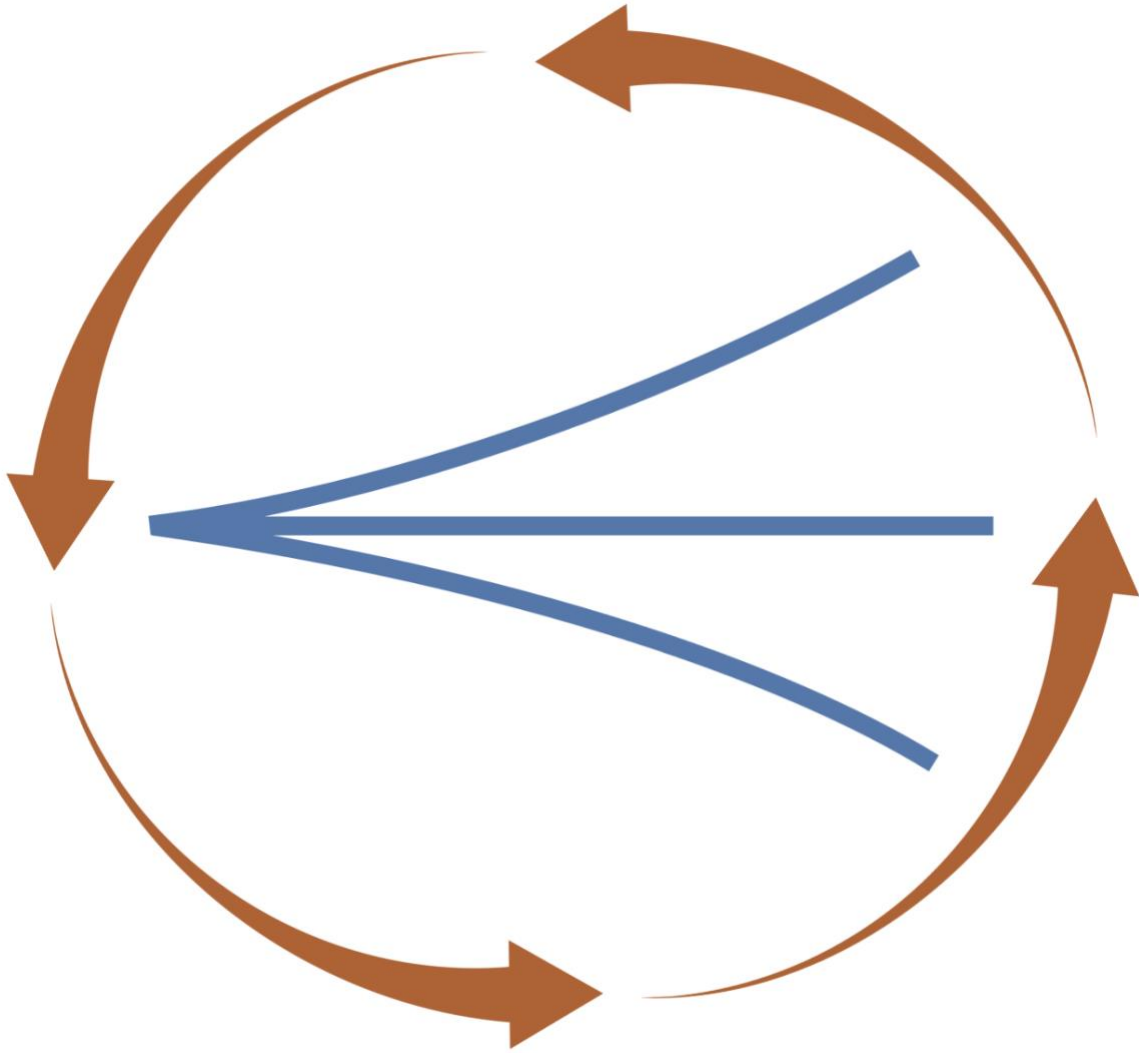# HI-PATH
Climate Resilient Development Pathways in the Hindu-Kush Himalaya Region

Exploring approaches for monitoring and evaluation of climate resilient development pathways: Lessons from the use of outcome mapping

Authors: *Edward Sparkes, Saskia E. Werners, Neera Shrestha Pradhan, Suzeena Shrestha, Nabina Lamichhane, Sidratun Chowdhury, Suruchi Bhadwal*

Partner institutes: UNU-EHS, BCAS, ICIMOD, TERI

Colophon

This report was produced under the *HI-PATH Project: Climate resilient development pathways in the Hindu Kush Himalayan region*.

The Hindu Kush Himalayan region is a climate change hotspot. For development to be sustainable in the Hindu Kush Himalayan region, interventions need to include choices and actions that improve livelihoods and alleviate poverty, counteract climate change, are inclusive for the most vulnerable and resilient over time. In this context, the HI-PATH project aimed to co-create climate resilient development pathways for the Hindu Kush Himalayan region. Climate resilient development pathways consolidate climate action and development decisions towards long-term sustainable development. The project built on livelihood innovations that were piloted by the Himalayan Adaptation, Water and Resilience (HI-AWARE) consortium under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA).

HI-PATH strengthened and maintained the HI-AWARE partnership. HI-PATH was implemented by six cooperating partner institutes: the Bangladesh Centre for Advanced Studies (BCAS), Bangladesh; the International Centre for Integrated Mountain Development (ICIMOD), Nepal; the Institute of Civil Engineering of the National University of Sciences & Technology (NICE - NUST) together with the Climate Change, Alternative Energy, and Water Resources Institute of the Pakistan Agricultural Research Council (PARC), Pakistan; the Energy and Resources Institute (TERI), India; Wageningen Environmental Research (WUR), the Netherlands; and the United Nations University - Institute for Environment and Human Security (UNU-EHS) (international coordinator).

1.0 INTRODUCTION

Decision making is occurring against a backdrop of unequivocal, widespread and rapid changes in climate and extreme weather, increasing socio-political challenges and multifaceted, complex and systemic risks (IPCC, 2021). The complexity that policy makers, researchers and practitioners now face means that sustainable decision making and planning are becoming increasingly difficult. However, the decisions made today will have future impacts that shape society, which is why it is important to assess them, their outcomes and the possible pathways taken to get there (Singh and Chudasama, 2021).

In order for any project, program, policy or investment (collectively named interventions) to navigate complexity and achieve social-ecological change, development decisions need to include choices and actions that improve livelihoods, counteract climate change, are inclusive and equitable towards the most vulnerable and are resilient over time. Climate resilient development pathways present an option to achieve these goals, by integrating adaptation and mitigation with development to generate pathways towards sustainable development. However, despite recent efforts to conceptually advance the understanding of climate resilient development pathways (Burch et al., 2014; Denton et al.,2014 ; Moss et al., 2019; Scholz and Methner, 2020; Tanner et al., 2019; Werners et al., 2021a), there are few examples of practical application to date.

One of the central uncertainties surrounding this lack of empirical evidence regards how climate resilient development pathways can be understood in real world situations. There is a need to thus define processes and tools that can help measure the objectives and direction of interventions which are introduced with climate resilient development pathways in mind. These approaches must indicate how the pathways are contributing to building climate resilience and sustainable development. However, this presents significant challenges because decisions are made in complex systems, comprising varying biophysical, socio-political, and cultural conditions. Therefore, in order to learn from decisions, acquire new knowledge and identify if climate resilient development pathways are moving towards sustainable development, robust monitoring and evaluation processes are needed that are effective in dynamic and nonlinear settings.

One monitoring and evaluation approach that aims to account for more complex and nonlinear interactions is outcome mapping, first developed by Earl et al (2001). The approach is centred around human values, behaviour, and interactions and is dynamic through building continual learning and reflection into development programs (Hearn, 2021).

1.1 Objectives of this report

This report explores how lessons from outcome mapping approaches (c.f. Earl et al., 2001), can support monitoring and evaluation of climate resilient development pathways. We will first present our understanding of climate resilient development pathways, followed by analysing what has been recommended and applied in peer reviewed and grey literature on monitoring and evaluation, and pinpoint what may still be missing. An overview of the principles, values and approach of outcome mapping will be given and empirical and conceptual lessons will be drawn upon to identify how they can contribute to closing the identified gaps. Lastly, an approach for monitoring and evaluation of climate resilient development pathways will be presented based on outcome mapping thinking, with inputs from other valuable sources.

1.2 Rational and methods of this report

It is widely agreed upon that monitoring and evaluation are important steps in any intervention. For interventions aiming to create transformative pathways towards sustainable development, monitoring and evaluation is critical due to long-term time frames, in settings where resources, rights and social-political direction are contested by stakeholders with competing interests, values and power (Abel et al, 2016). However, there is limited understanding of how this can be executed. Details and examples of important components to consider in dynamic and complex arenas such as those found in development

settings, and specifically through adaptation pathways approaches, are underrepresented in the literature (Hermans et al., 2017). This was recognised by the Intergovernmental Panel on Climate Change (IPCC) in its fifth assessment report (AR5, www.ipcc.ch/report/ar5/wg2/) chapter on 'climate resilient pathways', which flagged approaches and structures for monitoring, recording, evaluating, and learning from experience as priority research topics (Denton et al.,2014). Despite this call for attention, little work has gone into the role of various components and approaches that can be included for monitoring and evaluation of climate resilient development pathways since AR5.

To develop an approach for monitoring and evaluation for climate resilient development pathways based on outcome mapping thinking, evidence was taken from a combination of sources. First, we drew upon peer reviewed and grey literature on wider monitoring and evaluation frameworks, taking lessons useful for our framing of climate resilient development pathways. Second, discussions were held with experts and practitioners from the outcome mapping community to strengthen our understanding of the approach, its principles and how they can inform monitoring and evaluation for climate resilient development pathways. Third, evidence from empirical work using outcome mapping, conducted under a project named HI-PATH, that aims to co-create climate resilient development pathways in the Hindu-Kush Himalaya region, informed the results of this report.

2.0 MONITORING AND EVALUATION OF CLIMATE RESILIENT DEVELOPMENT PATHWAYS

In section 2, we present our framing of climate resilient development pathways and give a definition of the concept. This framing was developed through a systematic review of literature and reflexive expert focus group discussions conducted earlier in HI-PATH (Werners et al., 2021b). Based on this, we present what we define as necessary requirements for monitoring and evaluation, followed by the major challenges that will be apparent for practitioners aiming to incorporate these requirements.

2.1 Understanding climate resilient development pathways

In order to assess the use of outcoming mapping approaches for monitoring and evaluation of climate resilient development pathways, a better understanding of what climate resilient development pathways actually are, and a definition of the concept is needed. The concept has evolved from Chapter 20 of AR5, which discusses 'climate resilient pathways', broadly defined as development trajectories that combine adaptation and mitigation to realise the goal of sustainable development (Denton et al., 2014). As climate resilient development pathways are a newly emerging and evolving concept, there are differences among researchers and practitioners with regards to their content. Therefore, in order to best understand climate resilient development pathways for the scope of this report, it is effective to breakdown and look at the critical components.

Critical climate action components

The climate component entails that both adaptive and mitigating actions (known as climate action) should be included in the practice of climate resilient development pathways. Although there may be more emphasis on one depending on the goals and context of the intervention, neither should be actively excluded. Local adaptation efforts should synergies with mitigation, and vice versa. There is recognition of root causes of vulnerability here, as *'blind'* development, which does not consider climate action, will likely contribute to climate change, and therefore enhance vulnerability.

Critical resilience components

The resilience component can be understood as a descriptive concept that can give insight into dynamic system properties. For example, drivers and root causes of vulnerability, controlling variables, tipping points or lock-in. Resilience engages with the capacity to adapt and transform through its descriptive nature by identifying causal mechanisms and ways of managing them.

