RESEARCH



Ripple: a scalable, radically inclusive, and transdisciplinary approach for engaged design research on climate action



Orla Murphy^{1*}, Sarah Cotterill², Sawsan Bassalat¹ and Philip Crowe^{1,2}

*Correspondence: o.murphy@ucd.ie

 ¹ School of Architecture, Planning and Environmental Policy, University College Dublin, Dublin, Ireland
 ² School of Civil Engineering, University College Dublin, Dublin, Ireland

Abstract

There is considerable desire for climate action in Ireland, yet in practice it may not be seen as relatable, actionable or relevant to the reality of people's lives. Ripple: Making Connections between Water and Climate Change in our Towns, funded by Creative Ireland, aimed to co-create a novel approach to the design of climate-resilient green space in an Irish town, and develop tools that could be scaled up and out across projects and communities. The transdisciplinary team brought together skills from science, spatial design and the visual arts in a tangible way to demonstrate how local action can have a positive impact on climate adaptation in Irish towns, and provide communities with agency to transition to a more resilient future. The project sought to put people and communities at the heart of the design process through six public workshops, delivered through storytelling, co-design, making, and evaluation stages. Sixteen prospective ideas, that responded to a collaborative mapping of challenges relating to water, were co-designed and voted upon. The preferred idea, implemented in the third stage of the project, is a climate friendly, intergenerational amenity space and haven for wildlife, that slows rainwater runoff. A participatory Ripple Effect Mapping process was used to evaluate the project. This highlighted the need to build trust, use clear and consistent communication, avoid pre-conceived solutions, embed communities' deep understanding of place, respect diverse opinions that coexist within communities, and deliver a tangible return on investment, if communities are to adopt nature based solutions for climate resilience.

Highlights

- 1. Co-production of climate resilient spaces can foster local agency to address climate change.
- 2. Transdisciplinary teams working with communities can achieve more positive and lasting results than actors within a single discipline.
- 3. Building trust is an important element of co-production and requires adequate time and focus to achieve lasting impact.



© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/. 4. Methods of co-production adapted to place and replicated at scale can contribute to climate adaptation.

Keywords: Co-production, Co-design, Nature-based solutions, Transdisciplinarity, Adaptation, Climate change

Policy and practice recommendations

- Climate adaptation benefits from the trust and championing of local communities who know and understand their neighbourhoods;
- Actions focused on co-design and production of locally informed solutions should be encouraged;
- Greater support for transdisciplinary teams is needed at national and local level;
- Replicable methods can be tuned to local contexts, facilitating scaling up of tested and evaluated approaches;
- Critical evaluation of project successes and weaknesses is crucial to improve scaled out models through a lessons-learnt approach.

Introduction

Climate change impacts in Ireland include sea level rise, rising temperatures, and shifting precipitation patterns in terms of both frequency and intensity (Ryan et al. 2022; Sweeney 2020). For example, in 2023, counties in the west of Ireland experienced annual rainfall totals surpassing the Long-Term Averages from 1981–2010 (Met Éireann 2023), and heavy precipitation events are projected to increase in frequency by approximately 20% during winter and autumn in the coming decades (Nolan et al. 2017). These changes, along with the growing threat of extreme events, pose immediate risks to communities, including a heightened probability of fluvial and pluvial flooding (Government of Ireland 2024a; OPW 2023).

Ireland is a signatory to several international agreements and commitments addressing climate change mitigation and adaptation (Government of Ireland 2024a), and at a national level, the Government is committed to legally binding objectives and sectoral targets to achieve a 51% reduction in GHG emissions by 2030 and climate neutrality by 2050 (Government of Ireland 2021, 2024a). However, emissions reductions are currently falling short of the levels required (Government of Ireland 2024a) and it is clear that systemic change is needed (Government of Ireland 2023). Adaptation, coping, and learning mechanisms are required for systemic resilience to climate change (Butler et al. 2016), and Ireland's primary adaptation response is set out in the National Adaptation Framework (NAF) (Government of Ireland 2024b).

As sea level rise and shifting precipitation patterns in terms of both frequency and intensity are the major climate change impacts in Ireland, a prime focus of the NAF (Government of Ireland 2024b) is flooding. While significant investment has been committed by the Government to protect Irish properties against flood risks by deploying flood defences (OPW 2023) this mechanism on its own has not solved the problem as demonstrated by the Midleton floods in County Cork in 2023. Furthermore, adaptation

to flooding is not well integrated into urban planning and development policy, as illustrated by the recent Town Centre First: A Policy Approach for Irish Towns (Government of Ireland 2022a), which fails to mention flooding, despite a large number of Irish towns being located on rivers or in coastal areas.

It is recognised at an international and national level that the impacts of climate change are already being felt by every individual, household, and community (Government of Ireland 2023; IPCC 2023). The International Panel on Climate Change (IPCC) highlights the adverse effects on individual livelihoods and emphasizes the importance of addressing gender and socio-economic equity in the face of these challenges (IPCC 2023). Additionally, the IPCC states that vulnerable communities around the world are disproportionately affected by climate change impacts (IPCC 2023). The Irish Government acknowledges inequities (Government of Ireland 2022b, 2024a), including dimensions of the environmental and climate injustices faced by vulnerable and marginalized communities such as exclusion from environmental and planning decisions, higher exposure to pollution, and increased property damage (O'Neill et al. 2022). In particular, lower-income communities are more affected by energy poverty, flood damage, and exclusionary displacement (O'Neill et al. 2022). The National Dialogue on Climate Action (Government of Ireland 2022c), an initiative that sets out to fortify the social contract between the Irish government and communities regarding climate action, found that the majority of Irish people surveyed believe that communities are not equally affected by the national transition to carbon neutrality (Government of Ireland 2022b), and it is acknowledged that the transition to a climate-neutral economy requires targeted supports for groups, regions, and communities facing the weight of climate change impacts (Government of Ireland 2024a).

Importance of universal action and engagement to address Climate Change

It is also recognised that every individual, household, and community will have a vital role to play in addressing climate change and that successful adaptation is not only reliant on government initiatives, but also on the active and sustained involvement of a range of stakeholders (Government of Ireland 2024b). This is particularly important when you consider the timescales of delivery for the adaptation mechanisms (i.e. major flood relief schemes) in the NAF, which may take several years or decades to implement. Government policies on taxation, spatial planning, and the bioeconomy, *inter alia*, can provide an enabling framework and encourage both individual and collective climate action (Government of Ireland 2024a). However, the NDCA revealed a concern that disadvantaged communities may not have the capacity to manage imposed measures (Government of Ireland 2022c). There is therefore a need to engage citizens from all sectors of the community in climate change decisions (EPA 2019; Government of Ireland 2022b; Bolger et al. 2022).

While engaging citizens is imperative for successful climate adaptation, determining effective methods of citizen engagement can be challenging (CCAC 2020). The importance of giving individuals and communities a voice in shaping this transition is recognised (Government of Ireland 2024a), as is a need to transition from awareness-raising to inclusive and active participation (Baybay & Hindmarsh 2019; EPA 2019). Active participation processes need to empower communities by reaffirming their ownership of both the challenges and solutions related to climate change (CCAC 2020) and enabling their involvement in decision making processes (Bolger et al. 2022). These participatory approaches could facilitate new forms and levels of public engagement, such as dialogue on collective and personal accountability, societal goals, and the diverse spatial dimensions of mitigation and adaptation efforts from local initiatives to global frameworks (Fox & Rau 2017). For example, the international trend in water management, where there has been a move away from the conventional top-down approach to embrace more integrated initiatives that prioritize community-led action (Rolston et al. 2017; Grasham et al. 2021).

However, there are many challenges, including communication-related barriers (Moser & Ekstrom 2010), lack of motivation, resistance to power redistribution, and inadequate political socio-economic infrastructure (Khatibi et al. 2021).

