Grant agreement no. 776479

COACCH

CO-designing the Assessment of Climate CHange costs

H2020-SC5-2016-2017/H2020-SC5-2017-OneStageB

D1.4 Co-design and co-delivery protocol

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Disclaimer

Dissemination Level		
PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	
CI	Classified, as referred to in Commission Decision 2001/844/EC	

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Version log

Version	Date	Released by	Nature of Change
1.1	1/APRIL/2018	PWA	First Draft
1.2	17/APRIL/2018	PWA	Second Draft

Summary

To develop challenge-driven and solutions orientated research, COACCH is proactively involving stakeholders in co-design, co-production and co-dissemination. This deliverable, D1.4 (Co-design and co-delivery protocol), has undertaken a detailed literature review, using the findings to produce a set of guiding principles and a protocol for the COACCH project.

Review of co-design and co-production guidance and best practice

The deliverable has started with a detailed review of the academic and grey literature on co-design and co-production, focusing on the climate and research domains. It has reviewed existing evaluations and good practice guidelines - and their lessons and recommendations – and used these as the basis for developing a tailored set of guiding principles and a protocol for co-production in the COACCH project.

Co-Design and Co-Production Principles

Based on the literature review, a set of common principles and success factors have been identified. These set out that successful co-design and co-production should be:

- Process orientated, as the co-production process is as important as the outputs;
- Objective and outcome led, with clearly identified roles and responsibilities;
- Targeted, ensuring representative stakeholders are involved;
- User and decision orientated, to meet user needs and produce information of relevance for decisions;
- Joint product orientated, using outputs to help build the engagement and co-production process;
- Iterative, with an ongoing process of review and learning throughout the project;
- Time managed, with enough time, resources and facilities to deliver the process;
- Transparent and inclusive;
- Part of a cycle of evaluation and learning, drawing lessons from the process for future research programmes.

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These principles have been used to design the COACCH co-production protocol, working within the boundaries of the work packages and partner resources. This leads to a focus on instrumental ('bounded') co-production, which focuses on the generation of usable knowledge to help inform decision making. Based on this, it is proposed that the COACCH project should:

- Identify a group of representative stakeholders. This has been addressed through Deliverable 1.1 and is being taken forward with a set of four Thematic Working Groups. However, to allow more in-depth co-production and practice orientated research, a set of Deep Engagement Stakeholders has also been identified.
- Identify user needs and the potential uses of COACCH information for decisions. This should be based on discussion with the Thematic Working Groups and the Deep Engagement Stakeholders.
- Develop a process for co-production. This involves the identification of goals, outcomes, and roles and responsibilities for the co-production process (in a roadmap). These should then be discussed and agreed with stakeholders.
- Identify a set of joint products (outputs) that the project should work towards, identifying and agreeing these at the initial workshop with stakeholders.
- Allow sufficient time for the co-production process, and seek to build opportunities for continued engagement through the project.
- Allocate sufficient financial and staff resources to the co-production process and use a facilitated process for engagement.
- Adopt an iterative approach, providing opportunities to adjust the goals, method and outcomes as the project progresses, and identify check points for discussion.
- Ensure an inclusive process that recognises and respects different views.
- Ensure a continuous process of monitoring and evaluation, using this to inform the project as it progresses, and to provide lessons for future co-production at the end.

COACCH Protocol

To translate these findings into implementation, a series of steps have been identified that form the COACCH co-production protocol. These steps are:

1. Co-design.
2. Co-production.
3. Co-dissemination.
4. Evaluation.

Co-Design

The objectives of this step are to co-design and agree the co-production process, including the goals, outcomes, products and roles. The following activities are identified:

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- To identify a group of representative stakeholders. This task has been completed and was presented in Deliverable 1.1: Stakeholder Database.
- To develop the overall process for the co-production process. A co-production pathway/roadmap will be completed in advance of the first workshop, to set out the proposed process, goals and outcomes.
- To identify roles and responsibilities. Based on the proposal, it is proposed that PWA and Ecologic Institute act as the boundary agents for the overall co-production process and that each stakeholder is assigned a 'relationship manager' from across the consortium. Additional roles will be discussed and agreed at the first workshop.
- To identify potential user needs and decisions. This has been progressed through the development of a stakeholder template, completed for all stakeholders (in Deliverable 1.1). Further user needs will be discussed at the first workshop and key decisions will be identified through the Deep Engagement Stakeholder meetings.
- To identify a set of joint knowledge products (outputs), noting the existing products identified in Work Package 5 (policy briefs and a final policy synthesis (D5.3 and D5.4), database and simulator (D5.1 and D5.2) and co-production best practice guidance (D5.5)).
- To discuss and agree the format for the First Stakeholder Workshop (a planning session was held in Berlin on 22nd of March 2018 to do this) and identify a facilitator for the workshop.
- To present, discuss, revise and agree the process, goals, outcomes, product and roles at the first stakeholder workshop on 17th May 2018..

Co-Production

The objectives of the co-production phase are to deliver the agreed research, as part of an iterative and collaborative process with stakeholders. This will include a check point mid-way through the project for review (the interim workshop). It will also deliver the case studies working with the Deep Engagement Stakeholders on practice orientated interaction, i.e. identifying opportunities for the COACCH project to provide knowledge to help inform decisions. The following activities are identified:

- To translate the interests and agreements from the first stakeholder workshop into a programme of work for the project. This will include the specified scenarios and time-scales of interest for the analysis in WP2, based on the scenario sessions at the first workshop. This will include a list of tipping points to explore in WP3 and it will provide some early indications of possible policies to consider for WP4.
- To hold bi-lateral meetings with each Deep Engagement Stakeholders. To use the stakeholder questionnaire to elicit potential research collaboration, as well as to understand needs and organisational context. From this, to identify specific collaborative areas to progress with each DES, including possible case study work

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and to hold regular (6 monthly) bi-lateral meetings with them to progress the collaboration.

- To use the second workshop as an interim check (review) point with all stakeholders and review the direction of the work – with the opportunity for stakeholders to adjust the goals, method, outcomes and to hold discussion on the joint products, also linked to the products in Work Package 5.
- To use the final workshop to discuss the emerging project results and agree joint knowledge products.

Co-Dissemination

The objectives of the co-dissemination phase are to make sure dissemination, communication, and exploitation activities are designed to directly address the needs of the different stakeholders and end-users involved in the co-design process. It will also provide guidance on the appropriate design and format of research output to meet different user needs. The proposed activities are:

- To provide an early synthesis of the state of knowledge on the economics of climate change in Europe, for dissemination in advance of the first workshop.
- To discuss strengths and weaknesses of available products and different formats and develop initial proposals on joint products (e.g. web-tool, policy briefs, database) at the first stakeholder workshop
- To present draft versions of products for discussion at the second workshop and firm up these proposals on the basis of the emerging results. To use this to directly inform and frame the design of the tool, database and policy synthesis in WP5, as well as the preparation of Dissemination, Communication and Exploitation activities in WP6.
- To update the Communication, Dissemination and Exploitation Plan (WP6) accordingly.
- To present the resulting final (draft) products at the third workshop and discuss channels if distributing products and results (e.g. associations, emailing-lists, meetings, working groups, workshops, conferences).
- To discuss with stakeholders, especially Deep Engagement Stakeholders, on the procedure and content of dissemination activities (i.e., approval processes, media department engagement, how to deal with issues of potential concern or confidentiality).

Evaluation

The objectives of this step are to continuously review the project, and to draw lessons at the end to help inform future co-design and co-production research. The proposed activities are:

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- To provide a draft evaluation process, and present, discuss and agree this with stakeholders at the first stakeholder workshop. This should include a set of evaluation questions.
- To take stock of the project progress at the mid-term point at the second stakeholder workshop, to provide an opportunity to review progress and to make adjustments or corrections. To apply the evaluation questions and document lessons from the initial co-design phase and the emerging co-production phase.
- To take stock of lessons at the final workshop. To apply the evaluation questions and document lessons from the co-production phase.
- To summarize and provide lessons from the evaluation for future co-production at the end of the project (D5.5 Best-Practice for co-designed research).

A set of tips for engaging with end users on practice orientated research, particularly policy makers, has also been produced, based on the literature review.

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1. Introduction

1.1 Background and Task Description

The Horizon 2020 work programme highlighted the need for co-creation of knowledge and co-delivery of outcomes with economic, industrial and research actors, public authorities and/or civil society.

In response, the COACCH project has included co-design, co-production and co-dissemination as key principles for the development and delivery of research. This is reflected in the project title (**C**O-designing the **A**ssessment of **C**limate **CH**ange costs, COACCH). This process is being taken forward in Work Package 1, Stakeholder engagement & co-delivery.

This deliverable (Deliverable 1.4 Co-design and co-delivery protocol) falls under Work Package 1.3, which is focused on the Co-design of research questions, scenarios, outputs and outreach. The task description is provided in the box below.

The Deliverable has reviewed the existing literature on co-design and co-production, then used this to develop a protocol for the COACCH project. The deliverable is organized as follows.

Chapter 2 provides a summary of the literature review on the co-design, co-production and practice orientated research. The full review is included in Appendix 1.

Chapter 3 synthesizes the literature review findings to provide a set of key guiding principles for overall co-production for the COACCH project.

Chapter 4 translates these into a protocol with planned steps, objectives and activities for the COACCH co-design, co-production and co-dissemination steps.

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Work Package 1 Description

Work package 1 –stakeholder engagement and co-delivery - is at the core of the project. The objective of WP1 is to establish the overall co-design, co-production and co-dissemination activity of the project. This WP, driven by the interaction with the stakeholders, will run throughout the entire project, and uses an innovative science-practice and iterative policy methodology. To undertake a stock-take and identify current knowledge gaps;

Work Package 1.3 Co-design of research questions, scenarios, outputs and outreach

This task uses the co-design process from Task 1.1 and the output of the stock taking activity in Task 1.2 to define the project scenarios, research questions and outputs for the subsequent packages.

Research questions

During the first thematic working group meetings, the consortium will work with stakeholders to identify the needs of end-user, and thus work through to the research agenda. This will include:

• Understand user needs and identify the key questions and priorities that concern stakeholders. This will explore how these differ between workings groups (i.e. are policy makers interested in the same climate risks as business). The task will also elicit the potential impacts and time-scales of major concern.

• Understand what form of information and results are most useful for end-users.

• Identify case studies to provide new insights of direct relevance to decision-makers and practitioners.

• Identify engagement mechanisms to maximise the co-delivery and the impact of the research with stakeholders and other end-users.

• Identify what are the challenges on climate action (mitigation and adaptation) and what information would help address these challenges.

This information will be used to frame the technical analysis in WPs 2– 4, and specifically refine with stakeholders:

• The key climate change impact chains to be investigated in WP2. The task will address the impact chains of 1) short- to long-term climate events; 2) gradual changes in average conditions as well as changes in the extremes including early extreme events 3) EU wide and global impacts affecting the EU.

• Climate tipping elements and socio-economic tipping points (defined as climate-related shocks that could be triggered by climate change) to be investigated in WP3. Illustrative examples include multiple and extreme heat mortality episodes, new vector borne shocks, irreversible food production shocks in Southern Europe, large-scale migration, extreme events and failure of large-scale infrastructure.

• The policy actions and scenarios to be analysed in WP4.

These activities will help frame the analytical questions and analysis for the subsequent work packages, especially around the thematic groups and deep engagement case studies.

The Deliverable from WP1.3 is D1.4 Co-design and co-delivery protocol.

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1.2 Definitions

Deliverable 1.1 of the COACCH project (Stakeholder Database) undertook an initial literature review on participatory science, drawing lessons and recommendations from this literature for stakeholder engagement. It proposed the following definitions, for use in the COACCH project, which are also adopted here.

Co-design (cooperative design) is the participatory design of the research project with stakeholders (including the users of the research). Co-design is the first phase of the co-production process, in which researchers and non-academic partners jointly develop a research project and define research questions that meet their collective interests and needs.

Co-production (cooperative production) is the participatory development and implementation of a research programme or project with stakeholders. This uses practice orientated research (see below), co-producing the research using an iterative process to help the research translate into useful and useable information or knowledge. This is also sometimes called **joint knowledge production**.

Co-delivery / **co-dissemination** (cooperative delivery) is the participatory design and implementation of strategies for the appropriate use of the research, including the joint delivery of research outputs and exploitation of results.

Practice orientated research is the development of research to help inform decisions and/or decision makers. It is delivered using co-production and trans-disciplinary research. It is also sometimes known as actionable science or science policy practice.

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2. Literature Review

2.1 Summary of the Literature Review

In order to develop the Co-design and co-delivery protocol, a literature review has been undertaken. This includes academic publications and the grey literature. This has focused on previous reviews as well as guidance in the co-design/co-production/applied research field, to capture the lessons from a larger body of underlying theoretical and applied applications. The focus has been on the climate domain, though it has been extended to cover specific services (e.g. climate services) and general research.

The studies are reviewed in detail in Appendix 1, with salient recommendations and guidance (for COACCH) identified. The literature review is summarized below.

Beier et al. (2016) published '*A How-to Guide for Coproduction of Actionable Science*'. This focuses on producing scientific information for complex, long-term, large-scale challenges, focusing on adaptation to climate change. Of particular relevance, the authors provide a set of ten guiding principles and recommmended practice (see Appendix 1). These provide a set of useful inputs to the COACCH protocol, including the need to focus on decisions, to give priority to processes and outcomes, to adopt an iterative approach and on how to engage with stakeholders.

Harvey et al. (2017), in the report '*Designing Knowledge Coproduction for Climate and Development'*, reviewed how co-production processes had been applied in climate and development, analysing six case study examples. The paper reports on the potential benefits of co-production, but also highlights the high transaction costs and time demands. It also presents a heuristic of the spectrum of co-production, with a matrix that covers the possible aims and the approach. This highlights the difference between more instrumental or prescriptive co-production (creating useable knowledge to inform decision making) and emergent or reflexive co-production (challenging existing thinking and narratives, i.e. more transformational). This matrix has been used to help frame the type of co-production for the COACCH project (see Chapter 4). The paper also provides useful guidance on the success factors in the six case studies analysed, which provide lessons for the COACCH protocol. Importantly, they conclude that successful co-production has a clear emphasis on producing collectively owned outputs as a central aspect of the co-production. They also stress the need for a clear pathway that sets out processes, outputs and outcomes.