The 'expectations' of resilience: Resilience is not a normative concept, there are many different understandings of it depending on the research discipline, although it is commonly used in interventions as a positive attribute. Resilience can be broadly interpreted as the ability of a system to maintain important objectives in the face of changes or disturbance (O'Connell et al., 2015). It can be viewed as a neutral concept, which is neither positive nor negative (Chesterman et al., 2020). It is not the goal of this report to analyse resilience in depth, however for climate resilient development pathways, how resilience engages with adaptation and transformation is key. Resilience describes the state of a system's ability to withstand risks to its critical functioning. If a system's properties are overwhelmed, demonstrating insufficient resilience (e.g. from a climate shock or stress), this can indicate that adaptation or even transformation into a new system are required.

Critical development components

The central components of development are sustainability, equity, justice, gender and vulnerability considerations. This is because with development, trade-offs will have to be made (Ellis and Tschakert., 2019) and often, dominant actors' priorities do not reflect those of more vulnerable groups (Few et al 2021; Tebboth et al 2020). Using climate resilient development pathways as a means of creating

decision spaces around the most vulnerable groups is both moral and practical. Morally, it is the most fair thing to do, as those with the least causal responsibility are currently disproportionately affected. Practically, it actively engages with the values, aspirations and trade-offs of the most marginalised groups, whose participation is crucial for anyone engaging with the concept.

Critical pathways components

Adaptation pathways were first conceptualised as an adaptive planning tool. This component can be understood as a planning approach that can take into account ambiguity and uncertainty, which are inherent in climate, resilience and development contexts. A pathways approach is structured, and can offer tools to synthesise needs at different scales and levels to respond with flexibility to ambiguity and uncertainty (for example in climate change contexts) to adaptively move towards sustainable development. Furthermore, with this approach, synergies and trade-offs can be accounted for, which are inherent in development (as stated above). This can help to avoid mal-adaptive practices that are considerate of time frames, spatial scales and feedback loops, as what may be a trade-off at one point may not necessarily be so at a later point (Leal Filho et al., 2021). With this, pathways are used to monitor and evaluate to learn and inform on implementation and practice.
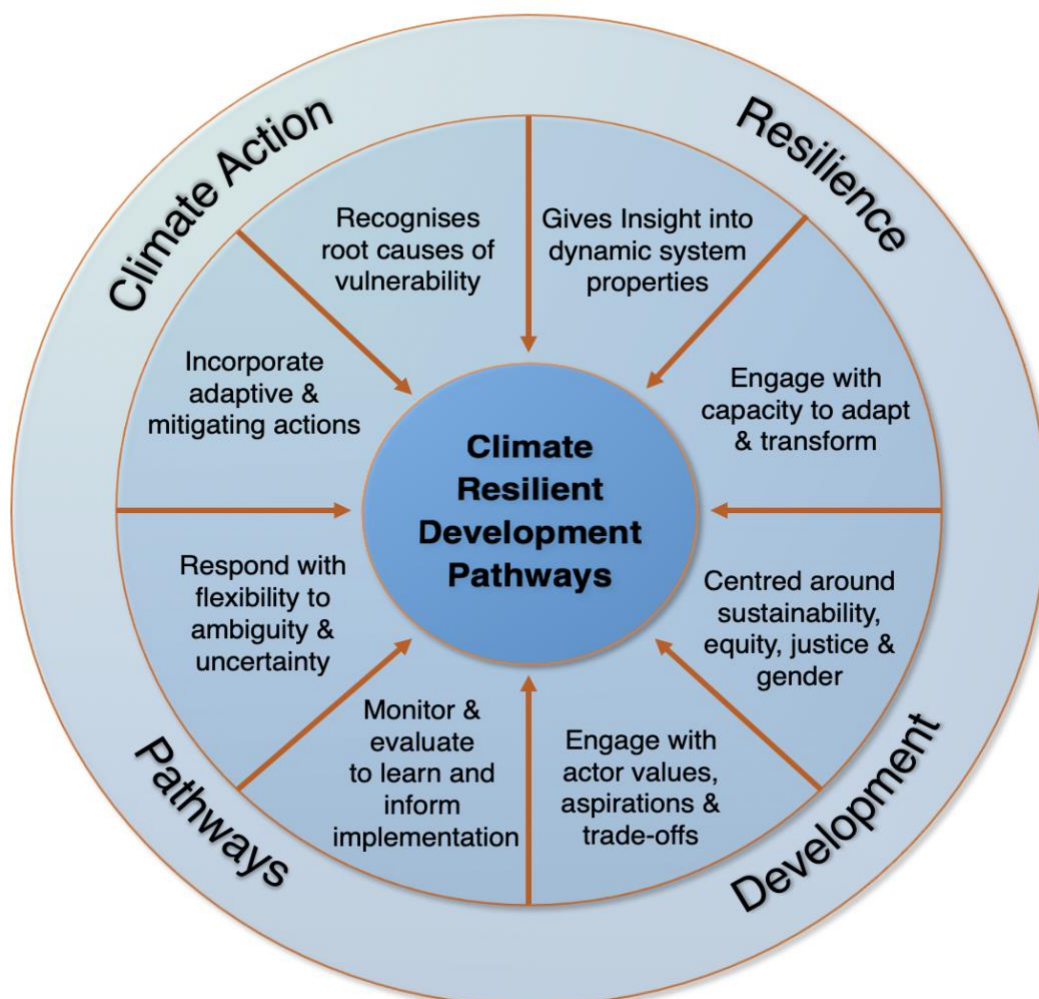
Figure 1: Critical components for the practice of climate-resilient development pathways (Werners et al., 2021b)

Defining climate resilient development pathways

For any intervention using climate resilient development pathways, we advise that the above critical components are a central focus. In consideration of these, 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 acknowledgement with values of different actors, connecting past development decisions with future aspirations and using multiple pathways to embed flexibility, anticipation and learning in planning. As climate resilient development pathways will involve trade-offs, decisions should include the aspirations of the most vulnerable, and if systems become overwhelmed there should be engagement with the capacity for transformation* (Werners et al., 2021b).

Figure 2 presents a simplified visual conceptualisation of climate resilient development pathways. The figure presents three future scenarios. Both sustainable and unsustainable decisions can be made, which lead towards sustainable or unsustainable (business as usual) development. Furthermore, it is likely that trade-offs will have to be made when making decisions, and multiple pathways can lead towards, or away from sustainable development, however it is uncertain in the present which this is.

Figure 2: Simplified visual conceptualisation of a climate-resilient development pathway

2.2. Monitoring and evaluation *requirements* for climate resilient development pathways

Now that we have an understanding of the critical components, and a definition of climate resilient development pathways, requirements for monitoring and evaluating can be analysed. Interventions applying the concept will not be able to use 'off the shelf' processes and toolkits such as single or multi-risk managem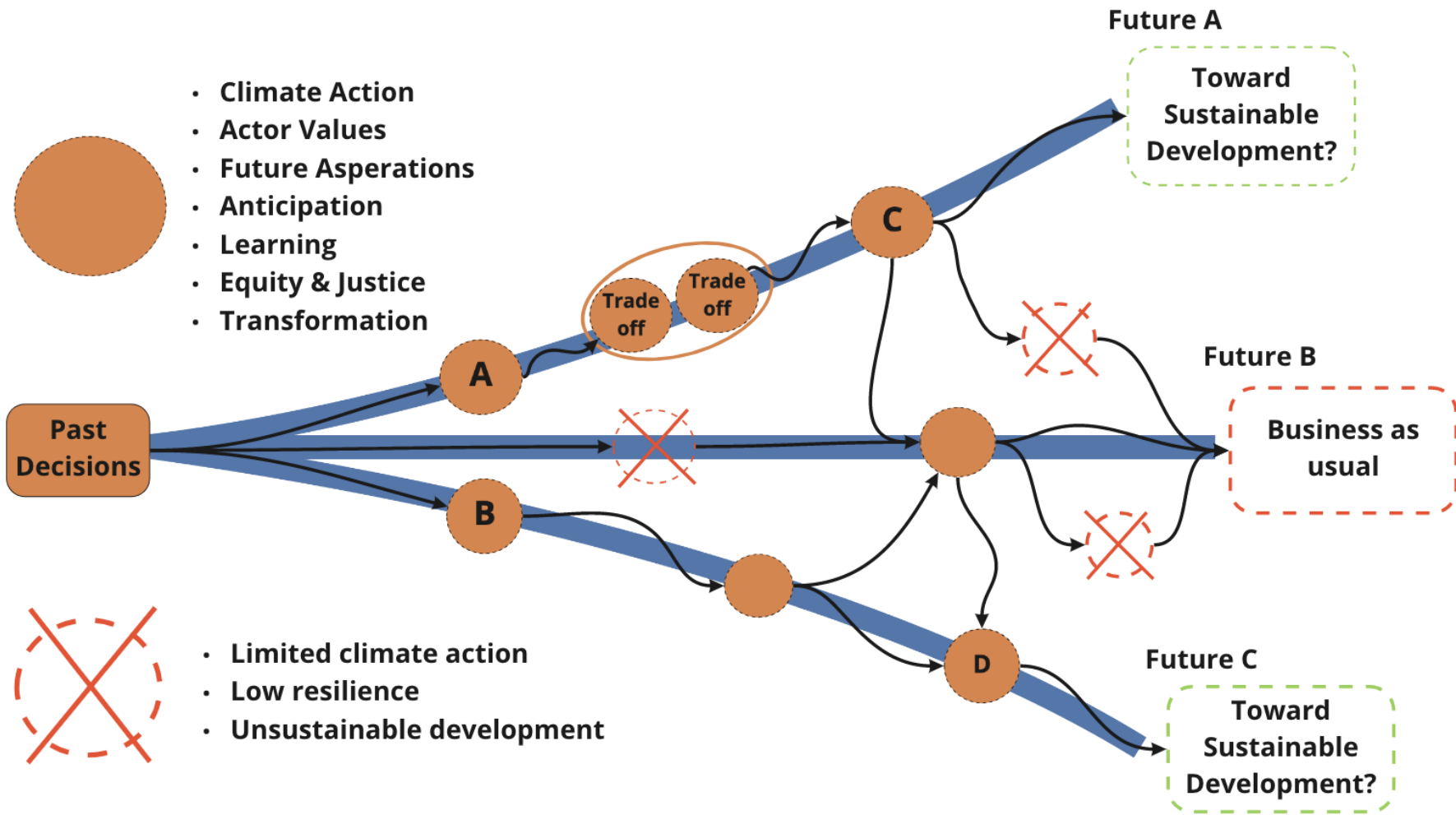ent that use a defined set of indicators (O'Connell et al, 2019). Due to system complexity and the uncertain nature of climate change and development, this would be too constricting. Rather, a framework must be tailored to the context and scale of the intervention. Based on our framing presented above, we present requirements that we feel should be included for all monitoring and evaluation approaches for climate resilient development pathways, regardless of the context of the intervention.

Climate action AND development

Firstly, monitoring and evaluation processes must account for both climate action and development, as these are central components of climate resilient development pathways. Further, understanding how these components influence resilience and are sustainable over time is essential.

Threats AND aspirations

Whereas many monitoring and evaluation frameworks may give more weight to either the threats *(climate risks, shocks and stressors)* or aspirations *(actions, desired end goal or vision),* both should be considered for climate resilient development pathways. This is because the concept engages with climate action (i.e. responses to threats) and also development (i.e. responses to aspirations). Climate resilient development pathways practitioners should acknowledge absorbing, rebounding and adapting to threats (e.g. recognition of root causes of vulnerability/ incorporating adaptive and mitigating actions) as well as the necessity for progression (incorporating mitigating actions/ engagement with transformation/ centred around sustainability).