Knowledge/action and concern/action gaps

While there is a broad consensus on the urgency of robust and early action to reduce Ireland's greenhouse gas emissions and enhance climate resilience (Government of Ireland 2023; O'Mahony et al. 2024), and therefore a fertile context for climate action engagement, this does not necessarily significantly influence behaviours or actions due to the "knowledge–action gap" (Knutti 2019; Mooney et al. 2022; Latkin et al. 2023) that exists between people's understanding of what needs to be done and what actions are actually implemented (Schweizer et al. 2013).

The "knowledge–action gap" can relate to communities feeling overwhelmed by, or disconnected from, the topic due to the complexity of the climate change discourse and a lack of local practical examples on meaningful interventions (Government of Ireland 2022c), the prevalence of a narrow technical view of climate change (Fox & Rau 2017), and a focus on risks and damages rather than positive examples of climate action (Kundzewicz et al. 2020; Feldman and Hart 2021). Climate change communications can be received in different ways, as messages put out pass through filters and reinterpretations shaped by communities of practice, cultural values, and socio-cultural conditions, that may end up downplaying people's role in climate action (Fox and Rau 2017). Additionally, not knowing how to get involved, or feeling unqualified due to lack of training in climate advocacy, have proven to be barriers to engagement in climate change (Latkin et al. 2023), and perceptions of injustice or lack of representation may cause people, especially in disadvantaged communities, to feel powerless or left out of the decision making process (Government of Ireland 2022c).

The 'knowledge-action' gap might also be caused by people prioritizing their personal interest over the common good (Knutti 2019), or facing difficulties in finding a clear path to altering their long-held habits (Government of Ireland 2022b). For instance, a majority of Irish people express concern regarding climate change, but are challenged when faced with prohibitive policies (such as banning peat, coal, and oil for domestic heating; higher taxes for petrol and diesel vehicles), support for which has declined by 20%, particularly among financially disadvantaged groups (O'Mahony et al. 2024). Support might be compromised by concerns, identified in the NDCA, relating to what climate action might mean for marginalised communities, and that some sectors are being

targeted disproportionately by climate measures (Government of Ireland (Government of Ireland 2022c).

Suggested methods of bridging the knowledge–action gap include highlighting changes to nearby environmental assets or cherished places and pastimes (Nisbet 2009); focusing on personally and culturally relevant information that is meaningful to the intended audience (Schweizer et al. 2013; Monroe et al. 2019); and being truly inclusive, place- and community-specific, going beyond an indiscriminate appeal to "homogenous imagined publics" (Fox & Rau 2017 p240).

The value of participatory approaches

Participatory approaches are consistent with concepts and theories in urbanism, such as ecological urbanism (Mostafavi & Doherty 2010; Hagan 2014), community resilience (Wilson 2015), social ecology ethics (Bookchin 1991), and more recently the New European Bauhaus (European Commission 2024). The latter lists 'participation' as one of three core 'working principles', along with multi-level engagement and a transdisciplinary approach, in addition to three values of sustainability, beauty and inclusivity (European Commission 2024).

A transdisciplinary approach can be considered appropriate for social-ecological systems research as an holistic view is required (Collier and Scott 2009) and a response to the increasing fragmentation of knowledge and consolidation of narrow disciplinary silos (Klein 2015). Transdisciplinarity and inclusivity are considered key aspects of effective community engagement approaches to climate change and sustainable development (Knutti 2019; Baybay & Hindmarsh 2019). Polk (2015) considers transdisciplinary research to be a "mode of knowledge production" (110) with a focus on participation of actors outside academia, that "bridges disciplinary and sector-based boundaries both within and between traditional forms of knowledge production in research and problem solving in 'real-life'" (Polk 2015, 110).

A transdisciplinary approach connects top-down and bottom-up actors through adaptive co-management, which creates potential for collaboration between citizens and government, the transfer of knowledge, and identification of new solutions (Olsson et al. 2006). It has a strong focus on community participation and social equity (Ahern 2011), recognising that people have knowledge of systems and their own actions (Pickett et al. 2004). Folke et al. (2005) describe a role for local governments in adaptive co-management as 'bridging organizations' that build adaptive capacity and act as catalysts and conduits that potentially buffer external effects and drivers. The role involves investing in building trust, the identification of common interests, and resolving conflict (ibid.). Wardekker et al. (2010) note that local communities need to be enabled to evolve their own response strategies, and provided with access to relevant information and systems, in order to reduce reliance on government to solve every problem.

Geekiyanage et al. (2021) observe that the majority of community engagement projects are at the 'inform' and 'consult' levels of Arnstein's (1969) ladder of citizen participation and describe more recent spectrums of community engagement from the International Association for Public Participation (AIP2) (inform; consult; involve; collaborate (includes creating solutions); empower (or citizen-led decision-making)).

Co-production of knowledge

Participatory approaches include co-production of knowledge at grass-root levels; community empowerment to inform and implement adaptation; and capacity building through a range of educational activities, workshops, and learning labs (Ziervogel et al. 2021). The term *co-production of knowledge* emphasizes the shared responsibility of actors to provide local and relevant knowledge as a baseline to inform problem solving (Polk 2015). At the community level, this can empower actors to assert perspectives with greater legitimacy and inform transformative adaptation (Ziervogel et al. 2021). A Royal Irish Academy White Paper from 2022 identifies benefits of co-production such as academic and non-academic partners working together and having access to expertise, knowledge and data; generation of research that is aligned with user needs; and creating buy-in and building capacity for taking action (Bolger et al. 2022). A co-production approach requires the creation of "spaces that are open, autonomous, unpredictable, dynamic, reflexive, and shared" (Polk 2015, p112).

Challenges and Barriers

Geekiyanage et al. (2021) identify challenges and barriers associated with participatory approaches from the literature, including potential capacity issues in communities. For example, civic participation tends to be less prevalent in more socially disadvantaged communities (Kavanaugh 2005) who can be time-poor and lack confidence or the knowledge required (Rowe and Frewer 2000; Marshall et al. 2024). There are also practical requirements, such as managing expectations, establishing clear protocols (Oliver et al. 2019) and clarity on a project's purpose and aims (Rowe and Frewer 2000; Gooch et al. 2018; Geekiyanage et al. 2020). In addition, DRCD et al. (2023) highlights the need to identify convenient times for engagement, provide adequate notice, ensure venues are accessible for everyone, and recognise language and literacy issues.

Motivating and recruiting participants can be challenging (Gooch et al. 2018) unless people feel deeply connected to the issues (Lowndes et al. 2001; Geekiyanage et al. 2021). Lowndes et al. (2001) explore reasons why many citizens tend not to participate in various types of engagement with Local Authorities, noting factors such as a negative view of the Local Authority; a lack of awareness of opportunities to participate; perceptions or experience of a lack of response from the Local Authority; and issues relating to social exclusion. Another factor is research fatigue, which may occur where projects require repeated engagement over time, certain groups repeatedly receive requests for participation (Clark 2008; Ashley 2020), or there is little evidence of tangible feedback or outcomes (Scottish Government 2017; Bokolo 2024). Potential failure to deliver beneficial outcomes can alienate stakeholders, compromise trust (Bolger et al. 2022) and damage reputations (Oliver et al. 2019).

Power dynamics exist in participatory approaches and can manifest in numerous ways, such as agenda control; who is invited to participate; scope (for example, funding structures can limit how much control can be released to citizens) and resources (time and people) (Gooch et al. 2018). Power dynamics exist between experts and non-experts (Knapp et al. 2019). Rowe and Frewer (2000) set out criteria for best practice in participation exercises, including engagement with a representative sample of the community

affected; conducting the participation process in an independent and unbiased way (for example, through a management team that includes diverse and neutral organisations such as universities); inviting the participation of the community as early as is practical; and ensuring the wider public can observe what is going on and how decisions have been made. Approaches to encourage participation include working closely with organisations that in some way represent the community to be engaged with, helping the project to access hard-to-reach communities and ensuring the invitation to participate is from people the prospective participants already know and trust (DRCD et al. 2023). Gooch et al. (2018) present a four-stage model of participation for addressing issues experienced by a community (identify the problems; generate ideas; develop projects; sustain success) and note that a face-to-face approach generated dialogue related to hyperlocal challenges, whereas an online approach produced more generic responses.

