

From Participatory Sensing to Co-Designed Portscapes: Building Resilient and Equitable Futures in Tyneside's Sustainable Transition

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Abstract

Portscapes—the transitional zones between ports and their surrounding urban and regional contexts—have attracted growing attention as contested spaces where digitalisation and decarbonisation transitions intersect with enduring socio-spatial inequalities. Conventional port (and portscape) planning paradigms, however, have largely excluded meaningful citizen participation, relying on top-down approaches that frame port territories as purely functional spaces, detached from civic engagement and lived community experience. This article presents a citizen-centric participatory planning framework centred on a purpose-built mobile application that operationalises the humans-as-sensors concept in a post-industrial coastal context. Working with the Port of Tyne in North East England, we deployed the application across 10 waterfront sites to support two interconnected phases of engagement. The first involved walking ethnographies with over 200 participants, generating geotagged photographic documentation, situated spatial commentary, and on-site collages. This was followed by scenario-mapping sessions with the Royal Institute of British Architects (RIBA) North East, bringing together participants from architecture and urban design, alongside members of local communities and representatives of community organisations to produce co-designed visual imaginaries for future portscapes. Drawing on a transdisciplinary framework synthesising just transitions theory, socio-ecological resilience, and participatory urbanism, we analyse how citizen-generated sensing data can challenge technocratic port planning rationalities and prefigure more equitable transition pathways. Results demonstrate that mobile application-enabled social sensing generates geolocated, neighbourhood-scale knowledge that conventional consultation methods may not capture, spatially situating residents' experiences and concerns, and rendering visible localised environmental justice concerns obscured in aggregate port sustainability metrics. This research provides methodological and

empirical evidence for integrating participatory sensing data and digital co-design tools into port and coastal planning, advancing inclusive, data-informed approaches to industrial transition governance.

Keywords

coastal communities; co-design; future scenario planning; green transition; portscapes; social sensing

1. Introduction

As urbanisation accelerates and coastal industrial regions face decarbonisation pressures, conventional planning struggles to integrate the spatial knowledge and aspirations of affected communities (Oliveira et al., 2025). This deficit is acute in portscapes, where top-down decision-making has privileged economic efficiency over community wellbeing and spatial equity (Lombard et al., 2023). The challenge concerns whose knowledge counts in shaping urban futures and how technologies can enable authentic participation in contested planning. This article responds by coupling a purpose-built mobile application as a citizen sensing platform with co-designed spatial scenarios that translate community data into portscape imaginaries.

Grounded in the human-as-a-sensor (HaaS) concept (Das et al., 2024), our approach treats community members as active producers of place-based spatial data—observers, narrators, and co-designers of their port communities. The in-situ, geotagged data capture embodied dimensions of community-environment interaction that structured methods miss. Through co-design, these sensing data were translated into spatial propositions for debate and development. The study establishes an evidential foundation for planning that is more spatially precise, socially inclusive, and attuned to lived realities.

The empirical focus is the Port of Tyne, which exemplifies tensions shaping contemporary port transitions. Located nine miles east of Newcastle upon Tyne, the port has transitioned from its historical role in coal exports and shipbuilding to handling biomass imports and supporting the handling, servicing, and maintenance of offshore wind components and equipment (Dickinson, 2021; Port of Tyne, 2021), aligning with net-zero by 2030 and fully electric by 2040 targets (Blake, 2022). However, these transitions have not integrated surrounding communities; the port remains an enclosed economic enclave reinforcing socio-spatial segregation. Adjacent areas—Wallsend, Jarrow, South Shields, and North Shields—experience being “left behind” with layered deprivation from long-term deindustrialisation (J. Jin et al., 2026; Office for National Statistics, 2022; Robinson & Townsend, 2016). In 2019, the Tyne 2050 strategy committed to a green port and community engagement (Port of Tyne, 2019). Yet as the UK promotes port town revitalisation (UK Government, 2023), a critical governance question remains: How can transitions advance digitisation and decarbonisation while simultaneously delivering tangible benefits to local communities, ensuring socially just processes, and maintaining democratic legitimacy?

Against this backdrop, this article addresses three interrelated research questions. First, what forms of spatial knowledge do port-adjacent communities generate through mobile application-enabled participatory sensing, and how do these differ qualitatively from the spatial priorities surfaced through conventional port consultation processes? Second, how can citizen-generated sensing data be translated into co-designed spatial scenarios that reconcile decarbonisation imperatives with environmental justice, community identity, and ecological recovery in a post-industrial portscape context? Third, what does the deployment of

participatory sensing and scenario co-design as a planning methodology reveal about the governance reforms needed to achieve procedurally just and spatially equitable port energy transitions? Together, these questions position the article at the intersection of participatory planning methodology, just transitions theory, and port governance reform.

The participatory mobile platform was developed at the intersection of two research programmes delivered by the authors: one on maritime port infrastructure resilience, and one on community-led brown-to-green transitions. Deployed via walking ethnographies around the Port of Tyne, it enabled multi-stakeholder engagement at the urban-industrial interface. The platform integrated geo-located data collection with creative spatial visualisation, offering three modes of inquiry: photographic documentation, location-anchored annotation, and visual collages articulating future spatial imaginaries (arkilab, 2024; Lutra Consulting, 2024). Citizen-generated data underwent qualitative and spatial analysis, yielding convergent priorities including accessibility, mixed-use amenities, industrial heritage, waterfront activation, and green industry employment pathways. The platform's in-situ, embodied data collection surfaced concerns unlikely to emerge from conventional formats, demonstrating participatory sensing's distinctive evidential value in contested post-industrial landscapes (Dooley, 2021; Leleux & Webster, 2018).

These social sensing data formed the evidential foundation for a second, forward-looking phase of engagement: a series of collaborative scenario-mapping sessions convened in partnership with the Royal Institute of British Architects (RIBA) North East, bringing together policymakers, planners, architects, and community members to collectively reimagine the future of the Tyne portscape. Rather than presenting predetermined development options for community endorsement, a common limitation in the UK planning process (Thorning et al., 2019), these sessions operationalised a counter-mapping methodology in which participants themselves became the authors of spatial futures (Erkılıç, 2026; W. Jin & Jin, 2024). Drawing on geotagged photographic archives, situated annotations, and place-based narratives generated through walking ethnographies, participants co-produced three speculative yet grounded scenarios across different sections of the port:

- The *productive waterfront* envisioned integrating green industrial activities with new biomass storage and bio-based material production to support local economic development.
- The *ecological corridor* prioritised the rehabilitation of estuarine habitats alongside blue-green public infrastructure, incorporating emerging hydrogen facilities and offshore wind support facilities within a rewilded industrial landscape.
- The *living heritage district* foregrounded cultural identity and intergenerational memory as organising logics for waterfront transformation, activating the existing cruise corridor between Newcastle and Amsterdam.

Crucially, this scenario-mapping process was not merely generative of alternative spatial imaginaries; it functioned as a deliberate counter to the top-down planning rationalities that have historically shaped portscape development.

This study contributes to three intersecting scholarly debates. First, it extends the HaaS paradigm into port and coastal industrial planning, positioning digital participation as an alternative epistemic infrastructure within domains long characterised by governance deficits and structurally constrained civic engagement

(Boullauazan et al., 2023). Second, drawing on the participatory GIS analysis of Port of Tyne and its surrounding communities, the study advances debates on digital participation by grounding them in a territorially specific context. It demonstrates how mobile application-enabled social sensing can move beyond tokenistic consultation toward the co-production of situated spatial knowledge (Bąkowska-Waldmann & Kaczmarek, 2021; Wilson & Tewdwr-Jones, 2021). This approach renders visible socio-spatial divisions that are routinely flattened or obscured by conventional planning instruments, thereby enhancing the granularity and accountability of planning evidence. Third, the article mobilises an environmental and social justice lens in co-envisioning future port-community transition scenarios (Hein et al., 2024). It shows how citizen-generated sensing data can foreground localised, lived impacts that aggregate accessibility metrics systematically suppress, thereby reshaping the evidential basis on which port futures and active waterfront development are negotiated and planned. Together, these contributions position the integrated participatory sensing and co-design not merely as a data collection method but as a transformative planning practice capable of reshaping epistemic hierarchies, reconfiguring power relations, and reorienting spatial priorities within the broader context of port energy transition.

