What is "good" co-production in the context of planetary health research, and how is it enabled?

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What is "good" co-production in the context of planetary health research, and how is it enabled?

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ABSTRACT

Involvement of non-academic stakeholders in research is essential when seeking to address global challenges, yet there is considerable uncertainty on how to do this well given the complexity. This paper aims to define more clearly what 'good' co-production looks like in the context of urban-planetary health research and how to operationalise it in research design, drawing on existing literature alongside case study experience from operationalising a major research programme. The first sections of the paper set out the rationale, and analyses key issues identified relating to co-production. The case study analysis is based on six headline themes: clarity of mission, language, societal impact, complexity, new approaches and limitations. Eight principles are presented alongside associated questions for research teams. Logic model development and co-production activities are plotted along the ten-year research trajectory, which reveals five key decision points and potential opportunities for optimising mission-oriented co-production in research design.

1. Introduction

'Planetary health' is a relatively new concept for a long-recognised global challenge, a central novelty of which is in uniting the vast health-world community explicitly with environment degradation (Whitmee et al., 2015; Meadows and Club of Rome, 1972; Prescott et al., 2019). It is defined in the Rockefeller Foundation-Lancet Commission report on planetary health as: "*the achievement of the highest attainable standard of health, wellbeing, and equity worldwide … the health of human civilisation and the state of the natural systems on which it depends.*" (Whitmee et al., 2015, p.1978) Research in this area is described by the Planetary Health Alliance (PHA) as "*a solutions-oriented, transdisciplinary field and social movement focused on analyzing and addressing the impacts of human disruptions to Earth's natural systems on human health and all life on Earth.*" (PHA, 2024) This paper focuses specifically on urban environments and their development in the context of planetary health (urbanisation is one of nine central themes listed by the PHA alongside, for example, water scarcity, changing food systems and biodiversity shifts). Given that cities consume, for example, 75% of human use of the Earth's natural resources and produce 70% of global CO2 emissions and 50% of its waste, it is crucial to understand their role and potential for change (OECD, 2023; International Resource Panel, 2018; Moerder et al., 2020). The design and planning of cities – e.g. their layout and accessibility, and the quality of their buildings, transport infrastructure, streets and green, blue and public spaces, the quality of food offering – have profound impacts on both human and planetary health (Moerder et al., 2020; Grant et al., 2017). Yet changing these built infrastructures and the unequal human and planetary health outcomes associated with them (and the associated human behaviours), many of which are already existing, is a highly complex challenge (Black et al., 2021; Pain et al., 2014; UKPRP, 2018; Stern, 2016). Given the number of people involved in the decision-making and the many more people affected by any changes, the role of citizen involvement in urban planning has long been a central feature.

It is now widely accepted that the involvement of external (non-academic) stakeholders is essential, not least due to an appreciation of the

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complexity of these challenges, the need for research to provide 'real world' solutions, and consequently the need for new approaches to research (UKPRP, 2018; Stern, 2016; UKRI, 2023; JPI Urban Europe, 2018; Bammer, 2013). The Earth Systems Governance Project makes clear its importance (ESG, 2018). While using the term 'collaboration' instead of co-production - definitions which we examine below - the PHA underline the need for "*massive collaboration across disciplinary and national boundaries*" (PHA, 2024), and the Rockefeller Foundation-Lancet Commission on Planetary Health the "*substantial and urgent expansion"* of transdisciplinary[2] research (Whitmee et al., 2015, p.1974; Alliance, 2023a; British Academy, 2016; Academy of Medical Sciences, 2016; OECD, 2020; Pohl et al., 2019). This has profound implications, not only for how research is operationalised, but how, and the extent to which, multiple systemic causes of planetary health problems can be identified, understood and tackled given their complex nature (Bammer, 2013; Black et al., 2023; Carhart et al., 2020). For although the literature provides a plethora of toolsets, frameworks and strategies for eliciting stakeholder views, there is relatively little consensus when applied to these vast research landscapes (Reed et al., 2009; Balane et al., 2020; Williams et al., 2020). As Vaughn and Jacquez observe: "*The ways in which stakeholders participate will vary at each step of the research process, and there are infinite options as to how to share decision making in each research task.*" (Vaughn and Jacquez, 2020, p.5)

With regards citizen engagement, specifically, in European and North American urban development contexts varying forms of engagement have been practised for decades, albeit framed as 'consultation', 'engagement' or 'involvement' following Arnstein's 'Ladder of Citizen Engagement' of 1969 (Arnstein, 1969; Wates, 1996; Lane, 2005). There is variable practice, and much could be characterised as following a 'tick box' approach, resulting in considerable cynicism as to the intentions of both the private and public sectors (Lane, 2005; Fioretos et al., 2016; Pacione, 2019; Innes et al., 2004; Tauxe, 1995). In addition to distrust, there also appear to be significant issues in terms of a lack of time and resource (financial and human). This in turn, can lead to a range of negative side effects such as: unrealistic raising of expectations; poor understanding of who should be involved and how; inability to engage diverse groups; and 'consultation fatigue' even in experienced, well intentioned engagement (Oliver et al., 2019; Rydin et al., 2000). This raises further research questions on how to transcend the limits of existing practice and enable the 'citizen voice' to be heard in targeted intervention areas (Black et al., 2022).

The National Institute for Health and Care Research (NIHR), a major funder of health research in the UK, advocate for co-produced research to involve 'all relevant evidence users', a point underlined too by the Earth System Governance Project (Bammer, 2013; ESG, 2018). While a laudable aim in theory, the challenge is how to make this possible in practice. In certain contexts, this may be easier to achieve. For example, in some areas of health research, key stakeholders might already be involved or at least known and relatively accessible (e.g. co-design of interventions to support stroke survivors or smoking cessation with school staff and pupils, or engaging with charities on mental wellbeing) (Hall et al., 2020; Hawkins et al., 2017; Hubbard et al., 2020). The same is true for some projects outside a health-world setting where target communities may be well defined, such as projects to tackle climate issues co-produced with local communities (Baztan et al., 2020; Satorras et al., 2020). However, over more numerous heterogeneous populations, in a planetary health (or *whole systems*) context, the level of complexity rapidly increases. '*Consideration of context'* is a primary core element in the UK's updated (2021) Medical Research Council (MRC)/NIHR Guidelines on the development and evaluation of complex interventions, which acknowledges explicitly both complexity and systems science (Skivington et al., 2021, p.4). Yet 'context' in urban development (for planetary health) involves highly complex 'systems of systems' containing a multiplicity of sectors and actors, making decisions across varied, wide-ranging contexts at micro-, meso- and macro-levels in an interdependent globalised context (Black et al., 2021, 2022; Pain et al., 2014; Gardner, 2016; Trejo-Nieto, 2020).

In this paper we aim both to define more clearly what is 'good' co-production in the context of planetary health research, and how that quality of stakeholder engagement might be improved. We do this by integrating analysis of the literature with perspectives from across an experienced project team, reflecting on the undertaking of a major research project/programme[3] entailing multiple forms of co-production (the two lead authors are both participants in the research programme, which employs a wide range of methods, including a significant research-on-research work strand with papers under review). While the central focus of the paper is on co-production, this topic raises issues relating to other academic fields, such as research management, transdisciplinary approaches and team science. Our contribution is therefore not just to summarise the ongoing debates on issues of language and meaning, but to reflect on both the literature and our experience in order to provide what we feel are important lessons learned in research operationalisation. In so doing, we provide practical steps for others seeking to optimise co-production within the context of urban and planetary health.

We start in section 2 by setting out the many and varied definitions of co-production (2.1), the examination of which highlights four further areas for deeper consideration (2.2–2.5): power sharing, stakeholder analysis, dealing with inevitable imperfection, and confusion of pathways. This exercise resulted in a framework of six headline themes, plus a framework of 17 key messages and questions (3) relating to the development of effective co-production in urban-planetary health research. In the fourth section we reflect on our experience in operationalising a major research programme, factoring in prior projects and pilot, the combined duration of which span over a decade. We review the main programme and pilot's foundational understandings, how the planetary health agenda influenced the co-production and research management approaches, and we explore how this is reflected in the findings, and our selection and development of interventions. In the fifth section, we present our research principles for how to enable "good" co-production alongside a series of questions that research teams might consider when designing their own research strategies. Based on these questions, we also present key decision-points and opportunities along a generic timeline based on our own research journey, including prior pilot and pre-projects.

2. Challenges on defining and implementing 'good' co-production

2.1. Plural understandings

There have been various attempts at categorising and defining the term 'co-production'. Moallemi et al. (2023, p.1) suggest there is '*limited conceptual clarity*', using content analysis and clustering to analyse 50 decision-making cases in order to synthesise recurring decision strategies, deficits and opportunities. In addition to four general areas –

[2] It is worth noting here the different understandings of 'transdisciplinary' and its overlap with co-production. Most appear to acknowledge there is a clear difference between *multi*disciplinary and *inter*disciplinary, which do not tend to infer engagement outside academia. However, there appears to be different understandings between the terms interdisciplinary and *trans*disciplinary, in the UK at least, with some seeing the two as broadly interchangeable, and others as crucially distinct. Perhaps the most notable confusion is whether or not transdisciplinary research must involve 'societal actors'.