Co-creation and co-design

Participatory approaches can also include co-creation or co-design, accommodating a broad range of design modes from diffuse (non-expert) to expert design, where people are actors in the process and not simply users, and networks (uncoordinated) and coalitions (coordinated) are created that operate on different scales that are interlinked and interdependent (Manzini 2015). Public and private actors proactively and collaboratively generate innovative and context specific solutions that create public value and address societal challenges such as climate change (Hofstad et al. 2022). The co-design with communities of methodologies and outputs is considered critical in the context of climate action (Nyhan et al. 2022; Hofstad et al. 2022). Transformative adaptation requires a shift from a top-down approach to processes of co-creation (Ziervogel et al. 2021).

In this paper we report on findings from *Ripple: Making Connections between Water and Climate Change in our Towns*, one of 15 Creative Ireland Climate Action funded projects (see Nyhan et al. 2022 for a report on all projects). The overall project aims were to co-create and test a creative and engaged approach to the design of climate resilient green space, involving residents, artists, and academics; and to explore how this could be scaled up and out to communities across Ireland, to change not just the physical and environmental character, but also the social and cultural values of these spaces, through collaborative placemaking. In doing so, we intended to answer the following research questions:

- (a) Does a transdisciplinary approach to co-design support local action-based climate initiatives?;
- (b) How can place-based approaches to co-creation be more inclusive? and
- (c) Can a scalable set of tools be developed for application in other projects and communities?

Methodology

The method described below was tested in a case study location. This was in a suburban social housing estate in Ballina, County Mayo, Ireland (Fig. 1). Ballina is located on the banks of the river Moy which flows into the Atlantic Ocean less than 10 km away. Rivers,



Fig. 1 Case Study Location and Context Map

lakes and the ocean have historically been an essential resource for the town, as a source of food, enabling trade, powering industries and supplying mineral water from a town centre spring. More recently, however, the decline in industries reliant on water has coincided with a decline in the economic success of the town, which now suffers from high unemployment and areas of deprivation. The housing estate in which the project was located was built in the 1980's. It comprises a population of 436 people in 197 homes and is elevated just above the confluence of the river Brusna and the river Moy. The housing estate is described as "extremely disadvantaged" on the Pobal HP Deprivation Index with a deprivation index of between -44.99 and -36.59 (Pobal 2022). The town of Ballina (population: 10,566 in 2022) varies between "Affluent" (17.00) and "Extremely Disadvantaged" (-47.61) on the Pobal HP Deprivation Index (Pobal 2022). There are high levels of unemployment (male unemployment rate: 43.14-64.29%; female unemployment rate: 29.73-31.25%). The lone parent ratio for the estate is between 36 and 56%, less than 7.59% of residents have received third level education, and 26-30% of residents only have primary level education. Despite these disadvantages, there is a strong community in the estate. The Residents Association have successfully campaigned to the Local Council for improved services and amenities in recent years. The community also has an active biodiversity group, with many residents passionate about biodiversity and the interdependence of water and local ecosystems. Both of these groups were involved in the early set up stage of the project in the estate and continued to support the project throughout its duration.

Transdisciplinary team

Key to the approach of the project was its transdisciplinary team. The Ripple team was composed of seven members: three academics based in University College Dublin; two representatives of Ballina Greenest Town; a practicing artist; and a Project Coordinator. The expertise of the team included registered architects specialising in engaged spatial practice and Irish towns; an engineer specialising in water systems; an independent councillor in Mayo County Council; and a creative practitioner whose work concerns embodied and spatial responses to climate change. The Project Coordinator managed logistics, communications and events and coordinated on the ground with residents throughout the duration of the project.



Project stages

The project involved five stages (Fig. 2). Stage 0 involved project set up, recruitment, graphic design and administrative set up within University College Dublin's Research and Finance structures. Ethical approval was sought for Stage 1. The estate was identified as a potential location for the place-based project and initial meetings were held with representatives of the Residents Association and the Biodiversity Group to gauge interest and support.

Stage 1 – Storytelling – involved a paper-based questionnaire (Appendix 1) and an in person workshop. The questionnaire was distributed to every household in the estate to record baseline quantitative and qualitative data on attitudes to both climate action and water. In the first workshops, held in February 2022, residents were invited to add their stories, feelings and perspectives about places in the estate to a collective map. Visual story cubes and sticker sheets with symbols were used to prompt sensory, playful or memory based responses such as sunny spot, noisy, soggy, puddle, wildlife, danger!, flood, squishy, marshy, dull, lovely as it is, could be better, as well as a prompt for further detail, using the "there is a story here" sticker (Fig. 3). Participants could



Fig. 3 Storymapping Workshop

also add their thoughts or drawings to the physical workshop pergolas, which had large raindrops added in hygroscopic paint. When it rained the paint became transparent revealing the idea or drawing beneath.

The results from the questionnaire and the mapping workshop were then combined into an illustrated map that was issued to all households, with an invitation to attend the next co-design workshop event. Full ethical approval for Stage 2 was then sought.

There were three on-site workshops in Stage 2, in March, May and July. These workshops involved idea generation, a democratic voting process to shortlist ideas, and staking out the preferred option on the ground to scale. In Stage 2's first workshop, the team sought to collaboratively design climate resilient ideas related to water and the common green spaces in the estate. Visual story cubes, this time with prompts of water- and nature-based solutions such as bio-swales, meadows, rain gardens and water butts, and sticker sheets with prompts were used to support the annotation of large scale maps full of participants' ideas, as had been done in the Storytelling phase. In the second Co-design Workshop (May 2022) residents were invited to vote for their favourite five ideas and discuss any hopes or concerns for the proposed ideas. In the third workshop (July 2022) the top ranking ideas were discussed further and staked out on the ground. Residents could veto proposals to which they strongly objected. The Paradise Garden was selected and taken forward to the making stage. The team appointed a landscape architect to advise on and develop the detailed design. The Paradise Garden was envisaged as a nature-friendly intergenerational meeting place, which also acted as a rain garden, slowing the movement of water in what was identified as an area prone to minor flooding. Residents also wished to include vegetable and flower planting, fruit trees and spaces to sit and for children to play and enjoy nature.

Stage 3 involved detailing the Paradise Garden and appointing contractors to make and install it. The contract was divided into three separate parts: hard landscaping, soft landscaping including planting, and woodworks including specialist timber play elements, raised beds and seating. Mayo County Council advised on services and gave input on future maintenance of the design. The developed design was discussed with the residents during a Community Day, and a workshop focused on water quality in the River Brusna was hosted with an ecologist. On-site sampling of water quality in the river and soil moisture content and soil type was conducted with the residents. As the works progressed on site during October and November, residents were invited to a planting workshop, with discussions of plant care and future maintenance of the garden. The local Karen Community Garden also facilitated a garden visit to share knowledge and plants with the local Biodiversity Group.

The focus of Phase 4 was to evaluate the impact of the Project with the residents using two methods: a questionnaire, issued to all residents, and a dedicated workshop involving a participatory Ripple Effect Mapping (REM) technique. REM was used to evaluate the community's perspective of the project, its outputs and outcomes. REM is a qualitative method for conducting impact evaluation using a diagramming process that represents connections hierarchically (Kollock et al. 2012). The team adapted a method from Chazdon et al. (2017) to discuss, understand and document what was achieved, how residents were engaged, and the project outcomes.