Identity, culture and values

Monitoring and evaluation of climate resilient development pathways should incorporate the identity, culture and values of actors into the process. Taking this approach can help to create an understanding of whose threats and whose aspirations need to be monitored and evaluated from the offset and throughout interventions progress (Leal Filho et al., 2021). Furthermore, efforts should be made to understand how past developments, including maladaptive developments that have created or enhanced vulnerability, have shaped the identity, culture and values of communities within the setting (Singh and Chudasama, 2021). Doing this can also help connect these past development decisions with present and future aspirations while also helping to identify requirements for monitoring and evaluation. Acknowledgement of power asymmetries will also be important (Leal Filho et al., 2021), to ensure that monitoring and evaluation processes are built around intervention progress for the aspirations of the right actors. This is why climate resilient development pathways should be used as a means of creating decision spaces around the most vulnerable groups (Werners et al., 2021).

Active learning

Active learning in interventions will be necessary to understand the evolving requirements for monitoring and evaluation of climate resilient development pathways (O'Connell, 2019).
Through active learning, monitoring and evaluation approaches must account for setbacks, trade-offs, and unexpected outcomes. This is because if both positive and negative feedback are not accounted for through monitoring and evaluation, learning and improvement is not possible.

Dynamic use of indicators

To help capture and simplify complex system properties, an understanding of how to employ indicators for interventions will be required. Many indicators can capture complex information into a

tractable form of information (O'Connell et al., 2013). Some of these indicators can capture overlapping system properties (named compound indicators). For example, some indicators of vulnerability (e.g. social, financial and cultural capital) also capture information about resilience as well (Chesterman et al., 2020). Compound indicators can help to narrow and simplify indicator selection in a complex and dynamic setting, which, in this example, can provide specific information on the condition of vulnerability and resilience simultaneously. Employing the use of compound indicators also incorporates flexibility into monitoring and evaluation, as a single indicator can provide information on multiple system characteristics or intervention goals.

Short and long time frames

Climate resilient development pathways involve climate action and development actions over both short term and long term time frames. Therefore, it is also critical to consider both short term and long term monitoring and evaluation requirements (Leal Filho et al., 2021). Further, it is important to consider shifting system dynamics over time, such as changes in climate stresses and development decisions, thereby adjusting monitoring and evaluation accordingly.

Co-creation

Co-creation of monitoring and evaluation processes through participatory approaches applied in the first stages of planning will help to include and synthesise the above requirements (Abel et al, 2016; Hermans et al, 2017; N.Pradhan, June 30, 2021). Orienting co-creation processes around central actors, especially those that are usually underrepresented, includes diverse knowledge that can help practitioners to avoid blind spots, centers issues and solutions around those in need and bolsters actor learning and interaction with pathways (O'Connell et al., 2013; Werners et al., 2021b).

2.3 Monitoring and evaluation *challenges* for climate resilient development pathways

Practitioners aiming to incorporate the requirements in 2.2 into monitoring and evaluation of interventions will face numerous challenges. In this section, we discuss some of the most pressing challenges, which will inform the recommendations presented in section 4.

Accounting for long term change

Monitoring and evaluating actions and decisions over long time frames is necessary to capture progression towards (or away from) sustainable development (Leal Filho et al., 2021; Rammel et al., 2007). This is a particular challenge in complex settings due to uncertainty and changing conditions. Actions in one setting have feedback effects that can both positively and negatively influence another setting. Furthermore, decisions made in the present will shape long term pathways and have large scale ramifications for future practitioners (Singh and Chudasama, 2021). However, it is not well understood how to account for changing conditions over long time frames.

Indicator selection and limitations

Indicator selection is a very important step for monitoring and evaluation of any intervention, and is challenging in many contexts. With climate resilient development pathways, this challenge is amplified as indicators need to be flexible to uncertain future system dynamics, such as changes in aspirations and values, and capture data on the implementation of alternative options, which are decided over longer time periods as specific conditions unfold (Abel et al, 2016; Hermans et al, 2017). Therefore, indicators should aim to capture information about non-linear relationships and feedback loops, across scales for direct and indirect cause-effect interactions. Developing and applying compound indicators that capture this, are scientifically robust, and also relevant to local sustainability issues and monitor local system variables is a significant challenge (O'Connell et al., 2013).

Competing stakeholder values

The inclusion of actors' perspectives into the monitoring and evaluation processes of climate resilient development pathways is highly difficult and complex. This is reinforced in regions where actors have contesting identities, cultures and values, where threats and aspirations are perceived differently, often in a conflicting manner (Abel et al., 2016). Seeking and synthesising multiple perspectives (through co-creation processes) to gain new monitoring and evaluation insights demands a high amount of resources and time (Hermans et al, 2017). This is largely experienced when one interacts with stakeholders at different levels and as you move from a smaller unit of individuals to households to different decision making levels further contributing to the complexities. Integrating stakeholder perspectives becomes more complex at larger scales, where multiple actors have competing voices (Abel et al., 2016). With this issue of scale, the challenges of trade-offs and feedback are introduced.

Appraising resilience

Along with the ambiguity and different understandings of the concept of resilience comes an issue of appraisal. Finding assessment tools to monitor and evaluate resilience in complex systems is a major challenge (Douxchamps et al., 2017). How characteristics such as trust and flexibility and values such as fair leadership be appraised is a major challenge for climate resilient development pathways.

Trade-offs and feedback

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. Equally, there are different pathways towards sustainability, which create, reinforce or address vulnerability, equity and social justice. These different pathways inevitably involve trade-offs and have complex feedback (Colloff et al., 2021). Full comprehension of how to identify and measure trade-offs and feedback loops between different actors and system properties is an important question (Ellis and Tschakert, 2019). Further, how they are accounted for as a result of complex interactions that are sensitive to scale and time presents a challenge. 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), and bridging these scales for climate resilient development pathways needs more research.

The systemic nature of risk

With increasing globalisation, interconnectivity and climate change, risk is becoming more unpredictable and complex (Gordon & Williams, 2020). The COVID-19 pandemic has demonstrated that approaching climate resilient development through a single or multi-risk perspective will not be sufficient. Attempting to do this may even be counter-intuitive and have unintended consequences (IRGC, 2018). However, comprehensive monitoring of non-linear, systemic risks is not yet well understood in the literature, which, combined with the limited attention given to monitoring and evaluation of adaptation pathways, presents a significant challenge for climate resilient development pathways (Citi GPS and Cambridge Centre for Risk Studies, 2021; Hermans et al, 2017).

3.0 LESSONS FROM OUTCOME MAPPING

Section three of this report presents how and where outcome mapping can match requirements and overcome challenges for monitoring and evaluation of climate resilient development pathways. First, the process of outcome mapping is presented to give a better understanding of it. Following this, connections are made between the principles of outcome mapping and monitoring and evaluation requirements of climate resilient development pathways. Lessons are then drawn upon from empirical application in the HI-PATH cases. Lastly, we discuss limitations of outcome mapping for monitoring and evaluation of climate resilient development pathways.

3.1 Understanding outcome mapping

Outcome Mapping was first developed by Earl et al (2001) for the International Development Research Centre (IDRC) as an open source toolkit. It is generally understood as an approach to understand change in complex systems, in which both climate action and development interventions can be planned, monitored and evaluated (Hearn, 2021; J.Van Ongevalle, August 5, 2021). Outcome mapping focuses on outcomes, defined as changes in behaviour,, relationships and activities of individuals, groups and organisations with whom the intervention interacts. Changes in behaviour are broadly understood as changes in activities, policies or practices, which may be expected or unexpected and match or mismatch the visions set in step 1 of the intervention framework (Figure 3) (Hearn, 2021). Outcome mapping differs from most monitoring and evaluation approaches, that tend to focus on the change in development impacts (for example, poverty alleviation, reduction in conflict or increase in the number of girls in education).

The idea to monitor changes in behaviour is embedded in the fact that development processes are complex, which makes it very difficult to attribute the direct causes and effects of an intervention, particularly over long time periods. Attempting to do this does not necessarily provide the kind of active learning that interventions and institutions require to improve their performance. Outcome mapping does urge practitioners to recognise the importance of long term development impacts, however, by focusing on change in behaviour, practitioners can better understand an intervention's direct and indirect contribution to the *causes* and *effects* of outcomes, which in turn, can enhance the possibility of development impacts (Earl et al, 2001).

Since its inception, outcome mapping has been used in a wide variety of projects across 127 countries, from community level, to government scale policy (Hearn, 2021; K.Ambrose, June 30, 2021). Table 1 presents some of the key monitoring and evaluation challenges that outcome mapping aims to overcome.

Table 1: Monitoring and evaluation challenges that outcome mapping aims to address (Earl, 2008)

Monitor and evaluate the impacts of development oriented research and interventions
Establish cause and effect relationships and feedbacks in complex, changing and open systems
Accounting for short and long term time scales of interventions
Incorporation of active learning through iteration in interventions
Include the values of practitioners and communities in the evaluation of interventions

Summary of the process

The approach involves 12 steps, divided into three stages (Figure 3). The first stage, intentional design, is broken into 7 steps that are usually developed in a sequential order. This is followed by 4 steps in the monitoring stage, with a final step for evaluation.
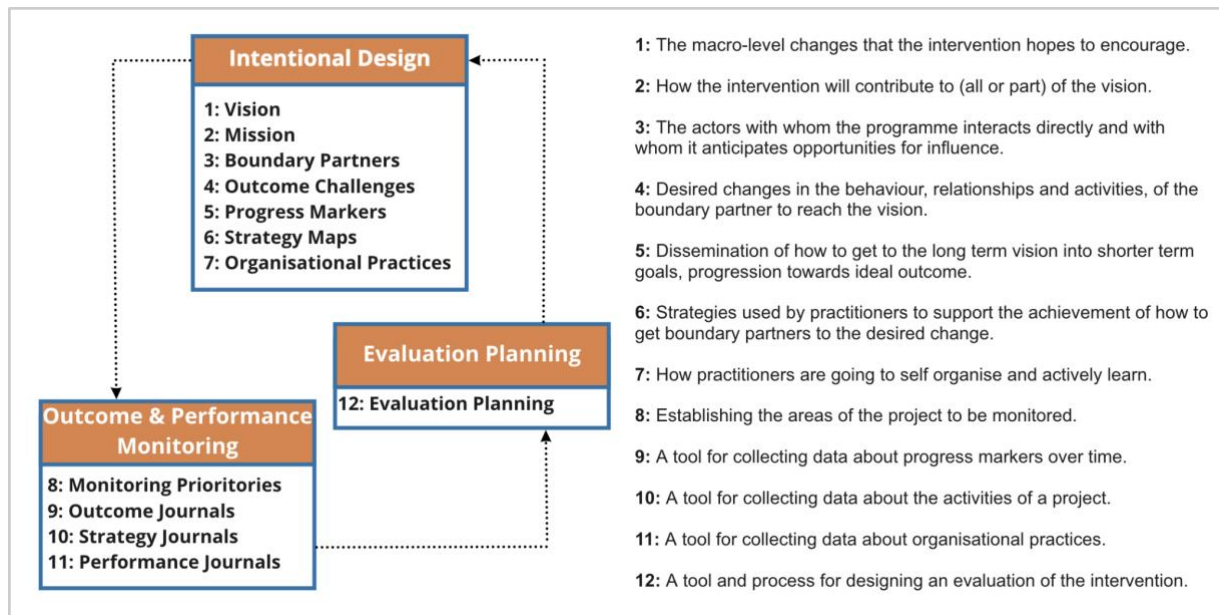
Figure 3: A summary of the 12 steps of outcome mapping (Earl, 2001; Hearn, 2013)

In the 20 years since its inception, outcome mapping has been adapted and advanced to account for improvements in human and ecological systems. The practical framework in Figure 3 can be used by practitioners for navigating complex change using all or some of the 12-steps for design, monitoring and evaluation (Hearn, 2021).