2. Literature Review

2.1. Participatory Sensing and Digital Civic Engagement

Participatory planning scholarship has long distinguished between tokenistic consultation where communities are asked to comment on predetermined proposals and authentic participation that affords meaningful influence over decisions (Arnstein, 1969). In port planning contexts, participation has historically been limited. Even when consultation occurs, it often takes forms that privilege technical expertise, favour organised stakeholder groups over ordinary residents, and fail to engage marginalised communities most impacted by port activities (Lombard et al., 2023). Authentic participation, by contrast, involves co-production of knowledge, shared decision-making power, and ongoing dialogue that shapes problem definition, solution development, and implementation (Bąkowska-Waldmann & Kaczmarek, 2021; Wilson & Tewdwr-Jones, 2021). It recognises that communities possess experiential, place-based knowledge essential for identifying problems, imagining alternatives, and evaluating proposals, knowledge that cannot be replaced by technical analysis alone (Ahmad & Abu Talib, 2015).

A significant recent development in participatory planning is the emergence of the HaaS paradigm, which reconceptualises citizens not merely as stakeholders to be consulted but as active producers of spatially and temporally precise urban data (Yu, 2025). This paradigm treats lived and embodied experience as a form of urban intelligence that neither remote sensing nor structured surveys can replicate: The resident who daily navigates a degraded waterfront path, experiences industrial noise at specific times, or recognises the heritage significance of a derelict building possesses localised spatial knowledge of a qualitatively different order from that available to planners working from aggregate datasets or site visits (Zeile et al., 2015). Analysis of participatory sensing data collected through mobile devices also enables real-time insights into citizens' behaviours, opinions, and environmental experiences, allowing planners to understand how communities actually interact with urban interventions and infrastructures rather than how they retrospectively report doing so (Resch et al., 2016). In post-industrial coastal contexts specifically, where landscapes bear complex historical sediments and evoke memories, attachments, and contested meanings not easily captured through conventional documentation, the in-situ, multimedia character of mobile sensing

data is particularly valuable, as it preserves the spatial specificity, emotional register, and situational context of community knowledge.

Digital technologies increasingly mediate participatory planning, offering new possibilities for spatial data collection, visualisation, and collaborative design. Participatory GIS applications enable citizens to contribute spatially referenced observations, photographs, and annotations, often through web-based mapping platforms (Bąkowska-Waldmann & Kaczmarek, 2021). Mobile applications can extend this participatory approach by supporting in-situ and temporally immediate data collection during walks, site visits, or everyday mobility, with location information captured through device-based geolocation. This enables participants to document experiences and environmental conditions as they encounter them (Danish et al., 2025; Malakar & Roy, 2024, 19–35). Digital tools such as extended reality platforms and interactive scenario visualisers further enhance this repertoire by enabling citizens to navigate and affectively engage with representations of proposed spatial futures rather than merely reading about them, strengthening the quality of deliberation and the specificity of community input.

2.2. Just Transitions and the Reconfiguration of Port Infrastructure

The concept of “just transition” has emerged as a critical framework for ensuring that shifts toward low-carbon economies do not reproduce or exacerbate existing inequalities (Axon & Morrissey, 2020). Originally articulated by labour unions concerned about job losses in fossil fuel industries, just transition principles have expanded to encompass broader dimensions of equity, participation, and recognition in sustainability governance (Upham et al., 2022). Applied to port contexts, just transitions demand attention to multiple dimensions of justice: distributive (who benefits and who bears costs), procedural (who participates in decision-making), recognition (whose knowledge and values are legitimised), and restorative (how historical harms are addressed).

Ports represent critical yet paradoxical sites of energy transition. Historically, they have functioned as critical nodes in fossil fuel supply chains, importing/exporting coal, oil, and gas while supporting carbon-intensive industries like shipbuilding, petrochemicals, and steel production (de Jong & Stremke, 2020). The physical infrastructure of ports like storage facilities, industrial hinterlands, and pipelines reflects this fossil fuel orientation and creates path dependencies that resist transformation. Yet ports are also well positioned to act as enablers of renewable energy systems supporting biomass supply, offshore wind logistics, hydrogen trade, and circular economy activities for a post-petroleum society (J. Jin & Zhu, 2024). This dual character raises critical questions about transition pathways, infrastructural reconfiguration, and the evolving spatial hierarchies within regional portscales.

Yet conventional approaches to port energy transitions remain largely technocratic and narrowly economic, privileging engineering efficiency and supply chain optimisation while sidelining concerns of environmental justice, community participation, and distributive equity (Hein et al., 2024). In neighbourhoods surrounding the Port of Tyne, planning processes typically unfold within closed institutional frameworks dominated by port authorities, shipping corporations, and industrial stakeholders. By reviewing relevant planning applications for the Port of Tyne and its adjacent land through government portals between 2015–2025, we found that neighbouring communities are typically limited to submitting objections or reactive feedback on proposed developments. They are thus positioned as passive, sometimes

reluctant, recipients of transition impacts, rather than active agents in shaping port futures. This governance deficit is especially pronounced where industrial zones abut residential neighbourhoods, producing localised concentrations of environmental burdens such as noise, traffic congestion, and visual degradation that disproportionately affect working-class and marginalised populations in the region. The transition to renewable energy infrastructures under Tyne 2050, while necessary, risks reproducing and potentially exacerbating these injustices if pursued without meaningful community engagement and redistributive mechanisms (Port of Tyne, 2019).

To address these deficits, this research adopts an integrative analytical framework that synthesises three complementary theoretical traditions. First, just transitions theory (Hein et al., 2024) provides normative foundations for assessing transition processes across multiple dimensions of justice, with particular attention to procedural inclusion, the recognition of diverse knowledge systems, and the equitable distribution of public and private benefits. It foregrounds the voices and lived experiences of those historically excluded from port planning, while emphasising accountability for restorative justice. Second, socio-ecological resilience frameworks (Hayes et al., 2019; J. Jin et al., 2026) illuminate the complex adaptive dynamics of port systems, emphasising feedback loops between ecological conditions, infrastructural configurations, and social practices. Resilience thinking highlights how community-based knowledge and adaptive governance capacities can enhance systemic robustness in the face of climate change and economic volatility, moving beyond narrow technical optimisation toward holistic transformation. Third, participatory urbanism scholarship (Abas et al., 2023; Artopoulos & Costa, 2019) elucidates mechanisms through which citizen-led spatial knowledge production can democratise planning processes, leveraging digital mapping technologies, participatory sensing, and collaborative design to challenge expert-dominated rationalities and assert community spatial priorities.

Integrating these frameworks enables a layered analysis of how participatory mapping practices can intervene in port transition governance. Specifically, this synthesis illuminates:

1. How community-generated spatial data can render visible localised environmental justice impacts that are often obscured, including the role of port infrastructures as accessibility barriers;
2. How participatory knowledge production challenges technocratic framings of port futures by foregrounding lived experience and place-based values;
3. How collaborative mapping establishes new institutional interfaces between port authorities and surrounding communities, fostering more open and inclusive dialogue;
4. How citizen-led cartographies can prefigure alternative port imaginaries that reconcile decarbonisation imperatives with environmental justice, social equity, and ecological regeneration.