[3] 'Project' and 'programme' are used interchangeably as it started at one large project/team (with separate work packages) before splitting in to seven interconnected, but semi-autonomous intervention areas/teams, which are arguably better described as a programme.

Table 1
Example critiques on co-production, taken from Durose et al, (2022).

Authors	Example critiques on 'co-production'
Durose and colleagues (2022, p.4)	'*messy and unclear concept*' with '*widely acknowledged sprawl*' that can be confused with the *"plethora of "co" words … as co-design, co-creation and co-governance … they call this 'cobiquity'"* (Durose et al, 2022)
Schultz et al. (2012, p. 129)	"*seek to avoid a 'flatland' of co-production"* where it might remain *"insufficiently examined and critiqued due to the limits of an overly essentialist or singular perspective on conceptualisation"* (Schultz et al., 2012)
Locock and Boaz (2019, pp. 411, 418)	"*consider efforts to bring greater clarity to debates on co-production as an 'unhelpful guarding of territory',* which *'wastes time'* and is tantamount to seeking to draw *'straight lines along blurred boundaries* (Locock and B., 2019)
Williams et al. (2020)	*"while standardisation would belie this complexity, lack of standardisation does not legitimise labelling any or all forms of collaboration as 'co-production'"* (Williams et al., 2020)

innovation, transformation, diversification and collaboration – the five challenges/opportunities they identify focus on inclusivity, diversity and power sharing. Bandola-Gill et al. (2023) use citation network analysis (on 529 papers) and full text review thematic analysis (on 50 papers) to establish meanings and theoretical insights. They argue that the term is a '*travelling concept*' (p.276), and that systematic categorisation enables a comparative analysis across different socio-political systems, institutions, practices and strategies. They identify five areas of contextual application: science-politics relationships; knowledge democracy; transdisciplinary research; boundary management; evidence use intervention. van der Graaf et al. (2023) identify four tensions in doing co-production: (1) idealistic, tokenistic vs realistic narratives, (2) power differences and (lack of) reciprocity, (3) excluding vs including language and communication, (4) individual motivation vs structural issues. Oliver et al. link co-production explicitly with the achievement of policy, practice or population health change, yet argue that "*there is little consensus about what coproduction is, why we do it, what effects we are trying to achieve, or the best coproduction techniques*" (Oliver et al., 2019, p.1). They also argue that it is not free of risk or cost, identifying five types of costs associated with co-produced research, which are rarely discussed in the literature despite affecting: i) the lmi itself, ii) the research process, iii) professional risks for researchers and stakeholders, iv) personal risks for researchers and stakeholders, and v) risks to the wider cause of scholarship. Williams et al. on the other hand point out there is a danger of legitimising the *"labelling any or all forms of collaboration as 'co-production'"*, and with real world consequences (Williams et al., 2020, p.3).

It is important to distinguish at this point the difference between the *concept* as opposed to the *methods of implementation*. Durose et al. (2022) provide a useful overview of the myriad attempts at *defining* co-production, from which we provide some example sources and critiques in Table 1. In short, they argue (p.9) for the holding of '*different approaches to conceptualisation in tension*'. NIHR (2021) on the other hand define co-production as 'an approach' (INVOLVE, 2019, p.4), while also pointing out that "*There is no single formula or method for co-production and such an approach would be counter to the innovation and flexibility that is implicit in co-produced research*". They set out five key principles in their guidance for co-producing research: sharing of power, including all perspectives and skills, respecting and valuing the knowledge of all those working together on the research, reciprocity, and building and maintaining relationships.

Despite the variation in both definitions and approaches, there are consistent themes (e.g. power sharing, plurality, working with uncertainty), and these align with the emerging best practice in transdisciplinary research. For example, Vienni-Baptista et al. (2022) and Hall et al. (2012)argue that it is only through these liminal contested spaces, where tension manifests, that change becomes urgent and progress can take place, while Bammer (2013) argues that working with unknowns and uncertainty is both uncomfortable and essential.

This plurality and ambiguity challenges research leaders to address issues such as how to: i) translate co-production principles into actionable research activities; ii) reconcile diversity in evidence and viewpoints; iii) efficiently operationalise co-production; iv) acknowledge that the generalisability, replicability and transferability of findings is itself a major challenge given diverse research contexts. Furthermore, tackling complex global problems in a manner that meets a yardstick of at least a generally 'acceptable' level of stakeholder involvement raises significant practical and political problems, such as what legitimate forms of institution can give 'voice' to otherwise voiceless yet relevant and interested groups. In the context of planetary health, for example, articulating the needs of the natural world and future generations opens up the challenge of how this should be affected in practice (González-Ricoy and Gosseries, 2016). The answer to these challenges are unclear, which has important implications for what 'good' co-production looks like in the context of planetary health, and how it should be enabled. A key aspect of this concerns issues of power, which is the focus of our next section.

2.2. Power sharing

Power sharing is already widely recognised as being crucially important in co-production (e.g. the first of NIHR's five key principles), with the need for it to be undertaken both with those affect*ed* (interested in) as well as those affect*ing* (with agency over) different aspects of the real world (UKPRP, 2018; Bammer, 2013; INVOLVE, 2019). The challenge, however, is how to do this in a meaningful way. We set out above how Moallemi et al. (2023) highlight the importance of addressing issues of diversity and inclusion, which they argue is an important element in re-imagining radical new futures and collaborative practice. Yet there are myriad elements that need to be factored in, and approaches to be considered, in order to address these issues of power.

For example, Farr (2018, p.641) underlines the importance of '*constant critical reflexive practice and dialogue'* when challenging power dynamics in a healthcare and public health setting (where she acknowledges the '*complex psychological, social, cultural and institutional interactions'*). Balane et al. (2020, p.1), who focus on stakeholder analysis (also in healthcare policy), state: "*Researchers seeking to influence policy must engage with relevant stakeholders. But whom and how?.. Stakeholders are typically analysed by their interests, position and, especially, their power … Yet, power is often poorly characterised in empirical research …*" Alongside their focus on stakeholder analysis, it is notable that power is only one of the four areas they identify in their framework, alongside: knowledge, interest and (policy) position. Lécuyer et al. (2024), who build on the work of gender activists and others in the development field, would see these different aspects as all part of a broader understanding of power. They propose an integrated framework, which they apply to six global case studies in biodiversity conservation. Their framework includes four types of power - 'power for' (combined vision, values and demands), 'power with' (collective strength and action), 'power to' (the potential to speak and take action) and 'power within' (self-worth and self-knowledge) – alongside four 'arenas of power': 'visible power', 'hidden power', 'invisible power' and 'systemic power'. This analysis and framework points to implications for, for example, global governance and the challenge of representation of non-human interests. Haugaard (2021) discusses four dimensions of power - agency-energy aspect of interaction, structural components, element of interaction, and social ontological elements of social subjects – beginning with the Bertrand Russell quote '*that the fundamental concept in social science is Power, in the same sense in which Energy is the fundamental concept in physics*.' (Haugaard, 2021; Russell, 1938, p.10) Echoing the challenge in defining the term 'co-production', a decade earlier Haugaard (2010) had acknowledged that power is an 'essentially contested concept' that requires a 'plural view'. He lists, non-exhaustively,

multiple types of power.

The literature on power is vast and we do not attempt to cover it all here. The central point we wish to make is not so much on the importance of power dynamics, which is well recognised, or on the different types of power and how they are exercised, but on what is practically possible given the inevitability of imperfect stakeholder involvement and representation. We therefore focus in these next sections on strategies for how to manage that imperfection, a key part of which relates to stakeholder analysis (Bammer, 2013; Williams et al., 2020).

2.3. Stakeholder analysis

Given that power and contextual understanding are widely regarded as critical in co-production, one might expect stakeholder analysis to be accorded a similar level of prominence, yet as Reed et al. (2009, p.1933) suggested: "*stakeholders are often identified and selected on an* ad hoc *basis*". Schiller et al. (2013, p.1) echoed this, stating that "*Although a rich body of literature surrounds stakeholder theory, a systematic process for identifying health stakeholders in practice does not exist*"; this deficit can be seen in even seemingly comprehensive guidelines on stakeholder analysis (Schmeer, 2000). Varvasovszky and Brugha (2000, p.338) warned of biases and uncertainties necessitating '*a cautious approach*', yet in a separate paper in the same journal (Brugha and Varvasovszky, 2000, p.239) also underline that it can be used "*to generate knowledge about the relevant actors so as to understand their behaviour, intentions, interrelations, agendas, interests, and the influence and resources that have brought … to bear on the decision-making process*". Or, as Reed et al. (2009) put it succinctly: *who's in and why?*

Over the past few decades we can see researchers attempting to grapple with stakeholder analysis and across a range of different disciplines, for example: mechanisms used in environmental science; questions of power, legitimacy and urgency in the world of management; operational aspects of problem structuring; questions of ethics in business; and analysis of actor roles and knowledge types in landscape development (Reed et al., 2009; Balane et al., 2020; Varvasovszky et al., 2000; Mitchell et al., 1997; Gregory et al., 2020; Goodpastor, 1991; Enengel et al., 2012). Balane et al. (2020, p.2), for example, suggest several specific challenge areas: fast-changing policy environments, number of stakeholders, ability to delineate personal versus role-driven opinions, sensitivities around power and interest, and potential bias of analysts. Reed et al. (2018) underline the importance of identifying those who have limited interest or influence, but who might be impacted negatively or positively by an initiative (e.g. seldom heard publics who could benefit significantly from research, but may have limited influence or (apparent) interest).

