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Advancing climate resilient development pathways since the IPCC's fifth assessment report

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ABSTRACT

Development processes and action on climate change are closely interlinked. This is recognised by the Intergovernmental Panel on Climate Change (IPCC) in its fifth assessment report, which reports on climate-resilient pathways, understood as development trajectories towards sustainable development which include adaptation and mitigation. The upcoming sixth assessment report dedicates a chapter to climate resilient development pathways. In this context, this paper asks what conceptual and empirical advances on climate resilient development pathways were made since the fifth assessment report. Through a literature review, this paper analyses goals and approaches for climate resilient development pathways, and discusses what conceptual advances have and could still be made. We find little evidence of dedicated concept development. Rather, we observe conceptual ambiguity. Literature showed four non-exclusive clusters of approaches: (a) climate action oriented, (b) social-learning and co-creation oriented, (c) mainstreaming oriented and (d) transformation oriented. We recommend operationalising climate resilient development pathways as the process of consolidating climate action and development decisions towards long-term sustainable development. This process requires explicit engagement with aspirations of actors, and connecting past developments with future aspirations and understandings of risk. Working with multiple pathways allows us to embed flexibility, anticipation and learning in planning. A greater focus is needed on issues linked to justice and equity as climate resilient development pathways will inevitably involve trade-offs. Substantiating the concept of climate resilient development pathways has the potential to bridge climate and development perspectives, which may otherwise remain separated in development and climate policy, practice and science.

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1. Introduction

Development is happening against a background of climate change. Development decisions in a changing climate need to include choices and actions that reduce greenhouse gas emissions and adapt to impacts of climate change to sustain development efforts over time. This is particularly pertinent given that the relationships between development and climate change are multifaceted. Development processes can enhance vulnerabilities to climate impacts by impairing the ability to adapt and mitigate (Lo et al., 2020; Thomalla et al., 2018). At the same time, poorly designed action on climate change may deflect sustainable development efforts (Eriksen et al., 2021). This was recognised by the Intergovernmental Panel on Climate Change (IPCC) in its fifth assessment report (AR5, www.ipcc.ch/report/ar5/wg2/) and its more recent Special Report on 1.5 °C (IPCC, 2018). Both reports emphasise the extensive links between climate and sustainable development calling for new approaches to sustainable development that these interactions. Chapter 20 of AR5 reports on 'climate-resilient pathways'. As a broad baseline, the Chapter defines climate-resilient pathways as "development trajectories that combine adaptation and mitigation to realize the goal of sustainable development" (Denton et al., 2014: 1104). Denton et al. (2014) understand climate action not as an outcome, but rather as a process, which can be achieved through a combination of incremental and transformational changes. They infer that "Although payoffs from specific long-term pathways may be unknown, strategies and actions can be pursued now that will contribute to moving toward resilient pathways, while helping improve livelihoods, social and economic well-being, and responsible environmental management" (Denton, 2014: 1113). Denton et al. (2014: 1105) conclude that "more research about the relationship between mitigation, adaptation, and sustainable development is needed, as well as research on the relationship between incremental changes and more significant transformations for sustainable development". For the IPCC's sixth assessment report (AR6) a dedicated chapter is under preparation on 'climate resilient development pathways'.

In this context, this paper asks what the conceptual and empirical advances on climate resilient development pathways have been since the IPCC's fifth assessment report. Understanding how the concept evolves is important to guide policy and research. This is timely, as the terminology has started to enter policy and practice (e.g. in the goals of the Green Climate Fund (Winkler and Dubash, 2016), in selected National Adaptation Plans (e.g. Government of the Republic of Fiji, 2018), and the SADC Futures foresight framework (Chesterman et al., 2020)). We offer a review of research in the larger domain of climate resilient development pathways, analysing definitions, goals and methods of researchers. We acknowledge that other concepts have been used to grapple with challenges of interactions, trade-offs and synergies between climate and development decisions. Examples include climate compatible development (e.g. Nunan, 2017; Stringer et al., 2014); triple wins for mitigation, adaptation and development (e.g. Suckall et al., 2015) and 'low carbon resilient development' (e.g. Fisher and Rai, 2016). Each of these concepts has also advanced in the period since AR5. However, as the IPCC selected 'climate resilient development pathways' as their wording and as we aim to trace how this concept evolved since AR5, we confine our review to this terminology. Next, we reflect on our findings with a panel of experts and discuss how the concept can be advanced. We find little evidence of dedicated empirical and conceptual work on 'climate resilient development pathways'. Use of the terminology in the domains of climate action, resilience, development and pathways research has given rise to conceptual ambiguity. We recommend operationalising climate resilient development pathways as the process of consolidating climate action and development decisions towards long-term sustainable development. Realizing the ambition of climate resilient development, we conclude, requires conceptualising sustainability, flexibility and equity as the goal for adaptation and mitigation, and supporting human agency in co-creating and enacting pathways that support transformation towards sustainable, just and equitable futures.