This framework therefore positions participatory mapping not merely as a data collection method but as a transformative practice capable of reshaping power relations, epistemic hierarchies, and spatial priorities within port energy transitions. It is nonetheless important to acknowledge that spatially oriented participatory frameworks have inherent limitations when applied to ecologically complex estuarine environments: Community-generated mapping captures social, perceptual, and justice dimensions of portscape conditions effectively, but cannot on its own represent dynamic biogeochemical processes, sediment transport, contaminant dispersion, or tidal nutrient cycling, that unfold across temporal scales inaccessible to snapshot cartographic representation (Ganju et al., 2016). Critically, however, participatory

sensing need not remain a one-off intervention; designed as a longitudinal practice, repeated cycles of community observation and geotagged documentation can themselves generate temporally layered datasets capable of tracking environmental change as perceived and experienced by those most exposed to it, complementing rather than substituting for biogeochemical monitoring.

3. Methodology: Spatial Analysis and Scenario Thinking Approach

3.1. Study Area

The Port of Tyne occupies a strategically important yet spatially contested position along the urbanised lower River Tyne corridor in North East England (Figure 1). Historically, Newcastle upon Tyne was a major hub for coal mining and shipbuilding, supported by direct access to the North Sea via the River Tyne (Simpson, 2024). As these industries declined from the mid-20th century and energy systems shifted toward cleaner sources, coal exports from the port steadily decreased (Bruno, 2022). In response, the port diversified, now handling automobiles, household goods, and supporting offshore and renewable energy logistics. Spanning both sides of the estuary, it comprises cargo terminals, vehicle handling facilities, and bulk import infrastructure (J. Jin & Zhu, 2024; Zhu et al., 2025). While the port remains a major regional economic asset, its proximity to long-established residential communities creates a complex interface where industrial activity, environmental exposure, and everyday urban life intersect.

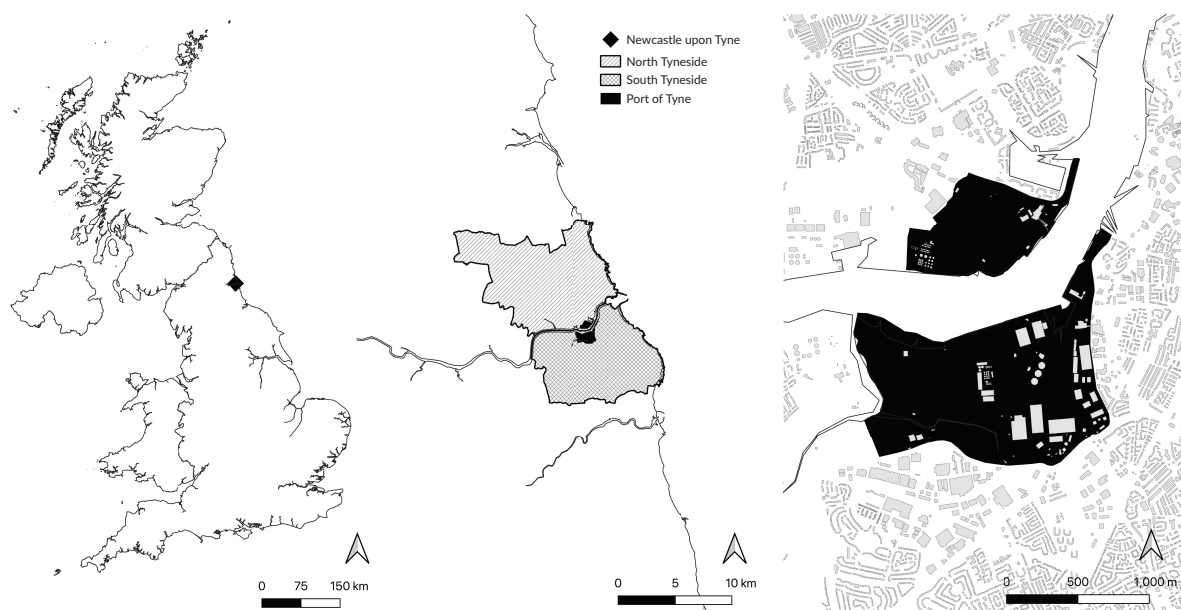


Figure 1. Locations of Newcastle upon Tyne within the UK, and the Port of Tyne in the Tyneside area.

This study focuses on the communities immediately surrounding the port, where residential neighbourhoods, industrial estates, and transport corridors are tightly interwoven with port activities. The study area is defined by a 15-minute pedestrian catchment (isochrone) from accessible port-edge interface points, capturing the zone of most frequent day-to-day interaction between port operations and nearby communities (Moreno et al., 2021). Within this boundary, conditions vary widely, from industrial sites to regenerated public spaces, and informal river banks shaped by vegetation and community use. This diversity makes the area a valuable case for

examining how contemporary ports shape accessibility, environmental justice, and urban liveability in adjacent communities, also where participatory sensing and citizen engagement can function as living laboratories.

3.2. Mixed-Method Research Framework

This study adopted a sequential mixed-method design to examine the relationship between the Port and adjacent communities and envision the transition, as shown in Figure 2.

Methods & Approaches

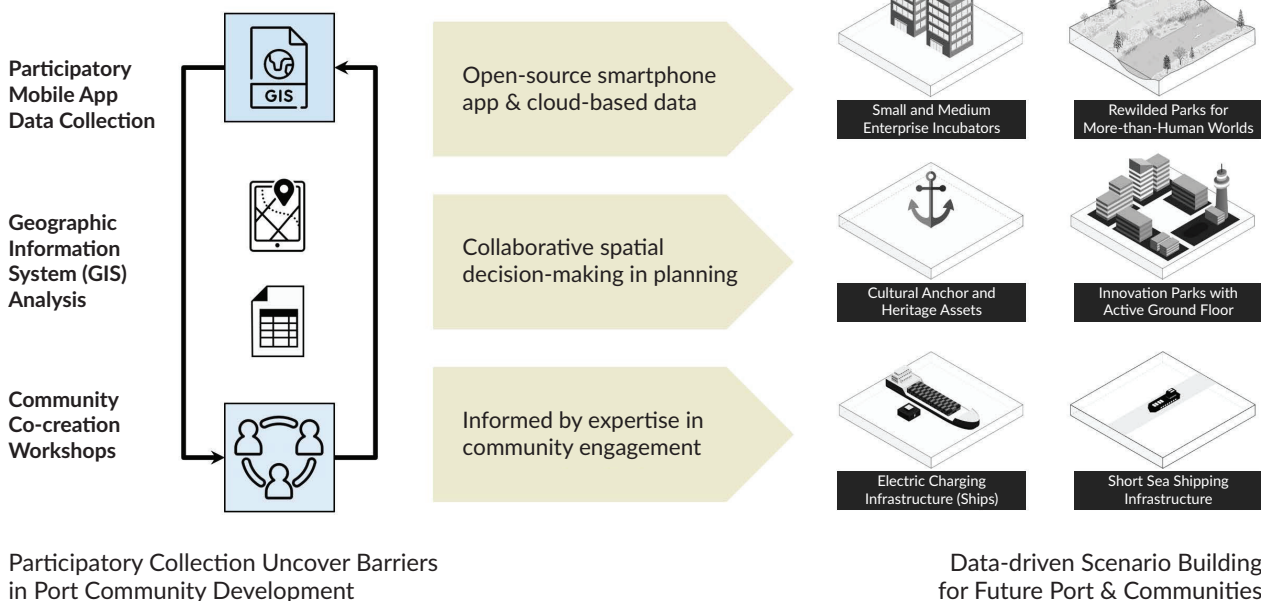


Figure 2. Methodological framework for participatory, data-driven research in port community planning, incorporating scenario-building processes.