As with power, we do not attempt to provide a comprehensive summary of developments in this space, but rather to underline that these types of critical inquiry into stakeholder analysis are particularly important in the context of co-production for planetary health. They help us move towards more effective problem identification and research operationalisation given the complexity of the problem space, alongside the inevitable limitations of - or imperfections in - resourcing, knowledge and understanding (Bammer, 2013; Hall et al., 2012; Gregory et al., 2020).

2.4. Dealing with inevitable imperfection

A further point for consideration is revealed when we consider, for example, best practice on the timing and nature of stakeholder engagement. While it may be possible within the context of a relatively narrowly bounded intervention area to engage with a consistent and representative group of stakeholders from start to finish, as recommended in the NIHR guidance (e.g. a local school active travel intervention), this is likely to be highly challenging when engaging within and across complex city, state and international systems (Bammer, 2013; Oliver et al., 2019; INVOLVE, 2019). Research builds on research, overlapping across different projects in different sectors. Stakeholder input in one project may be carried over to the next via the knowledge and understanding acquired by ongoing practitioners or researchers regarding which stakeholders to involve over time as a challenge space develops. Stakeholders and their relative influence are in constant flux. New stakeholders may need to be involved. While complete representation of all relevant groups may be logistically impossible, it is important to strive for the optimal while also 'not letting the perfect be the enemy of the good' (Williams et al., 2020; Oliver et al., 2019).

As stated in the introduction, there appears to be an underestimation of the difficulties involved in stakeholder involvement in research on complex global challenges, which is reflected in a lack of investment in resources to do this work effectively (Bammer, 2013; Oliver et al., 2019). The critical importance of resource, for example, appears robustly considered by the NIHR in their guidelines (NIHR, 2021). For example, public involvement is expected as the default position unless a research team can demonstrate that it is undesirable or logistically impossible. Yet resource is not simply a question of budgets and payment for participants' contributions, but the creation of time and space for developing understanding, relationship-building and other skills, with implications for funding and management (Hall et al., 2012). Managing uncertainty and imperfection is therefore a critical additional element. As Bammer (2013, p.24) puts it: it is how we deal with the '*inevitability of imperfection*'. Combined with the challenges of language, power dynamics and stakeholder identification, this all points to a significant difficulty in research operationalisation when planning co-produced pathways to impact.

2.5. Confusion of pathways

The inevitability of imperfection is a foundational understanding of systems science and, arguably, transdisciplinary research, and a central rationale for why co-production is so important for the *iterative* generation of 'programme theory' (Bammer, 2013; Skivington et al., 2021). According to the MRC/NIHR Guidelines on the development of evaluation of complex interventions, programme theory describes *"how an intervention is expected to lead to its effects and under what conditions*" (Skivington et al., 2021, p.4), and best practice includes (among other elements):

- Developing it at the beginning of the research project and refining it during successive phases
- Considering context and stakeholder engagement as primary core elements
- Undertaking post-study reflection for future improvement
- Focusing on programme theory as an important evaluation outcome (Skivington et al., 2021).

Yet as set out above co-production is far from straight-forward, even in the more tightly bounded spaces. In planetary health research, contexts are so complex - not just in terms of the number of variables, but also temporally given future concerns - that robust programme theories can only be developed through iterative and collaborative (co-produced) systems exploration (Whitmee et al., 2015; ESG, 2018; Black et al., 2023). These and other limits to co-production (explored in this paper) must be recognised and acknowledged (Williams et al., 2020; Oliver et al., 2019). Even the most well-developed programme theory is likely to be a simplification, which requires updating and adaption as events unfold.

This speaks to the call by the Academy of Medical Sciences (AMS) in 2016 for a '*radical change in approach to public health*', including: enhancing the coordination of research; the development of transdisciplinary research capacity; and working with all sectors of society (Academy of Medical Sciences, 2016). This AMS report was an important precursor to the UK Prevention Research Partnership (2018, p.3), a major research initiative and consortium of twelve funders, which states

Table 2
Comparing theory of change approach (and its outcomes framework) against programme theory (and logic models).

	Starting with end goal (and working backwards)	Starting with programme (working forwards)
Theoretical Approach	Theory of Change	Programme Theory
Model Used	Outcomes Framework	Logic Model
Focal areas	Focuses on detailed causal pathways (the 'how and why')	Table form/prompts ensure certain key areas covered (inputs, outputs, activities, stakeholders)

that '*new approaches to population health research are clearly needed*'. For example, the use of logic models is central to the development of programme theory, yet there are unresolved questions as to how exactly to apply them effectively within and across such complex contexts, with so many unknown (and possibly unknowable) causal steps, and with the exact nature of co-production central to that challenge (Black et al., 2021; Matthews-Simmons, 2019; Analytics in Action, 2023; CERE, 2021; Better Evaluation, 2023; Center for Theory of Change, 2023). There is even a lack of clarity on such seemingly mundane issues as to how programme theory and logic models differ from Theory of Change and 'outcomes frameworks' – see Table 2 for our simplified differentiation.

This 'confusion of pathways' – whether in the development of programme theory, the integration of effective co-production, or the clarity and use of logic models and theories of change – is just one of five areas we identified in the literature that required closer examination. The next section sets out how we derived a framework to help us reflect critically on the lessons learned in each of these areas.

3. Method and questions for reflection

In order to reflect critically on what is good co-production, and to help us think critically and systematically about these various understandings of language, core principles, approaches and tools, we pulled out headline themes and key messages from an early and extensive literature review that formed the grounding of this paper. We extracted each of the key points being made, noting the source for each, and listed in an Excel workbook (see Supplementary Material). Common themes were identified through an iterative process, expanding across multiple new worksheets, each one building and consolidated from the last, which set out: headline themes, sub-themes, key messages, sources and questions in relation to co-production. This process finally suggested six themes and 17 questions that appeared most useful to consider in post hoc reflection – Table 3.

In the next section, we use these questions to reflect critically on our own approach to co-production, splitting them into six headline themes, shortened as follows: i) Clarity of mission; ii) Language; iii) Co-production for societal impact; iv) Co-production in complex contexts; v) New approaches: optimising co-production; vi) Limits of involvement.

4. Case study learnings

The primary learnings for and contributions to this paper have been derived from the major project, TRUUD, which stands for '*Tackling Root Causes Upstream of Unhealthy Urban Development*' (Black et al., 2022) (TRUUD, 2024), however this paper also draws on a decade of research involving a number of separate projects, which inform critical decision points taken during that longer process. TRUUD is a major five-year research programme involving over 40 researchers across six universities in the UK. The primary focus of the UK Prevention Research Partnership is the prevention of non-communicable diseases and health inequalities, including those linked to planetary health. The 'grand mission' of TRUUD (Black et al., 2022, p.5) is "*to enable a paradigm shift in how health is valued and integrated at root-cause decision-making points*" (in city-region transport planning and large-scale property development). It was split into two main phases: i) phase 1 focused on the mapping and understanding of the UK's property and transport systems, mainly through qualitative interviewing and systems mapping to identify key leverage points for intervention; ii) phase 2 (ongoing) focuses on the development and testing of (seven) intervention areas identified. Work started in October 2019, just before the onset of the Covid-19 pandemic, and is due to complete in September 2025.

4.1. Clarity of mission

The project mission was defined largely through the development of an earlier three-year pilot project UPSTREAM (UPSTREAM, 2019) (Daniel Black + Associates, 2024), which aimed to understand the barriers and opportunities for integrating health outcomes into

Table 3
Headline themes and key questions prompted by the literature.

Headline themes	Questions in relation to co-production?
Need to address complex global challenges (planetary health)	1. Were all researchers, advisors and partners clear on the overarching mission(s)?
Language and shared understandings critical	2. Were there clear shared understandings of key terms, even if plural?
Concrete and coordinated policy/actions needed (to solve global challenges)	3. How was co-production geared towards concrete policy/practice and societal impact?
Context is highly complex (new methods essential)	4. How was the complexity of the challenge space being accounted for in co-production planning?
New approaches to research needed (inc. transdisciplinary, co-production)	5. Were approaches to working across disciplines and sectors, with key stakeholders (those affecting as well as those affected), effective? 6. Were funders and other influential leaders on side? 7. Were learnings being captured through effective reflection, evaluation and post hoc analysis? 8. How were power dynamics identified and power shared appropriately? 9. Were programme theory, theory of change and research design strategies developed iteratively and with the appropriate stakeholders? 10. Was there scope for change following new information/strategy? 11. Were individual values identified and accommodated? 12. Were all the various components brought together to the satisfaction of those designing the co-produced research? 13. Were systems approaches employed and to what extent? 14. What approach to (research) team working has been employed and was it successful?
Consideration of adequate resources and contextual limits on involvement (in highly complex systems)	15. How were resource limitations accounted/planned for? 16. What forms of stakeholder analysis were used and how appropriate were they? 17. How was this analysis used to inform the development of a co-production strategy grounded in an understanding of context and available resources?

Table 4
Timeline of programme theory development.