Lövbrand (2011) published a lessons paper on '*Co-producing European climate science and policy: a cautionary note on the making of useful knowledge'*. This reports on the findings of a previous co-production process between an EC RTD project and the European Commission climate policy team, which is highly relevant for COACCH. The paper presents a less positive story in relation to the first case study, highlighting that there are limits of co-production. It also identifies that the timing of policy cycle is

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important, i.e. the earlier in the policy cycle the co-production engages, the more freedom there is for expansive discussion and challenges. As a result, the paper concludes that there is a trade-off between research co-produced for the needs of decision-makers, versus co-produced research that seeks to challenge and transform existing ways of thinking. It presents a more positive engagement with the second case study, highlighting how a more instrumental approach led to positive co-production and the use of the research results in the policy domain to gain scientific support for existing policy goals and assumptions. The paper also makes a number of relevant recommendations (See Appendix 1).

Vincent et al. (2017) published co-production guidance for the climate services area, '*Guidance on Equitable and Inclusive co-production for Weather and Climate Services'*. The guidance undertook a review of co-production, and used this to develop the guidance, and thus it is highly relevant for COACCH, even though it has a different focus. The guidance is summarised in Appendix 1. A key finding was that the process of co-production is as important as the products. The guidance identifies several characteristics for good co-production, including that it should be decision-driven (addressing user needs), process-based (including iterative updates during the project), and time-managed (including time for developing and maintaining relationships among project partners). It also recommends that the process of co-production needs to be inclusive, collaborative and flexible. These findings have been useful for developing the COACCH protocol. The guidance sets out five concrete steps to advance good co-production (compile an appropriate team, identify actors and build partnerships, co-explore need, co-design solutions, and evaluation), which form a key input to the development of the protocol. Full details are provided in Appendix 1.

Visman et al. (2016) explores the process of co-production and learning, published in the report '*Learning to support co-production*'. This draws on the experience from a programme on Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED). It reports on a number of findings from the co-production process undertaken in this large project and sets out challenges and opportunities for learning (see Appendix 1). It has a strong focus on the practical aspects of collaborative working, and a key lesson is the need for recognising and respecting different viewpoints. It also identifies the need to allow sufficient time for relationship building and understanding of stakeholders needs, competencies, etc. and for clarity on roles and responsibilities.

Dilling and Lemos (2010) published a paper on '*Creating usable science: Opportunities and constraints for climate knowledge use and their implications for science policy'*. They undertake a review to understand opportunities and constraints to help inform policy design and implementation. The paper concludes that nearly every case of successful co-production (from their review) involved some kind of iteration between knowledge producers and users. The paper also synthesizes 'lessons learned' from the literature to identify the factors that shape usable climate science information for decision-making. It identifies the context (the institutional and organizational setting) as being critical. It also reports that greater interaction between producers and users

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significantly increases the use of climate science. Finally, it highlights that a key success factor in increasing usability is the use of an iterative approach. The paper presents a number of recommendations (see Appendix 1), with a strong focus on iterativity and the institutional arrangements and mechanisms that have been shown to improve the usability and uptake of information.

Moser (2016) synthesizes insights from real-life examples of co-developing research projects in the paper '*Can science on transformation transform science? Lessons from co-design'*. The paper synthesises experience and learning from 16 co-design projects in the transformation domain (which is focused on more emergent (reflexive) co-design). The paper concludes the empirical evidence shows that there is no uniform approach to co-designing research projects. However, it is possible to draw insights. It reports that the more direct, frequent and interactive the processes, the more co-ownership partners took of the process. It also highlights the need to establish a common language (i.e. disciplinary or practice-specific jargon) and for trust building. The paper synthesizes the benefits of the co-design activities, providing a useful list for the COACCH project (see Appendix 1).

Hegger et al. (2012), in the paper '*Conceptualising joint knowledge production in regional climate change adaptation projects: success conditions and levers for action',* developed an assessment (evaluation) framework for analysing the merits and limitations of joint knowledge production projects (co-production). The paper draws on the results of regional climate change adaptation projects in the Netherlands and Germany. The paper uses the criteria of salience, credibility and legitimacy to develop success factors, based on analysis of relevant actors (researchers and stakeholders), the discourse used, the rules and responsibilities, and the resources and process adopted. It identifies seven success conditions for joint knowledge production (see Appendix 1 for details), which include involving the relevant actors, sharing an understanding of goals, taking different perspectives (of various stakeholders) into account, identifying roles, using novel reward structures and ensuring availability of resources. These success factors are highly relevant for the design of the COACCH protocol.

A subsequent follow-on paper (Hegger et al., 2014) '*Toward successful joint knowledge production for climate change adaptation: lessons from six regional projects in the Netherlands',* carries out a comparative analysis of six Dutch adaptation projects using the seven success factors. Based on this, they propose two key design principles for joint knowledge production: the presence of broadest possible actor coalition, and presence of specific resources. They note that additional research is needed to determine the role of the other five success factors more precisely. They also found that success was more likely when the coordinating entity has characteristics of a boundary organization or knowledge broker, and that the most successful projects created a protected space for knowledge development, while establishing connections with ongoing policy processes. These findings have also been translated into the COACCH protocol.

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Groot et al. (2014) set out lessons from a detailed review of science practice interaction and practice orientated research for climate change adaptation in the brochure '*Productive Science-practice Interactions in Climate Change Adaptation*'. It highlights that climate change and climate adaptation have features that make such processes challenging. The paper provides guidance for productive science-policy interactions (see Appendix 1), providing particularly informative guidance on science-policy interactions. It also provides a series of steps for productive science-practice interactions: start up; implementation; and communication (including dealing with uncertainties). This includes the need to organise the process of interaction using a range of methods/techniques. It also describes the need to sustain participation over time, noting the time this takes is often underestimated. As with other literature, it also recommends an iterative approach and that it can be useful to identify a set of concrete products which can be jointly worked at and co-produced. A related publication (Hollaender and Groot, 2014) sets out a sequence of steps for advancing practice orientated research (see Appendix 1).

OECD (2016) in the report '*Tools to mainstream adaptation into decision-making processes, Climate Change Risks and Adaptation: Linking Policy and Economics'* provides some practical lessons for engaging with policy makers. It highlights a number of useful points (see Appendix 1). It also highlights some useful differences between mitigation and adaptation, and public and private decisions, that are especially relevant for the COACCH policy case studies (Work Package 4).

Mauser et al. (2012) in the paper '*Transdisciplinary global change research: the co-creation of knowledge for sustainability'* provides a useful framework for co-creation (see Figure 5, Appendix 1), identifying three main steps of co-design, co-production, and dissemination. They also provide a series of sub activities in each of these steps, which provides useful information for the COACCH protocol. The paper also identifies some challenges to the overall co-creation process and highlights how these can be addressed.

Durham et al. (2014) also provides useful guidance on stakeholder engagement, although it is focused on the biodiversity domain in the report '*BiodivERsA Stakeholder Engagement Handbook: Best practice guidelines for stakeholder engagement in research projects'*. This guidance also proposed a three-stage approach creation (see Figure 6 Appendix 1), with co-design, co-production and co-dissemination. Like many studies in this review, it considers that research (and co-production) needs to demonstrate credibility, relevance and legitimacy. It also has useful examples for engaging with stakeholders at different parts of the process, i.e. tools and methods for i) opening out ii) exploring, and iii) deciding.

Pohl et al. (2010) in the paper 'R*esearchers' roles in knowledge co-production: experience from sustainability research in Kenya, Switzerland, Bolivia and Nepal',* provide some discussion of interactive knowledge production, drawing on four examples of knowledge co-production. They highlight three basic roles through which sustainability researchers can meet the challenges of knowledge co-production:

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reflective scientist, intermediary and facilitator, and how these can address the challenges of co-production.

The N8 Research Partnership (Campbell et al., 2016) undertook a study to explore new models of 'co-production', with the findings published in the report '*Knowledge That Matters: Realising the Potential of Co-Production*'. The report identifies that co-production represents a qualitatively different form of research, and therefore the frameworks and criteria required should differ (from current research). The report draws together the lessons from the research programme to propose a series of recommendations, to assist in the effective implementation and development of co-production methodologies.

Finally, Tyler (2013) provides some useful practical tips for working with policy makers (see Appendix 1), which are particularly relevant for the Deep Engagement Process in COACCH.

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3. Guiding principles and framework for COACCH

Based on the literature review in the previous chapter and Appendix 1, we propose a set of proposals and guiding principles for the co-design and co-production activities in the COACCH project.

3.1 Co-Production Aims and Approach

The first question to address is on the type of co-design and co-production the COACCH project will implement. The literature identifies different orientations, as discussed in Moser (2016); Lövbrand (2011); and Harvey et al. (2017) and distinguishes between two aims for co-production (although in reality these are part of a spectrum):

- Instrumental co-production (also termed utilitarian or prescriptive), which is focused on creating useable knowledge (to inform decision making); and
- Emergent (critical/reflexive or descriptive) co-production which proposes new transformative ways of challenging existing thinking and narratives.

The literature also distinguishes between two types of approach that can be used for co-production:

- Brokered (with use of intermediaries or brokers who help to mediate across boundaries); and
- "agora" (the collaborative endeavour of academic and non-academic actors where these communities "confront one another's worldviews in an open intellectual and social space)."

COACCH is proposing to undertake bounded co-design and co-production, as it has to work within the constraints of the description of work packages and partner resources. It is therefore more suited to a prescriptive (instrumental) co-production approach.

COACCH is also seeking to work more directly as an intermediary with decision makers, and thus it is seeking to act to provide brokered co-production.

The planned COACCH activities are plotted below on Figure 2 from Harvey et al.

This focus on bounded and brokered co-production is in line with the aims of the COACCH project, and the literature findings which find that brokered and instrumental approaches (Harvey et al.) are more likely to yield tangible output-oriented knowledge products within a limited timeframe. This will also allow the COACCH project to take advantage of the opportunities to feed into EU and national strategy (see Deliverable 1.1) as well as the IPCC process. However, this means it is less well suited to more transformative aims, such as disrupting norms or existing worldviews.

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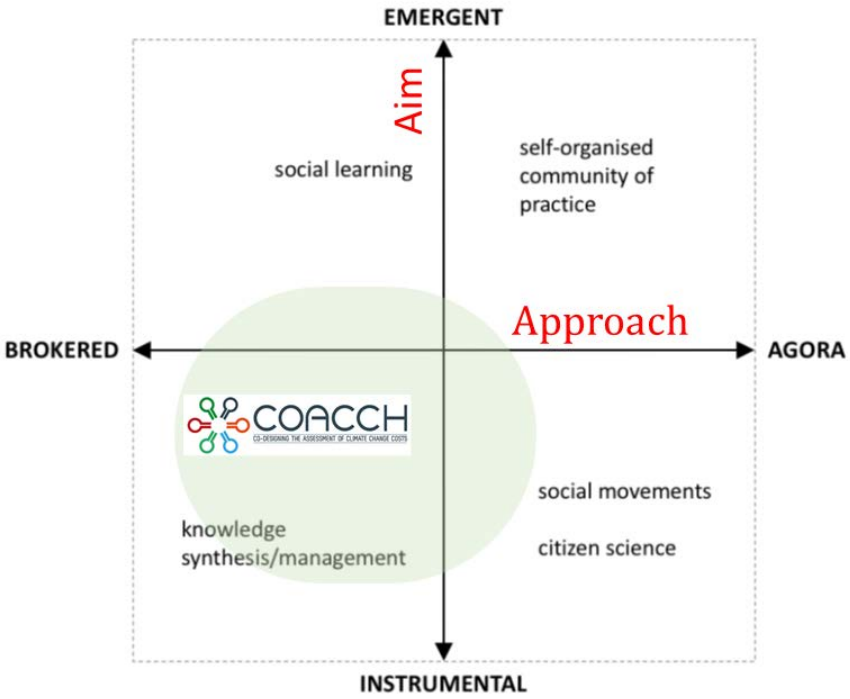

Figure 1. Position of the COACCH project on the Co-Production Matrix
(from Harvey et al. (2017).

The activities in COACCH will also be strengthened through the Deep Engagement Stakeholder interactions that are planned (see also Deliverable 1.1). These allow for more in-depth co-production interactions, focusing on the development of research to help inform decisions and/or decision makers. This is delivered using co-production and trans-disciplinary research.

A number of different terms are used in the literature for this type of in-depth interaction, including *practice orientated researc*h (Swart et al., 2014), *actionable science* (Bier et al., 2016), *science policy practice* (Dilling and Lemos, 2010) and *joint knowledge production* (Hegger et al, 2012). In COACCH, we primarily use the term practice orientated research.

3.2 Principles for Successful Co-Production

The literature review has identified a number of common (and repeated) themes, which are associated with successful co-production. These good practice lessons have been distilled into nine key co-production principles for the COACCH project, set out below, along with proposals on how these can be translated into project activities.

1. Process orientated

Several papers report that the process of co-production is as important as the product that results (Vincent et al., 2017: Beier et al., 2016). The literature also reports that

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successful co-production has a strong emphasis on bounded, output-oriented processes (Harvey et al. 2017), which involves establishing a common vision and shared objectives. The more clearly defined and well-structured these processes and outcomes are, the more chance there is of stakeholders agreeing on policy goals and working towards solving policy problems (Hegger et al., 2012). In turn, this is dependent on managing expectations regarding the outcomes of a process.

Based on the literature on good practice co-production, the COACCH project should focus on the process of co-production as well as stand-alone products. This should involve the proposal of the co-production process (a roadmap), and then discussion and agreement of this at the first stakeholder workshop.