Results

Storytelling

Initial Household Surveys were delivered to 197 houses in the estate. There were 36 (18%) questionnaires returned, of which 7 were unfilled, 10 were void and 19 were valid. The validation process required surveys to be signed and full consent agreed. The initial survey revealed that 88% of respondents save water at home, that the majority (76.5%) are concerned about climate change, and that 58% felt empowered to take action. In general, residents had a positive attitude to rain, and reported that they enjoy engaging with water in their neighbourhood.

Twenty-four residents attended the Storytelling Workshop, annotating large scale maps and verbally sharing their experiences with team members. The results of this are shown on an illustrated map of the estate, with key statistics from the questionnaire (Fig. 4). A copy of the map and project update was then delivered to every household in the estate.

Codesign

In the first co-design workshop in March 2022, twenty-four people attended and shared a range of ideas, including a 'herby rain garden'; 'rainwater collection champions'; a 'ripple mural', 'water trail' and an 'eco bus stop'. These were collated in an illustrated map that was distributed to every house in the estate (Fig. 5).

The sixteen co-designed ideas were translated into an outline sketch, accompanied by a short text description, and ranked by the project team on a scale of 0 to 3 raindrops in terms of their likelihood of attenuating rainwater (Fig. 6).

In the second Co-design Workshop (May 2022), where residents were invited to vote for their favourite five ideas (Fig. 6). The two ideas with the total number of votes and



Fig. 4 Ripple Storymap



Fig. 5 Ripple Co-Design Idea Map



Fig. 6 Collecting Votes at the 2nd Co-Design Workshop

weighted rank (allocating a different value for first to fifth preference) were the Eco Bus Stop and the Paradise Garden (Fig. 7). These were also two of the highest scoring ideas in terms of potential impact on water resilience-a criterion determined by the team. Residents could veto proposals to which they strongly objected. Despite a strong support for the Eco Bus Stop idea, a number of residents raised concerns about it. As such, the Paradise Garden-which had no recorded objections-was taken forward to the Making Stage.



Fig. 7 Result of the voting showing total number of votes, composition of 1 st - 5.th preference votes, and potential impact of solution on water resilience (water drops)

Making

Once quotations were sought and contractors appointed, work on site commenced in September 2022. A letter updating residents was delivered to all households and included an invitation to a final evaluation and planting workshop once the construction was completed.

The Paradise Garden design encouraged water runoff to flow and collect in a constructed well, which overflowed to a contoured rain garden, planted with water tolerant plants and surrounded by a wildflower meadow interspersed with fruit bushes and trees. Bespoke timber seating and large scale timber play elements encouraged nature based play, and raised beds accommodated vegetable and herbs for cultivation by residents. All planting was locally procured and favoured native and organically propagated plants. The construction was complete in November and residents were invited to plant up the raised beds with vegetables and tree nursery with acorns sourced from the local Old Head oak forest (Figs. 8 and 9).

Evaluation

Quantitative and qualitative methods were employed to evaluate engagement with the project. The questionnaires were sent to 197 households. For the baseline entry questionnaire, 36 were returned (17.6%), of which 19 were valid (9.3%), 7 were blank, and 10 were void. For the concluding questionnaire, 17 were returned (8%), of which 16 were valid and 1 was missing signed consent and therefore void. There was no trend in the number of participants recorded at each event over the project duration (Table 1). The minimum and maximum numbers observed were for events that were separate to the workshops—i.e. the guided tour and the community day, respectively. The number of participants per workshop was fairly consistent, although there was some variation in the exact composition of attendees. The largest recorded engagement was for Co-Design Workshop 2 in which 84 responses were recorded



Fig. 8 Residents planting up the Paradise garden at the final workshop



Fig. 9 The completed Paradise Garden—Summer 2023

(41% of the households). There were 84 unique participants recorded across all events at which consent was gathered. (This excludes the Community Day and the Voting Responses gathered at Co-Design Workshop 2.) Of these, 24 were children for whom Parental Consent was gathered. 60 participants attended just one event, 15 people attended 2 events, 4 attended 3 events, 1 attended 4 events, 2 attended 5 events and 3 people attended 6 events. Due to ethics considerations, no data was gathered from participants about age, ethnicity, income levels, time living in the estate. However, given the overall population of the estate of 436, the recorded participation is evidence of both a breadth of engagement (17% of the total recorded population of the

Table 1 Engagement Events and Participation

Public engagement events	Purpose	Date	No. of Recorded Responses/ Participants
Household Questionnaire 1	Baseline entry questionnaire to gauge attitudes to climate action and water	February 2022	19
Story Mapping Workshop	Workshop to gather and map stories, experiences, memories and perspectives related to water in the estate with local residents	February 2022	24
Do-Design Workshop 1	Workshop to gather and map ideas for positive change in the estate related to water and climate action	March 2022	24
Co-Design Workshop 2	Workshop to vote on and shortlist preferred ideas for implementation, and to identify vetoes	May 2022	16 in person plus 68 household votes submitted (84 total)
Co-Design Workshop 3	Workshop to stake out and modify selected ideas on the ground	July 2022	17
Community Day	River Ecology workshop	August 2022	Unrecorded numbers as local community organised event— estimated 100 +
Karen Community Garden guided tour	Visit and tour of nearby Karen Community garden to share ideas around planting, care and maintenance of a com- munity garden	October 2022	Core biodiversity group mem- bers—4
Evaluation Workshop	Workshop to evaluate the process and project using Ripple Effect Mapping—and to carry out planting of gar- den and information session	November 2022	8
Household Questionnaire 2	Closing questionnaire to identify any changes or impacts of the project on attitudes to climate action and water	November 2022	16

estate attended at least one event), and a focused group of approximately 25 people who attended between 2 and 6 events. This data is visualised in Appendix 2. Data from the Pobal Deprivation Index referred to above indicates the level of deprivation specific to the estate and gives a picture of the broad demographic and social challenges facing the population.

In the concluding questionnaire, 87% of respondents agreed or strongly agreed that they felt more empowered to take action on climate change after participating in the project (Fig. 10).

Similarly, 87% of respondents reported that the creative aspect of the project made them feel more engaged with Climate Action (Fig. 11), with one participant commenting, *"Being shown all the projects and ideas at the start shows that so much be done for climate action"*, and another who noted that the *"water survey was great as certain creatures are only in water of a certain quality. Pollution or temperature change could damage fragile co-systems"*.



Fig. 10 Responses to Q2 of the concluding questionnaire, 'I feel more empowered to take action related to climate change after attending and/or participating in the Ripple project'



Fig. 11 Responses to Q3 of the concluding questionnaire, 'The creative aspect of the project made me feel more engaged with climate action'

The team designed a bespoke REM exercise to capture resident's opinions on the achievements of the project; how we engaged with participants in the project, and what they thought the impact of the project was. Participants reported that they were delighted to see the project culminate in a tangible output, and appreciated the "bottom up" approach which allowed them to realise their ambitions for their neighbourhood and have a direct involvement in the design process, which was "empowering". They saw that their actions, energy and commitment could achieve tangible results. The value of the practical water-related workshops ["great to have hands-on activities"] was noted, which participants felt were an enjoyable, engaging and intergenerational way to learn

about water, river biodiversity and resource management. They made a direct connection between their own actions to protect their environment and the health and biodiversity of their local waterways.

Residents appreciated the different modes of communication about the project; including regular updates to every household ["door to door updates were useful for those that couldn't attend"], and via the information area at the tennis courts. They felt listened to, in terms of the idea taken forward ["local knowledge, photos and stories were shared to inform the design"] and where it was placed, ["residents were involved in the location choice as well as design ideas"].