Stage/Project	Co-Production (& broader Co-Development) Activities	Programme Theory Development
2 x feasibility studies on climate risk valuation	Regular meetings with Executive Board members of social housing and healthcare sectors over two years. Three large conferences with a wide range of practitioners, including major real estate and healthcare actors.	Developing critical early understanding of end user needs and constraints relating to health and climate risk and (corporate) decision-making processes. Refinement of approaches to environmental economics, GIS mapping, risk and business process modelling.
3-yr pilot project on urban/ planetary health	30 semi-structured interviews with senior public and private decision-makers. Linked public engagement activities. Major conference at the Royal Society of Medicine with senior public figures and funders.	Identified main problem areas alongside almost 200 barriers and opportunities, as well as gaps in research expertise (e.g. policy, psychology and trans-disciplinary working practice). Substantial development and feedback on economic model based on preliminary case study and interviews, suggesting considerable support for intervention approach.
Research development stage of main project on urban/ planetary health	Primarily internal meetings with academic research team leads, but also via multiple 1-to-1 in-person and phone conversations during recruitment with external partners and advisors, which included local governments, private and third sectors actors, and lay public representatives.	Theoretical foundations explored, including: frameworks (e.g. systems theory); plurality (private sector, cities, values); and methods (e.g. interviews, soft systems methods, deliberative mapping). Summary theoretical contributions provided from each of the core research leads on their own areas of specialism, including: e.g. urban governance, corporate decision-making, and law.
Main Project - Phase 1 on urban/ planetary health	132 interviews with 123 interviewees and large-scale analysis. Four supporting workshops with 47 attendees. External Advisory Board made up of senior experts across public and private sector and lay public. Lay Public Advisory Group to sense check research strategies and key outputs (recruitment and engagement of members of the public to our External Advisory Board). Two full time researchers-in-residence working in/with city and city region partners.	Phase 1 interviews strongly supported pilot findings that there is a demand for socio-environmental valuation on health outcomes, and with workshops identified a wide range of additional theme/problem areas (e.g short-termism, car dominant culture) and a long-list of 50 potential areas of intervention. These were short-listed to 7 and focused on: national government appraisal; psychology and corporate decision-making; real estate investment; transport planning at city region level; spatial planning at city level; local government legal capacity; and deliberative democracy approaches. The valuation tool was also further developed and tested through a new case study.
Main Project - Phase 2 on urban/ planetary health	Individual intervention area teams (x 7) continue engagement and development of their intervention areas with their end user partners across public and private sectors and with lay public. Approaches developed and refined on an iterative basis.	Preliminary visions for each intervention set out using terms of references and work plans, but substantially adapted through co-production with primary partners. E.g. public engagement focused originally on use of technology, but shifted to new forms of 'micro deliberative democracy'; national-level law intervention curtailed to focus on local government capacity and health impact assessment.

upstream urban development decision-making. It involved 30 formal interviews, substantive public engagement activities, as well as some limited, but high level, external outreach. The mission was refined (and expanded substantially in resource scope and ambition) through the development of the TRUUD research proposal, and largely in discussion internally with academic research team leads, but also via ad hoc conversations during recruitment with external partners and advisors, which included local governments, private and third sectors actors, and lay public representatives. Our 'sub-missions' were based on the stated aims and objectives of each work package and included: the development and testing of a multi-action intervention, changes to policy and practice, demonstration of scalability, production of replicable tools, and group wellbeing.

An internal mission and impact review was carried out at the midway point near the start of the second phase (in year four as it was delayed due to Covid and recruitment challenges) (TRUUD, 2023), which suggested that the consortium was on course to deliver on all stated sub-missions, albeit with further action needed to address some areas, in particular group wellbeing. This would indicate that the mission(s) was/were at least relatively well understood. However, the group had recurring and largely unresolved debates throughout phase 1 on the finer points of language (4.2) and the implications of this on research design and implementation, which created tensions, especially during the storming stage of the project as mission drift in some work packages became apparent. The issue of wellbeing, which had been compounded by Covid, was also an indicator of a lack of clarity. Considerable additional time for coordination had been required in phase 1 to ensure the group were coherent and all pulling towards the same end goal. This wasn't just due to clarity of mission, but also due to the complexity of effective co-production (4.3) the challenge space (4.4), and the development and testing of new approaches to research operationalisation (4.5).

4.2. Language

'Health' was not defined by the funder, which led the team to develop early multiple 'dimensions of health', including: clinical, public, individual, population, aggregate, distributive, biomedical, wellbeing, physical, mental, opportunities, outcomes, rights to, human and planetary (Black et al., 2024). While this helped disaggregate the range of different potential outcomes being sought and gave the group important nuance of understanding, the work was not progressed much further, due mainly to lack of time. This left uncertainty as to exact mission-orientation and potential trade-offs (prioritising one may require de-prioritisation of another).

'Planetary health' itself was not referred to explicitly within the original call documentation, though it was stated explicitly as a key implicit goal by the Chair of the Advisory Board at the kick-off meeting, a position formalised in the second round of funding (UKPRP, 2019). Given this qualification had come after the bid development and team-building stages for first round applicants, and given the different understandings of health across the UKPRP community, our consortium's formal understanding was mixed on whether and how to prioritise the planetary health agenda, but it was championed by some of the senior members of the group, not least given the growing evidence linking planetary health factors to non-communicable disease and health inequalities (Alliance, 2023b; Friel et al., 2011; Swinburn et al., 2019). It had also been central to the pilot project (UPSTREAM, 2019) Daniel Black + Associates, 2024. While the consortium proceeded with plural understandings therefore, planetary health was at least a central part of discussions on the meaning of health.

Somewhat inevitably, given the plural understandings set out in section 2.1 above, the meaning of the term 'co-production' was debated at length. Discussions internally were sometimes emotive and always inherently political. The main points of discussions tended to focus on what could be considered 'co-production', specifically. Some felt that

Table 5
The seven intervention areas, their number and style of engagements.

Intervention Area (IA) Development	Number and style of engagements
Intervention Identification	Six-month process following interview and workshop data analysis, long-list of intervention areas narrowed to short-list with iterative sense-checking with advisor groups and partners
Private Sector (Behaviour Change)	Targeted meetings with 'influencers' (recognised industry leaders) and their teams, and follow-up interviews (still in early stages)
Private Sector (Real Estate Investment)	Meetings and engagement ongoing with experienced senior industry actors from two global real estate companies (still in early stages)
National Government	Targeted meetings with civil servants in multiple teams working in relevant policy areas (9 to date)
City-Region/Transport	Daily/weekly meetings with partner via full time researcher-in-residence
City Council/Property	Daily/weekly meetings with partner via full-time researcher-in-residence
Law	Close collaboration with UK Government's Office for Health Improvement and Disparities (OHID). Seven day-long workshops and follow up meetings (Autumn 2023). Collaboration ongoing.
Lay Public	Representatives from newly established Public Advisory Group sat on programme advisory board, contributed to quarterly consortium meetings, advised on system mapping, and met with researchers to contribute to design of interventions.

the involvement of the public was not necessarily essential as long as external (non-academic) stakeholders were involved. Others were adamant that the lay public should be involved on an equal basis in all aspects of the research programme development for it to be considered authentic co-production (though they did also acknowledge that 'the lay public' was a vast and heterogenous group). Others pointed out that if this position is taken to its logical conclusion, then we had to consider also that the 'grand mission' set out by the funders had been designed prior to the programme starting, thereby precluding the programme as a whole from being considered to have been co-produced from the start. It could be argued that this absolutist position is irrelevant given it occurs prior to the research team's involvement, but it does raise a valid question about when co-production starts and stops. There were also mixed views as to what research activities can be counted as co-production, and over what timescales. For example, some felt strongly that the gathering of research data (e.g. via interviews) cannot be considered co-production, since this is a form of qualitative research (see INVOLVE/Health Research Authority Guidance) (INVOLVE, 2019). Others felt that qualitative research can count if conducted interactively and designed to identify through discussion with participants points, such as the direction of the research or what areas of intervention the project should prioritise, thereby contributing 'asynchronously' to the evolving design (or 'co-design') of the programme. Clearly, if we follow NIHR's principles of best practice (e.g. sharing of power), qualitative research can *contribute* to co-production, but it can not be considered a form of *co-production*. On the other hand, given the complexity of the planetary health research challenge, these principles (e.g. including all perspectives and skills) are likely to preclude most if not all forms of planetary health research from being labelled as co-production.

These debates, unresolved across the whole group, have led the authors on this paper to settle on our final, fuzzy position on terminology in relation to this term. The nuances did not affect much the design of the programme, which was already set in motion, but they did cause concern as to the robustness of the approach taken, with questions still outstanding of how "co-produced" the programme was. A main purpose of this paper is to learn from this and determine what is optimal.