2. Objective and outcome led, with clearly identified roles

Several papers stress the need for setting agreed goals, for example Dilling and Lemos (2010) highlight that the co-production process requires owning the problem and setting common goals and Vincent et al. (2017) recommend that co-production will benefit from clearly defined and jointly agreed goals. Harvey et al. (2017) highlight that for successful co-production, there is a need to create an environment wherein relationships are established, common vision is determined, and shared objectives are clear. The literature also highlights that these goal setting activities should take place early in the process, e.g. Visman (2016) recommends that consortium partners should agree a common understanding of the co-production process prior to project inception.

Following from this, the good practice guidance literature recommends that clear responsibility and roles are identified for the co-production process and into project implementation (e.g. Visman et al., 2016). Vincent et al. (2017) recommend that the roles and responsibilities of all participants are mutually understood and agreed upon. In practical terms, they recommend the appointment of a centralised coordination mechanism or project administration to implement the co-production process, and that it is also useful to allocate responsibility for oversight of the process with a knowledge broker or embedded researcher. Heger et al. (2012) report that the success of joint knowledge production is more successful if actors (researchers and stakeholders) decide, consciously and reflexively, which role to pursue in a project, how to define their identity in relation to the other actors, and to make their choices known to these other actors.

Based on the literature and good practice guidance, the COACCH project should set out agreed goals for the co-production process, identify outcomes of the process, and agree roles and responsibilities. This should involve the proposal of outcomes and roles, with discussion and agreement of these at the first stakeholder workshop.

3. Ensuring Representative Stakeholders are involved

The literature on successful co-production stresses the need to engage representative stakeholders (Harvey et al., 2017). These are defined as those with an interest in the

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area under consideration; and that can provide expertise and practical knowledge (Hegger et al., 2012), noting that for co-production to work, these stakeholders also need to be prepared to participate. However, as Hegger et al. stress, in any collaborative process, the number of actors needs to be limited to keep the process manageable: this highlights a trade-off between broadening the engagement process as much as possible (to arrive at socially robust knowledge) against the inherent limitations in how many actors can participate.

Groot et al. (2014) highlight that for a problem-oriented adaptation project, there is a need to identify relevant users of the project output and to develop understanding about the political and organizational context in which they are operating, which can also lead to identifying groups of users with similar information needs. Again, to allow this understanding, there needs to be focus.

There is also a need to consider the timing of engagement with the identified stakeholders. To generate usable science, one should involve stakeholders and decision makers from the start in helping to generate priorities for research and metrics for success (Dilling and Lemos, 2010).

Based on the literature, the COACCH project should identify a group of representative stakeholders. This has been identified in Deliverable 1.1 with the four Thematic Working Groups (Policy makers, Investment, Business and Industry, and Research).

It should also identify a set of stakeholders for more practice orientated research, to allow more in-depth knowledge production for decisions. A group of Deep Engagement Stakeholders for such engagement has been identified in Deliverable 1.1.

4. User and Decision orientated

A common theme in the reviews and good practice guidance is that co-production should focus on user needs and on decisions.

Groot et al. (2014) report that to align knowledge supply and demand, it is essential for researchers and boundary workers to start projects with an open discussion with all relevant users on the climate data and information needs and how to accommodate these. This is mirrored in guidance from Dilling and Lemos (2010), who identify that to generate usable science, one should involve stakeholders and decision makers from the start in helping to generate priorities for research and metrics for success.

Brier et al. (2016) highlight that co-production begins with decisions that need to be made, and further, that users may not actually know what they want (or at least what they need), and thus, decisions are more critical for users than detailed information. Similarly, Vincent et al. (2017) recommend that effective co-production should be decision-driven (addressing user needs) and Dilling and Lemos (2010) recommend that co-production requires establishment of a shared vision of what knowledge is usable in a given decision process. They also highlight that a better understanding of users' decision contexts can critically influence the ability of producers to meet users'

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expectations of climate knowledge as decision support information. However, it is important to note that different organisations need different information to make decisions, and each institution has unique values which affect how they use research information (Beier et al., 2016).

Looking at the case study lessons from Lövbrand (2011), it is also clear that the earlier in the policy cycle the co-production engages, the more freedom there is for expansive discussion and challenges to the status quo – in later stages, there is generally more need to accept the prevailing objectives and freedom to co-explore is more limited. On a related theme, Harvey et al. (2017) identify it is useful to focus on meaningful issues, in terms of relevance and/or resonance of the themes. Beier et al., (2016) also suggest that projects should focus on decision support services rather than decision support products (or tools).

Based on the literature on good practice co-production, the COACCH co-design process should focus on user needs and the potential use of information in decisions. This should be based on discussion with Working Groups in general and especially at the initial workshop, and with the Deep Engagement Stakeholders for the use of information in decisions.

5. Joint product orientated

The reviews of good practice co-production highlight that successful co-production often has an emphasis on producing a joint output (Moser, 2016) or a collectively owned boundary object (a co-produced knowledge product) as a central aspect of the co-production process (Harvey et al., 2017): this provides an important incentive towards ownership and it makes it easier to reach a specific endpoint where success can be declared (e.g. a co-production event is concluded; a question answered; or a product finalised). These outputs can contribute to the success of the co-production process, although this ranges from the anticipated "end" of the co-production itself to a catalyst to engage and sustains participation in the future (Harvey et al., 2017). Similarly, Groot et al. (2014) identify that given the time involved in co-production, it can be useful to identify a set of concrete products (such as a roadmap, a scenario analysis, a development plan, a pilot case study or a modelling exercise) which can be jointly worked at and co-produced.

Based on the literature, the COACCH project should identify a set of joint products (outputs) that the process should work towards, identifying and agreeing these at the initial workshop with stakeholders.

6. Time managed, with space and facilities for co-production

The literature reports consistently that the transaction costs and time demands of co-production are high: time constraints can therefore have a major influence on the success of co-production (Harvey et al., 2017). Organisations often underestimate the amount of time and resources required to develop and communicate decision-relevant climate information (Visman et al., 2016).

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Vincent et al. (see Appendix 1, Figure 4) compare the time inputs involved in co-design as compared to normal research design, identifying that co-production involves more stages (identification, preparation, early implementation, continuing implementation), and that for the stages involved in both traditional design and co-design (preparation, early implementation), co-production takes more time and resources. As a result, they recommend that sufficient time and resources need to be available to enable effective and inclusive co-production throughout the project lifecycle.

They recommend that effective co-production should be time-managed, including time for developing and maintaining relationships among project partners and time for various stakeholders (e.g. intermediaries, knowledge brokers, researchers) to discuss and establish shared goals and a roadmap (Vincent et al. 2017). This finding is mirrored by Visman et al. (2016), who identify that it takes time for partners to build a common approach and shared understanding across sectors, disciplines and levels of decision-making, thus there is a need to ensure sufficient time for relationship building and an understanding of each organisation's competencies, structures and ways of working.

It is particularly important to allow sufficient time for relationships to develop in the early stages of the co-production process – physical proximity (meetings) are essential (Vincent et al., 2017). However, the ongoing nature of co-production also requires regular contact and maintenance of relationships. The frequency and format of interaction should be mutually defined and agreed early in the project, though there should be the opportunity to check the level of engagement as the project progresses, and adjust at later stages if needed (Vincent et al., 2017).

The literature does identify that it is challenging to sustain this participation over time (Groot et al., 2014): there tends to be less interaction and user involvement during the knowledge production phase itself (following the design at the start and the results and use at the end). It is therefore useful to plan a number of checkpoints in between – to help the different participants to keep in touch with the developments and help keeping the topic on the policy and practice agenda (Groot et al., 2014).

Based on these literature findings, the COACCH project should allow sufficient time for the co-production process, and it should seek to build opportunities for continued engagement through the project with interim check points (such as the intermediate workshop).

Alongside time, the literature identifies the other main constraining factor for co-production is the availability of resources. Harvey et al. (2017) found the level of sustained investment (and resources), both in terms of finances and time commitment, was a key success factor in many cases of successful co-production.

Dilling and Lemos (2010) identify that there are a number of institutional arrangements and mechanisms that have been shown to be able to improve the connection between producers and users, including information brokers, boundary organizations, collaborative group processes, to bring together disparate interests and

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organizations, embedded capacity, and knowledge networks. These form one set of resources.

Hegger et al. (2012) also identify that the chance that co-production is successful is enhanced through the availability of specific resources (boundary objects, facilities, organizational form and competences) facilitating communication between communities. They identify that boundary objects can be used to address different perceptions among actors (defining these as concepts adaptable to different viewpoints but at the same time robust enough to maintain identity: they also give examples of GIS maps or tools).

The literature also reports that successful co-production is more likely in cases where actors make a conscious decision on the institutional location of the project around the research–policy nexus (Hegger et al., 2014): success was found to be more likely when the coordinating entity had characteristics of a boundary organization or knowledge broker.

Based on the literature on good practice co-production, the COACCH project should allocate sufficient financial and staff time resources to enable the co-production process to develop and run. It should also seek to build a facilitated process (with key team members acting as boundary agents).

7. Iterative

As highlighted in the literature, nearly every case of successful use of climate knowledge co-production involved iteration between knowledge producers and users, and iterative relationships critically shape the usability of science (Dilling and Lemos, 2010).

Co-production should therefore be seen as an ongoing-collaborative process (Visman et al., 2016). Iterativity is key for the co-production process to succeed: this requires institutional spaces and designated organizations to take this on, i.e. to own the process of creating usable science, and to agree accountability for outcomes on both the scientific and the user community side (Dilling and Lemos, 2010).

An iterative approach is important, because the process of co-delivering a solution is likely to involve several actors working together for the first time, and it is likely to be an iterative process based on trial-and-improvement: it is therefore important to include a learning mechanism to identify successes and challenges, and to implement a course correction if necessary (Vincent et al., 2017). Over the course of the project, there is a need to iteratively discuss key assumptions, models, approaches, data sources, and criteria (Beier et al., 2016) - this may mean that the project has to adjust goals and review key methodological decisions.

Based on the good practice co-production recommendations, the COACCH co-production process should adopt an iterative approach, providing opportunities to adjust the goals, method and outcomes as the project progresses. Review points for

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this discussion should be identified, and a critical point will be the second stakeholder workshop.

8. Transparent and inclusive

The literature stresses that the co-design processes have to be built for inclusivity and creativity, not just for efficiency and effectiveness (Moser, 2016).

This is because the various stakeholders involved in joint knowledge co-production projects will have diverging perspectives. The success of joint knowledge production will be enhanced if the different perspectives of stakeholders are recognised and respected (Hegger et al., 2012). This includes acknowledging their different knowledge and value systems, to appreciate the influence of contrasting contexts on knowledge formation and allowing for the development of a shared understanding (Visman et al., 2016). Hegger et al. (2014) also found that the most successful projects created a protected space for knowledge development, while establishing connections with ongoing policy processes.

Because of the contrasting views potentially involved, collaborative working often requires skills or mechanisms that can overcome boundaries (Visman et al., 2016), noting these can also be organisational or inter-personal, such as established hierarchies that can hinder collaboration and sharing of knowledge. Co-production can also use constructive decision-making and conflict resolution processes (facilitation and design factors) (Harvey et al., 2017).

Based on the literature, the COACCH project should therefore ensure an inclusive process that recognises and respects different views. It will be particularly important to ensure this is translated into practice at the first stakeholder workshop, to recognise the diverse set of stakeholders on the project and take on board differing views.

9. Part of a cycle of evaluation and learning

Much of the co-production guidance and literature highlights there is a need for a monitoring, evaluation and learning (MEL) to ensure the iterative approach, with feedback to the project, but also for subsequent development (Vincent et al., 2017). This recognises that successful joint knowledge production requires that space is allowed for making – and learning from – mistakes (Hegger et al., 2012).

To do this, it is recommended to evaluate co-production products, processes, and the actionability of the science of individual co-production projects, and disseminate these findings (Beier et al., 2016), and as project evaluations accumulate, revise recommended practices

Based on the literature on good practice co-production, the COACCH project should ensure a continuous process of monitoring and evaluation, using this to inform the project as it progresses, and to provide lessons for future co-production at the end of the project. This is captured in work package 5 and Deliverable 5.5.

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4. COACCH Co-Design and Co-Production Protocol

4.1 Key Steps for the COACCH Protocol

The previous chapter presents a set of key principles for the COACCH project to deliver successful co-production, based on bounded, output-oriented engagement.

The final task is to translate this into a protocol which sets out the methodology and steps to deliver these principles effectively. Several of the literature studies reviewed earlier provide steps for the co-production process and these have been reviewed to provide guidance for the COACCH project.

Mauser et al. (2012) identifies three key phases: co-design, co-production and dissemination, with a further set of sub-tasks in each (see Figure 5). Durham et al. (2014) also identify the three phases of co-design, co-production and co-dissemination, but identify different sub-tasks (see Figure 6). Vincent et al. (2017) outlines five steps: Identify actors and build partnerships, co-explore need, co-develop solution, co-deliver solution, evaluate (Figure 4).

Based on the literature, four phases are proposed for the COACCH project co-production protocol. These are:

- Co-design phase, which includes the first workshop.
- Co-production phase.
- Co-dissemination phase.
- Evaluation phase.

These are described below. The literature review has also been synthesized to provide a set of tips for working with policy and other decision makers in co-production.

4.2 Co-design phase

Objectives

The objectives of this phase are to co-design and agree the overall co-production process, including the goals, outcomes, products and roles.

Guiding principles

The guiding principles for this phase draws on key aspects from the good practice guidance and literature on co-production, i.e. to:

- Focus on the process of co-production (Vincent et al., 2017).
- Focusing on user needs (Groot et al, 2014).
- Involve stakeholders and decision makers from the start in helping to generate priorities for research and metrics for success (Dilling and Lemos, 2010).

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- Set clear objectives (goals) and outcomes (Beier et al., 2016: Dilling and Lemos, 2010) from the start, and agree these with stakeholders.
- Set out and agree clearly-defined and time-bound activities (Harvey et al., 2017).
- Set out and agree the engagement process with stakeholders (Vincent et al., 2017).
- Allocate responsibility for oversight of the process (e.g. a knowledge broker) and agree the roles and responsibilities of all participants and ensure these are mutually understood and agreed upon (Vincent et al., 2017).
- Agree common definitions.