First, walking ethnography gathered participatory spatial data: Guided group walks along key routes let participants log positive and negative local experiences via a custom mobile app, producing timestamped, geotagged annotated photos and collages stored as a cloud multimedia archive (app screenshots in Appendix A in the Supplementary File). Further methodological details can be found in a companion paper that adopted a similar research design and methodological approach (J. Jin et al., 2026). This approach broadens participation by accommodating diverse forms of expression, making it particularly suitable for engaging underrepresented groups such as young people and non-native speakers. It also enables place-based observations to be captured in situ rather than retrospectively through conventional consultation formats.

Second, GIS analysis using the Place Syntax Tool (PST) calculated pedestrian accessibility to green areas, accessible waterfronts (blue space), and third spaces, which describe informal gathering places distinct from the domestic realm (first space) and the workplace (second space), such as libraries, community centres, museums, galleries, cafés, and civic venues (Memarovic et al., 2014; Stavroulaki et al., 2019). By comparing PST results with participatory observations, the study pinpointed inconsistencies, for instance, where PST scores indicated reasonable waterfront proximity yet participants reported the absence of usable or welcoming public space, or conversely, where informal community appropriation of space had generated

positive place experience not captured by accessibility metrics. These inconsistencies were subsequently explored in follow-up scenario workshops.

Third, joint scenario workshops united residents, port officials, planners, and community groups to craft alternative futures of the port and its surrounding neighbourhoods using ethnographic and GIS evidence. These exploratory scenarios do not predict outcomes but unpack trade-offs to spark dialogue (Abou Jaoude et al., 2022; Godet & Roubelat, 1996). Each scenario weaves together four dimensions that participants themselves identified as central—how the port is governed, how environmental conditions are likely to change, what the spatial consequences might look like on the ground, and what communities actually want—into a narrative and visual proposition that non-specialist audiences can read, critique, and build on. Conflicting local opinions were fully voiced instead of smoothed into artificial consensus, creating a collaborative platform to negotiate equitable, ecological, and culturally appropriate port visions. All fieldwork secured prior ethical clearance from Northumbria University's ethics committee, with full informed consent obtained from every participant.

4. Results

4.1. *Participatory Sensing Data: Patterns and Priorities*

Over 200 participants joined the walking ethnography sessions, recruited via local social media, community events, and neighbourhood posters. No demographic information was collected to protect anonymity, a requirement under the project's ethical approval due to the location-specific geotagged data. Loose open participation made exact attendance tracking unfeasible, as some attendees joined spontaneously or shared devices with companions. In total, 1,749 annotated photos and 225 spatial collages were gathered for analysis; Figure 3 maps core research sites and visualises one active participant's spatial contributions.

Geotagged images and accompanying notes were coded inductively in NVivo without preset analytical frameworks, yielding five core community spatial priorities. These themes arose organically from on-location collective recording via the custom mobile app, marking a key methodological difference from rigid pre-designed survey tools and shaping the study's unique qualitative dataset.

The first and most consistently documented priority was waterfront accessibility. Participants recorded physical and perceptual barriers to the river edge: security fencing demarcating port operational zones, degraded pedestrian infrastructure along key desire lines, and the absence of legible wayfinding connecting inland residential areas to the waterfront corridor. A participant commented: "I've lived near the Tyne my whole life but there're whole stretches I've never been able to walk along. It's just barriers and signs telling you to keep out." Critically, participants did not merely document these barriers as neutral infrastructural deficiencies; they narrated them as experienced exclusions, articulating a strong sense that the waterfront, understood as a shared environmental inheritance, had been progressively privatised and foreclosed from community use over decades of port expansion.

The second core priority centres on integrated mixed-use amenities blending port-area jobs, recreation, culture, and green spaces. Participants rejected rigid zoning separating port functions from community life and called for permeable waterfront zones balancing port activity, local businesses, and public vitality. This

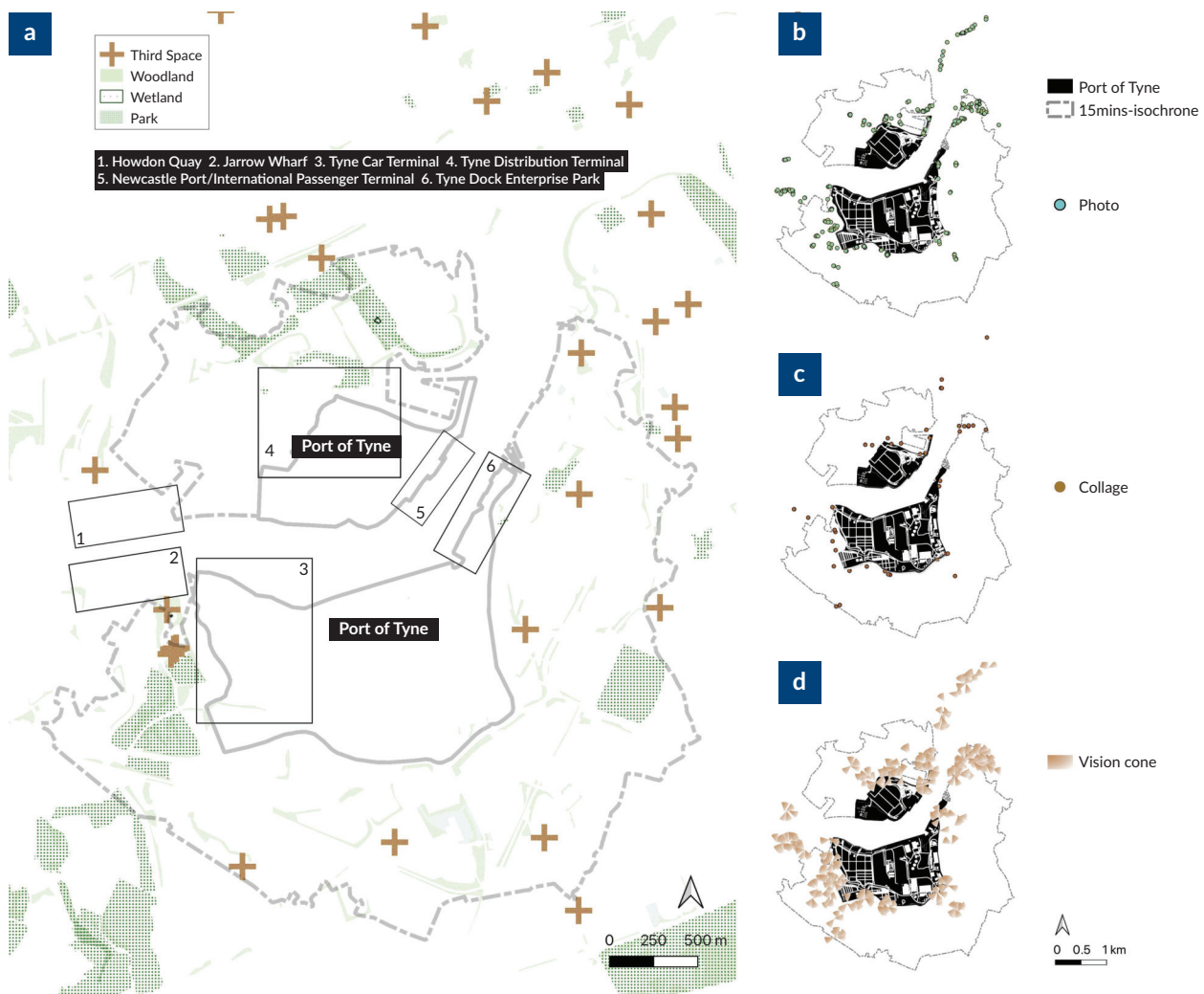


Figure 3. Spatial distribution of (a) key sites of interest, together with the locations of (b) photos, (c) collages, and (d) corresponding vision cones of the photos contributed by a highly engaged participant.

demand stood out among young and creative workers, who viewed repurposed historic port infrastructure as both economic and cultural assets. Though residents acknowledged necessary port security boundaries, they hoped to dismantle the port–community divide without disrupting operational safety. While participants could clearly outline this spatial conflict, they lacked professional regulatory and technical expertise to deliver actionable solutions.