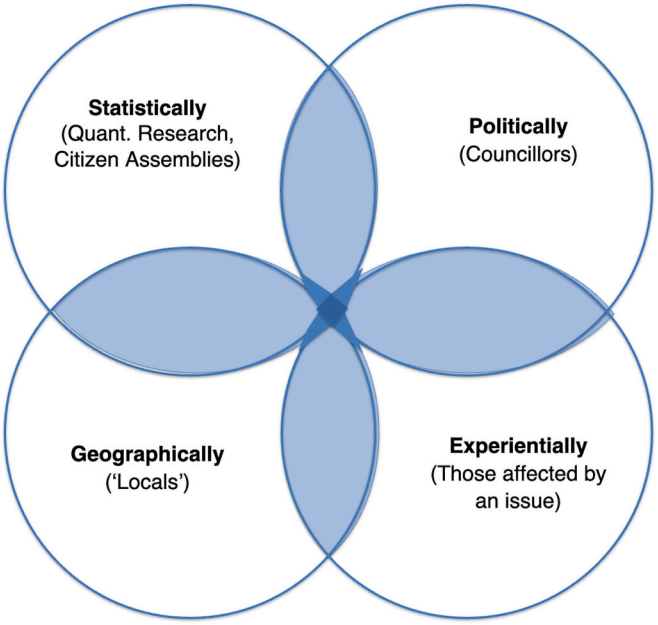


Fig. 1. An early conceptualisation to distinguish between different types of 'representativeness' of lay public.

4.3. *Co-production for societal impact*

End-user co-development - which includes or is synonymous with 'co-production', depending on your view - was central to the research design (Black et al., 2022). The extent of the co-development can be seen in Table 4 below, which sets out the key activities relating to the development of programme theory (including prior, relevant projects), and brief descriptions in Table 5 of the intervention areas' co-production with end users and stakeholders.

Building on prior projects, which had included relatively extensive end user engagement of various forms, including public engagement, the research team produced a high-level 'theory of change' following internal and (light-touch) external consultation with a range of stakeholder advisors in the bid development stage (Black et al., 2022). It was based on the funders' own theory of change, although as described above (section 2.5, Table 2), it was not a fully mapped out or validated outcomes framework (UKPRP, 2019). With regards to public engagement, for example, we designed in the establishment of a Public Advisory Group, which would advise on key areas of the research co-development, including designing the interview questions, analysing qualitative data, developing bridging mechanisms and policy recommendations. An early challenge, in addition to securing effective representation (see s.2.6 and Fig. 1 below), was reconciling plural theories: an arguably impossible task given the known risks (Bianca Vienni-Baptista et al., 2022; Cairney, 2013). The expectation was that the 'sum of the parts' would be greater and more appropriate by using multiple lenses to investigate (and 'triangulate') the problem space from different positions, as per a broader transdisciplinary and general systems theory perspective (Ison, 2008).

Following phase 1, internal analysis of the evidence from the pilot interviews, main programme interviews and workshops resulted in a long list of 50 areas of potential intervention, which were reduced to seven following a six-month process of identification, a main criterion of which was the fit to the research group's areas of expertise. Findings and proposals were sense checked with an External Advisory Board, which included a limited number of representatives from the lay public and city partners.

The seven new sub-groups then produced their own logic models setting out the main inputs, mechanisms and outcomes they anticipated.

While these logic models were created internally and not shared externally, the overarching approach was (and is being) developed in co-production with partners and targeted stakeholders. The logic models come in a variety of formats, dependent on the foci of the intervention sub-groups, and have little to no detailed pathway analysis. This was arguably inevitable due to the complexity of the context (see 4.4 below) and the gap between decision-making far upstream (e.g. changes to government policy on valuation mechanisms) and outcomes far downstream (e.g. future health impacts), but it nonetheless raises gaps in coherence and planning pathways to impact. Emerging evaluation planning is currently seeking to develop ways of assessing post hoc these pathways and potential for impact through validation with targeted end users, lay public advisors and representative stakeholders.

4.4. Co-production in complex contexts

Numerous attempts were made at the start of the main programme to clarify the context (or 'problem space'), a process we have described in a separate paper (Black et al., 2023). In hindsight, the expectation of the group arriving at shared understanding and conceptualisation of the problem space so quickly was naïve. The complexity of the context, which spans many and varied knowledge domains, is not something that can be communicated quickly or easily, especially in research where those involved have relatively deep and narrow areas of specialism. As such, the challenge was less about the communication of complex contexts, and more about the need for effective leadership and management and a culture of trust alongside clarity of mission, roles and responsibilities (see 4.1–3 and 4.5).

4.5. New approaches: optimising co-production

Notably, while all the other themes have just one question linked to them, this theme has 10 questions with the following sub-themes, all of which relate to co-production: transdisciplinary working, mission definition, missions and risk, innovation and experimentation, critical reflection and learning, power sharing, programme theory, dealing with values, integration of new approaches, systems thinking and team science. Some of these have been covered in this paper already (e.g. mission definition, critical reflection), and many others are addressed more fully in separate papers (Black et al., 2018)Black et al., 2023. The two remaining areas that do require attention however are: power dynamics and scope for change.

As set out in section 1 above, understandings of power and power dynamics have a long history, yet is also an area that appears not to be well understood in research according to Balane et al. (2020), at least from a health-world policy perspective. Discussions of power on TRUUD came up in a number of ways, for example:

1. One of our intervention areas has an explicit focus on power.
2. Power has been highlighted implicitly numerous times and throughout the research journey (4.4 above) – e.g. discussions on control of land, finance and planning permission, and public sector resource – although this was derived mainly through heuristic learning rather than traditional data gathering and so was not seen as sufficiently robust.
3. It was discussed indirectly through the stakeholder analysis in phase 1 (see 4.6 below), which touched on issues of influence, but not comprehensively.
4. It was an explicit part of the focus on co-production, and in particular in relation to public engagement, but again with limited success due to issues of complexity, scale, time and fair representation.

Power was also implicit in a range of other contexts too (e.g. peripheral discussions on ethics and the lack of "voice" of nature or future generations) (González-Ricoy and Gosseries, 2016), but the main point is that none of this was comprehensively analysed and planned for, but rather emerged in a semi-unconscious, ad hoc manner (e.g intuitive understandings of power and agency).

In terms of innovation and scope for change, our experience suggests this was very limited. Funder expectations and the constraints imposed by experienced research leads (most familiar with funder processes) with varying understandings and experience of co-production meant there were tightly bounded requirements, which severely limited the scope for learning by doing and innovation (e.g. timing of outputs, overall management approach, particularly in the more innovative and transdisciplinary first phase, which required the whole group to work together as one). The funder had foreseen the need for some leeway and had built in a relatively modest Discretionary Fund that allowed some small additional work to be commissioned as appropriate, but that too was limited by relatively stringent expectations rather than encouraging experimentation (e.g. the main project need was for more coordination and communication capacity, which was seen as unproductive and unnecessary). This is written up in more detail in a separate paper (Black et al., 2023), but the point here in relation to co-production is that these restrictions sat at odds with the experimental nature of the programme vision, which ended up requiring considerable time that could have been spent on planning and implementing greater levels of co-production.

4.6. Limits of involvement

As stated in our study protocol (Black et al., 2022, p.5), we were aware of some of the challenges of co-production: e.g. "*issues include …. the resource needed for effective co*-production". Yet the other issue under this theme, effective stakeholder analysis, which we touch on above in the introduction, surfaced repeatedly in core management discussions due to concerns about efficacy.

On the surface, our approach to stakeholder identification was fully comprehensive. A central component of our stakeholder analysis was that undertaken by the largest of the work packages, involving researchers across nine sub-groups representing different areas of expertise. The purposive sampling was based on the inclusion criteria of '*stakeholder influence and expertise in urban development decision-making in England*' (Le Gouais et al., 2023, p.2), and '*informed by desk-based searches, a policy review, established professional contacts and snowballing*' (Bates et al., 2023, p.391) (Table 2). The group also undertook a range of boundary and actor mapping exercises including the development of a three-dimensional conceptualisation connecting themes (e.g. power, incentives, valuation) to stakeholders (e.g. position, organisation, sector) to contexts (transport, property, land) (Black et al., 2023) (Table 4). While this stakeholder mapping was primarily used to develop a purposive sampling frame for qualitative research rather than as a basis for developing co-production, it illustrates the potential complexity involved. Another example of stakeholder analysis was our approach to public representation. The word 'representativeness' has different meanings which can sometimes lead to misunderstandings about what form of representativeness is required for co-production. An early exercise was to seek to identify different forms of 'representativeness'. To assist us in our thinking we developed a four-sided Venn diagram (Fig. 1), which separates representation statistically, politically, geographically or experientially, with the latter perceived to be of most relevance to our programme (i.e. those with 'lived experience' of urban-health issues).

Despite this seemingly comprehensive suite of approaches, various concerns persisted, again due in large part to differing understandings of what co-production is, especially given the scale and complexity of the urban-planetary health challenge space. Without consensus it was difficult to develop a strategic plan for co-production in the project. These difficulties were acknowledged limitations in interview sampling (Table 1): "*Covering multiple types of stakeholder groups creates challenges in identifying a robust and complimentary sample … Checking coverage across teams …*" (Bates et al., 2023, p.4). There was also an issue of expediency: the interview team state that each sub-group '*focused on a*

Table 6
Suggested principles and questions to aid in enabling 'good' co-production in research for complex global challenges.