The selection of representative stakeholders, including who to involve and how often, is set out in Deliverable 1.1 (Stakeholder Database) and is not repeated here.

The literature stresses that co-production takes time and is characterised by strong relationships built on trust and transparency (Moser, 2016: Visman et al., 2016). Furthermore, face-to-face meetings are an important prerequisite to building trust, instilling confidence, and offering the opportunity for dialogue (Vincent et al., 2017). It is therefore critical to ensure that each stakeholder has a focal point to build a relationship with. For this reason, in COACCH, we propose that each stakeholder has a designated focal point (a relationship manger).

The literature also reports that co-production is more successful in cases where the partners work towards joint knowledge production or output (Hegger et al., 2012: Moser, 2016: Groot et al., 2014: Harvey et al., 2017), i.e. producing a collectively owned co-produced knowledge product, as a central aspect of the co-production process. This could be concrete products (such as a roadmap, a scenario analysis, a development plan, a pilot case study or a modelling exercise) which can be jointly worked at and co-produced (Groot et al., 2014). Harvey et al. (2017) also highlight that it can be useful to chart a "co-production pathway" that sets out the assumed relationship between processes, outputs and outcomes in ways that ensure coherence between means and ends. In COACCH, there are a number of existing planned outputs that could form the basis for these joints products. These include policy briefs and a final policy synthesis (D5.3 and D5.4), the database and simulator (D5.1 and D5.2) and the co-production best practice guidance (D5.5).

In terms of workshop formats, Beier et al. (2016) recommends a skilled facilitator should lead the meeting. Several papers highlight the need for knowledge brokers or boundary organisations to help the co-design process (and thus the workshop process). Several papers provide a suite of arrangements and mechanisms for this initial co-production process. Harvey et al. (2017) highlights: dialogue events; Learning Exchange Workshops; Social Learning Sandbox events; and Write-shop processes. Groot et al. (2014) highlight the need for interaction to be actively organized, supported and structured by using suitable methods. They suggest a range of methods/techniques: Serious gaming; Strengths, Weaknesses, Opportunities and Threats (SWOT); Multi Criteria Analysis; Group model building; Scenario building workshops; and Touch table. For COACCH, it is therefore proposed that the workshop

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is led by a trained facilitator, and that a range of different session approaches are used to organise and maintain interest during the day.

COACCH project activities and roles

Based on the above, the following activities are identified for the first phase of the projects, i.e. the co-design phase:

- Identify a group of representative stakeholders. This task has been completed and was presented in Deliverable 1.1: Stakeholder Database.
- Develop the overall process for the co-production process. A co-production pathway/roadmap will be completed in advance of the first workshop, to set out the proposed co-production process, goals and outcomes.
- Identify roles and responsibilities. Based on the proposal, it is proposed that:
    - PWA and Ecologic Institute act as the boundary agents for the overall co-production process.
    - Each stakeholder is assigned a 'relationship manager' (see above). This person will be drawn from across the consortium, aligning to existing contact points.
- Identify potential user needs and potential decisions. This has been progressed through the development of a stakeholder template, completed for all stakeholders (in Deliverable 1.1). Further user needs will be discussed at the first workshop and through the Deep Engagement Process bi-lateral meetings.
- Identify a set of joint knowledge products (outputs), noting the formal products identified in Work Package 5 (policy briefs and a final policy synthesis (D5.3 and D5.4), database and simulator (D5.1 and D5.2) and co-production best practice guidance (D5.5).
- Discuss and agree the format for the First Stakeholder Workshop (a planning session was held in Berlin on 22nd of March to do this). Identify a facilitator for the workshop (this has been agreed, for the first workshop a facilitator has already been contracted).
- Present, discuss, revise and agree the process, goals, outcomes, product and roles at the first stakeholder workshop.

4.3 Co-production phase

Objectives

The objectives of the co-production phase are to deliver the agreed research, as part of an iterative and collaborative process with stakeholders. This will include a review check point mid-way through the project (the interim workshop) and it will discuss the emerging results at the third workshop. It will also deliver the case studies working with the Deep Engagement Stakeholders on practice orientated interaction, i.e.

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identifying opportunities for the COACCH project to provide information to help inform decisions.

Guiding principles

It is challenging to sustain participation over time (Groot et al, 2014) and there tends to be less interaction and user involvement during the knowledge production phase itself. Therefore, a key part of this phase of the project will be to ensure successful ongoing co-production. The guiding principles for this phase draws on key aspects from the good practice guidance and literature on co-production:

- Nearly every case of successful use of climate knowledge involved some kind of iteration between knowledge producers (Dilling and Lemos, 2010).
- The literature also identifies that face-to-face meetings should be planned to take place throughout the project lifespan (Vincent et al., 2017).
- The literature highlights the need to identify key decision points within the programme at the start. These decision points represent an opportunity to review progress and to make adjustments or course corrections (Vincent et al, 2017) and at these points, an analysis is needed of whether the programme is performing as expected or, if not, to understand what must be changed.
- It is useful to plan a number of checkpoints in between – to help the different participants to keep in touch with the developments and help keeping the topic on the policy and practice agenda (Groot et al., 2014).
- Beier et al. (2016) recommend that over the course of the project, the group should iteratively discuss key assumptions, models, approaches, data sources, and criteria. They also highlight that draft scientific products should be presented and discussed in relation to the decision-making contexts (Beier et al., 2016). This should occur early enough to allow time for significant adjustments if needed. Participants should discuss how various draft or hypothetical outputs would inform particular management or policy options (Beier et al., 2016).

The COACCH co-production process should therefore adopt an iterative approach, with continued face to face dialogue, and identify key checkpoints to engage stakeholders and review the changing needs or priorities of stakeholders (i.e. implement the iterative approach). The key checkpoints will be the workshops in months 24 and 36.

In terms of the Deep Engagement Process, there is the opportunity for more practice orientated research and co-production to inform decision. Based on the detailed literature review, a number of good practice principles have been identified for such research:

- Co-production begins with decisions that need to be made (Beier et al., 2016).
- Scientists should understand the decisions to be made, and the environment in which the decision will be made, before suggesting specific products. Likewise, users should aproach scientists with a management need, goal, or problem, rather than a request for a product (Beier et al., 2016).

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- A needs assessment can help the process of early joint knowledge production, in which researchers and boundary workers closely interact with the potential users to find out which data and information they require for supporting adaptation decision making (Groot et al., 2014).
- There is a need to develop understanding about the political and organizational context in which organisations are operating (Groot at al. 2014).
- Usability is influenced by many factors, but context (the institutional or organizational setting) is critical (Dilling and Lemos, 2010).
- To deepen the understanding about the political context in which the users are operating, researchers and boundary workers need to map relevant policies, plans, laws, regulations and procedures (Groot et al., 2014).
- It is important to note that different organisations need different information to make decisions, and each institution has unique values which affect how they use research information (Beier et al., 2016).

For the Deep Engagement Stakeholders, the COACCH project needs to understand the potential use of information in decisions, but also the organisational context, noting this will vary by stakeholder. To facilitate this, the project will hold early bi-lateral meetings with each DES, and to hold regularly (6 monthly) meetings to progress the practice orientated research.

To help facilitate these initial meetings and to understand DES needs and context, this deliverable has reviewed the various guidance.

Hollaender and Groot (2014) set out the following sequence of steps for advancing practice orientated research:

- Identify users of research;
- Develop understanding of work context, organisation, roles, objectives;
- Develop understanding of decisions;
- Identify opportunities for research to feed into decision making process;
- Assess end-use needs (needs assessment);
- Facilitate knowledge co-development;
- Produce concrete and tangible outputs;
- Ensure communication mechanisms.

Several of the papers and guidance documents provide lists of questions to help identify potential user needs, possible decisions, and organisational context. These are provided in Appendix 2. These have been synthesised in the box below for possible use in the Deep Engagement process.

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Example Questions for the Deep Engagement Process

Early framing

These questions will be more relevant for new stakeholders:

- What are the biggest challenges that you face? What role does the climate play in these? What interest do they have in climate risk and climate change?
- How does/has weather and climate affect(ed) your activities (in the past)?
- How do you anticipate climate change will affect your future activities?
- What analysis have you undertaken (if any) to look at future risks?
- Do you have any particular priorities or key concerns (risks)?
- Do you already use climate research or climate information? If so, how?

Understanding need

These questions can help identify and understand the potential needs of the organisation and the potential use of our research outputs or policy analysis.

- What problem or decision can we address with the research? Or if information was available, what decisions could it inform?
- What is the context in which the research (outputs) could be used?
- Who will use the information (including downstream uses) and how will they use it?
- What is the timing of decision/s. Flexible or limited in scope?
- How quickly would you need results in order for them to be useful?

Understanding context

These questions can help to understand the background on how the organisation currently uses climate information and makes decisions.

- What methods do you currently use to make decisions?
- Do you use economic tools for decisions (economic appraisal, investment IRR, CBA etc.) and if so what methods, inputs, assumptions (e.g. DR, threshold IRR), etc.?
- What time frame do these decisions get made in? What is the planning time horizon? What is the lifetime of decisions?
- Who makes decisions (that are influenced by climate change)?
- To what extent does the climate affect their planning and decisions already? What decisions are they making that are relevant to climate now (if any)?
- Do you use climate research or information to inform decisions and if so what sources?
- How do you currently factor uncertainty into decisions?
- What information would you like to be available? How could you use it?

Technical aspects

These questions can help understand the timescale and scenarios of interest, but also aggregation and uncertainty, i.e. what information do they want.

- What is the timescale of interest (General and specific, i.e. defined years or time periods).
- Are they specific scenarios of interest? RCP, temperature thresholds, etc.
- What resolution of data you are interested in?
- What spatial extent?
- What climate variables does the decision maker care about?

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- What output variables and metrics are most useful?
- What level of precision is realistic, achievable, and adequate for the decision or problem?
- How do they want uncertainty to be considered/presented?
- To what extent can multiple projections and uncertainty (e.g., emission scenarios, general circulation models) be considered (in general, in specific decisions)?
- Do you understand existing data fully; does it provide the information that you need to make decisions? Would additional explanations or information be useful?

Co-production

- What is a realistic expectation of working together, within the available time-scale of the project?
- What level of engagement level can you provide (workshops, bi-lateral, joint work, joint dissemination)?
- What is a realistic expectation for delivering results that meet your needs, within the description of work (bounded)?
- Are there joint knowledge products that we can develop together?
- Are there case studies that are of particular interest that we could focus on (DES)? If so, then understand the decision context, information needs, etc. (see above sections).
- Who else is important to engage within the organisation? Who else do they think should be playing a role in co-producing knowledge (outside the organisation)?

Outputs

- What data would help make better decisions or be most useful?
- What format would be most useful for results? This includes quantitative data, but also information (short summaries, briefing notes, technical reports)? It also includes the presentation of data. Is mapped output important? What results and disaggregation level are useful?
- Which dissemination/knowledge products would be interesting/needed?
- Are there issues with data availability and publication? Can data and results be accessible publicly or not?

To finish

- What would success look like?
- How regularly should we review progress, and update direction?

COACCH project activities

Based on the above, the following activities are identified for the second phase of the projects, i.e. the co-production phase:

- To translate the interests and agreements from the first stakeholder workshop into a programme of work for the project.
    - This will include the specified scenarios and time-scales of interest for the analysis in WP2.

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  - It will include a list of tipping points to explore in WP3.
  - It will provide some early indications of possible policies to consider for WP4.

- To hold initial bi-lateral meetings with each Deep Engagement Stakeholder, and use the questions in the box above to elicit potential research collaboration and to further understanding of needs, decisions and organisational context.
  - From this, to identify specific collaborative areas to progress with each DES, including possible case study work.
  - To hold regular (6 monthly) bi-lateral meetings with Deep Engagement Stakeholders, to engage in the detailed co-production case studies.
- To use the second workshop as an interim check (review) point with all stakeholders and review the direction of the work – with the opportunity for stakeholders to adjust the goals, method, outcomes and to hold discussion on the joint products.
  - This will review the process on WP2, WP3 and WP4 with stakeholders.
  - This will either build on or expand the formal products identified in Work Package 5 (policy briefs and a final policy synthesis (D5.3 and D5.4), database and simulator (D5.1 and D5.2) and co-production best practice guidance (D5.5)).
- To use the final workshop to discuss the emerging project results and agree joint knowledge products.

4.4 Co-dissemination phase

Objectives

The objectives of the co-dissemination phase are to make sure dissemination, communication, and exploitation activities are designed to directly address the needs of the different stakeholders and end-users involved in the co-design process. It will also provide guidance on the appropriate design and format of research output (products and services) to meet different user needs (indicators, data format, graphic design, communication of uncertainties).

Guiding principles

If the co-production phase is carried out successfully, the resulting knowledge products will be designed to meet expressed needs. This will increase uptake up by participating stakeholders.

The dissemination activities will be a planned process that involves consideration of the broader target audiencesand the settings in which the COACCH research findings are to be received. This invovles communicating and interacting with wider audiences in ways that facilitate research uptake in decision-making processes and practice (Wilson et al. 2010). Tyler (2013) identifies that for these research findings to be useful, mechanisms need to be established that facilitate communication (with

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translation) between researchers, policy makers and practitioners. Furthermore, the value of any knowledge product depends on its effective dissemination to the relevant audiences in a format that is usable and accessible (Ordoñez and Serrat, 2009).

In the context of co-dissemination, stakeholders are directly involved in the design and distribution of knowledge products and so increase the potential for uptake by ensuring the research outputs are useful and appealing to different groups and can perform different dissemination functions (i.e. for awareness, understanding and action (Ordoñez and Serrat, 2009)). Iterative processes that design, test and improve the products being created are important to co-production and co-dissemination as they mean that stakeholders own the process of creating useable science (Dilling and Lemos, 2010). This sense of ownership and close connection to the knowledge products will, in the best case scenario, mean that the stakeholders not only use the products themselves, but also become champions of the research, informing other users in their networks.