They reported that the voting exercise was a helpful way to ensure that all voices – both positive and critical – were taken into account in the co-design process, noting that "designs were revised to reflect residents' concerns" and that the "process had generated lots of ideas for future projects". Participants enjoyed making new connections during the project, but also importantly, continuing on beyond the immediate project and neighbourhood. Participants see the Paradise Garden as a beginning to be built on, more than a conclusion, commenting that, "residents had begun to plant up the veg beds" and that those who had interacted with the workshops would, "facilitate others to use and maintain the garden". They reported new connections with their neighbours, with the Karen Community Garden and the local Secondary School, and that the biodiversity group had grown in membership throughout the project duration.

Discussion

(a) Does a transdisciplinary approach to co-design support local action-based climate initiatives?

The project reflects the cross-disciplinary input, not only in the design itself, but in the methods in which the design came about, and the way in which the project team, and wider stakeholders, facilitated the projects' implementation and subsequent adoption by the local community. Ripple demonstrated how engineering, architecture and creative art practice can combine to achieve more than the sum of their parts.

The Ripple project embraced a transdisciplinary approach, with academic, social enterprise, local government and community partners bringing together different knowledge, expertise and experience, and working together to co-produce knowledge and solve problems on the ground (Polk 2015; Thompson Klein 2015). The project team's specialised expertise was used at various stages. For instance, the water engineer contributed examples of nature-based water management during co-design; architects produced scaled drawings of the estate and concept sketches of solutions; the artist led creative expression using hygroscopic paint, and the politician facilitated and expanded engagement between the community, the project team and relevant members of the local authority. However, disciplinary boundaries were also fluid, the water engineer had a keen interest and abilities in drawing and garden design, the artist had a deep understanding of climate science, and a community which had a considerable biodiversity knowledge and practical experience, all highlighting the need to avoid a reductive understanding of different disciplines and sectors. All team members contributed to event facilitation. Workshops often had several workstations for residents to interact with different members of the project team to define, explore and design creative solutions to water-related climate change in the estate.

The transdisciplinary approach in Ripple reflects an adaptive co-management structure where top-down and bottom-up actors can meet and collaborate, with the project team acting as bridging organisation (Folke et al. 2005), facilitating multi-level engagement (as promoted in the New European Bauhaus Working Principles (EC, 2022)), and reflecting the import "of improving synergies between national authorities and community-based initiatives for supporting inclusive participation and effective climate action", and the need for science projects to work across disciplines and communities towards tangible solutions (Nyhan et al. 2022, 8). The Ripple project can be seen to provide the local community with agency to evolve their own response strategies (after Wardekker et al. 2010).

A transdisciplinary approach can provide an opportunity to connect best practice and knowledge, and respond to interconnected factors relating to values, benefits, perceptions and behaviour relating to environmental changes through a range of "more nuanced methodologies" (Nyhan et al. 2022, 8). In Ripple, these included storytelling and voting, that helped the project respond to cultural and political dimensions of the particular community and place (Knutti 2019), and gain what appears to have been a high level of acceptability and trust within the local community, judging from the survey responses.

Transdisciplinary approaches require a change in mindset in how we evaluate and fund projects, not only to facilitate deep and effective collaboration between STEM and AHSS disciplines (Knutti 2019) and between different sectors, but also to allow projects to be truly/transparently responsive (it is not always possible to define with certainty how the project will proceed) and allow for uncertainty and evolution. The funding proposal for the Ripple project did not define challenges or solutions as these were only known after interaction between different actors and systems in the transdisciplinary process through the project stages. The project was funded by a creative arts organisation, and provides a template for building in this flexibility, and demonstrates potential benefits of the changes required.

(b) How can place-based approaches to co-creation be more inclusive?

Ripple was designed to be piloted in an area categorised on a national index as being of high deprivation to deliberately try to address the just transition for decarbonisation - to leave no one and no place behind. The project aimed to bridge the "knowledge-action gap" identified above to put people and communities at the heart of the design process, giving a voice and agency to those who may ordinarily feel disconnected from or over-whelmed by the complexity of climate change discourse and action. (Kundzewicz et al. 2020; Feldman and Hart 2021). The following strategies underpinned this approach.

A deliberate emphasis was placed on collecting and sharing positive stories about the neighbourhood during the Storytelling stage, as well as best practice, innovative examples of what can be done to improve climate resilience at a neighbourhood scale, during the Co-Design stage. By focusing on the positive—what can be done—instead of what needs to be 'fixed', the net impact was empowering, with 87% of participants either agreeing or strongly agreeing that they felt more empowered to take action in relation to

climate change after participating in the project. This affirms the underlying principles of the New European Bauhaus, connecting the value of and need for beauty and inclusion as co-pillars with sustainability in order to radically transform neighbourhoods, methods of production and behaviours in parallel to respond to climate change (European Commission 2024).

Clear and varied modes and tools of communication and engagement were designed and used throughout all stages of the project. The combination of expert and non-expert collaboration, active and passive options to engage, along with clear and open communication using multiple methods, demonstrates the benefit of approaches described by Manzini (2015) and Hofstad et al. (2022). Engagement methods included in person workshops, events and hands-on activities; anonymous feedback in a neighbourhood mailbox; illustrated mail drops, a looped video shown in the local supermarket, information posters and regular face-to-face contact with the project co-ordinator. This active and varied approach accompanied by rigorous ethical review, indicates the value of the human research ethics system as a critical friend to co-creation. It also points to the need for similar critical reviews or guidelines in any broader roll out of co-creation to ensure that protocols for inclusion, information, consent, data, diversity are afforded adequate time as part of co-design and co-creation projects.

Furthermore, the research team had to balance the need for comprehensive data collection with participants' willingness to engage. In an effort to minimise research fatigue, and ensure adequate participation, the research team chose to intentionally reduce the amount of demographic data collected. This simplified the consent process, so it was straightforward to describe in the ethical review, and less obtrusive for participants to complete. While this approach limited the quality of data on participants, it likely had a positive impact on the number of participants, the volume of ideas generated, and the positivity of the participants' engagement in the process.

Respect for local knowledge and networks echoes Polk's research on the value of coproduction of knowledge which sought to place value on deep local knowledge of the area to empower local actors to assert greater legitimacy and to inform transformative adaptation that is meaningful, relevant and special to them (Polk 2015). An added value of this approach is that more informed and aware place-making solutions can be realized through local highlighting of intangible traits – for example in Ripple the identification of sites of historic anti-social behaviour – that might otherwise not be picked up or understood by traditional placemaking strategies. The success or failure of public green space can depend on fragile networks, connections and processes and tuning into these through co-production methods allows more agency-based co-creation that builds on self-identified assets and respects boundaries and limits to change.

Building trust with the community was a gradual process. Our project leveraged pre-existing relationships within the community, particularly through our engagement with private crowds – such as the biodiversity group and the residents association, and through two team members who were born and raised in the town and actively involved in local community projects. These team members served as gatekeepers, facilitating engagement and ensuring accountability, reassuring the community that the project would not adopt a 'helicopter' approach but would be rooted in local context and concerns. The project outcomes would likely be significantly more difficult to achieve

in the absence of either of these existing relationships. Building trust takes time and as evidenced by participation rates in the course of the project, many and varied types of events during the course of the project were needed to ensure maximum inclusion and to gradually build trust around the project, its objectives and the reasonable expectation for its outcomes and trajectory after the project was completed. This would confirm challenges identified in the literature (Oliver et al. 2019), and point to the need for better and more longitudinal resourcing, and to embed co-creation skill sets within local authorities and other stakeholders tasked with implementing action on climate change.

Research suggests that participants can become frustrated or fatigued when there is no clear and tangible outcome from their involvement. The continued engagement seen in this project – with 84 unique participants across events, and 28.6% of participants attending more than one event – is likely to be related to the participants' knowledge that there would be a relatively quick return on investment, with funding ring fenced to be spent within their estate within the projects' timeline. This demonstrated a tangible output for their participation which not only facilitated engagement but helped to establish trust and intentions. Often, tangible outcomes can be frustrated by complex funding, procurement and regulatory conditions. A more agile, flexible regulatory environment could make tactical low risk project outcomes easier to achieve, thereby helping to build trust through recognisable and impactful action.