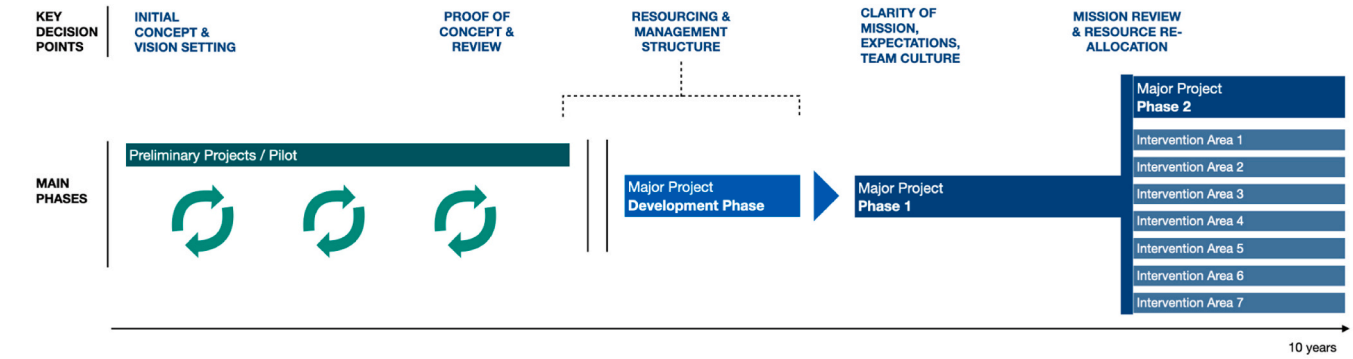
Suggested principles of 'good' co-production	Suggested questions for research teams to ask themselves
1. Broad contextual awareness: Grounded in a good understanding of the many, complex contexts nested within the wider context of planetary health, including key stakeholders, their influence, interests and levels of involvement, and underrepresented communities, non-human life systems and future interests	• If spanning multiple disciplinary areas, do we have sufficiently broad knowledge and contextual awareness to ensure alignment to the overall mission? • Are we experts in the contexts under investigation, including under-represented communities and non-human life systems, and is there scope for this to change as the understanding of the problem space(s) evolve? • Do we have a mature understanding of power, both internally and externally, including which actors and institutions wield power across the many and varied contexts?
2. Validated mission-orientation: Designed to lead to concrete and coordinated policy and actions, with well-defined missions and sub-missions, with equitable planetary health as the primary goal	• Do we have a clear shared understanding of the mission and sub-missions, with equitable planetary health as the overarching 'grand mission', and have we defined and communicated those sufficiently well at key stages? • Have we validated adequately our theory/ies of change (using logic models or outcomes frameworks) at key stages with critical stakeholder representatives? • Does our approach to stakeholder analysis include a sound rationale and method for identifying representative stakeholders, bearing in mind both human and non-human life-forms that are underrepresented? • Who and what might be missing and what gaps should we be aware of, including those with no voice (e.g. the natural world, future generations)?
3. Smart, flexible resourcing: Adequately resourced to achieve mission outcomes, including often overlooked core in-house capacity	• Do our resources cover both core research activities alongside essential additional time needed? (e.g. time needed for discussion to ensure psychologically safe working environment, complex internal and external communications, etc.) • Is there flexibility in our resourcing (e.g. phased allocation) to adapt to new strategies following co-production, including the recruitment of new knowledge domain experts? • Does resource planning include all essential 'non-productive' activities (e.g. high quality project management for agile transdisciplinary working)? • Are those with control of budgets clear on the grand mission and mission pathways, and is resource allocated correctly across phases to avoid mission-drift? • Have we factored in enough resource for high quality internal and external communications, using a wide range of media?
4. Power is balanced: Be demonstrably geared towards power-sharing in key strategic decision making, including those with limited voice	• Are we ensuring that underserved communities and other stakeholders (natural world, future generations) are included as far as practically possible, and that adequate resource is given to ensure fair and effective representation? • At the same time, do we understand clearly where power lies and is our theory of change designed with that in mind?
5. Core values are made explicit: Seek to make researcher and stakeholder values explicit, thereby helping inform foundational understandings	• Are we clear on what our core values, beliefs, agendas, and priorities are, especially the research leads? • If not, have we factored in time to enable us to do this and do we know how? • Are we able to do this with our stakeholders and, if so, how?
6. Shared language: Agree working definitions (including 'co-production') to allow progress to be made, with plurality welcomed	• What are the key terms that are causing or may cause confusion? • Have we agreed working definitions? • Do we each understand others' definitions? • Are all clear that plural understandings are welcome and how to minimise confusion and manage inevitable misunderstandings?
7. Make space for innovation: Embrace heterogeneity and imperfection, while managing expectations	• Are all clear that uncertainty is expected? • Are the team aware of what it's like to work with uncertainty and imperfection (e.g. working with discomfort and tension, the need for patience and flexibility)? • Is diversity a core priority in recruitment and is that factored in to working practice and dialogue? • Are all team members comfortable with speaking out, and is that balanced with a clear understanding of mission and effective decision-making?
8. Transdisciplinary working knowledge: Be grounded in a mature understanding of key supporting disciplinary areas in research operationalisation: transdisciplinary working, co-production, systems thinking, team science	• Do we have experts in the challenges and approaches to effective transdisciplinary working, including co-production, and have these been communicated effectively to the rest of the team at the start of the project? • Does our recruitment strategy prioritise the need for collegiate and flexible working where inter- and transdisciplinary working and co-production is expected? • Is critical and iterative reflection and shared learning a core part of the research process, including accounting for disciplinary and other biases? Are we open to sharing of knowledge space and power?

group of stakeholders that aligned with their area of expertise' (Le Gouais et al., 2023, p.3). Though inevitable that researcher expertise should boundary the investigation, it raises an important point in relation to the allocation, structuring and management of research funding (see 2.5 above). A final example was the focus on *influence and expertise,* which was partly informed by Reed (2016), whose templates encourage researchers to consider the *interest* and influence of stakeholders. This approach was adopted to reflect the need to gather insights from key decision-makers. For example, we had extensive engagement with specific departments at local and regional government level through two researchers-in-residence in one city and one city-region authority. Yet additional balance was needed from all the other many areas under investigation with insights needed from, for example, private sector actors responsible for directing finance capital flows and investments transforming urban environments (this within the context of the contemporary UK roll-back of state funding, and centralisation of public sector control) (Pain et al., 2014); (Black et al., 2021).

5. Principles & recommendations

Based on the literature and our own experience, we suggest there are 8 key principles essential for "good" co-production in the context of (urban and) planetary health research – Table 6. Each principle prompts us to provide a number of suggested questions that teams might ask themselves at key stages of the research cycle. These are not exhaustive, but should provide a useful starting point for those wishing to maximise the effectiveness of their co-production plans.

By mapping these principles and questions to the trajectory of the



	Preliminary Projects / Pilot			In-between Projects	Major Project / Programme				
Phases	Development Phase	Implementation - Beginning	Implementation - End		Development - Beginning	Development - End	Phase 1 - Beginning	Phase 1 - End	Phase 2 - Beginning
Logic Models & Theories of Change (equitable planetary health as 'grand mission')	Rough theoretical positions and impact pathways (highly conceptual)		Demonstrable support for concept and theory of change	**Key point of flex - rare opportunity to arrange:** • Project governance & leadership • Resource allocation (with 'controllers' aligned to mission and core principles) • Securing of resource for essential 'non-productive' work (e.g. internal and external communication and engagement) • Sufficient in-house capacity (e.g. communications, design) • Flexibility to resource to allow • Recruitment requirements (e.g. demonstrable collegiality/flexibility)	New, high-level theory of change - more targeted/clearly defined	Some clarification through graphic visualisations (e.g. of problem space)	High level individual logic models for each intervention area	Refined logic models
Co-Production (those affecting & affected, including natural systems and future generations)	Securing expressions of interest from project partners Recruitment of early advisors	Formal recruitment & engagement			Initial partners and advisors secured	Exploratory interviews and workshops	New intervention areas and logic models validated	Recruitment & engagement tailored to new intervention areas
Opportunities for improving co-production	Including, if possible, resource for training in key areas (e.g. trans-disciplinary working, systems, contextual understanding)	Early development of approaches to: • impact planning • trans-disciplinary working • stakeholder analysis • reflective practice	Post-hoc assessment review of what worked and what didn't		Develop high-level shared understandings amongst core team / research leads of mission(s), language, core theories, values Early development of graphic visualisations	Clarifying mission(s), language, core theories, power dynamics, etc. to wider team Setting out expectations, e.g. • Working with uncertainty • Funder expectations (e.g. timing/number of outputs) • Scope for experimentation Developing graphic visualisations (ongoing)		Stakeholder analysis - ensure identification strategy matches to mission and theories of change

Fig. 2. a and b: Example research development timeline based on our programme evolution experience with key opportunities for maximising co-production.

research journey we have been on over the last decade, Fig. 2 illustrates the key developments in theories of change and co-production activities. Based on this research trajectory, we highlight five main decision points and associated opportunities.

i) **Initial concept and vision-setting (in early project development):** at this stage resourcing was scarce so there was limited scope for gearing up capacity, but some early modest engagement in unfamiliar areas (e.g. transdisciplinary working, systems theory, knowledge brokerage) proved to be helpful foundations for critical later work on co-production (this was informed in part by substantial prior experience (non-academic) in public engagement of the research lead).

ii) **Proof of concept and review (during implementation and towards end of projects and beyond):** Having clear expressions of interest and robust testimonials alongside evidence of support for the approach was essential for justifying proof of concept (and potential pathways to impact). Reflecting on key linked areas in need of development - impact planning, stakeholder analysis, transdisciplinary working – provided some important groundwork for future developments.

iii) **Structuring resource and management (a critical point of flexibility, it includes recruitment, resource allocation and control):** While lacking in formal resource at this stage (and difficult to achieve in practice given work pressures and/or associated risks), this 'in-between' space is pivotal in establishing critical enablers including management and leadership structure, resourcing and control, and team character and composition. While not explicitly about co-production per se, these have substantial impact on all co-production activity.

iv) **Clarifying mission and expectations, establishing team culture:** In an ideal world, this would be the main opportunity for ensuring clarity across the wider (newly recruited) team on key areas such as mission and expectations. In practice, recruitment can be staggered, and some level of misunderstanding is inevitable, which requires care and attention to address. Perhaps more important is the establishment of team culture and working practice to ensure that your group can handle the inevitable (and desirable) tensions that will arise and know how to resolve them.

v) **Mission review and resource re-allocation:** In a project grounded in co-production, shifts in direction and resource should be anticipated and planned for (as best as possible), with mechanisms in place to enable those responsible for mission-orientation to review progress and direction, and to restructure accordingly. This should be a core expectation made clear up front to the team.

