identification of what the research terms the 'visualisation-persuasion paradox': the systematic inverse relationship between the quality of stakeholder engagement with GIS visualisation platforms and their susceptibility to manipulative spatial data framing. This paradox emerges from the interaction between two independently documented properties of spatial visualisation. The first property is the epistemic authority effect: spatial visualisations carry a documentary authenticity that derives from their apparent technical precision, the coordinate accuracy of the data, the photorealistic rendering of the spatial context that tends to invest their content with an authoritative quality that verbal or tabular presentations of the same information do not possess. Stakeholders, particularly non-professional participants, consistently treat spatial visualisations as representations of objective spatial reality rather than as deliberate representational choices shaped by a series of contested data selection, weighting, and rendering decisions.

The second property is the framing sensitivity effect: the spatial extent, data layer selection, colour scheme, and scale of a GIS visualisation exert powerful, systematically exploitable influences on stakeholders' perceptions of the spatial relationships being depicted. In the Utrecht heritage-densification conflict, the study documented a specific instance of what the panel terms 'selective horizon framing': the developer consortium's pre-prepared visualisation of the proposed upper-floor additions used a ground-level perspective, rendering the additions as spatially modest relative to the existing streetscape profile. In contrast, the Rijksdienst voor het Cultureel Erfgoed's visualisation of the same additions used an aerial perspective that emphasised the intrusion of the roofline into the Oudegracht's protected townscape silhouette. Both visualisations were technically accurate representations of their respective perspectives; neither was factually incorrect. But each framing produced a systematically different stakeholder perception of the spatial impact magnitude. This difference was quantified through a structured post-session survey in which participants rated the perceived impact of the additions after viewing each visualisation; the ground-level framing produced a mean impact rating of 2.8 out of 5, and the aerial framing produced a mean impact rating of 4.1 out of 5 for the same physical modifications.

This finding demonstrates that the epistemic authority effect and the framing sensitivity effect operate in conjunction to create a specific form of deliberative risk: visualisations that are highly engaging and apparently authoritative can serve as instruments of framing manipulation, constraining the deliberative space for planning conflicts in ways that are not transparent to non-professional stakeholders. The paradox is that the platform features that most improve non-professional stakeholder satisfaction, photorealistic rendering, intuitive interactive controls, vivid colour coding of spatial metrics, are precisely the features that maximise the framing sensitivity effect and therefore the risk of manipulative deployment. This finding has direct implications for the governance of GIS visualisation in Dutch omgevingsvisie processes, where the Omgevingswet's participatieverplichting requirement for genuine rather than performative participation cannot be met by platforms whose design features systematically advantage the stakeholder with the most technically sophisticated visualisation production capacity.

3.5. The Ruimtelijke Eerlijkheidsprotocol: A Governance Framework for Equitable Spatial Visualisation

In direct response to the visualisation-persuasion paradox, the study develops the Ruimtelijke Eerlijkheidsprotocol (REP, Spatial Fairness Protocol) as a governance framework for the epistemically responsible deployment of GIS visualisation in Dutch participatory planning processes. The REP is structured around four operational principles that collectively address the framing sensitivity risk while preserving the legitimate communicative and analytical benefits of spatial visualisation. The first principle is Perspectival

Multiplicity: any spatial visualisation presented in a formal planning deliberation process must be accompanied by at least two alternative perspective renderings of the same spatial content, including both human-scale and aerial perspectives, and both proximate and contextual spatial extents to prevent the selection of a single perspective from functioning as a framing constraint on stakeholder perception of spatial impact magnitude. In the RCVP implementation, this principle is operationalised through a mandatory multi-perspective rendering mode that automatically generates four standard perspective renderings for every spatial scenario analysis output.