2. Methods

We reviewed the academic literature on climate resilient development pathways. We followed the same four steps as Werners et al. (2021), which are based on Berrang-Ford et al. (2015) guidelines for systematic review in adaptation research, as applied by Tucker et al. (2015):

1. Question-setting and scope;
2. Literature search and selection of documents;
3. Data extraction and analysis;
4. Reflexive learning.

2.1. STEP 1: Question-setting and scope

This paper asks what conceptual and empirical advances have been made on climate resilient development pathways since AR5. To set the scope of the review, we performed multiple exploratory searches. The review was temporally restricted to papers from 2014 onwards, the review was not geographically restricted. We observed that a search in Scopus in September 2020 for the search term "climate resilient development pathway*" for the options (TITLE-ABS-KEY) yielded only 6 results, whereas "climate resilient pathway*" yielded 10 results. The search term (climate AND resilien* AND development AND pathway*) yielded 278 papers." yielded 10 results. The search term (climate AND resilien* AND development AND pathway*) yielded 278 papers.

Guided by the preliminary searches we topically limited the review to the domains of climate, resilience, development and pathways. We recognise that extensive literature exists relating in each of these domains, yet for this study we chose to consider only papers that engage with all four domains, though not necessarily with the exact term "climate resilient development pathways". The argument being that we felt that this body of literature was most representative of the current state of knowledge related to the concept of climate resilient development pathways. The review uses two sets of guiding questions:The argument being that we felt that this body of literature was most representative of the current state of knowledge related to the concept of climate resilient development pathways.

1. *how do papers approach the four domains that make up climate resilient development pathways?*
   - How do papers approach climate action (here understood as adaptation and mitigation)?
   - How do papers approach resilience?
   - How do papers approach development?
   - How do papers approach pathways?
2. *how and why are climate resilient development pathways approached?*
   - What definition is used?
   - What is the goal / desired impact / outcome?
   - What approach is used?
   - In what case / decision context is the approach applied?

2.2. STEP 2: Literature search and selection of documents

The literature was sourced from Scopus, searched on Sept 15, 2020 for the search terms:

1. Search terms: TITLE-ABS-KEY *(climate* AND *resilien** AND *development* AND *pathway*)* Scopus (278) No filters used.
2. Search terms: TITLE-ABS-KEY *"climate resilient development pathway* "* Scopus (6) No filters used.Scopus (6) No filters used.

3. Search terms: TITLE-ABS-KEY *"climate resilient pathway* "* Scopus (10) No filters used.

As per search rules, the specific phrase within speech marks (") will be found and any word that begins with the root/stem of the word truncated by the asterisk (*). This resulted in 294 unique publications since 2014. The titles and abstracts of these 294 papers were screened to identify papers for full analysis. Inclusion criteria were: applying the domains in whole or similar phrased terms (at least 3 of the 4 possible domains in the keywords, title or abstract) e.g. Climate Resilient Pathways or Climate Resilient Development.

The screening was done by the authors Werners, James and Siebeneck. Each paper was screened by a minimum of two people. These screening yielded 38 publications for full-text analysis.

2.3. STEP 3: Data extraction and analysis

The full texts of the 38 publications selected in Step 2 were reviewed, based on which 15 were selected for a detailed analysis and 23 were excluded on the basis that, although they mentioned at least three out of four of the concepts in the term 'climate resilient development pathways' in the abstract, the paper did not offer conceptual advances upon a full reading of the paper.

We analysed the papers and extracted the information related to the research questions in a simple table format. Headings for the data extraction were: (i) paper type (conceptual, case, review, guidance), (ii) definition and framing, (iii) goal / outcome, and for case paper: (iv) decision context, (v) method / approach.

2.4. STEP 4: Reflexive learning on climate resilient development pathways

In dedicated online sessions, we brought together researchers from the domains of climate, resilience, development and pathways to reflect on the review and what they consider the essence of climate resilient development pathways. First-authors from the papers selected in Step 3 were invited, whilst observing a balanced representation of the four domains. Participants could draw on experience in different geographic and institutional contexts, including Australia, Benin, Bangladesh, India, Nepal, the Netherlands, Pakistan, Papua New Guinea, South Africa, United Kingdom and Vietnam. We synthesized the results of these sessions to frame climate resilient development pathways and its future application. In this step we also consider papers relevant for our study that came out after our search in Step 2. These were not fully analysed but added to the discussion.

3. Results: conceptual advances and ambiguities in climate resilient development pathways

3.1. Conceptual advances and ambiguities in the domain of climate action (adaptation and mitigation)

AR5 positions climate-resilient pathways as "development trajectories that combine adaptation and mitigation to realize the goal of sustainable development" (Denton et al., 2014: 1104). In this paper, we use the term climate action to include both mitigation (efforts to reduce greenhouse gas emissions) and adaptation (efforts to respond to and prepare for climate-induced impacts). Most papers from our search report on experiences in the domain of adaptation (e.g. for water management in Australia's Murray-Darling basin (Abel et al., 2016), for rural livelihoods in Indonesia (Butler et al., 2014), or for Small Island Developing States (Mycoo, 2018)), whereas less focus on mitigation (e.g. in cities (Dovie et al., 2020)). The fewest number of papers offer a case which combines adaptation and mitigation. Examples are community-level experimentation on climate change across British Columbia, Canada (Burch et al., 2014), development pathways for agriculture (Stringer et al., 2020) and a critical review of synergistic mitigation-adaptation-development outcomes via climate-smart agriculture (also called triple-win logic) (Ellis and Tschakert, 2019).