3.2 Principles of outcome mapping that are useful for monitoring and evaluation of climate resilient development pathways

There are a number of principles, highly useful in development settings, that are foundational when using outcome mapping. Although these principles alone are not limited to outcome mapping, the framework makes it easier for practitioners to operationalise them (K.Ambrose, June 30, 2021; J.Van Ongevalle, August 5, 2021). Some of these principles align well with requirements and challenges for climate resilient development pathways.

Actor centred

Central to outcome mapping are the actors in which the intervention is built around (named boundary partners in step 3 of Figure 3). As it takes a systems oriented approach, understanding the interconnections between actors and their environment are key (K.Ambrose, June 30, 2021). Outcome mapping practitioners are encouraged to include a diversity of knowledge types through co-creation, and engage with how actors can access the power, knowledge and resources needed to influence the development impacts that affect them (Fetterman et al., 2013; Hearn, 2021). Firmly grounded in this thinking are gender-transformative approaches and considerations towards the vulnerable, which is central to the climate resilient development pathways framing (K.Ambrose, June 30, 2021).

Accounting for threats and aspirations

Through its actor centred approach, outcome mapping actively engages with threats and aspirations that are relevant to the context. The approach dictates that boundary partners, which can include individuals, groups or organisations, have the strongest influence in overcoming threats or achieving aspirations through their 'spheres of influence'. The intervention merely aims to facilitate this (Earl et al., 2001: Hearn, 2021). This is because long term threats and aspirations can not be overcome or achieved by the work of a single intervention, as at some point it will end and an organisation will leave (J.Van Ongevalle, August 5, 2021). Therefore, an important step of outcome mapping is developing an understanding of the systems threats and actors' aspirations (i.e. the vision and

15

outcome challenges (Figure 3)). Central to this principle are the inclusion of diverse perspectives, asking what needs to change, in what ways and why (J.Van Ongevalle, August 5, 2021). This requires decision makers to actively engage with whose voice and vision should be of consideration.

Understanding of interactions

With the core principles of change in behaviour and actor engagement comes the understanding of the relationships between actors. Acknowledging power imbalances and how they influence relationships and progression, particularly toward future visions, should be monitored by practitioners, ideally to create equal and fair decision spaces (K.Ambrose, June 30, 2021; J.Van Ongevalle, August 5, 2021). With this, the principles of outcome mapper merge well with equality and social justice in our framing of climate resilient development pathways.

Active learning

Built into the process is a purposeful effort to facilitate active learning and knowledge sharing to help both community members and practitioners collectively define and contribute to the changes they want to see. The design and theory of change of an intervention is flexible, and can be adjusted based on this reflection (J.Van Ongevalle, August 5, 2021). This reflexive process, which is essential for climate resilient development pathways, aims to make practitioners become increasingly aware of the dynamic contexts, people, organisations, institutions, and boundaries of their interventions (Hearn, 2021).

Adaptability to the context

The use of the framework (Figure 3) and tools can be completely driven by context, it should not be viewed as a stepwise framework. The steps are meant to be dynamic, and continuously adapted through active learning (K.Ambrose, June 30, 2021).

Progress markers

Progress markers are qualitative indicators that monitor the behavioural change of actors. They are a set of statements that indicate actors and practitioners' progression towards or away from the initial vision set in step 1. The statements are usually phrased as "expect to see, like to see, love to see" from the intervention's boundary partners. Progress markers are central for monitoring (Hearn, 2021). Useful for climate resilient development pathways, they can be adjusted during the intervention to account for unexpected changes in both behavior and system characteristics. They are generally applied to longer term time frames. Cumulatively, progress markers can capture complexity or logic of the change of actors in a system (Earl et al, 2001). Progress markers can also capture information about past development decisions and narratives through retrospective backcasting processes, in which actors start from the present day and work backward in time to capture important information (K.Ambrose, June 30, 2021). Examples of progress markers used in the HI-PATH project can be seen in Tables 3, 4 and 5 below.

3.3 Lessons from empirical application in HI-PATH

In this section, we draw on lessons from the application of outcome mapping processes applied in the HI-PATH project. HI-PATH mapped the outcomes of four livelihood innovations that were piloted in the Hindu-Kush Himalaya regions of Bangladesh, India, Nepal and Pakistan. Through applying outcome mapping processes, HI-PATH aimed to co-create climate-resilient development pathways for upscaling and outscaling of these pilots. The four pilot livelihood innovations are presented in Table 2.

Table 2: HI-PATH pilot livelihood innovations monitored and evaluated through outcome mapping processes

Climate and flood resilient housing in the Teesta river basin, Rangpur district, Bangladesh
Climate smart agriculture through improvement in land utilization patterns and livelihood augmentation in the hill district of Rudraprayag, Uttarakhand, India
Springshed restoration in selected communities in the Gandaki basin, Nepal
Portable solar pumping systems for agricultural irrigation in mountain areas of Pakistan

Suitability of outcome mapping

Due to its adaptability to the context, outcome mapping was deemed a useful monitoring and evaluation framework to apply in HI-PATH. This was due to the need for an approach that could be applied to four contexts. The livelihood innovations (Table 2), were first implemented in an intervention called HI-AWARE. Therefore, outcome mapping was applied retrospectively, and not all steps were followed, demonstrating the flexibility of the approach. This flexibility allowed practitioners to develop a blended methodology. Furthermore each area in which the innovations were piloted faces its own climate action and development challenges, with specific threats and opportunities facing communities of different cultures. Outcome mapping was able to capture some of the realities of each context through its flexibility (Bhadwal et al., 2021). Lastly, HI-PATH aligned with a principle of outcome mapping as there was focus on influencing processes that benefit vulnerable groups.

Usability

Along with a number of core principles that can be applied alongside the framework, outcome mapping aims to take a practical approach through its easy to follow steps in the framework. These steps aim to organise partners in complex contexts (Hearn, 2021). This was evident in the HI-PATH cases, with practitioners noting that the guided process was clear, understandable and easy to apply (N.Pradhan, June 30, 2021;). This easy to follow structure aligns well with the co-creation component of monitoring and evaluation of climate resilient development pathways, as complex frameworks are hard to apply through participatory processes, which are time and resource intensive.

Boundary Partners

Practitioners took different approaches when identifying boundary partners, further indicating the flexibility in outcome mapping approaches. These included a case study approach (Pradhan, Lamichhane & Shrestha, 2021; Ahmed, Ahmed & Khalid, 2021), an interest and influence matrix (Bhadwal et al., 2021) and an checklist of criteria to identify the study site location before selecting boundary partners (Syed & Chowdhury, 2021). However, there were only small variances in the selection of boundary partners for each intervention (for example, whether to include NGOs or intervention manufacturers and builders) which was mostly dependent on the individual case study. All practitioners included communities and local governments. There was more emphasis on boundary partners directly affected by the livelihood innovations (e.g. those that operated within the direct spheres of influence).

Box 1: Boundary partners in Rudraprayag, Uttarakhand, India

> In the India case of HI-PATH, there has been an attempt to see how the intervention has affected livelihoods, and if this change is sustained over time. Boundary partners at various levels were identified for interactions, including communities, the community based organisation working closely with the community in their planning processes and the state authorities. The objective was to understand decision making aspects of boundary partners for sustaining activities that contribute to climate resilient development pathways and their driving factors.

Dynamic use of indicators

HI-PATH practitioners adopted the use of progress markers (indicators) for outcome mapping. Each used the "Expect to see, Like to see, Love to see" wording as put forward by Earl et al (2001), however practitioners took different approaches, which demonstrates the flexibility of progress markers as qualitative indicators for monitoring and evaluation.

For the springshed restoration intervention in Nepal, practitioners used indicators at the project scale (Table 3). Although specific stakeholders are mentioned, there is no strict differentiation of indicators for individual groups. However, there was a tendency to focus on the community scale, which was seen in all cases. Their focus was mostly on indicators that capture how actors share knowledge and interact with one another regarding the livelihood innovation (Pradhan, Lamichhane & Shrestha, 2021).

Table 3: Indicators (*progress markers)* used by HI-PATH practitioners for springshed restoration in Nepal (Pradhan, Lamichhane & Shrestha, 2021)

Expect to see from **the project**

1. Stakeholders participating in meetings, focus groups and interviews
2. Stakeholders/ communities managing springs and conducting conservation activities for spring revival in collaboration with local government
3. Acquiring knowledge for springshed conservation

Like to see from **the project**

1. Community adapting local knowledge for springshed conservation and management
2. Developing good governance mechanisms for water supply and access
3. Contributing and collaborating with local government for technical support of springwater supply in the area
4. Local government engaged in infrastructure development for drinking water supply

Love to see from **the project**

1. Community sharing lessons and learning experiences with other communities
2. Local government sharing the springshed conservation work with provincial government for uptake
3. Identifying different opportunities and funding resources to carry spring development work

For the climate and flood resilient housing pilot in Bangladesh, practitioners took an approach that analysed individual actors (boundary partners) in relation to uptake of the livelihood innovation. Their focus was on how actors interacted with and took up use of the technology. Five boundary partners were selected, between 2 - 4 indicators were developed for each, giving a total of 43 indicators. A selection of progress markers from the report are presented in Table 4 (Syed & Chowdhury, 2021).

Table 4: Indicators (*progress markers*) used by HI-PATH practitioners for climate and flood resilient housing in Rangpur district, Bangladesh (Syed & Chowdhury, 2021)

Expect to see from **local community**

1. Accepting new innovations for adapting to climate change
2. Participating in meetings regarding project implementation
3. Acquiring new knowledge about the impacts of climate change

Like to see from **local entrepreneurs**

1. Promote the new technology to other entrepreneurs or communities
2. Providing climate and flood resilient housing to communities as part of their business

Love to see from **National Government**

1. Taking climate and flood resilient housing measures as adaptation practice for developing national adaptation plans
2. Establishing a monitoring and evaluation system for overseeing the project

Practitioners promoting sustainable agriculture practices in India developed indicators that aimed to monitor resilience. They approached this by capturing stakeholder progress through different levels of resilience on a matrix of behavioural attributes, in relation to (climate) risks. The four levels of resilience were as follows: awareness of climate change risks, ability to cope with risks, adapting to risks and transforming towards systems change (Bhadwal et al., 2021). Table 5 presents progress markers developed for farmers who were direct beneficiaries of the pilot intervention.

Table 5: Indicators (*progress markers*) used by HI-PATH practitioners for climate smart agriculture in Uttarakhand, India (Bhadwal et al, 2021)

Behavioural Attributes (Farmers)	Expect to see	Like to see	Love to see
Awareness of risk	Awareness of climate change concerns for agriculture	Aware of the climate change threats to agriculture	Farmers in neighbouring areas are aware of climate change threats to agriculture
Coping with risk	Coping with the current conditions	Responsive to threats and opportunities for agriculture	Farmers involved in the pilot build capacities for themselves and for other farmers in neighbouring areas to cope with risks and create opportunities
Adapting to risk	Identify measures to me taken	Introduce crops from the pilot and explore opportunities for utilisation of land resources	Farmers are engaging with others from neighbouring communities to expand opportunities
Transforming towards systems change	Widespread uptake of climate smart crops in the pilot	Explore opportunities for other crops, not from the pilot, with experimentational plots (upscaling)	Farmers in neighbouring areas are following similar practice (outscaling)

Practitioners from the Pakistan project followed a similar line to that of the springshed restoration intervention in Nepal, applying indicators at the project scale (Table 6), with no strict differentiation of boundary partners in each category, although they are indicated. The first set, 'expect to see from the project' is mostly concerned with awareness and education of the technology, whereas 'like to see from the project' focuses on adoption and uptake and 'love to see from the project' concerns upscaling and outscaling'.