A number of the studies provide suggestions on how research should be communicated. Of particular relevance, Groot et al. (2014) provide recommendations for communicating research results to decision makers.

- Do not provide too much information. Avoid lengthy research reports and ensure the language is brief and to the point and avoid scientific jargon.
- Develop a common language to communicate effectively between policy and science: this can use professional knowledge brokers.
- Use plausible scenarios of the future relevant for policy formulation (over a range of spatial scales).
- Use visualizations (after testing) and employ user panels to assess proposed visualisations or other interactive communication methods.
- Communicate in terms of information packages linked to current and future policy challenges.

However, as COACCH is engaged in co-dissemination, effective communication and distribution of research outputs is also dependent on the knowledge and experiences of the group. Each stakeholder will bring their own understanding of how best to reach different target groups and can contribute to the creation of a dissemination strategy that is specific to the needs of the COACCH project. Some questions to consider when devising co-dissemination activities are included in the box below.

Questions for consideration in co-dissemination

- Which outputs do we want to disseminate?
- Who are our target audiences and what are we offer
- Who in the group is best placed to carry out this particolar dissemination activity?
- When do we disseminate?
- Which formats should we use to reach these different audiences?
- Which multipliers, channels could give us additional support?
- How will we know if we have been successful?

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COACCH project activities

Based on the above, the following activities are identified for the third phase of the project, i.e. the co-dissemination phase:

- To provide an early synthesis of the state of knowledge on the economics of climate change in Europe, for dissemination in advance of the 1st workshop.
- To discuss strengths and weaknesses of available products and different formats and develop initial proposals on joint products (e.g. web-tool, policy briefs, database) at the first stakeholder workshop.
- To present draft versions of products for discussion at the second workshop and firm up these proposals on the basis of the emerging results. To use this to directly inform and frame the design of the tool, database and policy synthesis in WP5, as well as the preparation of Dissemination, Communication, and Exploitation activities in WP6.
- To update the Communication, Dissemination and Exploitation Plan (WP6) accordingly.
- To present the resulting final (draft) products at the third workshop and discuss channels for distributing products and results (e.g. associations, emailing-lists, meetings, working groups, workshops, conferences).
- To discuss with stakeholders, especially Deep Engagement Stakeholders, on the procedure and content of dissemination activities (i.e., approval processes, media department engagement, how to deal with issues of potential concern or confidentiality).

4.5 Evaluation Phase

Objectives

The objectives of the evaluation phase are to review and improve the project as it progresses, and to draw lessons at the end of the project to help inform future co-design and co-production research.

Guiding principles

As highlighted in the literature review, the final step of evaluation is critical. Evaluating co-production products and processes provides useful insights for the project team but also more generally (Beier et al., 2016). This can be more beneficial if integrated within an iterative process. Vincent et al. (2017) highlight the benefits of a monitoring, evaluation and learning (MEL) component to deliver the iterative approach, with feedback to the project, and to inform subsequent development of co-produced research.

Typical questions to present for this evaluation were included in Appendix 1, with the boxes related to Beier et al., 2016) and Vincent et al. (2017). Vincent et al. (2017) also highlights the need for proactive monitoring and learning throughout the project, as well as a final evaluation (so called continual monitoring, evaluating and learning

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(MEL). Ongoing review is essential in determining if the project is going in the right direction and, following its completion, if it was successful in achieving its goals. They highlight evaluation should focus on 1) the quality and benefits of the co-production process itself and 2) whether the co-production process produced better research.

This allows a more systematic evaluation and can provide information to build on successes and not replicate mistakes. Learning reflections should be recorded. Vincent et al. (2017) suggest ways to do this using individual submissions. They suggest using the possible use of email or an online form, workshop evaluation, in-person (minuted) staff meetings, and purposive engagement/follow-up, for example a phone conversation with workshop participants. Hegger et al. (2012) explicitly propose an assessment framework for retrospective analysis of (regional) joint knowledge production projects. This involves seven dimensions, set out in Appendix 1.

Finally, Groot et al. (2014) set out the co-design and practice orientated research process can be considered successful if it:

- Facilitates timely and coherent translation of research into policy options or advice;
- Facilitates uptake of research results by policy makers and/or practitioners;
- Alerts policy makers and/or practitioners about emerging issues;
- Contribute to the scientific quality control process by allowing critical assessment of scientific outputs in light of users' needs and of other types of knowledge;
- Enhances strategic orientation of research in support of policies and societal issues;
- Allows for exchange and co-evolution of scientific, policy and practical knowledge;
- Fits within the political and institutional limits and pressures of policymakers.

COACCH project activities

Based on the above, the proposed activities are:

- To provide a draft evaluation process, and present, discuss and agree this with stakeholders at the first stakeholder workshop. This should include formats for the evaluation (e.g. workshop evaluation, online form, personnel Exchange) and a set of evaluation questions.
- To take stock of the project progress at the mid term point at the second stakeholder workshop, to provide an opportunity to review progress and to make adjustments or corrections. To apply the evaluation questions and document lessons from the initial co-design phase and the emerging co-production phase for Thematic Working Group Stakeholders as well as for Deep Engagement Stakeholders.
- To take stock of lessons at the final workshop. To apply the evaluation questions and document lessons from the co-production phase. To discuss the lessons for the two different stakeholder groups: Deep Engagement Stakeholders and Thematic Working Group Stakeholders.To summarize and provide lessons from the

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evaluation for future co-production at the end of the project (D5.5 Best-Practice for co-designed research).

4.6 COACCH tips for working with policy makers and other end user stakeholders on practice orientated research

The guidance for scientists on working with policy makers (Tyler, 2013) (Appendix 1) has been updated below for the climate and COACCH project context, with additions from Groot et al. (2014), OECD (2016), Beier et al. (2016).

This provides additional suggestions on how to engage with stakeholders and especially Deep Engagement Stakeholders on practice orientated research:

- Making policy is difficult. Many policy decisions are not straightforward and (public) policy is complex, involving a wide range of issues, complicated interactions with other policies, and uncertain outcomes. Simple solutions to complex problems are rare. Most of the major policy areas that draw criticism from academics are far more complicated than just (scientific or economic) evidence: climate change falls into this category.
- No policy or decision will ever be perfect. Policy usually involves trade-offs between groups or across competing objectives. When considering policy decisions, it is important to consider this wider context.
- Climate change policy does not occur in a vacuum. It is essential to understand and integrate mitigation and adaptation within the existing socio-institutional landscape. Climate change will often be one of many policy objectives, and not necessarily the dominant one.
- Policy makers (and decision makers) can be experts too. Scientists/economists often consider themselves as the experts who engage with policy makers, but many policy makers have expertise: don't assume that you are the only expert in the room and note they will have expertise (in policy making, sector context) that far surpasses your own.
- Policy makers are not a homogenous group. It includes government officials (ranging from senior to junior level), generalists through to specialists, and includes connected agencies and regional governments. It also includes all the people who might not directly make the decisions, but as advisers or stakeholders can strongly influence them.
- Climate policy (and project) decisions are highly heterogenous. They involve a wide set of different decisions and it is not the case that one size fits all. Different information is needed for different decisions, scales and different users: this reflects the processes and decision methods used by various organisations. It is important to understand the policy and decision context before providing information or advice, and to tailor information and analysis to fit within the relevant socio-institutional landscape.

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- Policy makers are people. Policy makers, despite the best of intentions, will sometimes make bad decisions and get things wrong, or may choose to act in their own interests.
- Starting policies from scratch is very rarely an option. Academics often recommend what to do if designing the system from the beginning. However, in practice, solutions need to evolve from within the existing system and they also need to be pragmatic.
- There is more to policy than scientific evidence. Policies are not made in isolation. There is the critical starting point of current policy. There are usually some complex interactions between policies at different scales: local, national and international. Law, politics and public opinion are all important factors; scientific evidence is only part of the picture (that a policy maker has to consider). That said, economics and law are top in policy advice (and most sought after by policy makers).
- Policy makers do understand uncertainty. It is commonly cited that policy makers prefer to be given information that is certain, and that policy makers don't understand uncertainty. However, policy and decision makers are surrounded by and constantly make formal and informal assessments of uncertainty. Governments are expert at drawing up policy options (and making decisions) with incomplete information: noting complete information is almost never available. But policy makers do not like information with so many caveats that it is useless.
- There is rarely a clean and distinct policy cycle. Much of the applied science literature talks about "the policy cycle". This usually starts with an idea, moves through a sequence of research, design, implementation and evaluation, which then feeds back into the start of the cycle. In practice it is a lot more complicated. Policy making is iterative and involves the art of the possible.
- Policy and science operate on different timescales. When policy makers say that they need information soon, they mean within days or weeks. If scientists/economists want to engage with policy they need to be able to work to the policy makers' schedule. Asking policy or decision makers to work to a slower timetable will result in them going elsewhere for advice.
- It is important to identify entry points. This requires the identification of suitable (entry) points in the policy or project process (national, sector or project) where climate considerations can best be integrated. These entry points differ across sectors and national contexts, as well as across organisations.
- There are often limited opportunities to really influence policy or decisions. There are often particular windows of opportunity (intervention points) when it is possible to influence policy decisions. It is no use providing perfect information six months after these decision points. Similarly, providing information too late in the project cycle, e.g. once design is already completed, will reduce its uptake and use.
- There is a need to match demand and supply. Decision makers need to help researchers understand how they intend to use the information and how they make informed decisions (not perfect decisions) despite uncertainty. Scientists

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should describe the information and appropriate use of the information in decision making.

- Pragmatism is essential. Any approach (or support, advice or tool) needs to fit with the resource, time, capacity and expertise available for policy or project decisions, otherwise it will not get used.
- Make your advice concise. Policy makers are extremely time constrained. They will appreciate short, concise, and well written information (plain English), not long reports or technical jargon.
- Communication is key. For information to be useful, mechanisms need to be established that facilitate communication (with translation) between researchers, policy makers and practitioners. Information needs to be formulated in a way that is accessible to policy makers and practitioners, but also there is a need to ensure that end-users formulate their interests or questions in a way that is understandable for scientists. This is not always simple.
- Users may not fully comprehend the implications of key assumptions and the limitations of scientific models when this information is first presented, thus there is a need for transparency and honesty. In addition to providing information, an equally important task is to provide clear guidance on appropriate use of that information.
- Scientists tend to focus on downscaled climate projections, on the basis they assume users want more finer resolution data. However, actual decisions are more critical for users, and can often be made without such data (i.e. downscaled data is not a means to an end in itself).
- Decision support tools do not make decisions. It is often assumed that the use of decision support tools – such as cost-benefit analysis – 'tells' a policy or decision maker 'the (optimal) answer' and thus what to do. However, in practice, these tools are rarely used in this way. They more often are used to support the justification for an existing preferred decision, or to help influence the decisions (e.g. on options) around the margins. Nonetheless, decision support (and tools) has huge value from the process of working through a decision, looking at what is important, engaging stakeholders, etc.
- Decision making under uncertainty does not make decisions. What is true for decision support tools (above) is doubly true of decision making under uncertainty (for climate change). DMUU methods make critical assumptions, often subjective, that determine outcomes (e.g. the assumptions to produce probabilistic climate projections). They rarely provide concrete, single answers and are not a panacea (for tackling uncertainty), but they do add value by identifying what is important, identifying possible low regret options, and providing information on what we do know/are sure of.
- Policy makers aren't interested in science or economics per se. A few are, but on the whole, policy makers are interested in research evidence to inform policy

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making. Policy makers care about research evidence insofar as it helps them to make better decisions.

- Private sector (and investment) decisions are different. The issues above also apply to the private sector but there are differences. The most important determinant for the private sector is to maximise profit, and thus use a financial not an economic perspective.
- Mitigation and adaptation decisions are different. There are major governance, aggregation level and policy differences between mitigation and adaptation policy decisions. While it is possible to theoretically construct global mitigation and adaptation policy, in reality, these involve two completely separate groups of governance arrangements, policy makers and interests.
- It is useful for decision-makers to also identify opportunities that can be created by implementing mitigation and adaptation, rather than focusing only on the risks and amelioration actions.
- 'We need more research' is the wrong answer. Policy decisions usually need to be made pretty quickly, and asking for more time and/or money to conduct research is unlikely to go down well. Policy makers have to make decisions with incomplete information so they get frustrated with researchers who are unable to offer an opinion without funding for a multi-year research programme. This does not mean that more research isn't often needed; it is, but it is the wrong answer to a policy maker seeking advice.

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6. Appendix 1: Detailed Literature Review

6.1.1 Beier et al. (2016)

Beier et al. (2016) published '*A How-to Guide for Coproduction of Actionable Science*'. This focuses on matching scientific information for complex, long-term, large-scale challenges, focusing on adaptation to climate change, with decisions (which are typically short-term and local).

They highlight the problems of a science led approach is a particular problem for climate change, because of the complexity of the problem. As a result, neither decision makers nor scientists – oin their own - can specify what science products are needed, how they should be developed, and how they should be applied to climate policy or adaptation. In response the National Climate Change and Wildlife Science Center (NCCWSC) and the regional Climate Science Centers (CSC) developed a co-production approach for 'actionable' science. This involves the joint involvement of:

- The users of research (to explain the decision or planning issue at hand, the legal, political, social, and fiscal constraints, and how scientific information affects their decisions and downstream decisions);
- The producers of research (scientists) to ensure that the right product is developed and that users understand how to appropriately use the information; and
- Stakeholders (industry, landowners, downstream users, others affected by the decisions) who can provide insights on constraints and alternative courses of action that might affect the decisions and the research needed.

They define co-production as '*collaboration among managers, scientists, and other stakeholders, who, after identifying specific decisions to be informed by science, jointly define the scope and context of the problem, research questions, methods, and outputs, make scientific inferences, and develop strategies for the appropriate use of science*'. They use the term partners to collectively refer to these co-producers.

They define actionable science as '*data, analyses, projections, or tools that can support decisions in natural resource management; it includes not only information, but also guidance on the appropriate use of that information'*. They propose that actionable science must be '*credible (scientifically sound), salient (relevant to a management decision), and legitimate (fair and respectful of stakeholders'* divergent values), and that it is most reliably produced by iterative collaboration between scientists and managers'.