Conceptually it is noted that some authors exclude mitigation from their definition of climate resilient development (pathways). For example, Dovie et al. (2020) define climate-resilient development as the product of adaptation and development. Thus defined, it is not the main concept in their paper. Rather their main objective is low-carbon emission development. From the mitigation perspective, the authors call for mainstreaming mitigation and adaptation in 'climate compatible development', noting: "the standalone intersection between mitigation and development to deliver low-carbon emission development will not result in cities' resilience unless (i) co-benefits, which are outcomes of mitigation and adaptation, and (ii) climate-resilient development, the product of adaptation and development, coevolved." (Dovie et al., 2020: 1). Others recognise this ambiguity with the term climate compatible development, yet explicitly understand climate resilience to include adaptation and mitigation (e.g. Scholz and Methner, 2020).

3.2. Conceptual advances and ambiguities in the resilience domain

Douxchamps et al. (2017) deliver an extensive review of tools for resilience assessment and the most conscious reflection on assessment of resilience in the papers we reviewed. We note, however, that they have an inclination toward adaptation and define building climate resilience, as "the ability to anticipate, absorb, accommodate, or recover from climate change in a timely and efficient manner" (Douxchamps et al., 2017: 10). This inclination towards adaptation is found with all papers that conceptually engage with resilience in the context of climate resilient development (e.g. Abel et al., 2016; Scholz and Methner, 2020; Trabacchi and Stadelmann, 2016). In addition, the majority of these papers understand resilience from a social-ecological systems perspective. For example, Chelleri et al. (2016), who study trade-offs between community resilience and social-ecological vulnerability in Bolivian quinoa producing regions.

A conceptual ambiguity arises between using resilience as a metric and using resilience to symbolise a specific state of a system to aspire to with an established set of institutions, norms, and behaviours (Solecki et al., 2017). Related to this ambiguity is the relationship between resilience and transformation. Some authors set the two apart. For example, Solecki et al. (2017) see resilience as a less effective regime for change, and transformation as something which is stronger at reducing root causes of risk, characterized as "Embarking on fundamentally new development pathways and risk governance principles". Other authors see transformation as crucial in order to achieve climate resilience, or as a necessary part OF resilience, stating "large-scale transformations are needed to achieve greater climate resilience" (Scholz and Methner, 2020: 322).

Another ambiguity emerges between resilience and sustainability. Douxchamps et al. (2017) ask whether resilience is useful as a concept to guide development onto more desirable paths. Collier et al. (2017), after Derissen et al. (2011), understand resilience as a descriptive concept related to system dynamics, different from a normative concept like sustainability. Depending on the context, the resilience of a system may be perceived as positive or negative (Derissen et al., 2011). This contrasts with authors that use resilience with a positive connotation (e.g. Burch et al., 2014; Scholz and Methner, 2020). A positive framing of resilience can also be found in AR5 (Denton et al., 2014). Collier et al. (2017: 29) conclude that "in a decision-making context, (1) both sustainability and resilience are dependent upon what stakeholders feel is desirable in terms of goals and end states, and (2) multicriteria trade-offs are required to achieve these goals". Similarly, the relationship between system's resilience and community vulnerability highlights emerging trade-offs among adaptive capacities and exposures to different (and new) threats. In this context, Chelleri et al. (2016: 2229) argue that positive attributes assigned to resilience should be taken with caution, and should take into account "to whom or to what is positive which

adaptation" and "which trade-off should be accepted, and why".

3.3. Conceptual advances and ambiguities in the development domain

In the papers we reviewed, the term development is used for aspiration of socio-ecological 'growth' (e.g. Stringer et al., 2020), as well as for a more broad notion of change (e.g. understanding development as projecting a pathway through time (Solecki et al., 2017)). In low to lower-middle income contexts, the emphasis is more on vulnerability and poverty reduction (co-benefits for the poor) (e.g. Butler et al., 2014; Chelleri et al., 2016), whereas in middle to high income contexts there is more emphases on mainstreaming and reaching climate targets (e.g. Dovie et al., 2020). This resonates with Chapter 20 of AR5, which notes that development responses differ regarding socioeconomic, cultural, biophysical and institutional contexts (Denton et al., 2014).