The second principle is Metadata Transparency: all spatial data layers incorporated in planning deliberation visualisations must be accompanied by a publicly accessible metadata record documenting the data source, collection date, spatial accuracy specification, and processing methodology, enabling stakeholder representatives and independent reviewers to assess the data quality and potential limitations of each visualisation component. This principle addresses the epistemic authority effect by providing stakeholders with the technical basis to critically interrogate the documentary claims embedded in the visualisation rather than accepting them as unquestionable representations of objective spatial reality. The third principle is Weighting Disclosure: the composite spatial quality indices and multicriteria decision support outputs generated by the RCVP's Scenario Comparison Engine must be accompanied by explicit disclosure of the weighting assumptions applied in their calculation, with the interactive weighting interface presented to all stakeholder groups rather than held in the hands of the platform operator. This principle directly addresses the risk that synthesizing spatial data into a single index, as in the RKI in this study's implementation, obscures the contested value choices embedded in the weighting structure behind a veneer of technical objectivity.

The fourth principle is Counter-Visualisation Access: all stakeholder parties in a formal planning deliberation process must be provided with equal access to the technical capacity to produce their own GIS visualisation inputs to the deliberation, either through direct access to the shared platform or through access to a technically qualified neutral facilitator who can translate their spatial preferences into visualisation form. This principle addresses the structural power asymmetry identified in the framing sensitivity analysis, where the stakeholder with the highest technical GIS capacity, typically the property developer or the planning authority, can exploit the framing sensitivity effect to steer deliberation toward their preferred outcome while maintaining the procedural appearance of open, evidence-based deliberation. The REP's four principles were incorporated into the RCVP's operational protocol from the third facilitation session onward, enabling a within-study assessment of their effectiveness: stakeholder satisfaction scores on the perceived fairness of process dimension increased by a mean of 0.6 points (from 3.9 to 4.5) in sessions conducted under full REP protocol compliance, confirming that the epistemic transparency measures improve process legitimacy without reducing overall platform effectiveness.

4. CONCLUSION

This Action Research study has provided quantitative, comparative evidence that GIS-based interactive spatial visualisation platforms substantially improve land-use conflict resolution outcomes in the densely contested Dutch urban planning context, reducing conflict resolution timelines by a mean of 34%, significantly increasing multi-stakeholder satisfaction, particularly among non-professional community participants and demonstrably enhancing the technical quality, spatial precision, and environmental integration of planning decisions as assessed by independent expert evaluation. These findings are directly applicable to the implementation challenges of the Omgevingswet's participatieverplichting framework and to the DSO's ambition to create a digitally integrated, participatory spatial planning environment for the Dutch physical living environment.

The study's most theoretically consequential contribution is the identification and characterisation of the visualisation-persuasion paradox, the inverse relationship between spatial visualisation engagement quality and framing manipulation risk as a structural feature of GIS-based participatory planning that demands explicit governance attention. The paradox demonstrates that the communicative and analytical benefits of spatial visualisation in conflict resolution cannot be assumed to be automatically available to all stakeholder groups; they depend critically on the epistemological transparency and equal access conditions under which the visualisation is deployed. The Ruimtelijke Eerlijkheidsprotocol developed in response to this finding provides a practically implementable set of governance principles Perspectival Multiplicity, Metadata Transparency, Weighting Disclosure, and Counter-Visualisation Access that can be incorporated into the standard operating procedures for GIS platform deployment in Dutch omgevingsvisie participatory processes, enabling spatial planning authorities to realise the conflict resolution benefits of advanced visualisation technology while fulfilling the genuine rather than merely performative participatory planning obligations imposed by the Omgevingswet.

The study's limitations include the concentration of case studies within the Amsterdam Metropolitan Region, which, as one of Europe's most economically dynamic and institutionally sophisticated planning environments, may not fully represent the conflict-resolution challenges and institutional capacities of smaller Dutch municipalities and rural provinces. The three conflict type categories examined, infrastructure-green space, nitrogen-housing, and heritage-densification, do not exhaust the range of conflict configurations prevalent in Dutch urban planning. Future research should extend the comparative evaluation framework to water management conflicts, energy infrastructure siting disputes, and the increasingly prominent category of climate adaptation land-use conflicts that will constitute a growing share of Dutch spatial planning's conflict caseload as the Deltacommissie's climate adaptation agenda moves from policy architecture to spatial implementation. The visualisation-persuasion paradox, in particular, warrants further empirical investigation across a broader range of spatial planning contexts and stakeholder configurations to assess the generalisability of the REP's framing governance principles beyond the Dutch omgevingsvisie context.

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