Industrial heritage preservation emerged as a third, closely related priority. Participants across the North and South Shields sites documented surviving maritime infrastructure, slipways, engine houses, chandleries, and dock walls, with a combination of pride and anxiety, recognising these as irreplaceable material records of the communities’ historical relationship with maritime industry and the river. People mentioned: “I remember seeing the ships being built when I was a kid,” and “Mad to me that we don’t have a museum dedicated to ship building.” A participant recalled their childhood experiences exploring the former shipyard in the early 1990s:

We used to go into the remains of Hawthorn Leslie and climb the cranes that were still standing, even venturing out along the jibs. It was incredible to see firsthand how everything had once been organised

for shipbuilding. I feel very fortunate to have experienced it....As kids, we always imagined these places running...waiting for things to change so shipbuilding could begin again.

The concern was not merely preservationist; participants articulated a direct connection between the erasure of industrial heritage and the erosion of collective identity and inter-generational narrative, particularly in communities where deindustrialisation had already severed many of the economic and social structures through which place identity had historically been reproduced.

Fourth, ecological quality and environmental health stood out as a major concern largely overlooked by standard consultations. Participants recorded industrial water and sediment pollution, waterfront waste, and damaged riverside habitats, alongside calls for wetland restoration, softened engineered shorelines, and blue-green waterfront development (Gann et al., 2019). Their input embodies environmental justice: Local communities disproportionately harmed by industrial degradation deserve a voice in ecological redevelopment. Like most participatory research, their insights draw on present-day lived experience rather than deep environmental history; participatory sensing supplements, rather than replaces, professional hydro-ecological baseline studies.

Lastly, residents held mixed attitudes toward green industrial job transitions. Though they backed the port's offshore wind and net-zero growth, they worried local people would be locked out of new green jobs without targeted youth training and apprenticeships, fearing economic gains would be seized by outside corporations: "There should be proper training, apprenticeships for young people from here. Not just contracts going to companies from outside the area." These grassroots worries ground the study's just transition framework, proving procedural and distributional justice are tangible spatial concerns for riverside communities, not merely theoretical ideals.

4.2. Site Characterisation: Port-Community Interface

Figure 4 shows PST 500-metre (15-minute round trip) accessibility outputs. Its right subplots map access to blue, green, and third spaces; darker road segments indicate closer amenities and better walkability; areas beyond 500 m are omitted. Table 1 weights pedestrian network length by geometric length per access tier for accurate comparison. Results reveal severe blue-space disconnection and constrained third-space availability. Green space is relatively accessible, though port-adjacent communities face major shortages. These findings confirm widespread accessibility inequities across the local walking network.

More specifically, for blue space, meaningful Tyne River access is mostly restricted to Royal Quays Marina, while Fish Quay sits outside the 15-minute walking radius. Long waterfront stretches around Howdon lack public river access; the south bank's viable waterfront is limited to South Shields ferry and town centre, with Jarrow residents only accessing the River Don rather than the main Tyne estuary. Many riverside neighbourhoods are thus cut off from blue-space amenities. Green space access is better at the study area's peripheries but drops sharply near port zones, most notably the north bank's industrial Howdon Quay stretch; aside from central South Shields, the south bank also suffers poor green-space connectivity. Access to third spaces is the most socially uneven indicator: The north bank lacks inclusive civic hubs, with only exclusive retail near the passenger terminal. The south bank fares slightly better with accessible clusters around transit stops, yet vast swathes still lack walkable community venues.

Participant accounts validated PST-measured spatial disparities. Waterfront zones geographically close to the river often lacked lighting, seating, and social facilities, rendering them functionally inaccessible. Residents also cited industrial noise, air pollution, and inadequate active travel infrastructure near port zones. Meanwhile, informal culturally significant sites such as unregulated riverbanks and disused heritage plots carried social value invisible to quantitative accessibility analysis. Overall, the results indicate that waterside communities face overlapping amenity shortages rooted not just in distance, but industrial land occupation, disjointed urban layout, and inequitably distributed public infrastructure.

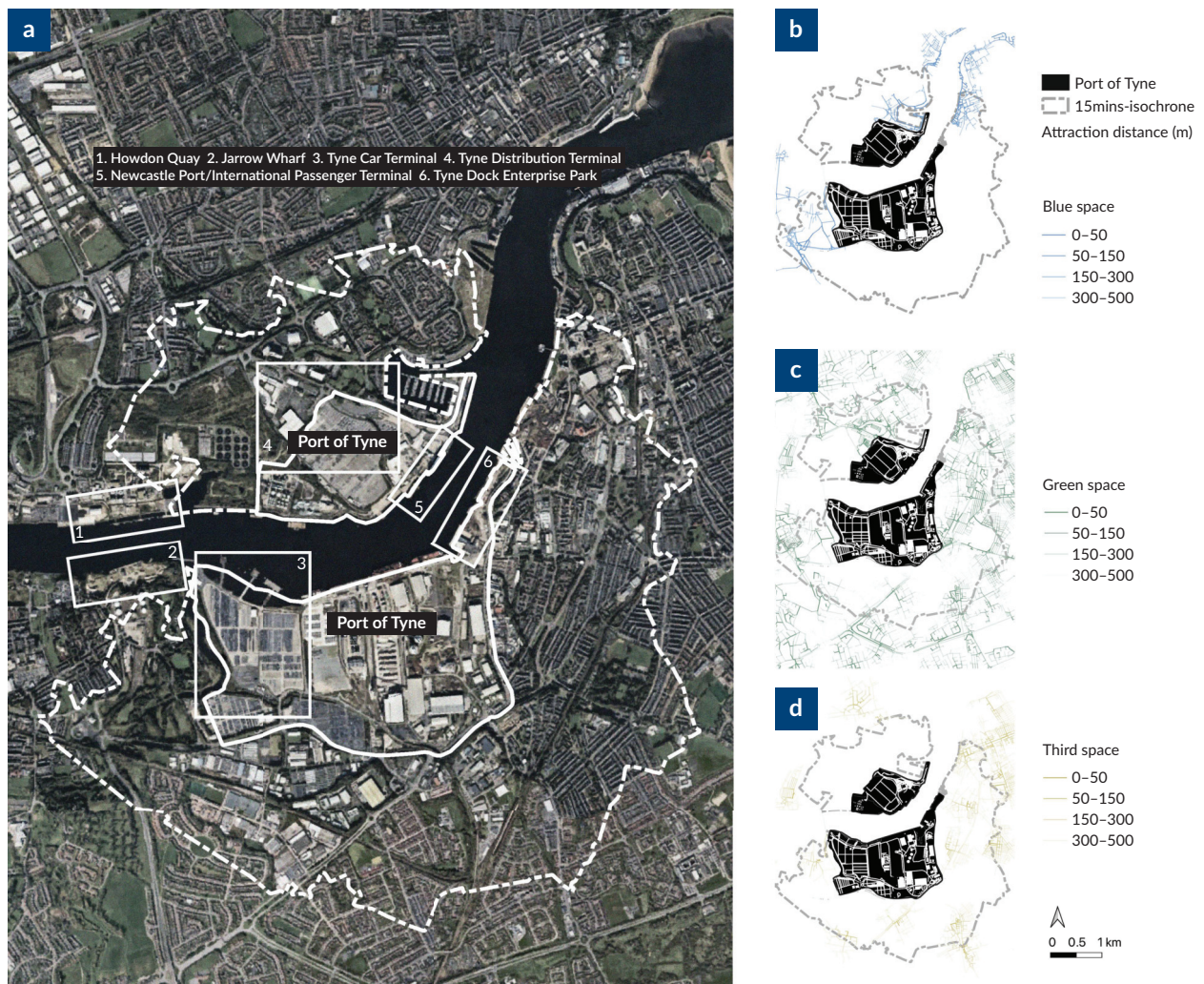


Figure 4. Spatial distribution of (a) key sites of interest overlaid on Google Maps satellite imagery, together with the amenity accessibility assessment of surrounding communities focusing on (b) blue, (c) green, and (d) third spaces.