Ambiguity arises with the goal of climate resilient development and the explicit mentioning of sustainable development and sustainability. Authors agree that climate action needs to be addressed within a broader socio-economic and environmental context, and that it must be part of long lasting development plans and not a project per se (e.g. Artur et al., 2018). Arguments in favour of this position include that (i) responding to local development needs prioritizes locally grounded interventions and embeds adaptation and mitigation agendas in local institution's everyday planning, making it sustainable over time (Artur et al., 2018; Butler et al., 2014), (ii) co-benefits, synergies and trade-offs can be considered, for example between modernisation and traditional values in rural development settings (Butler et al., 2014; Chelleri et al., 2016). However, Chelleri et al. (2016), after Lauer et al., (2013) note the difficulty in making clear distinctions between opportunities and threats in the development context. This lack of transparency can lead to unpredictable, unwanted and unsustainable development trajectories. We will revisit this point in the discussion.

3.4. Conceptual advances and ambiguities in the pathways domain

Pathways are found to be used as a metaphor or as an analytical tool (cf. Lin et al., 2017). As a metaphor, 'pathways' shape narratives, which capture the adaptive or maladaptive choices that decision-making entities could undertake over time in response to uncertain change (e.g. Kamei et al., 2016; Stringer et al., 2020) and which help create an environment in which stakeholders can deliberate (e.g. Butler et al., 2014). In combination with development (understanding development as projecting a pathway through time), Solecki et al., (2017: 5) look upon pathways as "the historic and constantly evolving relationship between social and biophysical systems, mediated by policies and practices, in relation to sustainability limits". Conceptualizing climate action using the pathways metaphor, rather than as one specific action, permits embedding the challenge of adressing climate challenge within the overall challenge of social-ecological development (e.g. Skrimizea and Parra, 2020). Burch et al. (2014) elaborate on a conceptual framework for understanding the dynamics of community-level development pathways that both reduce greenhouse gas emissions and enhance community resilience. They find that such climate-resilience development pathways are more likely "if policy employs a longer time horizon, recognition of adaptability and feedbacks, integrated decision making, and systems thinking" (Burch et al., 2014: 467). As an analytical tool, 'pathways' provide sequences of actions for progressive implementation under future dynamics (Lin et al., 2017). Thus understood, pathways aim to deal with uncertainty by embedding flexibility within planning. The outcome is forward looking, action oriented and requires monitoring and evaluation to decide when to switching between actions and pathways for achieving predefined goals (Lawrence and Haasnoot, 2017; Lin et al., 2017; Werners et al., 2021).

To-date no general procedure for pathways creation and appraisal exists (Werners et al., 2021). Authors that offer guidance are from the domain of adaptation pathways (e.g. Abel et al., 2016; Lin et al., 2017). Abel et al. (2016) flag that development and implementation of pathways is complicated by the diversity of case and decision contexts (differences in stakeholders' values, diverse decision-makers and multiple contested views). Focusing on adaptation and pathways towards transformation, the authors offer criteria for sequencing actions along adaptation pathways. These criteria include "feasibility of the action within the current decision context, its facilitation of other actions, its role in averting exceedance of a critical threshold, its robustness and resilience under diverse and unexpected shocks, its effect on future options, its lead time, and its effects on equity and social cohesion" (Abel et al., 2016: 1). Other authors, who use pathways as a metaphor for a trajectory or strategy, draw on tools such as life cycle analysis (Collier et al., 2017).

In sum, we observed the following ambiguities in this domain: 1) whether 'pathways' are understood loosely as development narratives, or analytically as sequences of actions that include flexibility to accommodate uncertainty, 2) whether pathways are directed towards alternative (resilience) regimes or to reaching a well-defined target under uncertainty, and 3) whether development path(ways) refer to evolving developments, to processes of transformative change or to both.

3.5. Synthesis of conceptual and empirical advances

In this section we synthesise our findings on conceptual and empirical advances. In our literature review, we find little evidence of dedicated concept development. Lessons from the domains of climate action (e.g. Dovie et al., 2020), resilience (e.g. Douxchamps et al., 2017; Wenger, 2017), development (e.g. Lo et al., 2020) and pathways (e.g. Scoones et al., 2020; Werners et al., 2021) are yet to come together. Of the papers we analysed, many elaborated on combinations of two or three domains and all covered some form of climate action. Papers from Burch et al. (2014), Moss et al. (2019), Scholz and Methner (2020) and Tanner et al. (2019) do touch upon all four of the domains, yet no author does so with the aim to conceptually advance climate resilient development pathways. No attempts are undertaken to comprehensively define the concept or offer a conceptual framework. Instead we observe ambiguity in the use of the terminology in the literature that we reviewed.

To summarise, most papers focus on either adaptation (e.g. Mycoo, 2018) or mitigation (e.g. Dovie et al., 2020), with the fewest paying attention to both (e.g. Burch et al., 2014). Resilience is described as both a metric and as an end goal (Solecki et al., 2017), with some stating it is an essential and desirable component (Abel et al., 2016) and others asking if it is necessary for long term sustainable development (Douxchamps et al., 2017). Development is treated as an action, a driver of vulnerability or as an outcome in the context of sustainable development. Pathways are used as a metaphor for transformative change (e.g. Lin et al., 2017), as well as an analytical tool for providing sequences of actions (Lawrence and Haasnoot, 2017).

Our literature review also asked how and why climate resilient development pathways are used. Although we found insufficient material for conclusive answers to these questions, we do find trends, which are elaborated below.