Table 6: Indicators (*progress markers*) used by HI-PATH practitioners for Portable solar pumping systems for agricultural irrigation in mountain areas of Pakistan.

Expect to see from **the project**

1. Stakeholders have the orientation of PSPS through project activities performed by the Hi-AWARE team
2. Stakeholders understand the need and associated benefits of PSPS
3. Stakeholders know operations and maintenance of PSPS

Like to see from **the project**

1. Stakeholders adopting PSPS for the irrigation purpose in their fields
2. Local manufacturers can fulfill the demand for PSPS on their own in local workshops
3. Collaborations among stakeholders for instance local farmers, government officials, and local manufactures for the adoption of PSPS

Love to see from **the project**

1. Adoption of PSPS in other areas of Pakistan to reduce energy dependence in the agriculture sector
2. Lessons learned by local manufacturers and farmers shared with farmers of other areas
3. Further advancements in technology so that it can also be widely used for domestic use of farmers

Considerations towards gender and vulnerable groups

HI-PATH practitioners aimed to capture the perceived threats and aspirations of vulnerable or marginalised individuals and communities when applying outcome mapping. This was done by designing methodologies that focused on vulnerable groups, through both data collection and analysis. In Nepal, for example, the intervention included a focused on Dalit communities, a group who are marginalised based on caste, that make up 13% of the countries population. Furthermore, survey questions were designed and analysis was conducted regarding how the intervention has influenced/ benefitted women (Pradhan, Lamichhane & Shrestha, 2021). In Bangladesh, focus group discussions, surveys and interviews were conducted with only female participants. Creating a single gender dynamic allowed women to discuss issues that they likely would not have raised in front of men, for example issues regarding menstruation during flooding periods (Syed & Chowdhury, 2021).

3.4 Limitations of outcome mapping for monitoring and evaluation requirements of climate resilient development pathways

Outcome mapping presents a number of useful components for monitoring and evaluation of climate resilient development pathways. However, it does not meet all of the requirements and overcome all of the challenges presented in section 2. In this section we present the limitations of outcome mapping in this context.

Development focused

Arguably the most pressing limitation with outcome mapping if it is being applied in the context of climate resilient development pathways is that it is highly focused on development impacts. This focus takes emphasis away from the critical climate action component, particularly for climate mitigation. This was also evident in the HI-PATH livelihood innovations, which were more focused on development and adaptation, with the exception of solar irrigation in Pakistan (Table 2). This

development focus, which positions relationships and behaviour change as central, leads to approaches that are more qualitative. However, climate resilient development pathways also require monitoring of climate mitigation practices, which generally relies on quantitative approaches, for example through modelling and remote sensing. Quantitative approaches do not easily align with outcome mapping (J.Van Ongevalle, August 5, 2021).

System boundaries

Outcome mapping requires practitioners to set system boundaries by identifying the areas of concern that the intervention intends to influence. This is done in the intentional design phase (stage 1). This is a step that interventions must take in light of real world constraints, and outcome mapping does encourage non-linear monitoring and evaluation by thinking about indirect cause-effect relationships through 'spheres of influence' (Hearn, 2021). However, as discussed in 2.3, interconnectivity of systems has increased the complexity of risks and impacts, which do not operate within system boundaries. Outcome mapping approaches do not present a methodology to capture direct and indirect effects and impacts occurring outside of the 'spheres of influence' that may still be important to monitor and evaluate.

Boundary partner selection

Setting system boundaries during the intentional design phase of an intervention requires practitioners to be selective when identifying boundary partners. The main issue associated with this is the boundary partners are selected at early stages of the intervention, which can be restricting as the extent of the intervention's influence is uncertain at this stage. Furthermore, it is encouraged to focus on a smaller number of stakeholder groups. This is because the core principles of outcome mapping, such as participation, co-creation and actor empowerment, dictate that practitioners should remain focused and deep, rather than wider and general (K.Ambrose, June 30, 2021). This can lead to the exclusion of important but external stakeholders. Although active learning encourages adaptability, in real world situations, changing boundary partners mid way through an intervention requires a lot of resources. These limitations for boundary partner selection leave critical questions of which vulnerable groups are excluded and which indirect effects and feedback are not accounted for, which are critical components for monitoring and evaluation of climate resilient development pathways.

Progress Markers

Progress markers are dynamic and, with the correct facilitation, can capture local development, sustainability and climate change challenges. However, they are highly qualitative, which renders their effectiveness for capturing quantitative information (e.g. for climate mitigation) as limited. Furthermore, as progress markers are centred around stakeholders within the intervention, they are not well suited to capture information about biophysical and ecosystem properties, which are important to monitor and evaluate in the context of climate change. As discussed in section 2, developing comprehensive indicators for climate resilient development pathways is highly difficult (O'Connell et al., 2013).

The influence of unexpected shocks

Climate change is increasing the frequency and intensity of climate hazards and risks are becoming more complex. Therefore, there is a need for climate resilient development pathways to monitor how unexpected shocks influence an intervention, system properties and stakeholders. This is particularly true if an objective of an intervention is to build resilience, part of which is maintaining important objectives in the face of unexpected shocks (O'Connell et al., 2015). Outcome mapping has limitations for monitoring and evaluating response to shocks as the process is more targeted towards anticipated changes (Hearn, 2021). Further, its usefulness immediately after a shock is questionable as time and reflection are required to process responses. Progress markers too, are generally targeted towards long term change rather than short term shocks (K.Ambrose, June 30, 2021).

The need for strong facilitation

Although practitioners noted that outcome mapping was easy to follow and adaptable to different contexts, it does require skilled facilitation from experienced experts. This is because monitoring and evaluation cycles with outcome mapping rely on personal and close encounters that can capture incremental behavioural interactions through stakeholder feedback. Particularly in a development intervention, there is a risk of a notion of appreciative inquiry within the communities with which you are working. People may feel that they have to respond positively in order to satisfy the needs of those inquiring. For example, if they associate an organisation with climate change research, they may respond with answers structured around that topic (K.Ambrose, June 30, 2021; N.Pradhan, June 30, 2021). In order to overcome this and incorporate the core principles, practitioners are required to navigate complex informal settings and have an in-depth understanding of the local setting, particularly when working with vulnerable individuals.

3.5 Matching

In section 2, an overview of the requirements and challenges of monitoring and evaluation of climate resilient development pathways are given, followed by what outcome mapping can offer as an approach in section 3. Table 6 gives an overview of where outcome mapping approaches can match the requirements of climate resilient development pathways, and where it is insufficient. Based on this matching, a novel approach is presented in section 4.

Table 7: Matching of what outcome mapping can offer and where it is insufficient for the requirements and challenges of monitoring and evaluation of climate resilient development pathways

Climate resilient development pathways	Outcome mapping	
Monitoring and evaluation requirements and challenges	What can outcome mapping offer	Where outcome mapping is insufficient
Actor centred, capturing threats, aspirations, identity culture and values	Through its participatory and systems oriented approach of focusing on behaviour change, outcome mapping provides practitioners with the tools to capture these components within an intervention	It requires highly skilled facilitation to capture these complex components, which is exasperated through its participatory approaches
Active learning and co-creation, giving a platform for the most vulnerable	Co-creation and active learning are embedded in outcome mapping, which is targeted towards all actors (including practitioners) and merges very well with equity and social justice by acknowledging power imbalances and how they influence relationships. These processes also help include competing voices and values	It can be overly restricting in defining boundary partners and the system of interest, therefore 'spheres of influence' may leave out important actors
Flexible indicators that capture complex system dynamics and properties (such as resilience) under uncertain conditions	Progress markers are easy to develop, use and are relevant to the local context. They can be adjusted as an intervention progresses and interpreted with flexibility	Progress markers capture qualitative information and are not targeted toward climate action (particularly mitigation). They are also insufficient at monitoring biophysical system properties and unanticipated change

Desegregation of long term goals into short term actions and overcoming issues of scale (temporal and spatial)	Through 'spheres of influence' and boundary partners, defining the system is clear. Outcome mapping is also useful for capturing long term incremental changes and goals	Short term (climate) shocks are not accounted for as the process is targeted toward anticipated changes. It can be overly restricting in defining boundary partners and the system of interest, therefore 'spheres of influence' may leave out important actors
Accounts for trade-offs and feedback in non-linear, uncertain and systemic risk settings	Behaviour change and adaptability through active learning encourage adjusting to uncertainties	The process is targeted toward anticipated changes. As system boundaries are well defined, non-linearity and systemic risks are not well captured

4.0 TOWARDS AN APPROACH FOR MONITORING AND EVALUATION OF CLIMATE RESILIENT DEVELOPMENT PATHWAYS, LESSONS FROM OUTCOME MAPPING

Monitoring and evaluation approaches for climate resilient development pathways need to transcend the use of generic indicators, assessment tools and frameworks. Achieving this will require operationalising the appraisal of attributes in complex systems that account for components such as feedback loops, changing values, resilience and transformation (Douxchamps et al., 2017). In this section, we present an approach for monitoring and evaluation of climate resilient development pathways, drawing on theoretical lessons and practical application of outcome mapping from HI-PATH.

4.1 Guiding practices, towards an approach for monitoring and evaluation of climate resilient development pathways

Before reaching the stage of an intervention when practitioners are designing a monitoring and evaluation approach, a number of important steps must already have taken place. Using outcome mapping language, this would be the steps in the intentional design phase (See Figure 3). Also see O'Connell et al (2019), Hagenlocher et al (2018) and Welle et al (2014) for useful guidelines on scoping and goal setting for interventions in dynamic systems. Monitoring and evaluation is frequently included as one of the last steps in intervention planning, to understand what progress has been made, what obstacles need to be overcome and what adjustments need to be made (Hagenlocher et al., 2018). However, each monitoring and evaluation approach will be unique based on the context, needs of the intervention and implementing organisation. The steps prior to defining monitoring and evaluation are critical in making up the content of the framework, therefore, it is not possible to separate the two exercises for any intervention. However, based on our framing of the requirements and challenges for climate resilient development pathways, and taking lessons from outcome mapping approaches and principles, we recommend the following seven steps, with an additional 3 core components, should be of critical consideration.

1. Learn from past developments

Taking a systems oriented approach is essential for the application of outcome mapping (K.Ambrose, June 30, 2021). This approach is equally important for climate resilient development pathways. It is important to connect past developments in the research setting (that have had both positive and negative impacts) with future aspirations of actors. Doing this will identify five important system characteristics that should be built into the monitoring and evaluation approach. Past social practices, power asymmetries, biophysical and social drivers of vulnerability, past path dependencies and historical triggers that have influenced resilience or shifted transformation (Abel et al., 2016; Leal Filho et al., 2021; Scheffer et al., 2021; Tubi, 2020). Local stakeholders, with practitioners, can then construct monitoring and evaluation approaches that build on this information. For example, by understanding historical triggers, such as an extreme drought or flood event, actors can plan monitoring intervals in conjunction with extreme weather forecasts, which then may capture important information regarding climate shocks and how they relate to resilience or a transformative shift (Tubi, 2020). Retrospective backcasting presents one qualitative tool for practitioners whereas agent based modelling combined with historical climate modelling presents a quantitative approach that can capture and structure such information (K.Ambrose, June 30, 2021; Scheffer et al., 2021).

2. Revisit objectives and underlying assumptions

Outcome mapping encourages reflection on the design and theory of change as an intervention grows, which is a useful lesson for climate resilient development pathways (J.Van Ongevalle, August 5, 2021). After completing step 1, revisit intervention objectives and underlying assumptions. Reflect on the relevance of information gained during the scoping such as which actors, institutions, threats,

aspirations, goals and time period, among others, were defined (Hagenlocher et al, 2018). This is because climate resilience development occurs in dynamic, uncertain and connected complex systems, where change frequently influences important factors. Therefore, understanding which objectives and assumptions have changed before developing monitoring and evaluation plans will be important to ensure relevance and robustness.