Table 1. Distribution of pedestrian network accessibility by amenity type (% of total network length).

	No access (> 500 m)	Low (300–500 m)	Medium (100–300 m)	High (< 100 m)
Blue space	91.7	4.3	2.9	1.2
Green space	20.3	23.3	39.4	16.4
Third space	80.1	11.9	7.2	0.8

4.3. The Evidential Value of Participatory Sensing

Comparing participatory sensing data with Port of Tyne consultation archives and the Tyne 2050 strategy exposes major mismatches between the methodologies' identified spatial priorities. Tyne 2050 contains no targeted pledges for port-side neighbourhoods, ignoring waterfront access, environmental health, and local jobs, and limiting public involvement to charity outreach instead of collaborative spatial planning. Standard consultations prioritise broad economic indicators and merely communicate pre-set plans, overlooking nuanced, location-specific community environmental feelings captured by on-site sensing.

This divide stems from methodological differences. The custom mobile app captured residents' immediate, on-location experiences, yielding granular insights on access barriers, pollution sites, and heritage attachments unobtainable via traditional consultation tools. Their exclusion from official strategies signals a fundamental disconnect between institutional planning and grassroots lived realities.

Crucially, the value of participatory sensing in this study extends beyond evidence generation. Walking ethnography findings were consolidated into themed planning toolkits covering access, amenities, heritage, ecology, and jobs, translating personal, place-based observations into shared planning material for stakeholders. The method thus serves both as an assessment tool and a bridge connecting local knowledge and spatial design, shifting the process from documenting present issues to jointly designing alternative futures. These datasets ultimately formed the basis for community co-mapping scenarios rooted in resident experience.

5. Discussion on Scenarios for Future Portscapes

Converting participatory sensing data into spatial scenarios involved shifting from recording current landscapes to drafting alternative futures. Collaborative mapping served as a deliberative tool for participants to test varied spatial, governance, and decarbonisation pathways along the Tyne corridor. Scenarios were developed through workshops with over 50 participants—mostly local residents, including planning, architecture, and design professionals living in the area, plus a few external practitioners for broader perspectives. Scenarios were grounded in geotagged observations and qualitative insights from the walking ethnography phase, representing situated projections anchored in lived experience rather than speculative abstractions.

Before the workshop, the research team categorised annotated photographs from the walking ethnography by relevance to six key sites (Figure 3). These curated image sets opened each session, grounding discussion in community-generated visual records. Facilitated discussion identified key concerns and prioritised transition interventions per site. Participant-produced collages then shifted conversation from diagnosis to projection, prompting articulation of envisioned spatial steps and design interventions. The research team developed scenario themes and initial sketch propositions during workshops from these discussions. Final scenario visualisations emerged as an interpretive synthesis of community inputs, particularly the spatial collages providing direct visual material, rather than arising independently of the participatory process (see Appendix B in the Supplementary File for selected participant-contributed collages).

Three scenarios were synthesised, articulating distinct yet overlapping approaches to port-community transition: productive integration, ecological rehabilitation, and cultural continuity. Each scenario is grounded in a specific section of the Tyne corridor, selected to reflect the distinct spatial character and community circumstances of that stretch. The Productive Waterfront focuses on the inner river between Jarrow Wharf on the south bank and Howdon Quay on the north. The Ecological Corridor addresses the zone centred on the Tyne Car Terminal and Tyne Distribution Terminal, two large vehicle-processing facilities. The Living Heritage District is situated further down the river, encompassing the passenger terminal and the Tyne Industrial Park. Together, they span the port corridor from inner estuary towards the river mouth, allowing the scenarios to address the entire range of spatial conditions, land uses, and community relationships.

5.1. Productive Waterfront: Localising the Green Transition

The Productive Waterfront scenario (Figure 5), spanning the stretch between Howdon Quay and Jarrow Wharf, foregrounds the integration of green industrial development with local economic systems. Rather than treating the port as a spatially segregated logistics enclave, this scenario positions it as a productive landscape embedded within its surrounding urban context. Its design draws on participatory data highlighting community concerns about economic exclusion and limited access to employment opportunities associated with ongoing port transformation. Though residents backed the port's shift to low-carbon, renewable industries, they doubted whether these developments would generate tangible benefits for local communities.

In response, the plan features local value-retention tools such as SME production incubators and decarbonised port systems focused on vessel shore power and battery storage. These energy assets connect renewables, port activity, and new supply chains rather than functioning as separate tech facilities. Rooted in just transition principles, the framework prioritises distributional justice, examining equitable sharing of the energy transition's jobs, resources, and infrastructure across local social groups.



Figure 5. The visualisation of Scenario One: a productive waterfront that extends and strengthens the bio-based production ecosystem and SME activities at Howdon Quay and Jarrow Wharf, fostering a resilient local economy (Icons redrawn and adapted from Agterdenbos et al., 2024).

5.2. Ecological Corridor: Rebalancing Environmental and Energy Infrastructures

The Ecological Corridor scenario (Figure 6) repositions the Tyne waterfront as a multifunctional socio-ecological infrastructure in which environmental restoration, climate rehabilitation, and emerging energy systems are spatially integrated. This scenario examines how blue-green infrastructure and low-carbon energy networks

can coexist within a reconfigured port landscape. It builds on ongoing transformations at the Port of Tyne, which is positioning itself within the emerging hydrogen economy through developments in production, storage, and logistics, including the Lhyfe green hydrogen facility at Wallsend.