First, there has been a shift away from climate action in support of sustainable development (Denton et al., 2014) toward climate proofing of development (e.g. Moss et al., 2019; Sánchez-Arcilla et al., 2016). AR5 emphasizes that adaptation and mitigation are processes that have the potential to both contribute to, and impede sustainable development, which is framed as the "ultimate goal" for climate action (Denton et al., 2014: 1104). The papers in our review in the development domain, frame development as the action, which, depending on how sustainable it is, enhances the natural resilience of the studied systems (Sánchez-Arcilla et al., 2016).

Second, mainstreaming climate action into development paths at every level is discussed as essential (Burch et al., 2014; Dovie et al.,

2020; Mulugetta and Castán Broto, 2018; Ferreira Costa, 2020; Tanner et al., 2019). To what extent this occurs depends on appropriate governance, regulations, knowledge and education, and resourcing (Schipper et al., 2020; Stringer et al., 2020). Evidence from Mali, for example, indicates that most communities "do not have the technical or financial resources to elaborate a development pathway sensitive to the increasing pressures of climate and environmental change" (Martin et al., 2018: 16). With respect to the issue of scale, of the literature that we analysed in detail, content was more concrete at smaller scales (e.g. Butler et al., 2014) and became more abstract at larger scales (e.g. Tanner et al., 2019).

Third, a substantial number of authors elaborate on actor involvement and social learning processes. It is argued that reflexive governance approaches based on social learning creates opportunity for desired end goals (Burch et al., 2014; Moss et al., 2019; Mulugetta and Castán Broto, 2018; Scholz and Methner, 2020; Stringer et al., 2020; Tanner et al., 2019). Multiple authors place reliance on informal processes, advocated for by central stakeholders for stimulating this. For example, Tanner et al. (2019) argue that informal processes championed by so-called "policy entrepreneurs" can break institutional locks. Dovie et al. (2020) emphasize that "local leadership" will increase rates of adoption and transfer to low carbon technologies in cities. Abel et al. (2016) refers to "agents of change", who are important in facilitating transformation through enhancing connectivity and adoption of practice and Lawrence and Haasnoot (2017) employ a method that uses "knowledge brokers" for the uptake of dynamic adaptive policy pathways. Although presenting different respective cases, authors concordantly discuss social learning and co-creation processes (Abel et al., 2016; Lawrence and Haasnoot, 2017; Moss et al., 2019; Scholz and Methner, 2020).

Fourth, multiple authors reflect on the need and virtue of transformative change. Climate resilient development may call for transformation in such settings, where high levels of vulnerability are generated by dominant development paradigms, conflicting stakeholder values and power structures (Abel et al., 2016; Moss et al., 2019; Scholz and Methner, 2020). In such contexts, governance that avoids undesirable trade-offs, while simultaneously achieving shared objectives is identified as key (Burch et al., 2014). We reflect on the issue of transformation in the discussion section.

In sum, analysis of literature in the domain of climate resilient development pathways points towards four non-exclusive approaches, which we label building on Werners et al. (2021): (a) climate action oriented (e.g. Mulugetta and Castán Broto, 2018; Stringer et al., 2020), (b) mainstreaming oriented (e.g. Dovie et al., 2020; Ferreira Costa, 2020; Tanner et al., 2019), (c) social-learning and participation oriented (e.g. Moss et al., 2019; Scholz and Methner, 2020), and (d) transformation oriented (e.g. Abel et al., 2016; Burch et al., 2014; Schipper et al., 2020). These approaches broadly correspond to four desired goals of climate resilient pathways development: (i) planning for specific climate actions for meeting short and long-term sustainable development goals, (ii) mainstreaming climate action and development, including synergies/co-benefits and trade-offs, (iii) promoting reflexive learning, adaptive decision-making and adaptive capacity, (iv) accounting for multiple drivers (such as root causes of vulnerability, injustice and poverty), path dependency and a potential need for transformation towards long-term sustainable development.

4. Discussion

In this section, we bring together lessons from the literature review and reflexive learning sessions to (1) Frame climate resilient development pathways and address ambiguity in use of the concept, (2) Provide a research agenda for advancing climate resilient development pathways.

4.1. Framing climate resilient development pathways

Given the diverse applications and range of scholars engaging with the four domains, we find that a narrow definition of climate resilient development pathways may be exclusive. An attempt to do this could restrict application. However, without guidance, climate resilient development pathways will likely become misinterpreted, and may become misappropriated. In consideration of this, we recommend operationalising climate resilient development pathways as the process of consolidating climate action and development decisions towards long-term sustainable development. We also feel it is important that ambiguities are addressed. To this end we make the following recommendations. The lessons for the practice of climate resilient development pathways are summarised in Fig. 1.