The paper presents seven recommended practices to help scientists, managers, funders and other stakeholders carry out a co-production project, one recommended practice to ensure that partners learn from attempts at co-production, and two practices to promote co-production at a programmatic level. (10 recommendations in all). These aim to focus research on decisions that need to be made, to give priority to processes and outcomes over stand-alone products, and to allocate resources to

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organizations and individuals that engage in co-production. These recommendations are reproduced below.

Guiding principle 1. Co-production begins with decisions that need to be made.

Recommended practice 1. Managers: Approach scientists with a management need, goal, or problem, rather than a request for a product.

Recommended practice 2. Scientists: Before suggesting specific products, make sure you understand the decision to be made, and the environment in which the decision will be made.

Recommended practice 3. Partners: Invest in at least one in person meeting of all potential partners and stakeholders to specify the types of decisions to be made and the types of scientific information needed to support those decisions.

Guiding principle 2: Partners should give priority to processes and outcomes over stand-alone products

Recommended practice 4. All partners: For a large, complex project, engage a subset of key people to serve on a technical advisory group that will adjust goals, review key methodological decisions, and co-produce inferences. Recruit a smaller steering committee to manage the project calendar, products, and workflows.

Recommended practice 5. All partners: Over the course of the project, iteratively discuss key assumptions, models, approaches, data sources, and criteria.

Recommended practice 6. Decision makers: Explain to scientists how risk is evaluated and managed in your organization. Help scientists appreciate how you make informed decisions (not perfect decisions) despite uncertainty about current or future conditions and the outcomes of interventions. Explain the context in which decisions are made, the limitations on your authority, and to whom you are accountable. If multiple agencies are responsible for decisions, make sure that scientists provide the array of scientific information that each agency needs to act independently.

Recommended practice 7. Scientists: Honestly convey the meaning of uncertainty in your results, but (respecting the fact that decisions must be made) clearly convey the main implications of your research. In addition to providing information, an equally important task is to provide clear guidance on appropriate use of that information. Expect managers to challenge your science. Be open about your policy preferences.

Recommended practice 8. Scientists, funders, boundary organizations: Evaluate co-production products, processes, and the actionability of the science of individual co-production projects, and disseminate these findings. As project evaluations accumulate, revise these recommended practices.

Guiding principle 3: Build connections across disciplines and organizations, and among scientists, decision makers, and stakeholders

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Recommended practice 9. Funders, universities, and governments: Create and grow the capacity of boundary organizations dedicated to co-production of actionable science.

Recommended practice 10. Funders, managers, universities, agencies, and NGOs: Create incentives for academic scientists to consider co-production of actionable science as a rewarding line of work.

They also provide a set of questions for co-production, reproduced in the box below.

Questions that could be used as agenda items at a Goal-Defining Meeting for a co-production project. Reproduced from Beier et al. (2016)

- What is the issue at hand? What questions are being addressed? What topics are included or excluded from consideration?
- What decisions are being made? Are they flexible or limited in scope?
- Who will use the scientific information (including downstream uses) and how will they use it?
- In what form, process, or product will the data be most useful to the users?
- Given that decisions must be made before the science can be "settled," what is a realistic expectation of what is possible and useful within the available time and budget?
- What is necessary to make data accessible to all projected users? Who will own the data or other products? Where will the products reside?
- What would success look like for all parties?
- What alternatives are available to achieve success? What is gained or lost by pursuing one alternative over another?
- What variables does the decision maker care about? What resolution of data? What spatial extent? What level of precision is realistic, achievable, and adequate for the decision? If such precision is not feasible, should the project be abandoned or modified?
- What is the planning time horizon? Is this horizon appropriate for the purposes agreed on by the stakeholders?
- How will uncertainty be addressed? To what extent can multiple projections (e.g., emission scenarios, general circulation models) bracket uncertainty?
- Is a technical advisory group or steering committee needed for this project? If so, who should serve?

A further set of questions is provided to evaluate actionable science. These are relevant for the COACCH best practice guidance on co-design. These are also reproduced below.

Questions to address in evaluating a project to co-produce actionable science

- How well did scientists and managers specify the problem statement at the outset?
- In retrospect, would different scientific information and processes have been more useful? What steps could have better set up the project at the outset?
- Did the project give appropriate priority to process and products? Was the process collaborative, communicative, and positive for both scientists and managers?
- If scientists provided post contract advice on the appropriate use of the information, was this continuing engagement properly budgeted for?
- Were the scientists appropriately rewarded by their employers, and by the satisfaction of contributing to better decisions?

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- What practical steps could have been taken to provide better guidance on appropriate use of the scientific products?
- Did the scientific information and process lead to better decisions (or was it capable of doing so, even if constraints precluded a better decision)? How should future projects be managed to better meet this goal?
- What obstacles to collaboration were encountered in shaping the goals and final results?
- Is the product being used in the way it was envisioned? If not, why not?
- Was a mechanism created to insert new scientific results and learning that occurred by observing the outcomes of decisions made using the products?

Of particular relevance to COACCH, the paper identifies:

- While users may request information on 'risks' or 'vulnerability, after additional discussion, they may change this to realise they need information on which alternative adaptation strategies are most robust to uncertainty, which actions can best manage risk, or the relative costs of alternative strategies. This highlights that users may not actually know what they want (or at least what they need).
- Scientists tend to focus on downscaled climate projections much more than developing or appraising adaptation strategies, on the basis they assume users want more finer resolution data. However, the decisions are more critical for users, and can often be made without downscaled data (i.e. downscaled data is not a means to an end in itself).
- Scientists should understand the type of decisions a decision maker can make, the fiscal, policy, social and political constraints, and incentives and disincentives faced.
- Before the initial workshop, the convenors should identify the types of decisions needing scientific support, the types of scientific information that might be relevant, the timeframe needed for completion, and key stakeholders.
- A skilled facilitator should lead the meeting. A summary of the meeting, and each subsequent meeting, should be promptly sent to all partners.
- A focus on process, outcomes, and adequate interaction should be explicitly built into project design from the beginning, and projects should focus on decision support services rather than decision support products (or tools).
- Draft scientific products should be presented and discussed in relation to the decision-making contexts. This should occur early enough to allow time for significant adjustments if needed. Participants should discuss how various draft or hypothetical outputs would inform particular management or policy options.
- Similarly, scientists should describe the information and appropriate use of the information in decision making, and key decision makers explain how they intend to use the information.
- Different organisations need different scientific information to make decisions, and each institution has unique values and affect how they use a given type of scientific information.

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- Users may not fully comprehend the implications of key assumptions and the limitations of scientific models when this information is first presented, thus there is a need for transparency and honesty.
- It is useful to work with decision makers to develop decision trees or tables describing the most appropriate way to apply the information in each anticipated decision-making context.

6.1.2 Harvey et al. (2017)

Harvey et al. (2017) (*Designing Knowledge Coproduction for Climate and Development*) reviewed how co-production processes have been applied in climate and development, analysing six case study examples. The paper reports on the potential benefits of co-production, and its ability to draw in knowledge from across disciplines; promote shared learning based on collective experience; increase the legitimacy, relevance and usability of the knowledge being generated for non-academic stakeholders; and even challenge entrenched norms of knowing and doing.

The paper has a useful discussion of the definitions of co-production, highlighting the boundaries differ, e.g. whether co-production is defined as a sub-component of the overall co-creation process (in a sequence of co-design then co-production then dissemination), or whether co-production is seen as the overall framing concept, and as such, includes co-design, collaborative planning and co-implementation. They highlight there are two broader interpretations of co-production. The first (instrumental) focuses on the role in creating "useable knowledge", i.e. to *get knowledge into accessible formats and relevant contexts to inform decision making on major challenges like the impacts of climate change*. The second (emergent) is bolder and proposes co-production as a new transformative way of challenging existing thinking (an *idiom that offers new ways of knowing and representing the world across social and natural orders…to challenge the hegemony of particular ways of knowing and to invite a more conscious reflection*).

It also sets out different process for co-production, differentiating between i) the use of knowledge intermediaries or brokers (boundary organisations), i.e. third parties that encourage interactions between science and non-science actors and ii) through direct interaction where equal participation occurs from the idea development until the dissemination of outcomes.

The paper maps out this spectrum of co-production, presenting a heuristic (shown below), to help identify which modality and process are most appropriate for respective resources, timelines and objectives. The spectrum of co-production is set around its aim/ends (from instrumental to emergent) and its approach (from brokered to "agora" [defined as the direct interaction between these actors in a space of confluence]).

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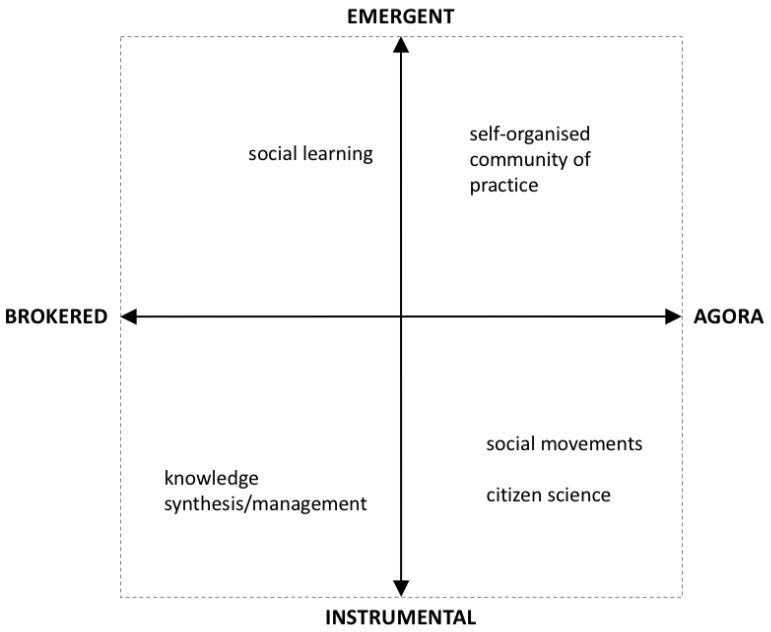

Figure 2. A design heuristic for knowledge co-production. Harvey et al. 2016.

The paper argues that while the theory is sound, in practice, co-production processes suffer from a limited conceptualisation of how process meets outcomes. They therefore examine three questions to address this issue:
1) What kinds of questions or problems are successful co-production approaches being used to answer or resolve in climate and development?
2) In these successful cases, how does the co-production context and process influence its outputs and outcomes?
3) How do success factors vary across different co-production approaches or problem types?

Based on their analysis, they identify a number of common factors in the success of the co-production processes. These are:

- Focusing on meaningful issues, described as relevance and/or resonance of the themes;
- Engaging representative stakeholders;
- Facilitating shared, iterative learning;
- Using constructive decision-making and conflict resolution processes (facilitation and design factors);
- Producing a boundary object (a co-produced knowledge product), which featured strongly as an incentive;
- The influence that language barriers and time constraints can have on the success of co-production.
- The role of sustained investment, both in terms of financing and commitment from organisational leadership, was particularly highlighted in (some) cases;

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- Ownership is important, but can also be a barrier. It is easier where there is a more clearly-defined and time-bound activities (i.e. when focusing on useable knowledge).

They find that successful co-production examples have a clear emphasis on producing collectively owned outputs (boundary objects) as a central aspect of the co-production. This may make reaching a specific endpoint where success can be declared more feasible (e.g. a co-production event is concluded; a question answered; or a product finalised). The importance of the outputs to the overall aims of the co-production activity differed however, ranging from being the anticipated "end" of the co-production itself to being an incentive that catalyses and sustains participation in the process.

In addition, the paper highlights that:

- Successful" co-production has a strong emphasis on more bounded, output-oriented processes.
- There is a need to create an environment wherein relationships are established, common vision is determined, and shared objectives are clear.
- The transaction costs and time demands for co-production are high.
- There is the possibility of charting a "co-production pathway" that sets out the assumed relationship between processes, outputs and outcomes in ways that ensure coherence between means and ends.

6.1.3 Lövbrand (2011)

Lövbrand (2011) published a paper on '*co-producing European climate science and policy: a cautionary note on the making of useful knowledge'*. This examines how knowledge-making practices can be incorporated into European climate policy-making, and uses case studies to assess co-production between climate policy research and EU climate policy. The paper focuses on co-production as a normative framework for improved science–society interaction, notably around science policy practice 'usefulness', and the assumption that involvement of potential recipients of knowledge in its production will increase the likelihood of use.

The paper recognises that co-production processes can foster enhanced communication, build networks, and strengthen trust among partners, but it also highlights that even when these benefits are realised, this does not always translate into the production of usable scientific knowledge. To demonstrat this, the paper uses two examples of co-production from a major EC funded research project (ADAM). The ADAM project was designed to facilitate a co-production process between the involved researchers and the EU climate policy community, including the use of social learning.

The first case study was focused on co-production between the research team and the European Commission arouond climate policy. The finding of this case study suggests that the interaction with the European Commission (EC) offered little scope for

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thinking beyond policies already formulated by officials. It therefore provides cautionary information on the possible limits of co-production.

The paper examines why this co-production example was limited. It identifies a mismatch in the timing (of results to needs) and the type of information produced (qualitative production versus quantitative [economic] needs). With respect to timing, the paper highlights that the co-production possible is dependent on the particular stage in the policy cycle. The earlier in the policy cycle the co-production engages, the more freedom there is for expansive discussion and challenges to the status quo – whereas in later stages, there is generally more need to accept the prevailing objectives and freedom to co-explore is more limited. In the case study, at the time the research projected engaged with the EC, the Energy and Climate Change Package was already formulated, and there was little room and interest for wider research reflections on European policy (i.e. the Commission was trying to close down and get agreement among Member States, not open up the policy issues again). Instead, the main need from the Commission was for quantitative inputs. While the research team was prepared to adjust their research design to meet these needs, the work package on had trouble finding policy actors with the time and interest to engage in meaningful dialogue on their qualitative research questions, thus the project shifted back to a traditional research design. As a consequence, the EC asked another European research group to conduct the quantitative policy evaluations they needed for the policy analysis.