3. Avoid inflexibility when defining the system

Outcome mapping focuses on anticipated changes of behaviour of actors directly influenced by an intervention, which is a critique as outcomes outside the 'spheres of influence' can be missed (J.Van Ongevalle, August 5, 2021; K.Ambrose, June 30, 2021). Rigidly defining 'spheres of influence', 'the system of interest' or 'anticipated changes' you want to monitor can be a limitation as it does not account for unanticipated interactions or the systemic nature of risk in complex systems. COVID-19 is a useful example here, which highlights the interconnected and transboundary nature of risks. Lock-down interventions, which were imposed to ease the capacity of the health care system to deal with the virus by lowering infection rates, had widespread health, societal and economic impacts on a global scale. Therefore, rather than defining 'spheres of influence', we recommend a more open process, in which practitioners can identify and describe observed changes and outcomes, without making presumptive decisions about system and actor boundaries. This open process means that as an intervention progresses, it can capture information that is not of a direct cause-effect nature (Hearn, 2021). Exercises such as mapping 'webs' of direct and indirect impacts, that start in relation to the intervention's goals, but expand beyond them, can help practitioners to understand system interconnectivity and identify important components to monitor, such as entry points for drivers of vulnerability. In the end however, there is always a trade-off between remaining focused and more detailed, or open and more broad.

4. Develop indicators

See section 4.2 for guidance on indicators for climate resilient development pathways.

5. Consider power and gender dynamics

In conjunction with developing indicators, practitioners must decide the most robust ways of collecting data. In HI-PATH, a mixed methods approach of surveying, interviews, focus group discussions and quantitative modelling was employed in a consortium of six organisations in Bangladesh, Germany, India, Nepal, the Netherlands and Pakistan. Outcome mapping requires practitioners to be considerate of power dynamics, gender inclusiveness and differences in culture when planning data collection activities (Earl et al., 2001; J.Van Ongevalle, August 5, 2021; K.Ambrose, June 30, 2021). These considerations are essential if monitoring and evaluation of climate resilient development pathways is to capture information regarding the true to life situation. In HI-PATH for example, focus group discussions, interviews and surveys targeted towards women undoubtedly captured a lot of information about vulnerabilities women face, that would not have been shared in a mixed sex group (Pradhan, Lamichhane & Shrestha, 2021; Syed & Chowdhury, 2021). Further, to avoid a notion of appreciative enquiry, which is particularly important when practitioners are not from the immediate local area, researchers trained local persons to conduct data collection activities and collect data through citizen science (Pradhan, Lamichhane & Shrestha, 2021).

6. Establish a baseline for developed indicators

Through scoping, connecting past development, and revisiting underlying assumptions, practitioners will have a strong understanding of system characteristics and the baseline situation. However, it is very important to solidify an understanding of the baseline situation of the indicators that have been co-developed before collecting data. This is because there must be an understanding of the current system states in order to evaluate if the intervention has had an influence. For example, if the intervention concerns resilience and transformation of small scale farmers, collect baseline data that indicates these system properties before monitoring phases. Eliciting and building on stakeholder

knowledge to provide a baseline will create a better understanding of the current state than through non-participatory methods (O'Connell et al, 2019). Doing this allows practitioners to understand how the intervention has improved livelihoods and system properties, and also where it has not been effective. In the India intervention of HI-PATH, for example, baseline data was collected to gather information on the ground conditions prior to implementing actions, taken with the intent to promote climate resilient development pathways (Bhadwal et. al., 2021).

7. Desegregate long term goals into short term monitoring actions

The last step before conducting monitoring and evaluation activities is to decide when you will monitor and evaluate. Outcome mapping encourages desegregation of long term goals into a series of short term actions for reaching the desired vision, which are monitored through progress markers. This lesson is highly useful in the application of climate resilient development pathways, which requires both short term and long term planning. Desegregation of monitoring and evaluation actions builds structured reflection into the intervention, allowing room for managing trade-offs, readjustment to avoid path dependencies or lock-in and for the accommodation of uncertainties (Leal Filho et al., 2021). However, although outcome mapping is effective for capturing incremental changes in behaviour of central actors, it is not effective for giving insights into how systems and actors respond to short term (climate) shocks, as well as for quantitative information related to mitigation, which is a weakness (K.Ambrose, June 30, 2021). Pathways approaches are highly useful here, which, with effective monitoring and evaluation, synergises with tools and indicators that provide data on social-political and biophysical tipping points and levers for transformational shifts. Furthermore, if possible, conducting monitoring activities soon after climatic shocks, such as a cyclone, flood or heat wave will be useful to understand how an intervention has reduced vulnerability or increased resilience. If the resources are available, informal monitoring on a bi-monthly basis is useful, for example by having conversations with key informants. At a programme level, 6 monthly cycles of thorough monitoring and evaluation, with detailed data collection and analysis, is useful to ask if the intervention and actors are on the expected pathways, or if readjustments are needed based on expected or unexpected change (J.Van Ongevalle, August 5, 2021).

Three core components

Along with the seven recommended steps above, there are three core components that align closely with outcome mapping principles, that practitioners should always aim to include in a monitoring and evaluation approach for climate resilient development pathways.

Co-create

Outcome mapping dictates that people contribute to their own well-being, and that organisation can only have a limited influence (Hearn, 2021; J.Van Ongevalle, August 5, 2021). In order to give actors the power to do this, co-production is the most important component to include and should be in any framework or approach for climate resilient development pathways (N.Pradhan, June 30, 2021). Without co-production, interventions can fail due to a mismatch about issues, actions, actors and outcomes, for example by not fully accounting for gains and losses to individuals and vulnerable communities in monitoring and evaluation cycles (Few et al 2021; Matthews, 2013; Tebboth et al 2020). Furthermore, co-production gives local actors agency, which refers to the ability of actors to achieve objectives through mobilizing knowledge, resources, and social networks, either within current structures, or by working to change them (Wyborn et al., 2015). Creating agency is important for local organisations, to influence their own climate resilient development (J.Van Ongevalle, August 5, 2021). To co-produce, researchers and practitioners are required to relinquish their status as 'experts' and see their role as participants rather than a source of knowledge to address problems (Colloff et al., 2021). They must re-frame their values, rules and knowledge to be respectful of partnerships and cultural differences, particularly when working with indigenous peoples, where 'scientific' framing of topics such as future adaptation planning may not align. Hill et al (2020)

recommend co-producing through five tasks, prepare, communicate, discuss, bring together and apply.

Embrace systems complexity

Outcome mapping asks practitioners to take the position that although data is evaluated on the intervention's actions and on changes in its boundary partners, there should be no assumption that there is a direct causal relationship between the two. This is because an intervention is only one of the many influences on boundary partners (J.Van Ongevalle, August 5, 2021). Building on this, and suggested step 3, it is important to accept uncertainty and embrace the complexity of systems for monitoring and evaluation of climate resilient development pathways. Practitioners should approach the monitoring and evaluation of interventions with openness, and accept that threats, aspirations, indicators and underlying assumptions will change, particularly over long time scales which are needed in climate action and development settings. Disaggregating long term goals into short term monitoring actions, building flexibility into indicators and incorporating active learning into interventions can help practitioners to embrace systems complexity, account for uncertainty and adjust accordingly.

Actively learn

Active learning is the process of giving space in an intervention's planning for reflecting on current actions and their outcomes. It allows for the reframing of assumptions and direction by responding to unprecedented change and embracing complexity in scenarios for which there are no tested solutions (O'Connell et al, 2019). Active learning is applied through a structured approach that is tightly coupled with monitoring and evaluation. Critical reflection sessions with central actors should be planned after evaluation of indicators. It is important for actors to challenge results, dominant paradigms and power asymateries, particularly with the aspirations of local and vulnerable actors in mind. Active learning will initially be guided by the goals of the intervention, however, adjustments will likely occur to account uncertainties over time. Building this core component into interventions can help to define and adjust important monitoring components to account for change, such as indicators. Furthermore, it is useful for building capacity of involved actors as it provides accountability of actions through reflexive steps and informs the adaptive processes of intervention components.
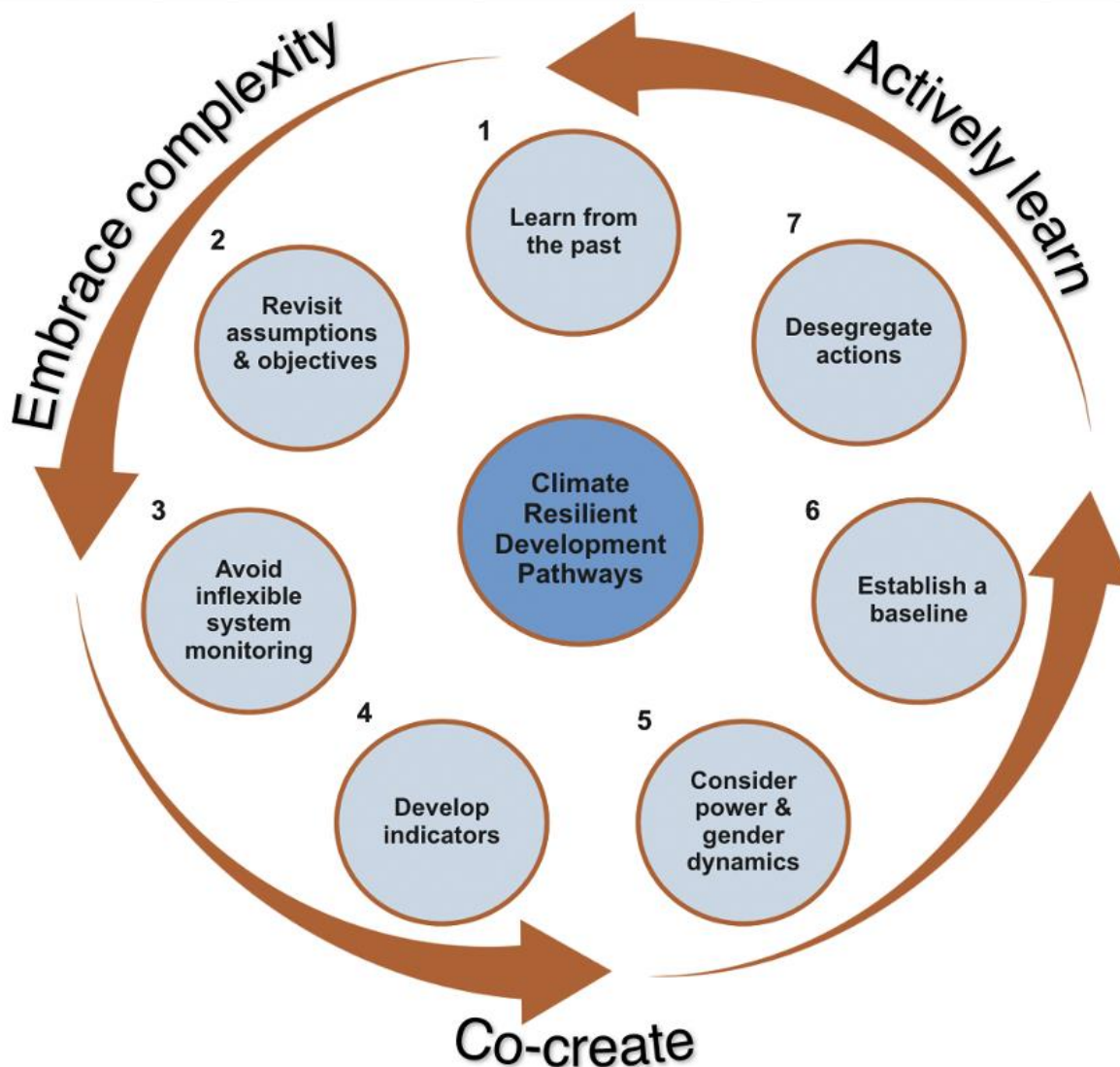
Figure 4: Guiding practices for monitoring and evaluation of climate resilient development pathways.