First, adaptation and mitigation actions both need to be considered in the practice of climate resilient development pathways. There may be more emphasis on one or the other, depending on the decision context, however, neither should be wholly excluded. Climate resilient development pathways should engage with adaptation and mitigation synergies and trade-offs across sectors, scales and peoples (cf. Leal Filho et al., 2021). At the same time, climate action should aim to facilitate pathways toward sustainable development. This will require a shift in climate policy, away from nationally defined targets and toward indicators of progress cognisant of processes driving vulnerability. This may include moving away from growth, modernity and efficiencies and towards narratives of meeting basic needs, enhancing well-being and creating agency (Eriksen et al., 2021).

Second, as climate action is increasingly mainstreamed into development, the practice of climate resilient development pathways will have to challenge the vision and goal of development. We follow environmental justice scholarship and highlight the need to include justice and equity within climate resilient development pathways (cf. Martin et al., 2020). There is a risk in presenting climate resilient development pathways as apolitical, failing to appreciate the social, political and, power dynamics at play, which can marginalise other forms of knowledge and people (cf. Few et al., 2021). It will be important to reflect on whose vision and whose goals are considered, as evidently, benefits and trade-offs will have to be made. This draws attention to who is involved in climate resilient development pathways. It is recommended that the practice of climate resilient development pathways gives space for participation of non-government actors (including micro and small business entrepreneurs and community leaders) (Dovie et al., 2020) as well as those that are the most marginalised and vulnerable (Leal Filho et al., 2021). Partnerships between researchers, stakeholders, and decision makers enable collaboration on desired futures, pathways, and best practices for sustainability, while maintaining broad levels of support (cf. Klein et al., 2019). Here, sustainable development may need to be re-conceptualised in the context of ongoing change and it has to be discussed whether the sustainable development goals, the flagship target for sustainable development globally, could be more explicitly recognized as targets for climate resilient development pathways against which performance can be monitored and evaluated.

Third, resilience is to be understood as a descriptive concept that can give insight into the dynamic properties of a system, including drivers and root causes of vulnerability, controlling variables, feedback, tipping points and the capacity for transformation (cf. Walker and Salt, 2012). These properties go beyond how well that system absorbs, recovers (Douxchamps et al., 2017) or rebounds from internal and external shocks, and allow to put "the core of the system configuration as such into question" (Solecki et al., 2017: 3). Resilience is the ability to learn, adapt and change while coping with disturbance, which includes and may require transformation. Resilience also draws attention to working across scales. If the changes required to adapt are so great that it overwhelms the adaptive capacity of a system at a particular time and scale, transformation into a new system based on other resources will have to happen (Douxchamps et al., 2017). But this transformation from one

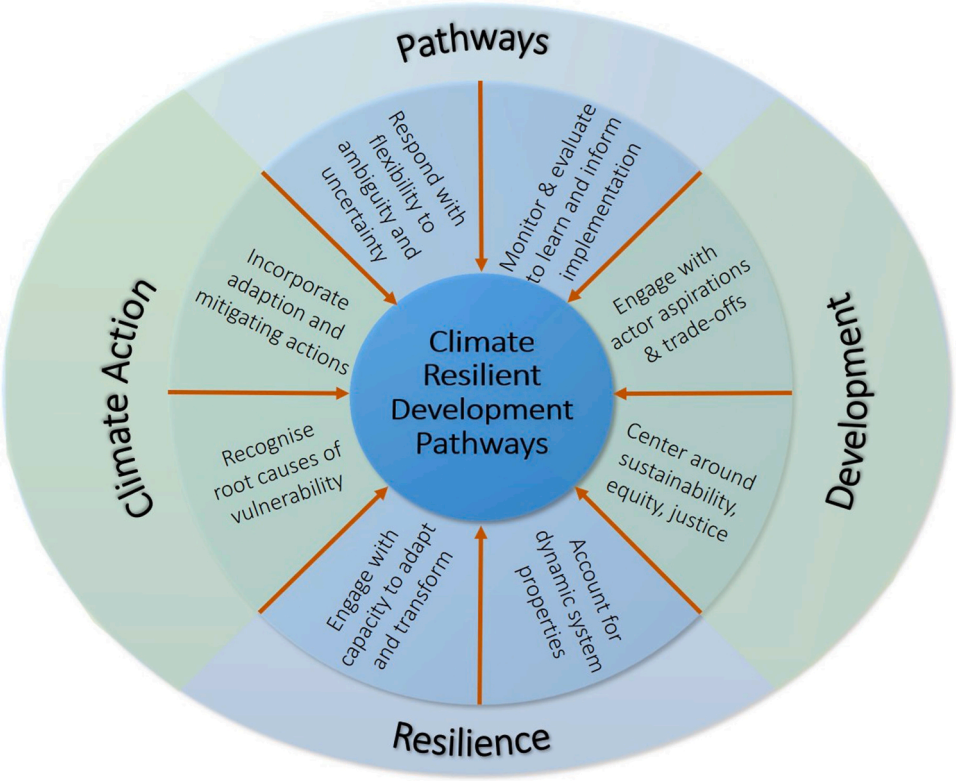

Fig. 1. Lessons from four domains for the practice of climate resilient development pathways that consolidate climate action and development decisions towards long-term sustainable development.

system into another might be embedded in a common higher scale system that builds resilience over time on a certain development pathway (cf. Walker, 2020). Thus, working across scales, considering values and reciprocity, is critical for climate resilient development pathways. Furthermore, as resilience is dynamic and not inherently normative, it also demonstrates the persistence of a system, therefore, positive aspects of resilience, and their unwanted counterpart can become apparent depending on framing and decision contexts (Chelleri et al., 2016).