6. Conclusion

The aims of this paper are to help clarify what "good" co-production looks like, and how to design research accordingly when seeking to address complex global challenges like urban and planetary health (Gardner, 2016). There is a wide range of research co-production approaches, frameworks and tools, developed by a multiplicity of academic disciplines (Moallemi et al., 2023; Bandola-Gill et al., 2023; Durose and Richardson, 2022). From one perspective, the diversity of

approaches offers an open and permissive set of learning experiences, whereas another interpretation is that it comprises divergent viewpoints each setting an unassailable 'gold' standard. This lack of certainty creates risks, potentially significant risks, both to research quality and to societal outcomes (Farr, 2018).

Research leaders seeking to embed co-production within their research process have decision points at each stage in the evolution of their project or programme, including (and especially) in advance of early proposal development when key decisions are made. Co-production in this area is likely to feel uncomfortable, given it is both incremental and iterative, and characterised by various unknowns: it will need to be agile and opportunistic, rather than idealistic. A co-production strategy will require the management of expectations alongside constant self-evaluation, maintenance, and effort to integrate knowledge from and across the project, which requires time, resource and experience in advance to allow for this. Above all therefore, this important research challenge area requires the prioritisation and attention of research leaders as well as funders.

CRediT authorship contribution statement

Daniel Black: Writing – original draft, Visualisation, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualisation. **Geoff Bates:** Writing – review & editing, Validation, Project administration, Methodology, Investigation, Formal analysis, Conceptualisation. **Andy Gibson:** Writing – review & editing, Visualisation, Validation, Formal analysis. **Kathy Pain:** Writing – review & editing, Validation. **Ges Rosenberg:** Writing – review & editing, Validation, Methodology, Investigation, Funding acquisition, Formal analysis. **Jo White:** Writing – review & editing, Validation.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.esg.2024.100229.

Data availability

No data was used for the research described in the article.

References

Academy of Medical Sciences, 2016. Improving the Health of the Public by 2040.
Alliance, P.H., 2023a. Planetary health [cited 2023 11/10/23]. https://www.planetaryhealthalliance.org/planetary-health.
Alliance, N., 2023b. Environment and Climate.
Analytics in Action, 2023. Theory of change vs logic model. https://analyticsinaction.co/theory-of-change-vs-logic-model.
Arnstein, S.R., 1969. A ladder of citizen participation. J. Am. Plann. Assoc. 216–224.
Balane, M.A., et al., 2020. Enhancing the use of stakeholder analysis for policy implementation research: towards a novel framing and operationalised measures. BMJ Glob. Health 5 (11).
Bammer, G., 2013. Disciplining interdisciplinarity: integration and implementation sciences for researching complex real-world problems. In: Disciplining Interdisciplinarity: Integration and Implementation Sciences for Researching Complex Real-World Problems.
Bandola-Gill, J., A, M., R, I.L., 2023. What is co-production? Conceptualising and understanding co-production of knowledge and policy across different theoretical perspectives. Evidence & Policy 19, 275–298.
Bates, G., Ayres, S., Barnfield, A., Larkin, C., 2023. What types of health evidence persuade policy actors in a complex system? Policy Polit. 51 (3), 386–412. https://doi.org/10.1332/030557321X16814103714008.
Bates, G., Le Gouais, A., Barnfield, A., Callway, R., Md Nazmul, H., Kwon, H.R., Peake-Jones, S., White, J., Bondy, K., Ayres, S., 2023. Balancing autonomy and collaboration in large-scale and disciplinary diverse teams for successful qualitative research. Int. J. Qual. Methods. https://doi.org/10.1177/16094069221144594.
Baztan, J., et al., 2020. Facing climate injustices: community trust-building for climate services through arts and sciences narrative co-production. Clim Risk Manag 30, 100253.
Better Evaluation, 2023. Develop theory of change/programme theory. https://www.betterevaluation.org/frameworks-guides/rainbow-framework/define/develop-programme-theory-theory-change.
Bianca Vienni-Baptista, I.F., Lyall, Catherine, Pohl, Christian, 2022. Embracing heterogeneity: why plural understandings strengthen interdisciplinarity and transdisciplinarity. Sci. Publ. Pol.
Black, D., Ayres, S., Bondy, K., et al., 2022. Tackling Root Causes Upstream of Unhealthy Urban Development (TRUUD): Protocol of a five-year prevention research consortium [version 2; peer review: 3 approved]. Wellcome Open Res. 6, 30. https://doi.org/10.12688/wellcomeopenres.16382.2.
Black, D., Bates, G., Ayres, S., Bondy, K., Callway, R., Carhart, N., Coggon, J., Gibson, A., Hunt, A., Rosenberg, G., 2023. Operationalising a large research programme tackling complex urban and planetary health problems: a case study approach to critical reflection. Sustain. Sci.
Black, D., Coggon, J., Hatchard, J. What 'health' means and why that matters. https://truud.ac.uk/wp-content/uploads/2024/07/What-health-means-and-why-that-matters-July-2024.pdf.
Black, D., et al., 2021. Overcoming systemic barriers preventing healthy urban development in the UK: main findings from interviewing senior decision-makers during a three-year planetary health pilot. J. Urban Health.
Black, D., A, S., Bondy, K., et al., 2022. Tackling Root Causes Upstream of Unhealthy Urban Development (TRUUD): Protocol of a Five-Year Prevention Research Consortium. Wellcome Open Access, London.
Black, D., Scally, G., Orme, J., Hunt, A., Pilkington, P., Lawrence, R., Ebi, K., 2018. Moving Health Upstream in Urban Development: Reflections on the Operationalisation of a Trans-disciplinary Case Study. Global Challenges. Wiley. https://doi.org/10.1002/gch2.201700103.
British Academy, 2016. CROSSING PATHS: INTERDISCIPLINARY INSTITUTIONS, CAREERS, EDUCATION AND APPLICATIONS. British Academy, London, UK.
Brugha, R., Varvasovszky, Z., 2000. Stakeholder analysis: a review. In: Health Policy and Planning.
Cairney, P., 2013. Standing on the shoulders of giants: how do we combine the insights of multiple theories in public policy studies? Pol. Stud. J. 41 (1), 1–21.
Carhart, N., R, G., Pregnolato, M., 2020. Understanding Emergent Behaviour within the Economic Infrastructure System-Of-Systems.
Center for Theory of Change. *What is Theory of Change?* Setting Standards for Theory of Change 2023 25 10 23]; Available from: https://www.theoryofchange.org/what-is-theory-of-change/.
CERE, 2021. Logic Models vs Theories of Change. Available from: https://cere.olemiss.edu/logic-models-vs-theories-of-change/#:~:text=The%20main%20distinction%20between%20a,component%20is%20expected%20to%20result.
Durose, C. Perry, B. Richardson, L. 2022. Is co-production a 'good' concept? Three responses. Futures.
Daniel Black + Associates, 2024. Moving planetary health upstream in urban development decision-making 2015-2019. https://www.db-associates.co.uk/enabling-healthy-urban-development-pilot.html.
Enengel, B., M, A., Penker, M., Freyer, B., Drlik, S., Ritter, F., 2012. Co-production of knowledge in transdisciplinary doctoral theses on landscape development—an analysis of actor roles and knowledge types in different research phases. Landsc. Urban Plann. 105 (1–2), 106–117.
ESG, 2018. Science and Implementation Plan of the Earth System Governance Project.