The author concludes that there is therefore a trade-off between research co-produced to be accountable to the knowledge needs of societal decision-makers, and co-produced research that seeks to challenge and transform existing ways of thinking. In suummary, researchers who wish to be useful to policy practitioners may have to operate within existing policy goals and agendas. This closes down more fundamental questions around meaning and value, and will not produce shifts away from current dominant assumptions.

The second example involved interaction with the EC and the ADAM team, and centred on a change to the work programme in order to be useful for the Commission in ongoing UN negotiations on climate change. The ADAM researchers were asked to give scientific support (technical and economic feasibility), rather than to challenge, the policy goals formulated by the EU (400 ppm targets/2°C – lower than had been planned for in the project). This provides an example of a more instrumental approach: results were well received by the European policy community and gave the EU important scientific ammunition in the continued UN climate talks. To some extent it generated results that were both challenging to the climate science community and useful to the European policy community. However, the main aim was to gain scientific support for existing policy goals and assumptions.

Based on the case studies, the paper makes a number of recommendations. First, the case studies show there can be close links between European climate science and

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policy. The project's mandate to produce policy relevant knowledge did shape the research questions and methods, and researchers wanted their research to be used. They therefore had more ambitious stakeholder exercises and developed closer links to European climate policy-makers than in traditional academic research. Second, the project did contribute to the ongoing policy discussion, within the framework of current climate policy. Scientific findings can do more than simply legitimise existing assumptions, and help inform climate governance as well as being informed by it.

The paper concludes that in contrast to the positive stories of co-production found in the science studies literature, the reality may be rather different. Instead of innovation, re-examination and learning, the ADAM project was asked to respond to a restricted policy interpretation of useful knowledge. As the project's contract with the EC hinged on its policy relevance and usefulness, the space for critical engagement was restricted. It therefore closed down, rather than opened up, the overall interpretation of feasible and desirable climate policy goals in the post-Kyoto era. It also gave a small group of EU policy-makers the mandate to determine what counts as useful knowledge, with the policy appraisal process giving researchers little room to think or do things differently. It therefore identifies the difficulties that academics may encounter when seeking to co-produce knowledge with policymakers. The timing of the co-production invention is key (whether early or late in the process), as this opens or limits the potential for freedom of thinking. The final recommendation is for scholars in this field to carefully assess the conditions under which co-production makes sense and when usefulness works as an appropriate standard of success.

6.1.4 Vincent et al. (2017)

A recent application of co-production guidance has been developed in the climate services domain, with a co-production guidance document (*Guidance on Equitable and Inclusive co-production for Weather and Climate Services*) for the WISER project (Vincent et al., 2017). The guidance was developed based on a review of co-production.

A key finding was that the process of co-production is equally as important as the products. The guidance sets out good practice in co-production requires that the (weather and climate) service itself exhibits several characteristics, and the process of developing that service is based on certain principles (shown below). They propose that an effectively co-produced weather and climate service should be decision-driven (addressing user needs), process-based (including iterative updates during the project), and time-managed (including time for developing and maintaining relationships among project partners. In order to achieve this, the team involved should be aware that the process of co-production needs to be inclusive, collaborative and flexible.

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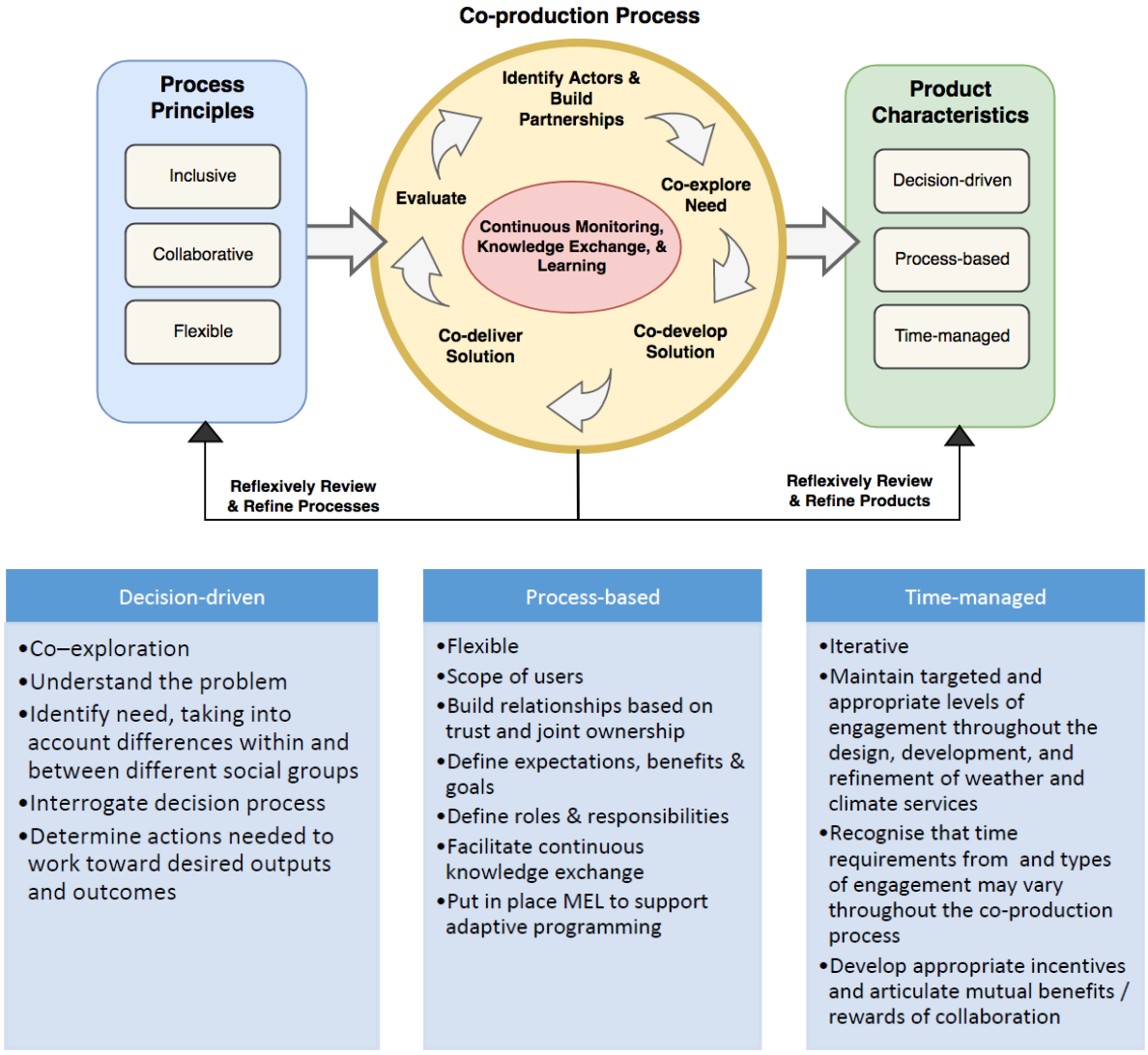

Figure 3. Co-Production Process. Source Vincent et al. 2017.

The guidance stresses that the nature of decisions of different groups of people will differ, and that these can be enabled through co-exploration. Co-exploration can take place through a series of facilitated dialogues, whether in a collective workshop format, or through individual interviews. It also sets out that flexibility and appropriate time and financial resources should be built into project proposals in order to ensure they are decision-driven.

The guidance identifies a series of decision driven questions, i.e. to help the co-design process and to identify needs, shown in the box below.

They also expand on the importance of process, proposing that a 'co-developed weather and climate service can aim to develop a usable product, but should equally focus on the process through which the service is developed. This is essential to

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building relationships of mutual respect and trust between stakeholders. Furthermore, a flexible and iterative process-based approach can enable the refinement of the weather and climate services to ensure that they are relevant and reliable enough to inform decision-making'. They note that a process-based weather and climate service is quite different to normal climate product development and funding mechanisms, not least because the ultimate product is not defined at the outset, and will vary to the indications in the proposal due to user needs.

As the co-production process progresses, they stress the need for an iterative programme of monitoring and learning, to reflect on how the process can be better managed, different forms of engagement, more regular contact, or alternative ways of sharing information and enabling participation.

The guidance provides advice on making the process time-managed. It stresses that co-production require extensive time for engagement between producers and users, as a standard project cycle, as shown below. This includes time at the very start of the process in order to identify stakeholders and then co-explore problem(s) that a new weather and climate services may address. Subsequently, once a need has been identified, time is required for the facilitated process of joint engagement between producers and users. This includes time for various stakeholders (e.g. intermediaries, knowledge brokers, researchers) to discuss and establish shared goals and a roadmap for service development. There is a need to allow sufficient time for relationships to develop – and in the early stages – physical proximity (meetings) are essential.

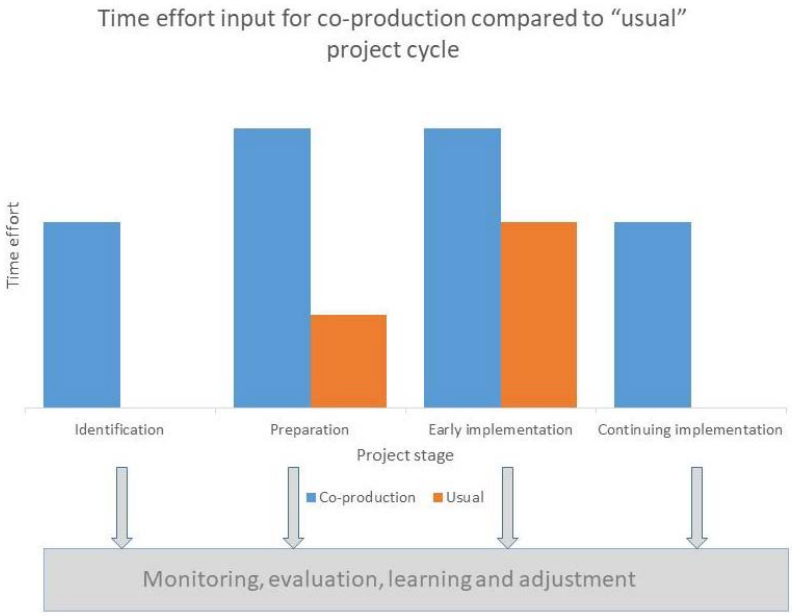

Figure 4. Time effort for co-production versus usual projects. Source Vincent et al. 2017.

The guidance highlights that the ongoing nature of inclusive collaboration requires regular contact and maintenance of relationships. The frequency and format of

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interaction should be mutually defined and agreed early in the project, with opportunities to revisit whether and adjust at later stages. There is also a need for a monitoring, evaluation and learning (MEL) component to ensure the iterative approach, with feedback to the project, but also for subsequent development.

It also stresses then need to make the process inclusive, with respect to the selection of stakeholders, avoiding bias, reinforcement of existing power structures, or systematic exclusion of groups that are typically marginalised. The guidance stresses the need for producers and users working together, and report that this requires an open mind and a willingness to consider new forms of knowledge, experiences, and perspectives from different actors. Users are typically driven by a range of political, economic and social drivers and their capacity to actively engage in co-production fluctuates depending on other pressures on their time.

The guidance stresses the need for flexibility. This is critical for the iterative process recommended between producers and users. It involves a cycle of developing, testing, and refining the services in response to users' needs and feedback. However, such an iterative approach has consequences: users may make requests for additional or different services that were not anticipated during the initial co-design step. To address this there is a need to build in flexibility. This requires identifying key decision points within the programme at the start. These decision points represent an opportunity to review progress and to make adjustments or course corrections. At these points, an analysis is needed of whether the programme is performing as expected or, if not, to understand what must be changed. This can include the changing needs or priorities of stakeholders. This is often referred to in the literature as learning-by-doing approach (or adaptive management or programming) that incorporates learning into activities in real time. It also notes that relationships between partners evolve over time, as do their respective knowledge, capacities, and needs. There is therefore a need to enhance flexibility among the organisations and individuals involved in the co-production process. The guidance recommends developing a centralised project administration or coordination mechanism to do this.

Finally, the guidance sets out the need for Continual monitoring, evaluating and learning (MEL) during the course of a co-productive process, stressing this is essential in determining if the project is going in the right direction and, following its completion, if it was it successful in achieving its goals. MEL for a co-productive process requires two stages: taking place continually during the process itself and upon completion.

The guidance sets out five concrete steps to advance good co-production:

Compile an appropriate team. These should be transdisciplinary and contain a broad range of expertise. The team should also consider the need for someone to manage the co-production process throughout the lifecycle. This task should involve the whole team.

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Identify actors and build partnerships. This involves three sub activities, and should involve the entire team.

- Identification of stakeholders. This can ask relevant questions to identify these (see box) but it is important to include intermediary actors (boundary organisations or knowledge brokers).
- Analysis of the level of interest of stakeholders, with initial meetings to scope whether these actors would be interested as potential partners. The guidance recommends face-to-face meetings are an important prerequisite to building trust, instilling confidence, and offering the opportunity for dialogue.
- Building relationships. The process of building - and then maintaining – relationships is essential to successful co-production. Adequate time and resources should be made available for building and maintaining relationships, with face-to-face contact being very important.

Co-explore need. This involves exploring what (weather or climate) service is needed and ensuring that the needs of all potential users and decision-makers are addressed. This may require different methods of engagement. Having identified stakeholders who are interested, the next stage is to investigate a specific decision that requires weather or climate information, and what type of information might be required. Face-to-face meetings are recommended as it increases response: this may take place through individual interview or workshops. It should be led by the co-design facilitators.

Co-design solutions. The process of co-delivering a solution is likely to involve several actors working together for the first time. It is also likely to be an iterative process based on trial-and-improvement, and thus a learning mechanism is essential to identify successes and challenges, and implement course correction if necessary. This task should be undertaken by the whole team. there may be need for training.