Fourth, pathways are to be recognised in the practice of climate resilient development pathways as a planning approach that considers ambiguity and uncertainty, which are inherent in climate, resilience and development contexts. Specific long-term goals should be set with caution due to uncertainty, complexity and feedback loops (cf. Rammel et al., 2007). However, a structured pathways approach can offer tools to discuss and operationalise what is needed at different scales and levels to respond *with flexibility* to climate change and other future dynamics, including changes in values and understanding. We underline that preparing for uncertainty by co-creating and enacting plural alternative pathways is different from an approach that aims to identify the pathway towards the 'most resilient' future. Framing pathways through questions such as "to whom, in what context, or to what is climate action positive" and "which trade-off should be accepted, and why" can serve as a tool for sustainable development, while avoiding lock-ins (Chelleri et al., 2016: 2229). We note that there is a tension between the pathways concept, which is long term, has no defined end, and may require a built-in revenue-earning component to sustain it, and the development project concept which has a defined end date and budget. To overcome these contrasting ways of thinking about social-ecological change, long-term perspectives should aim at setting priorities and defining the milestones that facilitate pathways towards sustainable development, which could be framed a desirable future. The disaggregation of long-term goals into a series of short-term development actions is critical, with continuous monitoring and evaluation, to assess whether the set of actions are on track for reaching desired future goals. This reflexive process offers room for all actors involved, from communities to international governance organisation, to readjust and accommodate for uncertainties and changing values. To gauge if actions are on track to reach desired futures, outcome mapping developed by Earl et al. (2001) can be useful. This process moves away from more traditional indicators and aims to monitor and evaluate change in behaviours and relationships of stakeholders based on changes in their surroundings.

4.2. *A research agenda for conceptual and empirical advances*

Our review and reflexive workshops identified scope for conceptual and empirical advancement of climate resilient development pathways. As they become more widely deployed, some of ambiguities presented in this paper may resolve themselves in the light of real-world constraints. An objective of conceptual framing is to guide policy actions for empirical cases, specifically, supporting actors in making informed decisions that can be sustainable in climate change and development contexts. Climate resilient development pathways would benefit from further conceptualisation through the following research questions:

4.2.1. *How do concepts such as equity, environmental justice, social vulnerability and well-being intersect with climate action and sustainable development?*

An outstanding and central ambiguity of climate resilient development pathways concerns their orientation or 'goal'. This ambiguity provides both opportunity and risk. The opportunity lies in the potential to create deliberative spaces, in which the recognition of the complexity of social systems and plural knowledge can occur. In so doing, climate resilient development pathways can accommodate multiple, diverse visions and consider the deep uncertainty that exists when exploring possible futures (Ellis and Tschakert, 2019; Ranger et al., 2013). The risk

with an ambiguous and open-ended approach is that in situations where priorities are ill-defined and contested, the dominant ideas of influential actors may perpetuate that impacts fall on less powerful and more vulnerable groups (Few et al., 2021). This agrees with Eriksen et al. (2021), who show that adaptation interventions can and do reinforce, redistribute, or create new vulnerabilities rather than effectively respond to risks linked to climate change. Practical guidance and research is needed on how to orient climate resilient development pathways and evaluate whether actions are 'on track'.

4.2.2. How to connect future pathways with past and current trajectories and narratives?

By making this link, more insight could be given as to how complex path-dependency from past decisions may influence future trajectories. These path-dependency can inform new narratives. This also raises the question how deliberative, participatory and anticipatory learning can be operationalised in climate resilient development pathways approaches, recognising the diversity of knowledge types and governance systems (cf. Werners et al., 2021). Much of the current literature remains strongly grounded in western scientific philosophies, which differ substantially from those of traditional and Indigenous approaches (see e.g. Bates, 2007 for consideration of Inuit views on time and future planning). More work is needed on how Indigenous and local perspectives may be better incorporated into pathways concepts, or indeed, whether social-learning and participation-oriented approaches involving indigenous and local knowledge could offer alternative ways towards climate resilient development.

4.2.3. How can the full scale of trade-offs and feedback loops be accounted for in climate resilient development pathways?

Abel et al. (2016) discuss the dangers and contradictions of trying to maintain the resilience of all social-ecological systems at all scales, and the consequent need for triage. In consideration of increasing systemic risks and complexity, full comprehension of how to identify and measure these trade-offs and feedback loops are an important question (Ellis and Tschakert, 2019). The dependency between different spatial, temporal and social scales during co-evolutionary dynamic processes has been recognized quite some time ago (e.g. Hartvigsen et al., 1998), but bridging scales in decision making needs more research.