By earning the trust of a community in an area of high deprivation through active participation, co-production of knowledge and co-design, it flips the usual model of high level experts, to one of bottom-up action, based on locally defined priorities and arguably allows for more rapid and transformative adaptation that is local responsive, as called for by Ziervogel et al. (2021). As one resident noted "Every neighbourhood should have the opportunity to take part in a project like this".

(c) Can a scalable set of tools be developed for application in other projects and communities?

Ripple was specifically designed to be based in a suburban housing estate to test whether the proposed process could work in such a setting. Suburban and peripheral housing neighbourhoods are widespread in Ireland. Most of them include notional green spaces that, while included as part of the planning process, are almost always underused grassed areas that require regular maintenance, but have little social or physical resilience. Such places offer significant potential to absorb rain water run-off, to be more biodiverse, to become habitats and corridors for nature, and to be of more social value to the communities who live near them.

One of the project's aims was to develop a scalable approach that could be used across different communities, due in part to the ubiquity of underused green space in housing estates around Ireland, the indiscriminate nature of climate change impacts across communities, and the need to engage citizens from all sectors in climate change decisions (EPA 2019; Government of Ireland 2022c; Bolger et al. 2022).

Whilst the project wasn't specifically about water management, this was an example of how climate action can be applied to something which is tangible to local communities given the heightened probability of fluvial and pluvial flooding from changes in precipitation patterns (Government of Ireland 2024a, Government of Ireland, 2024b; OPW 2023). However, the approach could equally be applied to the design and upgrade of public space, urban greening or sustainable transport initiatives demonstrating scalability.

The tools developed offer a means of addressing the 'knowledge-action gap' (Government of Ireland 2022c) by providing a structure of activities that can be used to support communities that may otherwise feel disconnected from climate action. By seeking to capture personally and culturally relevant information that is meaningful to a specific place or community (Schweizer et al. 2013; Monroe et al. 2019), and discussing physical changes to their local environment (Nisbet 2009), our process sought to overcome the knowledge-action gap through tangible activities that built trust, developed knowledge, redefined power dynamics and empowered communities to implement project outputs (Ziervogel et al. 2021).

The potential exists for local authorities to use the methodology and tools in any of the neighbourhoods in their charge, by deploying in-house skills. This also has the potential to build strong relationships between communities and their local authority, as collaborative partners in the stewardship and future regeneration of the spaces they inhabit, and contributing actors in building cohesive and resilient communities.

However, whilst the tools are in theory scalable, one of the challenges in implementing them is the capacity of agencies or organisations to deploy them in their communities. There is a potential risk of failure if organisations do not have the resources required to facilitate such an engaged process, if they do not adequately manage expectations (Oliver et al. 2019), or if they are unable to adequately balance the power dynamics between different stakeholder inputs (Knapp et al. 2019).

Scalable use of these tools therefore requires dissemination of their benefits and limitations. To date, the tools have been shared with Climate Action officers during the Mary Robinson Climate Conference; at the Architecture at the Edge festival in 2023; and through the Europe-wide New European Bauhaus network, after the project received a prize in the Reconnecting with Nature category demonstrating effective implementation of their values of beauty, sustainability and inclusion. The tools will be further scaled and tested in a second Creative Ireland Climate Action-funded project, 'Cascade', which aims to redeploy the 'Ripple' methodology in a new application.

Conclusions

This study reports the findings from *Ripple: Making Connections between Water and Climate Change in our Towns,* a 12-month long climate action project in Ireland.

We sought to co-create and test an engaged approach to the design of climate resilient green space through a model of respectful support, listening and practical hands-on activities. Our findings highlight the following:

- 1. Transdisciplinary teams working with communities, can achieve more positive and lasting results than actors within a single discipline.
- 2. Building trust is an important element of co-production and requires adequate time and focus to achieve lasting impact.
- 3. Diverse opinions and perspectives co-exist within communities and need to be respected.

- 4. The described methods of co-production could be replicated at scale and delivered by local authorities or other organisations provided adequate resources for facilitation and stakeholder input is available.
- 5. The engaged approach applied is not topic-specific and could be adapted to the design of other climate action initiatives, as required based on the needs identified from locals' knowledge, priorities and deep understanding of place. This approach helps to ensure a tangible return on investment for communities' trust and time.

The Paradise Garden was designed to require minimum maintenance and is now cared for by a small group of residents with overview by the local authority Parks Department. Members of the team have continued to engage with residents and visitors formally and informally in the garden since its completion, on at least 7 occasions. Further research is planned to gauge residents' views on the long-term impact of the project, how they use the garden and any challenges or benefits they have experienced related to it, since the completion of the project.

The approach of this project was time and resource intensive, and while the outcomes and impact were significant, a long-term liaison with the community beyond the funded time frame, built into the project funding, could ensure anticipated impact is planned for, maintained and built on.

Future research may seek to evaluate how transferable this method is in other communities, on other topics, or in different parts of the public realm.

No	Question		
Q1.1	Do you worry about Climate Change?		
Q1.2	Do you feel your own actions matter in regard to climate change?		
Q1.3	Do you feel empowered to take action in regard to climate change?		
Q1.4	Is there anything you think we could do in this project that might help you to take action in relation to climate change in your local neighbourhood of Greenhills estate?		
Q2.1	Do you like the rain?		
Q2.2	Have you ever experienced a flood in the estate?		
Q2.3	Have you ever experienced a drought in the estate?		
Q2.4	Have you ever experienced a Boil Water Notice in the estate?		
Q2.5	Do you try to conserve water in your household?		
Q2.6	How do you enjoy water in your area?		
Q2.7	In recent years have you noticed the following: It rains more frequently; It rains more heavily; It rains for longer; We've had longer dry spells; the river levels are less predictable; I haven't noticed any change		
Q3.1	What are the green spaces usually called?		
Q3.2	What activities currently happen in each green space?		
Q3.3	What spaces are more likely to flood, or be wet, or have puddles?		

Appendix 1

Appendix 2



Blinded number and frequency of event participants

Acknowledgements

We would like to acknowledge the following contributors to the project: Ripple Team Members—Mark Duffy, Kevin Loftus, Ríonach Ní Néill, Rebecca O'Malley; Roisín Byrne, Landscape Architect; Martin McGarrigle, River Ecologist; The Karen Community Garden; Kilcross Construction (project build); Shaws Garden Centre (project build); ABC of Gardening (project build); Alan Meredith Studio Joinery (project build) and St Muredach's Secondary School, Ballina who provided the project team with an office in their Innovation Hub. Additionally, Mayo County Council gave their full support to the project, advised on service connection, maintenance and technical design guidance, including rain garden implementation.

Artificial Intelligence Declaration

The authors acknowledge the use of Elicit.com to generate analysis of relevant research papers for this essay.

Authors' contributions

OM, SC and PC collectively conceptualized the study, participated in data collection, and co-wrote the methods, results, discussion and conclusions. SB completed the literature review search and drafted the introduction section. OM, SC and PC collectively edited all drafts of the manuscript. All authors read and approved the final manuscript.

Funding

Ripple was funded under the first round of Creative Ireland's Climate Action Call. Creative Ireland provided support on evaluation, knowledge sharing across teams and local contact points. Creative Ireland received their funding from the Department of Environment, Climate and Communications and the Department of Culture, Heritage and the Gaeltacht.

Data availability

The authors confirm that the data supporting the findings of this study are available within the article [and/or] or is available from the author upon reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval for each project stage was obtained through University College Dublin's Life Sciences Human Research Ethics Committee (LS-HREC). All community participants gave informed written consent to participate in the project's activities and contribute to published research outputs. Informed written consent for participants under the age of 18 was obtained with parent/guardian consent forms.