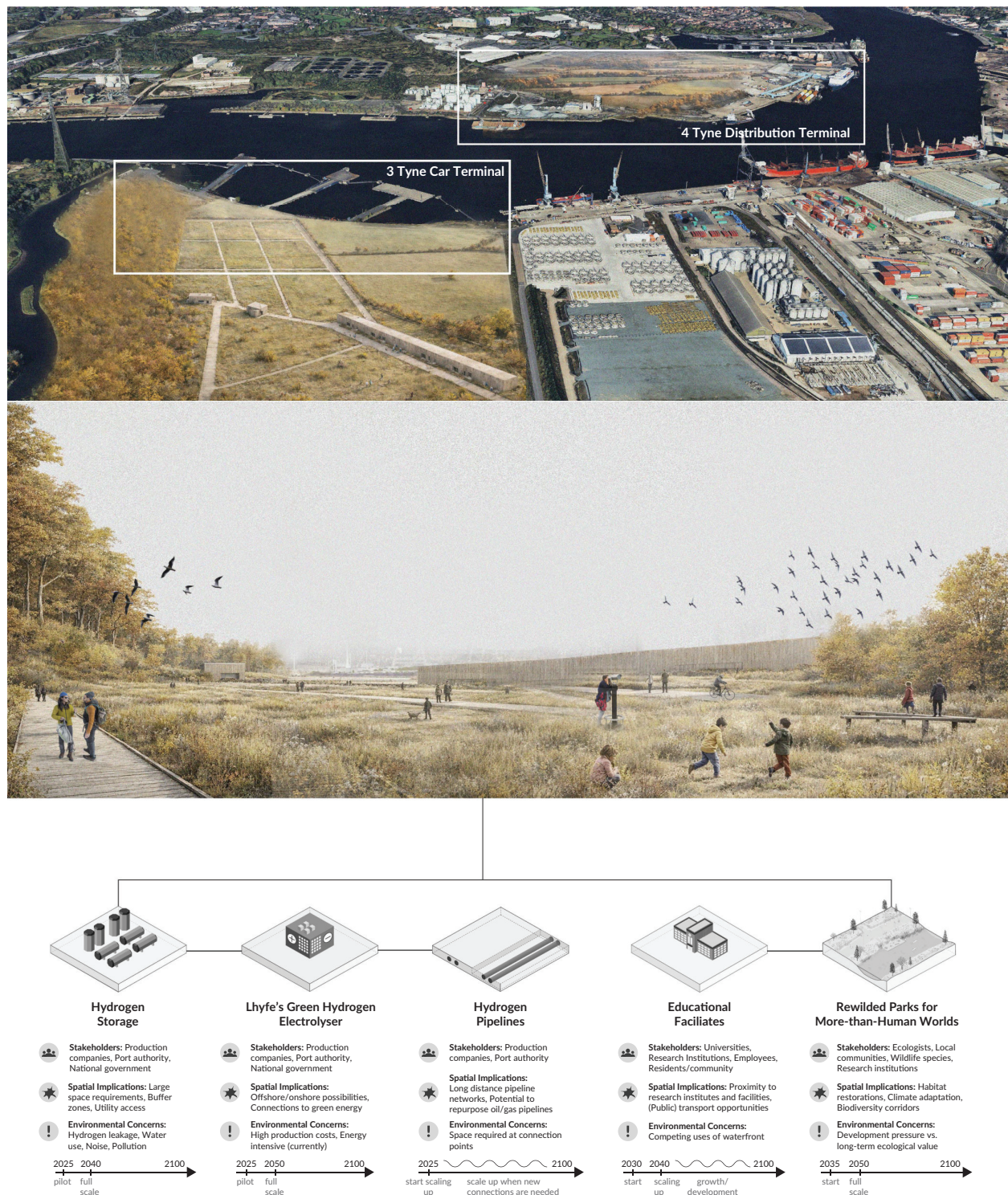


Figure 6. The visualisation of Scenario Two: an ecological corridor that transforms the current Tyne Car Terminal and Distribution Terminal into a continuous green infrastructure network (Icons redrawn and adapted from Agterdenbos et al., 2024).

At the same time, decarbonisation trajectories suggest the potential reconfiguration and partial rewilding of existing car and distribution terminals. The scenario leverages these shifts by embedding hydrogen-related infrastructures within a broader ecological framework, reimagining them not as isolated industrial enclaves but as integral components of a continuous landscape system. Hydrogen production and storage sites are therefore co-located with restored ecological zones, while pipeline networks are aligned with existing infrastructure corridors to minimise further spatial fragmentation.

5.3. Living Heritage District: From Transit Node to Destination Waterfront

Building on participants' strong engagement with industrial heritage, the Living Heritage District (Figure 7) scenario moves beyond preservation to explore how existing infrastructures—particularly the international passenger terminal—can help reconnect the port with surrounding communities and urban life. A key insight from fieldwork and stakeholder discussions is that the busy Newcastle-Amsterdam DFDS ferry terminal acts only as a transient transit hub, failing to channel tourism and economic gains to Tyneside due to uneven travel volumes favouring outbound trips.

In response, the plan redevelops the terminal into a mixed-use waterfront destination with innovation spaces, retail, dining, and community amenities, turning passenger transit into a driver of local vitality through adaptive reuse of maritime heritage structures. Its cohesive architectural design bridges the port and neighbouring districts for greater public accessibility.

At the same time, the scenario recognises the competitive pressures facing contemporary ports and proposes a more specialised operational role, including terminals designed for handling niche cargo types. This strategic repositioning complements, rather than competes with, larger-scale logistics hubs, enabling the port to maintain economic relevance while supporting a more locally embedded development model. Under just transition frameworks, it advances procedural and recognition justice by centring local residents' cultural identities, while recirculating revenue from cross-border passenger travel to deliver fairer economic distribution.

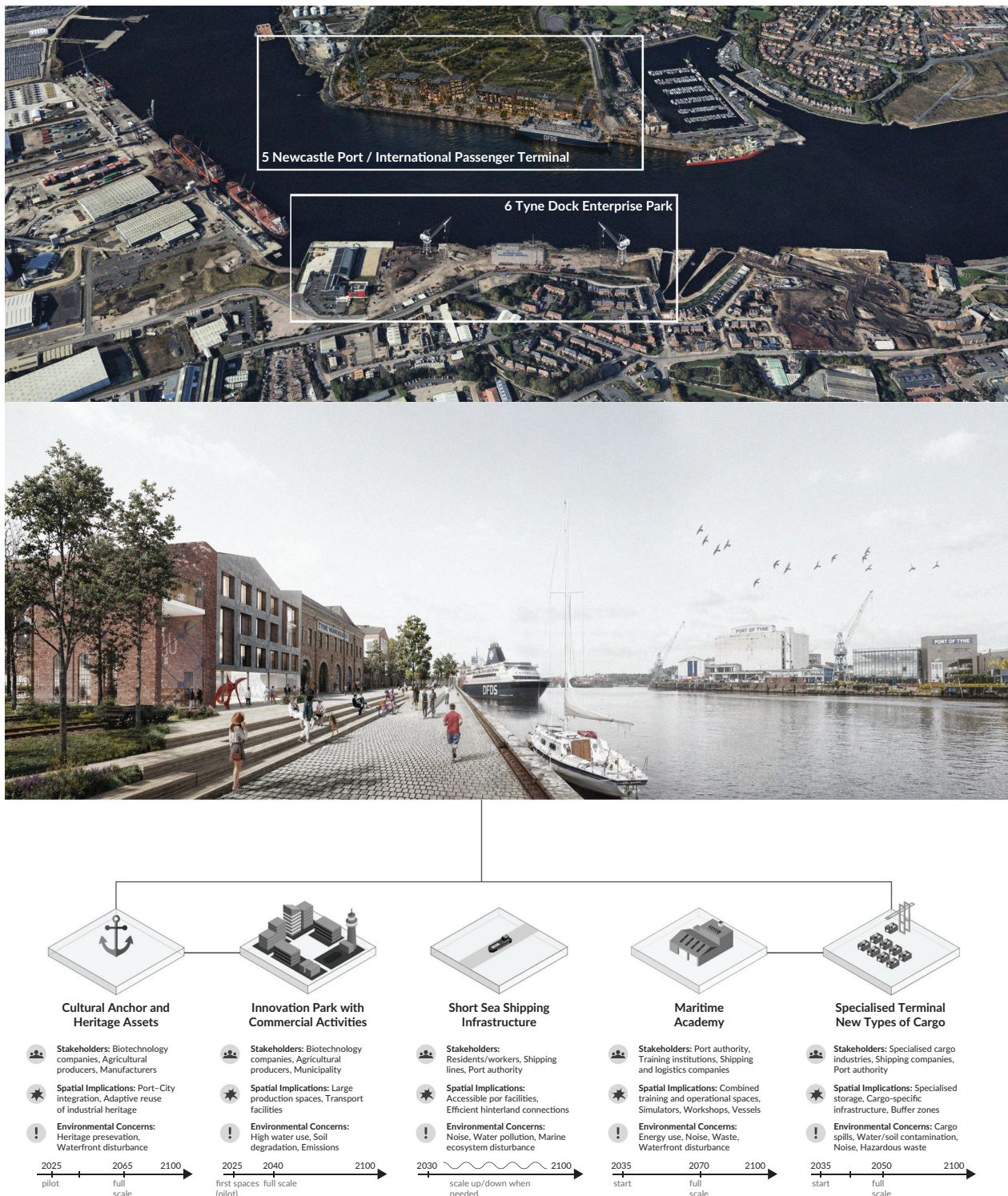


Figure 7. The visualisation of Scenario Three: a living heritage district that reimagines the international passenger terminal and the Tyne Dock Enterprise Park (Icons redrawn and adapted from Agterdenbos et al., 2024).

5.4. Scenario Synthesis: Toward a Composite Portscape Vision

Taken together, the three scenarios expose structural tensions at the core of port transition, rather than offering discrete or easily reconcilable futures. Each scenario foregrounds a different constraint—institutional, spatial, or socio-economic—revealing that the challenge is not simply how to design better portscapes, but how to negotiate competing priorities within constrained governance systems.