4.2.4. How can resilience be appraised under dynamic, diverse and unexpected drivers and shocks?

Douxchamps et al. (2017: 10) in a comprehensive review of resilience assessment tools, finds that "a major challenge is to ensure that simple and operational tools can address complexity". Appraisal of attributes in complex systems, such as feedbacks, leadership and trust, is difficult and needs further attention.

4.2.5. How can transformation and its utility to climate resilient development can be understood and how governance regimes can be conducive to climate resilient development pathways?

Operationalizing climate resilient development pathways will require transformation with appropriate institutional arrangements and inclusive dialogue, as well as a monitoring and evaluation framework embedding values and goals of all social groups, especially for the most vulnerable. We note that lessons from social psychology suggest that participation, tangible short-term goals and the use of skilled facilitation agents can engage stakeholders and governance actors. However, enacting governance regimes onto long term climate resilient development pathways will require more than this. Scoones et al. (2020) present three approaches (structural, systemic and enabling) that may offer principles for exploring the role of transformation in climate resilient development pathways. In doing this, addressing simultaneous questions regarding how transformation intersects with resilience will also be useful. The practice of climate resilient development pathways will furthermore benefit from research on the relationship between incremental changes and significant transformations regarding sustainable development.

5. Conclusion

This paper reviewed conceptual and empirical advances on climate resilient development pathways since the fifth assessment report. Although the concept has received modest attention in the domains of climate action, development, resilience and pathways, we find little evidence of dedicated concept development and empirical examples. Our analysis points towards the following developments. Conceptually, there has been a shift from identifying sustainable climate action and avoiding mal-adaptation to mainstreaming of climate action into development decisions. Here the pathways construct permits embedding climate action within the overall challenge of social-ecological development (e.g. Skrimizea and Parra, 2020). Methodologically, we observe a cautious shift from approaches of either retrospective analysis OR future planning towards approaches that recognise path-dependency and that connect past decision pathways to future development pathways (e.g. Abel et al., 2016). On case context, we note a shift from resource management to complex social-ecological systems (e.g. Chelleri et al., 2016). In cases from low to low-middle income countries, there is more emphasis on vulnerability and poverty reduction and co-benefits for the poor (e.g. Butler et al., 2014), in middle to high income countries, there is more emphasis on mainstreaming and reaching climate targets (e.g. Dovie et al., 2020).

Analysis of literature found four non-exclusive clusters of approaches, which we labelled building on Werners et al. (2021): (a) climate action oriented, (b) mainstreaming oriented, (c) social-learning and co-creation oriented, and (d) transformation oriented. These approaches broadly correspond to four desired outcomes of climate resilient pathways development: (i) undertaking specific climate actions for meeting sustainable development goals, (ii) mainstreaming climate action and development, including synergies/co-benefits and trade-offs, (iii) promoting collaborative learning, adaptive decision-making and adaptive capacity, (iv) accounting for multiple drivers (such as root causes of vulnerability, injustice and poverty), path dependency and long-term change, including a potential need for transformation towards long-term sustainable development.

The emergence of climate resilient development pathways is illustrative of shifting climate policy from a focus on defending against and coping with climate impacts to a narrative of sustainable development, opportunity and change. It also signifies changing development in its orientation towards growth. Development and transformation along climate resilient pathways mean that trade-offs must be negotiated. These trade-offs have different environmental, economic, and equity effects over scales and society. Deeply embedded in climate resilient development pathways is a set of justice questions regarding how ongoing and future climate actions and coupled development should be structured. Understood this way, climate resilient development pathways will involve debate and struggle, resulting in winners and losers. Therefore, a multi-dimensional understanding that includes traditional concern for fairness in representation and respect for diverse rights, cultures and knowledge systems is crucial.

In sum, the concept 'climate resilient development pathways' reorients the climate challenge from delivering on climate targets to facilitating long-term sustainable development. In this context, resilience, pathways, and transformation can be understood as boundary concepts to consolidate climate action and development decisions towards long-term sustainable development. Lessons from these concepts include engagement with justice and equity issues and imbedding flexibility, anticipation and learning in decision-making. Developing the concept of climate resilient development pathways has the potential to bridge climate and development perspectives, which otherwise remain too often artificially separated in current development and climate change debates, and their scientific analysis.

CRediT authorship contribution statement

Saskia E. Werners: Conceptualization, Methodology, Project administration, Funding, Writing – original draft. **Edward Sparkes:** Formal analysis, Writing –original draft, Visualization. **Edmond Totin:** Conceptualization. **Nick Abel:** Writing – review & editing. **Suruchi Bhadwal:** Writing – review & editing. **James Butler:** Conceptualization. **Sabine Douxchamps:** Writing – review & editing. **Harrhy James:** Methodology, Validation, Formal analysis. **Nadine Methner:** Writing – review & editing. **Jana Siebeneck:** Methodology, Validation, Formal analysis, Writing – original draft. **Lindsay C. Stringer:** Writing – review & editing. **Katharine Vincent:** Writing – review & editing, Conceptualization. **Russel Wise:** Writing - review & editing, Conceptualization. **Mark G.L. Tebboth:** Writing – review & editing.

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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