Competing interests

Not Applicable.

Received: 17 April 2024 Accepted: 27 December 2024 Published online: 13 February 2025

References

- Ahern J. From Fail-Safe to Safe-to-Fail: Sustainability and Resilience in the New Urban World. Landsc Urban Plan. 2011;100(4):341–3. https://doi.org/10.1016/j.landurbplan.2011.02.021.
- Arnstein S. A ladder of citizen participation. J Am Inst Plann. 1969;35:216–24. https://doi.org/10.1080/0194436690 8977225.
- Ashley F. Accounting for research fatigue in research ethics. Bioethics. 2020;35:270-6.
- Baybay CSQ, Hindmarsh R. Resilience in the Philippines through effective community engagement. 2019.
- Bolger P, Brereton P, Grant O, Torney D. Better together: knowledge co-production for a sustainable society. 2022. https://www.ria.ie/news/science-committees-climate-change-and-environmental-sciences-committee/ ria-white-paper-better.
- Bokolo A. The Role of Community Engagement in Urban Innovation Towards the Co-Creation of Smart Sustainable Cities. J Knowl Econ. 2024;15(1):1592–624. https://doi.org/10.1007/s13132-023-01176-1.
- Bookchin M. The Ecology of Freedom: The Emergence and Dissolution of Hierarchy. Black Rose Books; 1991.
 Butler D, Ward S, Sweetapple C, Astaraie-Imani M, Diao K, Farmani R, Fu G. Reliable, resilient and sustainable water management: the Safe & SuRe approach. Glob Chall. 2016;1(1):63–77. https://doi.org/10.1002/gch2.1010.
- Chazdon S, Emery M, Hansen D, Higgins L, Sero R. A field guide to ripple effects mapping. University of Minnesota Libraries Publishing; 2017. Retrieved from the University of Minnesota Digital Conservancy, https://hdl.handle. net/11299/190639.
- Clark T. "We're over-researched here!": Exploring accounts of research fatigue within qualitative research engagements. In: Sociology. Vol. 42, Issue 5. SAGE Publications Ltd.; 2008. p. 953–70. https://doi.org/10.1177/00380 38508094573.
- Climate Change Advisory Council. Annual Review 2020. 2020. https://www.climatecouncil.ie/councilpublications/annua Ireviewandreport/.
- Collier MJ, Scott M. Conflicting Rationalities, Knowledge and Values in Scarred Landscapes. J Rural Stud. 2009;25(3):267–77. https://doi.org/10.1016/j.jrurstud.2008.12.002.
- Department of Rural and Community Development (DRCD), Pobal, Community Work Ireland, & Irish Local Development Network. 2023. A Guide for Inclusive Community Engagement in Local Planning and Decision Making. https://www. gov.ie/pdf/?file=https://assets.gov.ie/282582/5db44ee8-17b4-4bbd-b20a-9a4d25efce4f.pdf#page=null.
- Desmond O'Mahony, Conor Quinlan, Eimear Cotter, Mary Frances Rochford, Anthony Leiserowitz, Aoife O'Regan, Jennifer Carman, & Seth Rosenthal. Climate Change in the Irish Mind: Wave 2, Report 1. 2024. https://www.epa.ie/publicatio ns/monitoring-assessment/climate-change/Climate-Change-in-the-Irish-Mind-Wave-2-Report-1.pdf.
- Environmental Protection Agency. How do we engage communities in climate action? Practical learnings from the coal face. 2019.
- European Commission. New European Bauhaus. 2024. https://new-european-bauhaus.europa.eu/index_en.
- Feldman L, Hart PS. Upping the ante? The effects of "emergency" and "crisis" framing in climate change news. Clim Change. 2021;169(1–2):10. https://doi.org/10.1007/s10584-021-03219-5.
- Folke C, Hahn T, Olsson P. Adaptive Governance of Social-Ecological Systems. Annu Rev Environ Resour. 2005;30:441–73. Fox E, Rau H. Disengaging citizens? Climate change communication and public receptivity. Ir Pol Stud. 2017;32(2):224–46. https://doi.org/10.1080/07907184.2017.1301434.
- Geekiyanage D, Fernando T, Keraminiyage K. Assessing the State of the Art in Community Engagement for Participatory Decision-Making in Disaster Risk-Sensitive Urban Development. Int J Disaster Risk Reduction. 2020;51. Elsevier Ltd. https://doi.org/10.1016/j.ijdrr.2020.101847.
- Geekiyanage D, Fernando T, Keraminiyage K. Mapping participatory methods in the urban development process: A systematic review and case-based evidence analysis. Sustainability (Switzerland). 2021;13(16). MDPI. https://doi.org/10.3390/su13168992.
- Gooch C, van der Linden J. Amplifying Quiet Voices: Challenges and Opportunities for Participatory Design at an Urban Scale. ACM Trans Comput-Hum Interact (TOCHI). 2018;25(1).
- Government of Ireland. Climate Action and Low Carbon Development (Amendment) Bill 2021. 2021. https://www.gov.ie/ en/publication/984d2-climate-action-and-low-carbon-development-amendment-bill-2020/.
- Government of Ireland. Town Centre First: A Policy Approach for Irish Towns. 2022a. https://www.gov.ie/en/publication/ 473d3-town-centre-first-policy/.
- Government of Ireland. Climate Conversations Summary Report 2022. 2022b. https://www.gov.ie/en/publication/bb1a3climate-conversations/#2022.
- Government of Ireland. National Dialogue on Climate Action (NDCA) Monitoring and Evaluation Report 2022. 2022c. https://www.gov.ie/en/publication/4bf2c-national-dialogue-on-climate-action-ndca/#ndca-monitoring-and-evalu ation-report-2022.
- Government of Ireland. Climate Action Plan 2023. 2023. https://www.gov.ie/en/publication/7bd8c-clima te-action-plan-2023/.
- Government of Ireland. Climate Action Plan 2024. 2024a. https://www.gov.ie/en/publication/79659-clima te-action-plan-2024/.
- Government of Ireland. National Adaptation Framework 2024, Planning for a Climate Resilient Ireland. 2024b. https://www.gov.ie/en/publication/fbe331-national-adaptation-framework/.
- Grasham CF, Calow R, Casey V, Charles KJ, de Wit S, Dyer E, Fullwood-Thomas J, Hirons M, Hope R, Hoque SF, Jepson W, Korzenevica M, Murphy R, Plastow J, Ross I, Ruiz-Apilánez I, Schipper ELF, Trevor J, Walmsley N, Zaidi H. Engaging with the politics of climate resilience towards clean water and sanitation for all. Npj Clean Water. 2021;4(1):1–4. https://doi.org/10.1038/s41545-021-00133-2.
- Hagan S. Ecological Urbanism: The Nature of the City. Routledge; 2014.
- Hofstad H, Sørensen E, Torfing J, Vedeld T. Designing and leading collaborative urban climate governance: Comparative experiences of co-creation from Copenhagen and Oslo. Environ Policy Gov. 2022;32(3):203–16. https://doi.org/10. 1002/eet.1984.

IPCC. Climate Change 2023 Synthesis Report. 2023. https://www.ipcc.ch/report/ar6/syr/.

Kavanaugh A, Carroll JM, Rosson MB, Reese DD, Zin TT. Participating in civil society: The case of networked communities. Interact Comput. 2005;17(1):9–33. https://doi.org/10.1016/j.intcom.2004.10.006.

Khatibi FS, Dedekorkut-Howes A, Howes M, Torabi E. Can public awareness, knowledge and engagement improve

climate change adaptation policies? Discov Sustainability. 2021;2(1):18. https://doi.org/10.1007/s43621-021-00024-z. Klein JT. Reprint of 'Discourses of Transdisciplinarity: Looking Back to the Future'. Futures. 2015;65:10–6. https://doi.org/10. 1016/j.futures.2015.01.003.