4.2 Indicator guidance for climate resilient development pathways

Although 'off the shelf' processes that use a defined set of indicators will not be effective for interventions aiming to incorporate climate resilient development pathways approaches, a strong understanding of types of indicators, and how they can be applied is an important step in guiding practices (Chesterman et al., 2020; O'Connell et al., 2019). In this section, some suggestions are made for the types of indicators that could be used to track progress for climate resilient development pathways.

Selecting Indicators

As a starting point, it may be useful to look at published lists of indicators that can describe system characteristics or actor behaviour for inspiration [1]. Using published lists is helpful as methods used to calculate each indicator are usually outlined (Welle et al., 2014). It is critical to insure that selected indicators are relevant to the local contexts sustainability, climate action and development threats,

---

[1] Sources such as the World Bank Development Indicators (http://datatopics. worldbank.org/world-development-indicators/), Food and Agricultural Organisation of the UN (http:// www.fao.org/sustainable-development-goals/indicators/en/), and the Sustainable Development Goals Indicator data base (https://unstats.un.org/sdgs/indicators/database/) can be useful.

and should always keep the interventions goals in mind (Chesterman et al., 2020; Haasnoot, van 't Klooster and van Alphen, 2018; O'Connell et al., 2019). Therefore, highly synthesised compound indicators such as GDP will likely have little relevance to the system of interest (O'Connell et al., 2015). Co-creation with local actors when selecting and developing indicators will be very important soas they are relevant for community apriations. Additionally, indicators should aim to provide insights into how the intervention influences the critical components of climate resilient development pathways. Relevant Indicators should represent the issues practitioners would like to address, while being accessible and affordable with reasonable efforts and clear in their direction. For example, an increase or decrease in indicator value should be unambiguous in relation to the system property or characteristic being monitored. Examples of indicators relevant to HI-PATH innovations could be:

1) **HI-PATH livelihood innovation:** Climate and flood resilient housing, Rangpur, Bangladesh
   Indicator: Rural - urban migration of local carpenters
   Representative intervention issue(s): Rural livelihood opportunities (i.e. does the intervention provide stable working conditions and income for carpenters constructing climate and flood resilient housing compared with moving to a city for work?).
   Critical climate resilient development pathways components: Aspirations, system sustainability and trade-offs.

2) **HI-PATH livelihood innovation:** Climate smart agriculture, Uttarakhand, India
   Indicator: Crop diversity in small scale agricultural practices:
   Representative intervention issue(s): Resilience of small scale farmers (i.e. does the intervention introduce new crops that will not fail under an extreme cold event?)
   Critical climate resilient development pathways components: System sustainability, capacity to adapt.

3) **HI-PATH livelihood innovation:** Portable solar irrigation pumping systems, Potohwar & Thal, Pakistan.
   Indicator: Womens ownership of solar irrigation pumping systems
   Representative intervention issue(s): Opportunities for women to build their own sustainable livelihoods (i.e. does the intervention improve gender equality for female farmers?)
   Critical climate resilient development pathways components: Equity, justice and equal gender rights

4) **HI-PATH livelihood innovation:** Springshed restoration, Gandaki basin, Nepal
   Indicator: Access to spring water resources for Dalit communties
   Representative intervention issue(s): Discrimination faced by Dalits using commnuity springs (i.e. does the intervention provide enough access points to water for the provention of confrontation and caste segregation)
   Critical climate resilient development pathways components: Equity, justice and equal rights

Adjusting indicators to account for systems change

In closed systems and research settings, adjusting indicators will significantly affect results. However, for climate resilient development pathways, updating or adjusting indicators to be relevant to changes over time will be important for monitoring and evaluation practice. Changes in climate systems and societal shifts will influence development goals, meaning that relevant threats and aspirations when developing monitoring and evaluation frameworks will change. Furthermore, interventions will have an influence, for example through implementing adaptive or mitigating practices, or through enhancing a systems resilience, as will wider policy actions at regional and global scales. As these changes occur,

indicators used at an intervention's starting point will become less robusts or relevant (Barry and Hoyne, 2021). Lessons from outcome mapping progress markers are useful here, as they can be adjusted over long time frames to account for both expected and unexpected change in system characteristics or actor behaviour (Earl et al, 2001; K.Ambrose, June 30, 2021). An example is given below of how the above indicators could be adjusted to account for changes over time.

1) **HI-PATH livelihood innovation:** Climate and flood resilient housing, Rangpur, Bangladesh
   Indicator: Traineeships for local carpenters to specialise in climate and flood resilient housing
   Representative intervention issue(s): Increase in demand for local carpenters (i.e Is the intervention creating thriving working conditions and a need for a larger workforce of carpenters for specialist construction).
   Critical climate resilient development pathways components: Aspirations, system sustainability.

2) **HI-PATH livelihood innovation:** Climate smart agriculture, Uttarakhand, India
   Indicator: Small scale farmers self-organising to share practices on diversifying crops
   Representative intervention issue(s): Transformative behaviour of small scale farmers (i.e. is the self mobilisation of farmers out-scaling the interventions goals without input from practitioners?)
   Critical climate resilient development pathways components: System sustainability, capacity to transform.

3) **HI-PATH livelihood innovation:** Portable solar irrigation pumping systems, Potohwar & Thal, Pakistan.
   Indicator: Women's access to agricultural/ climate/ weather information services
   Representative intervention issue(s): Equal opportunities for women to adapt their agricultural practices (i.e. does the intervention improve women's access to agricultural education/ information)
   Critical climate resilient development pathways components: Capacity to adapt and transform, equity, justice and equal gender rights

4) **HI-PATH livelihood innovation:** Springshed restoration, Gandaki basin, Nepal
   Indicator: Dalit communities conducting spring restoration activities
   Representative intervention issue(s): Self mobilising among the marginalised caste (i.e. is the intervention creating awareness and capacity building for climate resilience among Dalits)
   Critical climate resilient development pathways components: Equity, justice and equal rights, recognises root causes of vulnerability, System sustainability, capacity to adapt.

Quantitative approaches

A weakness of outcome mapping for climate-resilient development pathways is its strong focus on development and the fact that it does not synergize well with quantitative approaches (J.Van Ongevalle, August 5, 2021). Climate model projections can be a useful quantitative tool for monitoring indicators over long time frames. Indicators should be representative of intervention goals and clear in their direction in relation to long-term model projections of change in climate shocks and stresses, such as increases in the severity and frequency of precipitation or temperature change (Arnell et al., 2021). HI-PATH relevant examples include the % chance of a one in ten flood year event in the Teesta river basin, Bangladesh, the number of cold days below x°C in Rudraprayag, Uttarakhand, India or land-use suitability for the upscaling of portable solar irrigation pumping systems in Pakistan. Representative concentration pathways (RCPs) can give a range of potential future scenarios that inform intervention actions for climate-resilient development pathways. However, although model projections and outputs are useful to inform decision making, they should always be coupled with the

three core components of 1) co-production, to ensure that models and indicators are relevant and representative for key actors, 2) embracing systems complexity, so practitioners are not over reliant on model projections and aware of unpredictable conditions and the systemic nature of risks, 3) active learning, to reframe assumptions of intervention goals and community aspirations based on updated model projections.

Box 2: Monitoring and evaluation for springshed restoration in the Gandaki basin, Nepal

The HI-AWARE project was able to map 69 springs in the research site surrounding the Gandaki basin, Nepal, out of which 36 were monitored by engaging the local resource person during the project period. Taking a citizen science approach, local knowledge was tapped to understand the historical evidence of springshed locations in the research area, especially prior to the devastating earthquake in 2015 that shifted spring locations. A detailed, quantitative hydrogeological study of 4 springs was also conducted to identify its recharge area. Due to the drying of springs as a result of climate change, which leads to water scarcity for communities, the different adaptation pathways adopted by the communities included seeking an alternative source of springs to fulfill the water demand, buying land increase access to spring sources, switching to collecting water from rivers, diverting river canals, and introducing lift water irrigation systems.

To overcome the issue of drying springs, the communities minimised their water use and consumption. Monitoring revealed that apart from drinking and cooking, communities usually depend on the river for cleaning, washing, bathing, and for water provision for livestock. The spring management activities also included afforestation near the spring sources, cleaning the spring sources, checking the spring pipelines and water tanks every week and spreading awareness of techniques for the preservation of water. The local government provided water tanks and water pipelines to individual households and at a community level through installing community water taps.

5.0 DISCUSSION

The approach in section four highlights that there are many considerations for practitioners when aiming to develop monitoring and evaluation frameworks for climate resilient development pathways. This seven step approach should not be thought of as an 'off the shelf' toolkit, that can be applied to any intervention. This is because there is no 'one size fits all' framework that will work in all scenarios, especially over long time frames in complex settings with changing conditions such as those often found in interventions applying climate resilient development pathways. Rather, the framework must be tailored to the context, specific goals and resources of the intervention. However, taken together, the seven steps can be useful for informing the details of a comprehensive monitoring and evaluation approach.

We recommend that interventions incorporating climate resilient development pathways consider these seven steps, and strongly recommend building the three core components into the makeup of the intervention. This is because, if climate resilient development pathways are to be successful in empirical application, frameworks should aim to meet the monitoring and evaluation requirements presented in section 2.2, and the monitoring and evaluation challenges presented in section 2.3 of this report. The approach presented here has been designed to meet these requirements and overcome these challenges as best as possible. Furthermore, monitoring and evaluation is often thought of as structure and deterministic, particularly when applying pathways approaches to interventions. However, this report demonstrated that in true to life situations, it is not that simple. Actively learning, embracing systems complexity and co-creating are aspects that will allow practitioners to look beyond the deterministic nature of monitoring (and pathways), making them more effective when empirically applied.

As our approach has been informed by matching the numerous lessons from outcome mapping with the requirements and challenges for monitoring and evaluation, many specific gaps are covered that can often be overlooked in conventional frameworks. Particular attention has been given to bottom-up processes that account for values, stakeholder interaction, behaviour and power asymmetries. These components are highly important to consider, and are relevant in relation to the framing presented in Figure 1 from Werners et al (2021b). Moreover, empirical application in HI-PATH has given insight into the limitations of outcome mapping. Understanding these limitations informs and strengthens our seven step approach, specifically through asking practitioners to enable flexibility and embrace uncertain conditions. There are, however, a number of limitations to this report which have influenced the approach presented in Figure 4.

Firstly, our framing of climate resilient development pathways, presented in Figure 1, is from earlier work in HI-PATH by Werners et al (2021b). This framing, although developed through a comprehensive and systematic process with a range of experts on the topic, is still only one position on a rapidly evolving concept. Second, to date there is a lack of empirical application of climate resilient development pathways. Therefore, the requirements and challenges presented in section 2 have mostly been developed through the position paper from Werners et al (2021b), expert interviews and from a range of peer reviewed and grey literature, rather than through lessons from real world application. Furthermore, testing the proposed framework through application in interventions would strengthen it. Third, although we have aimed to overcome issues relating to decision making power, notions of appreciative inquiry and siloed knowledge views in HI-PATH, we are still presenting this approach from the perspective of how we understand systemic issues related to climate action and development (Pelling, 2011). This perspective, by default, privileges western 'scientific' knowledge over other ways of thinking, for example through long term future planning, which is not something considered of importance in some indigenous cultures (Bates, 2007).