Farr, M., 2018. Power dynamics and collaborative mechanisms in co-production and co-design processes. Crit. Soc. Pol. 38 (4), 623–644.
Fioretos, O., F, T., Sheingate, A., 2016. Historical institutionalism in political science. In: The Oxford Handbook of Historical Institutionalism. Oxford University Press, Oxford.
Friel, S., et al., 2011. Climate change, noncommunicable diseases, and development: the relationships and common policy opportunities. In: Annu Rev Public Health, pp. 133–147.
Gardner, G., 2016. The city: a system of systems. In: State of the World. Island Press, Washington, D.C.
González-Ricoy, I., Gosseries, A., 2016. Institutions for Future Generations. Oxford University Press, Oxford.
Goodpastor, K., 1991. Business ethics and stakeholder analysis. Bus. Ethics Q. 1 (1), 53–73.
Grant, M.B.C., Caiaffa, W.T., Capon, A., Corburn, J., Coutts, C., Crespo, C.J., Ellis, G., Ferguson, G., Fudge, C., Hancock, T., Lawrence, R.J., Nieuwenhuijsen, M.J., Oni, T., Thompson, S., Wagenaar, C., Ward Thompson, C., 2017. Cities and health: an evolving global conversation. Cities & Health 1 (1).
Gregory, A., A, J., Midgley, G., Hodgson, A., 2020. Stakeholder identification and engagement in problem structuring interventions. Eur. J. Oper. Res. 283 (1), 321–340.
Hall, K.L., et al., 2012. A four-phase model of transdisciplinary team-based research: goals, team processes, and strategies. Translational behavioral medicine 415–430.
Hall, J., et al., 2020. A co-production approach guided by the behaviour change wheel to develop an intervention for reducing sedentary behaviour after stroke. Pilot Feasibility Stud 6, 115.
Haugaard, M., 2010. Power: a 'family resemblance'concept. Eur. J. Cult. Stud. 419–438.
Haugaard, M., 2021. The four dimensions of power: conflict and democracy. J. Polit. Power 14 (1), 153–175.
Hawkins, J., et al., 2017. Development of a framework for the co-production and prototyping of public health interventions. BMC Publ. Health 17 (1), 689.
Hubbard, G., et al., 2020. Co-production of "nature walks for wellbeing" public health intervention for people with severe mental illness: use of theory and practical know-how. BMC Publ. Health 20 (1), 428.
Innes, J.E., Booher, D.E., 2004. Reframing public participation: strategies for the 21st century. In: Planning Theory and Practice.
International Resource Panel, 2018. The Weight of Cities: Resource Requirements of Future Urbanization. United Nations Environment Programme, Nairobi, Kenya.
INVOLVE, 2019. Guidance on Co-producing a Research Project.
Ison, R., 2008. Methodological challenges of trans-disciplinary research: some systemic reflections. Natures Sci. Soc.
JPI Urban Europe, 2018. Sustainable urbanisation global initiative (SUGI)/Food-Water-Energy nexus. Available from: https://jpi-urbaneurope.eu/calls/sugi/.
Lane, M.B., 2005. Public participation in planning: an intellectual history. Aust. Geogr.
Le Gouais, A., Bates, G., Callway, R., Kwon, H., Montel, L., Peake-Jones, S., White, J., Hasan, M.N., Koksal, C., Barnfield, A., Bondy, K., Ayres, S.. Understanding how to create healthier places: A qualitative study exploring the complex system of urban development decision-making. Health & Place. https://www.sciencedirect.com/science/article/pii/S1353829223000606.
Lécuyer, L., B, E., Butler, J.R.A., Barnaud, C., Calla, S., Locatelli, B., Newig, J., Pettit, J., Pound, D., Quétier, F., Salvatori, V., Von Korff, Y., Young, J.C., 2024. The importance of understanding the multiple dimensions of power in stakeholder participation for effective biodiversity conservation. People and Nature.
Locock, L., B, A., 2019. Drawing straight lines along blurred boundaries: qualitative research, patient and public involvement in medical research, co-production and co-design. Evidence and Policy 15, 409–422.
Matthews-Simmons, F., 2019. What's the difference between a program logic and a theory of change? https://www.linkedin.com/pulse/whats-difference-between-program-logic-theory-change-matthew-simmons/.
Meadows, D.H., Club of Rome, 1972. The Limits to Growth; a Report for the Club of Rome's Project on the Predicament of Mankind. Universe Books, New York, p. 205.
Mitchell, R., A, B., Wood, D., 1997. Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts. Acad. Manag. 22, 853–886.
Moallemi, E.Z., F, Hebinck, A., Szetey, K., Molina-Perez, E., Zyngier, R., Hadjikakou, M., Kwakkel, J., Haasnoot, M., Miller, K., Groves, D., Leith, P., Bryan, B., 2023. Knowledge co-production for decision-making in human-natural systems under uncertainty. Global Environ. Change.
Moerder, C., Hamilton, L., Alper, J., 2020. Health-focused public-private partnerships in the urban context. Proceedings of a Workshop. Washington (DC).
NIHR, 2021. Briefing notes for researchers - public involvement in NHS, health and social care research. https://www.nihr.ac.uk/documents/briefing-notes-for-researchers-public-involvement-in-nhs-health-and-social-care-research/27371.
OECD, 2020. Addressing societal challenges using transdisciplinary research. In: OECD Science, Technology and Industry Policy Papers. OECD Publishing, Paris.
OECD, 2023. Cities and Environment. https://www.oecd.org/cfe/cities/cities-environment.htm#:~:text=Cities%20account%20for%20more%20than,half%20of%20the%20world's%20population.
Oliver, K., Kothari, A., Mays, N., 2019. The dark side of coproduction: do the costs outweigh the benefits for health research?. In: Health Research Policy and Systems. Health Research Policy and Systems, pp. 1–10.
Pacione, M., 2019. The Rhetoric and Reality of Public Participation in Planning, 63. Urban Development Issues.
Pain, K., Van Hamme, G., 2014. Changing Urban and Regional Relations in a Globalizing World: Europe as a Global Macro-Region. Edward Elgar, Cheltenham.
PHA, 2024. About PHA. https://www.planetaryhealthalliance.org/planetary-health.
Pohl, C.W.G., 2019. Methods for coproduction of knowledge among diverse disciplines and stakeholders. In: Hall, K., Vogel, A., Croyle, R. (Eds.), Strategies for Team Science Success. Springer.
Prescott, S.L., Logan, A.C., 2019. Planetary health: from the wellspring of holistic medicine to personal and public health imperative. Explore 15 (2), 98–106.
Reed, M., 2016. Research Impact Handbook. Fast Track Impact.
Reed, M.S., et al., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. J. Environ. Manag.
Reed, M., B, R., Machen, R., 2018. Pathways to policy impact: a new approach for planning and evidencing research impact. Evidence and Policy 14 (3), 431–458.
Russell, B., 1938. Power: A New Social Analysis. George Allen & Unwin, London.
Rydin, Y., Pennington, M., 2000. Public participation and local environmental planning: the collective action problem and the potential of social capital. Local Environ.
Satorras, M., Ruiz-Mallén, I., Monterde, A., March, H., 2020. Co-production of urban climate planning: insights from the barcelona climate plan. Cities 106.
Schiller, C., et al., 2013. A framework for stakeholder identification in concept mapping and health research: a novel process and its application to older adult mobility and the built environment. BMC Publ. Health 13, 428.
Schmeer, K., 2000. Stakeholder analysis guidelines. Analysis.
Schultz, W., C, C., Lum, R., 2012. Scenarios: a hero's journey across turbulent systems. J. Future. Stud. 17 (1), 129–140.
Skivington, K., M, L., Simpson, S.A., Craig, P., Baird, J., Blazeby, J.M., Boyd, K.A., Craig, N., French, D.P., McIntosh, E., Petticrew, M., Rycroft-Malone, J., White, M., Moore, L., 2021. A new framework for developing and evaluating complex interventions: update of Medical Research Council guidance. BMJ.
Stern, N., 2016. Building on Success and Learning from Experience. An Independent Review of the Research Excellence Framework, p. 56.
Swinburn, B.A., et al., 2019. The global syndemic of obesity, undernutrition, and climate change: the lancet commission report. Lancet.
Tauxe, C.S., 1995. Marinalizing public participation in local planning- an ethnographic account. J. Am. Plann. Assoc.
Trejo-Nieto, A., 2020. Financialising city statecraft and infrastructure. In: Regional Studies.
TRUUD, 2023. Phase 1. https://truud.ac.uk/wp-content/uploads/2024/02/TRUUD-Phase-1-Report.pdf.
TRUUD. About TRUUD. https://truud.ac.uk/.
UKPRP, 2018. The UK Prevention Research Partnership (UKPRP): Vision, Objectives and Rationale. https://ukprp.org/wp-content/uploads/2019/08/UKPRP-Background-and-Rationale.pdf.
UKPRP, 2019. Resources. UK Prevention Research Partnership. https://ukprp.org/resources/.
UKRI, 2023. Co-Production in Research. Available from: https://www.ukri.org/manage-your-award/good-research-resource-hub/research-co-production/#:~:text=Co%2Dproduction%20often%20includes%20academic,ethics%20around%20their%20joint%20research.
UPSTREAM. About UPSTREAM. Website. https://urban-health-upstream.info/.
van der Graaf, P., et al., 2023. Leading co-production in five UK collaborative research partnerships (2008-2018): responses to four tensions from senior leaders using auto-ethnography. Implement Sci Commun 4 (1), 12.
Varvasovszky, Z., Brugha, R., 2000. How to do (or not to do)…: a stakeholder analysis. In: Health Policy and Planning.
Vaughn, L., Jacquez, F., 2020. Participatory research methods – choice points in the research process. J. Participatory Res. Method Res. Methods.
Wates, N., 1996. Action Planning: How to Use Planning Weekends and Urban Design Action Teams to Improve Your Environment. The Prince of Wales' Institute of Architecture.
Whitmee, S., et al., 2015. Safeguarding human health in the anthropocene epoch: report of the rockefeller foundation-lancet commission on planetary health. Lancet.
Williams, O., et al., 2020. Lost in the shadows: reflections on the dark side of co-production. Health Res. Pol. Syst. 18 (1), 43.