Knapp CN, Reid RS, Fernández-Giménez ME, Klein JA, Galvin KA. Placing Transdisciplinarity in Context: A Review of

- Approaches to Connect Scholars. Soc Action Sustainability. 2019;11(18):4899. https://doi.org/10.3390/su11184899. Kollock DH, Flage L, Chazdon S, Paine N, Higgins L. Ripple effect mapping: A "Radiant" way to capture program impacts. J Ext. 2012;50(5):5TOT6.
- Knutti R. Closing the Knowledge-Action Gap in Climate Change. One Earth. 2019;1(1):21–3. https://doi.org/10.1016/j. oneear.2019.09.001.

Kundzewicz ZW, Matczak P, Otto IM, Otto PE. From "atmosfear" to climate action. Environ Sci Policy. 2020;105:75–83. https://doi.org/10.1016/j.envsci.2019.12.012.

Latkin C, Dayton L, Bonneau H, Bhaktaram A, Ross J, Pugel J, Latshaw MW. Perceived Barriers to Climate Change Activism Behaviors in the United States Among Individuals Highly Concerned about Climate Change. J Prev. 2023;44(4):389– 407. https://doi.org/10.1007/s10935-022-00704-0.

Lowndes V, Pratchett L, Stoker G. Trends in Public Participation: Part 2 - Citizens' Perspectives. Public Adm. 2001;79(2):445–55.

Manzini E. Design, When everybody designs: an introduction to design for social innovation. The MIT Press; 2015. https:// www.academia.edu/43526442/Design_When_Everybody_Designs.

Marshall S, Farndon D, Hudson-Smith A, Kourniotis A, Karadimitriou N. Urban Design and Planning Participation in the Digital Age: Lessons from an Experimental Online Platform. 2024. https://doi.org/10.3390/smartcities7010025.

Met Éireann. Annual Climate Statement for 2023. 2023. https://www.met.ie/annual-climate-statement-for-2023#:~:text= Annual%20rainfall%20totals%20ranged%20from,18th%20August%20during%20storm%20Betty.

Monroe MC, Plate RR, Oxarart A, Bowers A, Chaves WA. Identifying effective climate change education strategies: a systematic review of the research. Environ Educ Res. 2019;25(6):791–812. https://doi.org/10.1080/13504622.2017. 1360842.

- Mooney ME, Middlecamp C, Martin J, Ackerman SA. The Demise of the Knowledge-Action Gap in Climate Change Education. Bull Am Meteor Soc. 2022;103(10):E2265–72. https://doi.org/10.1175/BAMS-D-21-0256.1.
- Moser SC, Ekstrom JA. A framework to diagnose barriers to climate change adaptation. Proc Natl Acad Sci. 2010;107(51):22026–31. https://doi.org/10.1073/pnas.1007887107.
- Mostafavi M, Doherty G. editors. Ecological urbanism. Springer; 2010.
- Nisbet MC. Communicating Climate Change: Why Frames Matter for Public Engagement. Environ Sci Policy Sustainable Dev. 2009;51(2):12–23. https://doi.org/10.3200/ENVT.51.2.12-23.
- Nolan P, O'Sullivan J, McGrath R. Impacts of climate change on mid-twenty-first-century rainfall in Ireland: a high-resolution regional climate model ensemble approach. Int J Climatol. 2017;37(12):4347–63. https://doi.org/10.1002/joc. 5091.
- Nyhan M, O'Dwyer B, Columbié YJ. Connecting People to Climate Change Action: Informing Participatory Frameworks for the National Dialogue on Climate Action (C-CHANGE). 2022. https://www.epa.ie/publications/research/climatechange/Research_Report_425.pdf.
- Oliver K, Kothari A, Mays N. The dark side of coproduction: do the costs outweigh the benefits for health research? Health Res Policy Syst. 2019;17(1):33. https://doi.org/10.1186/s12961-019-0432-3.

Olsson, Per, Lance H Gunderson, Steve R Carpenter, Paul Ryan, Louis Lebel, Carl Folke, and C S Holling. Shooting the Rapids: Navigating Transitions to Adaptive Governance of Social-Ecological Systems. Ecol Soc. 2006;11(1):art18–art18. https://doi.org/10.5751/ES-01595-110118.

O'Neill S, Gleeson C, Torney D, Mercier S, Daly C, Wall R. Environmental Justice in Ireland: Key dimensions of environmental and climate injustice experienced by vulnerable and marginalised communities. 2022. https://communityl awandmediation.ie/wp-content/uploads/2022/03/Environmental-Justice-in-Ireland-230322-1.pdf.

OPW (Office of Public Works). Managing Flood Risk in Ireland - Leaflet. 2023. https://www.gov.ie/en/policy-information/ dd855f-flood-risk-management/.

Pickett STA, Cadenassso ML, Grove JM. Resilient Cities: Meaning, Models, and Metaphor for Integrating the Ecological, Socio-Economic, and Planning Realms. Landsc Urban Plan. 2004;69:369–84.

Pobal. Pobal Deprivation HP Indices. 2022. https://data.pobal.ie/portal/apps/experiencebuilder/experience/?id=3b0ac ba7eb694ffa85340a60f81d516c. Accessed 5 Apr 2024.

Polk M. Transdisciplinary co-production: Designing and testing a transdisciplinary research framework for societal problem solving. Futures. 2015;65:110–22. https://doi.org/10.1016/j.futures.2014.11.001.

Rolston A, Jennings E, Linnane S. Water matters: An assessment of opinion on water management and community engagement in the Republic of Ireland and the United Kingdom. PLoS ONE. 2017;12(4). https://doi.org/10.1371/journal.pone.0174957.

Rowe G, Frewer LJ. Public Participation Methods: A Framework for Evaluation. 2000.

- Ryan C, Curley M, Walsh S, Murphy C. Long-term trends in extreme precipitation indices in Ireland. Int J Climatol. 2022;42(7):4040–61. https://doi.org/10.1002/joc.7475.
- Schweizer S, Davis S, Thompson JL. Changing the Conversation about Climate Change: A Theoretical Framework for Place-Based Climate Change Engagement. Environ Commun. 2013;7(1):42–62. https://doi.org/10.1080/17524032. 2012.753634.

Scottish Government. Barriers to community engagement in planning: a research study. 2017. https://www.gov.scot/ binaries/content/documents/govscot/publications/factsheet/2017/05/barriers-to-community-engagement-inplanning-research/documents/barriers-community-engagement-planning-research-study-pdf/barriers-commu nity-engagement-planning-research-study-pdf/govscot%3Adocument/Barriers%2Bto%2Bcommunity%2Beng agement%2Bin%2Bplanning%2B-%2Ba%2Bresearch%2Bstudy.pdf.

- Sweeney J. Climate Change in Ireland: Science, Impacts and Adaptation. 2020. p. 15–36. https://doi.org/10.1007/ 978-3-030-47587-1_2.
- Wardekker JA, De Jong A, Knoop JM, Van Der Sluijs JP. Operationalising a Resilience Approach to Adapting an Urban Delta to Uncertain Climate Changes. Technol Forecast Soc Chang. 2010;77(6):987–98. https://doi.org/10.1016/j.techf ore.2009.11.005.
- Wilson GA. Community Resilience and Social Memory. Environ Values. 2015;24(2):227–57. https://doi.org/10.3197/09632 7114X13947900182157.
- Ziervogel G, Enqvist J, Metelerkamp L, van Breda J. Supporting transformative climate adaptation: community-level capacity building and knowledge co-creation in South Africa. Climate Policy. 2021;22(5):607–22. https://doi.org/10. 1080/14693062.2020.1863180.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.