With the growing need for climate action and development to intersect and synergise, tangible empirical efforts must now be made for monitoring and evaluation frameworks for climate resilient development pathways. Therefore we recommend that the framework presented in this report is applied to interventions and a useful guideline. This will need to be adjusted to account for needs and context of the intervention, and real world application will likely inform improvements to the approach. In consideration of the fact that monitoring and evaluation is of critical importance for climate resilient development pathways, this report has contributed to closing a significant gap in the literature.

6.0 CONCLUSIONS

This research report has aimed to present steps towards a novel approach for monitoring and evaluation of climate resilient development pathways based on outcome mapping thinking. There is a necessity for this work, as it is currently underrepresented in the literature. Climate resilient development pathways will be applied in complex, dynamic and uncertain settings. Therefore, there will be numerous challenges for practitioners aiming to monitor and evaluate. The framework presented here has aimed to stimulate thinking and be useful in a wide range of contexts, however it will need to be adapted to the specificity of the intervention. Outcome mapping presents a number of useful principles that can be used to inform considerations for the challenges and requirements for climate resilient development pathways, however, like all approaches, it has its limitations. These limitations have informed and strengthened our framework. Furthermore, as climate resilient development pathways gain momentum as an empirical tool for climate action and development, developing and evolving monitoring and evaluation approaches become a necessity. Therefore we recommend that this approach is ground truthed in real world settings, which will likely contribute to its improvements. This ground truthing will strengthen the monitoring and evaluation framework, which

will in turn reduce vulnerability and enhance resilience for communities involved in interventions applying climate resilient development pathways approaches.

References

Abel, N., Wise, R.M., Colloff, M.J., Walker, B.H., Butler, J.R.A., Ryan, P., Norman, C., Langston, A., Anderies, J.M., Gorddard, R., Dunlop, M., O'connell, D., 2016. Building resilient pathways to transformation when "no one is in charge": insights from Australia's murray-darling basin. Ecol. Soc. 21.

Arnell, N., Kay, A., Freeman, A., Rudd, A. and Lowe, J., 2021. Changing climate risk in the UK: A multi-sectoral analysis using policy-relevant indicators. *Climate Risk Management*, 31, p.100265.

Bates, P., 2007. Inuit and Scientific Philosophies about Planning, Prediction, and Uncertainty. Arctic Anthropology 44, 2, 87-100.

Bhadwal, S., Pruthi, A., Malhotra, S., Lopez, P., Bharti, N. 2021. From HI-AWARE to HI-PATH, Guiding the transition using Outcome Mapping And Application for the case study area in India. The energy and resource institute, India. Not Published.

Burch, S., Shaw, A., Dale, A., Robinson, J., 2014. Triggering transformative change: A development path approach to climate change response in communities. Climate Policy 14, 4, 467-487.

Chesterman S, Neely CN, Thornton P and Pereira L. 2020. Climate-Resilient Development Pathways. SADC Futures: Developing Foresight Capacity for Climate Resilient Agricultural Development Knowledge Series. CCAFS Report. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: www.ccafs.cgiar.org.
Citi GPS and Cambridge Centre for Risk Studies, Systemic Risk: Solutions for an Increasingly Interconnected World, 2021; Citi GPS: Global Perspectives & Solutions and Centre for Risk Studies, University of Cambridge, Judge Business School

Colloff, M., Gorddard, R., Abel, N., Locatelli, B., Wyborn, C., Butler, J., Lavorel, S., van Kerkhoff, L., Meharg, S., Múnera-Roldán, C., Bruley, E., Fedele, G., Wise, R. and Dunlop, M., 2021. Adapting transformation and transforming adaptation to climate change using a pathways approach. *Environmental Science & Policy*, 124, pp.163-174.

Denton, F., T.J.Wilbanks, Abeysinghe, A.C., Burton, I., Gao, Q., Lemos, M.C., Masui, T., O'Brien, K.L., Warner, K., 2014. Climate-resilient pathways: adaptation, mitigation, and sustainable development, In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., L.L.White (Eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1101-1131.

Douxchamps, S., Debevec, L., Giordano, M., Barron, J., 2017. Monitoring and evaluation of climate resilience for agricultural development – A review of currently available tools. World Development Perspectives 5, 10-23.

Earl, S., Carden, F. and Smutylo, T. 2001. *Outcome Mapping: Building Learning and Reflection into Development Programs*. Ottawa: International Development Research Centre.

Earl, S. 2008. Outcome mapping webinar. Retrieved July 14, 2021 from:
https://www.youtube.com/watch?v=fPL_KEUawnc
Ellis, N.R., Tschakert, P., 2019. Triple-wins as pathways to transformation? A critical review. Geoforum 103, 167-170.

Fetterman, D., Rodríguez-Campos, L., Wandersman, A. and O'Sullivan, R. 2013. Collaborative, Participatory, and Empowerment Evaluation. *American Journal of Evaluation*, 35(1), pp.144-148.

Few R, Jain G, Singh C, Tebboth M, Chhotray V, Marsh H, Ranjit N, Madhavan M (2021) Why Representation Matters in Disaster Recovery. The British Academy, London

Gordon & Williams. 2020. Are there fundamental characteristics of systemic risks? UNDRR. Retrieved 4 August, 2021 from: https://www.preventionweb.net/news/view/71267

Haasnoot, M., van 't Klooster, S. and van Alphen, J., 2018. Designing a monitoring system to detect signals to adapt to uncertain climate change. *Global Environmental Change*, 52, pp.273-285.

Hagenlocher, M., Schneiderbauer, S., Sebesvari, Z., Bertram, M., Renner, K., Renaud, F., Wiley, H., Zebisch, M. 2018. Climate Risk Assessment for Ecosystem-based Adaptation – A guidebook for planners and practitioners. Bonn: GIZ.
Hearn, S. 2013. Steps of outcome mapping. Better evaluation. Retrieved July 14, 2021 from: https://www.betterevaluation.org/en/plan/approach/outcome_mapping

Hearn, S. 2021. 20 years of Outcome Mapping: Evolving practices for transformative change. OutcomeMapping learning community. IDRC.

Hermans, L.M., Haasnoot, M., ter Maat, J., Kwakkel, J.H., 2017. Designing monitoring arrangements for collaborative learning about adaptation pathways. Environ. Sci.Policy 69, 29–38.

Hill, R., Walsh, F., Davies, J., Sparrow, A., Mooney, M., Wise, R. and Tengö, M., 2020. Knowledge co-production for Indigenous adaptation pathways: Transform post-colonial articulation complexes to empower local decision-making. *Global Environmental Change*, 65, p.102161.

IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [MassonDelmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

IRGC (2018). *Guidelines for the Governance of Systemic Risks*. Lausanne: International Risk Governance Center (IRGC). DOI: 10.5075/epfl-irgc-257279

Leal Filho, W., Stringer, L.C., Totin, E., Djalante, R., Pinho, P., Mach, K.J., Carril, L.R.F., Birkmann, J., Pandey, R., Wolf, F., 2021. Whose voices, whose choices? Pursuing climate resilient trajectories for the poor. Environmental Science & Policy 121, 18-23.

Matthews, T., 2013. Institutional perspectives on operationalising climate adaptation through planning. *Planning Theory & Practice*, 14(2), pp.198-210.

Moss, R.H., Avery, S., Baja, K., Burkett, M., Chischilly, A.M., Dell, J., Fleming, P.A., Geil, K., Jacobs, K., Jones, A., Knowlton, K., Koh, J., Lemos, M.C., Melillo, J., Pandya, R., Richmond, T.C., Scarlett, L., Snyder, J., Stults, M., Waple, A.M., Whitehead, J., Zarrilli, D., Ayyub, B.M., Fox, J., Ganguly, A., Joppa, L., Julius, S., Kirshen, P., Kreutter, R., McGovern, A., Meyer, R., Neumann, J., Solecki, W., Smith, J., Tissot, P., Yohe, G., Zimmerman, R., 2019. Evaluating knowledge to support climate action: A framework for sustained assessment. Report of an independent advisory committee on applied climate assessment. Weather, Climate, and Society 11, 3, 465-487.

O'Connell, D., Braid, A., Raison, J., Hatfielddodds., S., Wiedmann., T., Cowie., A., Littleboy, A. & Clark, M. 2013. Navigating sustainability: measurement, evaluation and action. Australia: CSIRO.

O'Connell D, Walker B, Abel N, Grigg N. 2015. The Resilience, Adaptation and Transformation Assessment Framework: from theory to application. Australia: CSIRO.

O'Connell, D, Maru, Y, Grigg, N, Walker, B, Abel, N, Wise, R, Cowie, A, Butler, J, Stone-Jovicich, S, Stafford-Smith, M, Ruhweza, A, Belay, M, Duron, G, Pearson, L, and Meharg, S. 2019. Resilience, Adaptation Pathways and Transformation Approach. A guide for designing, implementing and assessing interventions for sustainable futures (version 2), CSIRO.

Pelling, M., (2011). Adaptation to climate change: from resilience to transformation, Routledge, London.

Pradhan, N., Lamichhane, N., Shrestha, S. 2021. HI-PATH, Adaptation pathways for water resource management in Gendaki Basin Nepal: lessons from springshed management. International centre for integrated mountain development. Not Published

Rammel, C., Stagl, S., Wilfing, H. 2007. Managing complex adaptive systems — A co-evolutionary perspective on natural resource management. Ecological Economics 63 (1) 9-21. https://doi.org/10.1016/j.ecolecon.2006.12.014.

Scheffer, M., van Nes, E., Bird, D., Bocinsky, R. and Kohler, T., 2021. Loss of resilience preceded transformations of pre-Hispanic Pueblo societies. *Proceedings of the National Academy of Sciences*, 118(18), p.e2024397118.

Scholz, G., Methner, N., 2020. A social learning and transition perspective on a climate change project in South Africa. Environmental Innovation and Societal Transitions 34, 322-335.

Singh, P. and Chudasama, H., 2021. Pathways for climate resilient development: Human well-being within a safe and just space in the 21st century. *Global Environmental Change*, 68, p.102277.

Syed, A., Chowdhury, S. 2021. Outcome mapping and adaptation pathways for upscaling and outscaling of climate and flood resilient housing. Bangladesh centre for advanced studies. Not Published.

Tanner, T., Zaman, R.U., Acharya, S., Gogoi, E., Bahadur, A., 2019. Influencing resilience: the role of policy entrepreneurs in mainstreaming climate adaptation. Disasters 43, S3, S388-S411.

Tebboth, M.G.L., Few, R., Assen, M., Degefu, M.A., 2020. Valuing local perspectives on invasive species management: Moving beyond the ecosystem service-disservice dichotomy. Ecosystem Services 42, 101068.

Tubi, A., 2020. Recurring droughts or social shifts? Exploring drivers of large-scale transformations in a transformed country. *Global Environmental Change*, 65, p.102157.

Welle, T., Witting, M., Birkmann, J., Brossmann, M. 2014. Assessing and monitoring climate resilience: From Theoretical Considerations to Practically Applicable Tools – A Discussion Paper. Bonn: GIZ, UNU.

Werners, S.E., Wise, R.M., Butler, J.R.A., Totin, E., Vincent, K., 2021. Adaptation pathways: a review of approaches and a learning framework. Environmental Science & Policy 116, 266-275.

Werners, S., Sparkes, E., Totin, E., Abel, N., Bhadwal, S., Butler, J., Douxchamps, S., James, H., Methner, N., Siebeneck, J., Stringer, L., Vincent, K., Wise, R. and Tebboth, M., 2021. Advancing climate resilient development pathways since the IPCC's fifth assessment report. *Environmental Science & Policy*, 126, pp.168-176.

Wyborn, C., Yung, L., Murphy, D. and Williams, D., 2014. Situating adaptation: how governance challenges and perceptions of uncertainty influence adaptation in the Rocky Mountains. *Regional Environmental Change*, 15(4), pp.669-682.