The Productive Waterfront highlights a fundamental governance gap. While participatory processes can articulate locally grounded economic aspirations, their implementation depends on cross-sector coordination between port authorities, local governments, and private actors—an alignment that remains weak in current UK port governance. The Ecological Corridor introduces a more direct spatial conflict. Establishing a continuous ecological network would require the reallocation—or partial withdrawal—of existing port infrastructure, challenging the assumption that environmental transition can be accommodated within existing spatial arrangements. In this sense, the scenario reveals the limits of technocratic approaches that frame decarbonisation as a largely technical adjustment, rather than a process involving material trade-offs and spatial redistribution. The Living Heritage District foregrounds a different tension between cultural continuity and market dynamics. While heritage-led regeneration can reinforce local identity and social cohesion, it also risks accelerating displacement in the absence of protective mechanisms.

The scenarios clarify these hidden conflicts overlooked by traditional planning that falsely assumes aligned economic, environmental, and social goals. Across all three scenarios, participants consistently emphasised the importance of public waterfront access, the value of industrial heritage as both a spatial and cultural resource, the need for locally accessible employment pathways, and the necessity of more inclusive governance structures.

These shared priorities suggest that the scenarios should be understood not as competing alternatives, but as complementary perspectives on a shared transition challenge. Taken together, they point toward a composite portscape in which economic, ecological, and cultural objectives are held in productive tension, rather than reduced to a single dominant vision. This scenario method's strength is not delivering a single optimal solution, but reframing planning as collaborative negotiation to counter technocratic and token public engagement. Beyond gathering data, participatory sensing fosters joint creative vision and dialogue between locals, planners, and port authorities, letting grassroots knowledge steer port redevelopment from its earliest stages rather than being added as an afterthought.

6. Discussion

6.1. Transformative Potential and Governance Realities

The participatory sensing framework developed in this study demonstrates considerable methodological potential to generate spatially precise, community-grounded evidence capable of challenging the technocratic rationalities that often shape port planning. However, the transformative potential of such evidence ultimately depends on whether decision-making authorities are both willing and institutionally equipped to incorporate it into planning processes. This is a critical limitation rather than a minor caveat. As a trust port, the Port of Tyne concentrates strategic decision-making within a board that has limited

formal accountability to neighbouring communities. While participatory planning research can produce evidence that reflects community priorities and lived experiences, its influence remains constrained in the absence of governance reforms that establish binding mechanisms through which community knowledge can shape institutional decisions. Without such reforms, participatory evidence risks serving only an advisory function—or, more critically, becoming a symbolic exercise that legitimises existing decision-making without altering it. Consequently, the question of who is empowered to listen, and under what institutional obligations, is not peripheral but fundamental to the just transitions agenda advanced in this article.

6.2. Limitations of Mobile Application-Enabled Participation

Several limitations of the mobile application methodology need acknowledgement. First, participation was self-selected through existing community and institutional networks, which likely skewed engagement towards residents already motivated to participate and excluded those facing barriers of digital access, language, or civic disconnection. This is the well-documented “usual suspects” effect that structural outreach strategies alone cannot fully resolve (Brownill & Carpenter, 2009). Second, the method introduced specific digital literacy requirements: Participants needed smartphones and sufficient proficiency with them to photograph, annotate, and geotag observations. While the research team helped with the installation and configuration on participants’ own devices and provided on-site support throughout, this support structure was resource-intensive and may not be replicable at scale. Third, the emphasis on in-situ data collection through walking privileged participants’ experiences as pedestrians, potentially underrepresenting the perspectives of community members who engage with the area in other roles or through different modes of mobility. Fourth, despite robust ethical procedures and secure data management, participatory sensing may create privacy risks in small communities where location-specific images can indirectly identify participants. Future applications should incorporate privacy-by-design measures, including image anonymisation and greater participant control over data retention. Fifth, time-limited mapping workshops weakened the thoroughness and democratic validity of co-designed future scenarios; extended long-term community input would improve outcome quality and participatory integrity.

6.3. Limitations of Scenario Visualisation

Scenario visuals were neither drafted live at workshops nor literal reflections of participant views. Instead, the research team synthesised two rounds of community feedback and translated grassroots ideas into spatial frameworks, acting as co-production mediators (Albrechts, 2013; Healey, 1997). This interpretive filtering is inherent to participatory planning: Locals supply spatial visions, while planners translate them into debatable, actionable spatial proposals using professional expertise (Albrechts, 2004). Such a process inevitably draws on the disciplinary knowledge in the research team. The scenarios visuals should therefore be read as researcher interpretations grounded in participant data, not as democratically ratified outputs. Following completion, they were shared with participants who had provided contact details, a limited form of member-checking that, while falling short of full participatory validation, ensured the scenarios were not produced in complete isolation from the communities.

A second limitation concerns the ecological knowledge underpinning the scenarios. Participants’ observations reflected contemporary, place-based sensory experiences and therefore captured current environmental conditions rather than the longer-term ecological history of the River Tyne. This is not a

shortcoming unique to the present study but a structural characteristic of participatory research more broadly. Community-generated knowledge is particularly valuable for identifying lived environmental concerns, local changes, and experiential understandings, but it cannot substitute for specialist hydro-ecological analysis or historical ecosystem reconstruction. Instead, participatory sensing should be understood as complementing scientific evidence by contributing locally grounded insights that conventional technical assessments often overlook.

7. Conclusion

The empirical findings advance three interconnected claims. First, participatory sensing when deployed through accessible, in-situ digital tools, can reveal the granular, place-based, and emotionally embedded dimensions of community–environment interaction that conventional port consultation methods routinely overlook. By employing walking-based fieldwork, the research elicited residents’ spatial priorities through direct observation and lived experience rather than predetermined survey categories. These insights informed the development of planning scenarios grounded in community perspectives rather than institutional assumptions. Second, the study shows that collaborative scenario mapping provides a practical means of integrating environmental, social, cultural, and economic dimensions of justice within spatial planning. Rather than promoting a single preferred development pathway, the scenarios expose the inherent trade-offs and competing priorities involved in port decarbonisation, creating space for more transparent and deliberative decision-making. Third, the findings suggest that participatory sensing should be understood not merely as a method of data collection but as a transformative planning practice. By recognising residents as producers of spatial knowledge rather than passive consultees, the approach redistributes epistemic authority and broadens the evidence base upon which port transition strategies are developed.

These findings also carry important implications for UK port governance. Although participatory methods can generate robust, community-grounded evidence, their influence depends on governance arrangements that translate community knowledge into decision-making. Without transparent and accountable institutional mechanisms, participation risks becoming consultative rather than transformative. A just transition therefore requires governance reform alongside improved methods of engagement. The participatory sensing framework presented here contributes to this agenda by generating spatially explicit evidence that can strengthen planning deliberation and legitimacy. As ports become central to achieving net-zero ambitions, the challenge is not only to accelerate decarbonisation but also to ensure its benefits are distributed equitably. By positioning communities as co-producers of spatial knowledge, participatory sensing supports more just, democratic, and socially legitimate port futures.

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Conflict of Interests

The authors declare no conflict of interests.

Data Availability

The participatory data, including the walking ethnography and workshop of this study, include information such as personalised comments and visual collage that may contain identifiable individuals and were collected under ethics approval with informed consent that does not permit public sharing. The data are therefore not publicly available in order to protect participant privacy. The PST analyses data were generated from open access data that can be shared upon request.

LLMs Disclosure

The authors used Claude for improving the writing of this manuscript only, including grammar and style.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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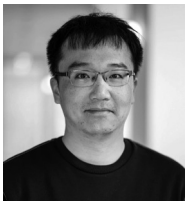
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