Evaluation. The final stage is the evaluation. There needs to be proactive monitoring and learning throughout the service development, as well as a final evaluation. Evaluation should focus on 1) the quality and benefits of the co-production process itself and 2) whether the co-production process produced better climate services.

Questions to form an appropriate co-production team

- What are the embedded assumptions and motivations of initiating the co-production process?
- Are we including/planning to include all potential users and decision-makers?
- Are all parties willing to work in a collaborative manner?
- How do we see the process of co-production?
- What other actions do we need to take to continue a process of co-design?).

Decision driven questions:

- What problem or decision are we trying to address with the research?
- Do we know enough about user needs?
- Do we know enough about the context in which the research (outputs) will be used?

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- How are the target decisions in the relevant sector made, and how will the research inform this?

Questions to identify stakeholders:
- Who makes decisions that are influenced by climate?
- Who can provide information?
- Who do we include to ensure that all decision-makers are included?).

Questions to identify needs (with stakeholders):
- What are the biggest challenges that you face? What role does the weather and/or climate play in that?
- How does/has weather and/or climate affect(ed) your activities (in the past)?
- What weather and/or climate information do you use, and from where? (including indigenous knowledge)
- For what purpose do you use this weather and/or climate information? What decisions does it inform?
- Are there limitations to the weather and/or climate information that you use? (i.e. is it available for the appropriate time and spatial scale; is it available in a timely fashion; do you understand it fully; does it provide the information that you need to make decisions?)
- What weather and/or climate information would you like to be available? How would you use it?

Questions to ensure process-based co-production:
- Have sufficient time and resources been allocated to enable effective and inclusive co-production throughout the project lifecycle?
- Is there evidence of appropriate incentives and recognition for active participation in the co-production process (as opposed to just outputs or products)?
- Are clearly defined and jointly agreed upon goals in place?
- Has someone been allocated responsibility for oversight of the process (e.g. a knowledge broker or embedded researcher) and are the roles and responsibilities of all participants mutually understood and agreed upon?
- Is there an active procedure of monitoring, evaluation, and learning to enable reflection on the process and opportunities for modification of the service?

Questions to ensure a service is time-managed:
- Has sufficient time been allocated for engagement processes throughout the lifespan of the project?
- Has the frequency and format of interaction between stakeholders been defined at the outset, with explicit opportunities to review and revise modes of engagement at later stages?
- Has sufficient time been allocated to ensure identification of users?
- Has additional time been allocated at the start of the project for co-exploration and the development of mutually-beneficial relationships between producers and users?
- Are adequate time and resources included to manage and sustain collaborative relationships?
- Are incentive and reward structures in place to reflect the time-intensive nature of co-production on participants in the process?

Questions to understand the potential of stakeholders to engage in the process:

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- To what extent does the climate affect their planning and decisions?
- What interest do they have in climate?
- What information do they want from you?
- Who else might be influenced by their opinions?
- Who else do they think should be play a role in co-production?

Questions to ensure a collaborative process:

- Does the project team have the right mix of individuals across disciplines and with the needed experience, expertise, and skills to develop a usable climate service?
- Are adequate resources earmarked to enable collaboration (e.g. for engagement activities, such as meetings, workshops, as well as programme management)?
- Are mechanisms in place to ensure effective inclusion (e.g. translation/language, support for those with disabilities (e.g. non-visual materials, sign language) transport availability, ensuring time of meetings that fits with gender roles)?
- Do the various parties feel joint ownerships of the process?
- Is the process putting in place/developing the networks and capacity necessary to ensure sustainability of collaboration post-project?

Questions to ensure a process is flexible:

- Have periodic opportunities to revisit the goals, activities, and timelines been built in to the programme?
- Is there scope for adjustment and flexibility based on ongoing monitoring, evaluation and learning?
- Have key decision points been identified within the programme at the outset, where course corrections or adjustments could be made?
- Has an ethic of 'learning-by-doing' been fostered among all actors to better incorporate evolving priorities and interests?
- Has ongoing monitoring, evaluation, and learning been build included in the design to inform programming, both at the beginning and throughout the project?
- Have opportunities for joint reflection and dialogue among partners been built in to the programme?

Questions for final evaluation:

- How well did scientists and other stakeholders specify the problem statement at the outset of the project or programme?
- In retrospect, would different scientific information and processes have been more useful? What steps could have better set up the project at the outset?
- Did the project give appropriate priority to process and products?
- Was the process inclusive, collaborative, communicative, and positive for both scientists and stakeholders, including women, the disabled, and the poorest of the poor?
- Was the role of researchers and stakeholders, and their respective knowledges, clear and adhered to?
- Were there appropriate incentives and rewards structures in place for scientists and stakeholders to participate in co-production, and by the satisfaction of contributing to better decisns?
- Did the scientific information and process lead to better decisions (or was it capable of doing so, even if constraints precluded a better decision)? How should future projects be managed to better meet this goal?

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- What obstacles to collaboration were encountered in shaping the goals and final results?
- Are the knowledge and / or associated products being used by the target groups and in the desired way? If not, why not?
- Was a mechanism created to insert new scientific results and learning that occurred by observing the outcomes of decisions made using the products?

Reproduced from Vincent et al., 2017

6.1.5 Visman et al. (2016)

This report (Visman et al., 2016)) explores the process of co-production and learning ('Learning to support co-production'), drawing on the experience from a programme on Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED).

The document defines Co-production as *the bringing together of different knowledge sources and experiences from across different disciplines, sectors and actors to jointly develop new and combined knowledge*. It outlines that co-production of knowledge is not limited to bridging the science-public gap but also describes efforts to integrate between any knowledge sources or ways of framing information or knowledge. The note has a greater focus on learning, and the social learning and social network literature (for more on this, see Bharwani et al. (2013).

It reports on a number of findings from the co-production process undertaken in the project (challenges and opportunities for learning), set out below:

- Co-production entails recognising and respecting other people's knowledge and value systems, being able to appreciate the influence of contrasting contexts on other's knowledge formation and allowing for the development of a shared understanding. This can take time.
- Within collaborative work, learning can be felt as self-assessment and reflection to enable improvements in the implementation of joint activities (this can include improvements in the learning process itself).
- Working collaboratively in learning processes requires skills or mechanisms that can overcome boundaries, noting these can be organisational (silos in organisations). Boundaries can also be inter-personal, such as established hierarchies and competition that can hinder collaboration and sharing of knowledge.
- For some partners, it was the first experience of working on co-production, and it takes time for these partners to build a common approach and shared understanding across sectors, disciplines and levels of decision-making.
- There is a need to ensure sufficient time for relationship building and an understanding of each partner's and co-production organisation's competencies, structures and ways of working.

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- With hindsight, several organisations felt they had underestimated the amount of time and resources required to develop and communicate decision-relevant climate information. This was not helped as prior to project inception there was limited common understanding across consortia partners of the co-production process.
- The need for clarity on roles and responsibilities is needed throughout the co-production process and into project implementation.
- There was a high turn-over of staff amongst partners and stakeholders. This placed strain on investment to sustain institutional knowledge and relationships.
- Co-production is an ongoing-collaborative process, in which the knowledge resources of all partners are valued.
- A range of related complementary initiatives can make clear that all partners need to share responsibilities for learning. Co-production requires each organisation to develop its capacities for collaborative learning across sectors and levels of decision making.

6.1.6 Dilling and Lemos (2010)

Dilling and Lemos (2010) published a paper on *Creating usable science: Opportunities and constraints for climate knowledge use and their implications for science policy*. This focuses on usable science for decision making. They undertake a review to understand opportunities and constraints to science use in order to inform policy design and implementation, focusing on the production and use of climate science (science policy practice).

The paper finds that climate science usability is a function of the context of potential use and of the process of scientific knowledge production itself. Furthermore, it finds that nearly every case of successful use of climate knowledge (that they reviewed) involved some kind of iteration between knowledge producers and users, i.e. providing the evidence base for the benefits of co-production.

The paper highlights the difference of what is ‘‘readily usable’’ for decision making and that there is a difference between what scientists might think is useful, and what is actually usable in practice. Addressing this requires the establishment of a shared vision of what knowledge is usable in a given decision process. They propose a useful analogy of ‘usability’ as a function of both how science is produced (the push side) and how it is needed (the pull side) in different decision contexts. To deliver this requires deliberate science policy design.

The paper synthesizes ‘lessons learned’ from the literature to understand the factors that shape information use. It classifies science–policy interaction into three typologies, science push (pursuit of knowledge itself drives scientific production and subsequent policy applicability), demand-pull (science is commissioned or sought out by stakeholders), and a combined science push-demand pull (co-production), in which

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the research agenda is shaped in an ongoing, iterative fashion between knowledge producers and users to produce useful and useable information.

It then looks at the elements of usable climate science for decision making, initially looking at the climate services domain for examples.

The paper reports that usability is influenced by many factors, but context (the institutional or organizational setting) is critical. This includes a number of elements. First, there can be major institutional and governance barriers that make it difficult for information to be used. Further, in many cases, information that might seem relevant, is less usable in practice, as it competes with many other factors shaping the decision context. Third, organizational culture and individual reward structures can play a role in whether or not decision-makers will use climate knowledge to inform their decisions. Fourth, the cultural context of information use shapes its adoption (and here, uncertainty is a critical issue). Finally, the availability of realistic alternative courses of action is a key factor shaping usability: even if information is useful in theory, it may not be usable if potential users lack the means to implement.

The other main factor the paper identifies for usability are intrinsic. First, although scientists cannot control the decision context in which their information is used, a common factor that influenced usability was the fact that information producers were sensitive to specific decision contexts they were targeting. Conversely, a further intrinsic factor was the users' perspectives of the utility of the science for their own decision processes. The paper reports that greater interaction between producers and users significantly increases the use of climate science, by addressing these factors. Second, issues of spatial and time scales and level of skill of climate information production also influence usability. The timing of climate information release can also be critical in this regard. Third, the level of trust of users in the forecasts and their legitimacy can be critical to usability. Finally, information needs to be accessible.

The paper highlights that a key success factor in increasing usability is the use of an iterative approach. This improves producers' understanding of the decision-context of users, and allows for better customization of knowledge to meet specific needs. Further, through the process of iteration, producers and users may uncover new uses for climate knowledge that might not have been identified before.

While many constraints and opportunities for knowledge use are beyond the control of the scientist, a better understanding of users' decision contexts can critically influence the ability of producers to meet users' expectations of climate knowledge as decision support information.

The paper presents a number of recommendations for users to increase the usability of climate science in different contexts. These are set out below:

Owning the problem and setting common goals. Iterativity is key for the co-production process to succeed, thus there is a need to develop the conditions and mechanisms for it to happen (noting it often does not). This requires institutional spaces and

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designated organizations, i.e. to own the process of creating usable science, and to agree accountability for outcomes on both the scientific and the user community side. Further, to generate usable science one should involve stakeholders and decision makers from the start in helping to generate priorities for research and metrics for success.

Establishing innovative mechanisms to foster iterativity. There are a number of institutional arrangements and mechanisms that have been shown to be able to improve the connection between producers and users:

- Information brokers, i.e. an intermediary between the users and the scientists, i.e. individuals that understand both contexts;
- Boundary organizations, which can also play the intermediary between the users and the scientists but may have more resources to tailor information and produce value-added products than individual brokers;
- Collaborative group processes, to bring together disparate interests and organizations;
- Embedded capacity, with technical capacity and leadership enhancing usability of climate knowledge;
- Knowledge networks, which are comprised of policy makers, scientists, government agencies and nongovernmental organizations that communicate with each another and share information across areas of practice.

Institutionalizing incentives for usable science in science policy practice. This includes a number of aspects including:

- Acknowledging the need for flexible research agendas;
- Identifying success—the essential role of metrics (beyond publications in the academic literature), evaluating success in terms of usability, with metrics on other outcomes such as relationships with stakeholders, accessibility of knowledge, and progress on specific societal outcomes.

6.1.7 Moser (2016)

Moser (2016) synthesizes insights from real-life experiences of co-developing research projects (*Can science on transformation transform science? Lessons from co-design*). The paper starts with an analysis of the definitions of co-design, in the context of knowledge production, services, planning design, product design, and policies and processes. It defines co-design as first phase of the knowledge co-production process, in which researchers and non-academic partners jointly develop a research project and define research questions that meet their collective interests and needs.

The paper synthesises experience and learning from 16 co-design examples, focusing on transformation. The focus on transformation means that it is focused on more descriptive (emergent or critical/reflexive) co-design.

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The paper reports that the empirical evidence shows that there is no uniform approach to co-designing research projects, partly because of differential capacities among those facilitating the process as well as among those participating in it, and partly because of the different topics, actors and purposes involved. However, it is possible to draw insights and the paper does this. It finds that the more direct, frequent and interactive the processes were, the more co-owner-ship partners took of the process, and the more empowered they became in the co-design of the research proposal. The paper provides a useful list of different co-design approaches (see below)

Note: Activities used during co-design can have multiple purposes and involve one or more elements from the list below. Choices depend on project goals, skills of facilitators and partners and judgment around cultural appropriateness. The resulting activities will differ in exact design and implementation.

Purpose: Team- and trust-building

Social capital building elements such as:

- Making and sharing food
- Storytelling
- Sharing responsibility for different parts of the co-design process
- Reciprocity ring
- Expressive arts activities such as role playing, drawing, writing, comedy
- Fun

Purpose: Opening up, making connections and knowledge exchange

Communication elements such as:

- Storytelling
- Dialogue
- Presentations
- Providing background information
- Online exchange
- Talking in pairs or small groups
- Various forms of discussion, panels, forums
- Read-shops

Purpose: Issue exploration

- Elicitation elements (e.g., brainstorming, World Café, appreciative inquiry, visioning, stakeholder mapping, value mapping, systems mapping, U-process, time-lining)
- Experiential learning elements (e.g., field trips, site visits)
- Research elements (e.g., wide suite of methods, incl. surveys, interviews, case studies, participatory mapping, document analysis, mapping, observation)

Purpose: Joint learning

- Integration elements (e.g., system mapping, write-shop, synthesis, graphic representations, compare/contrast)
- Reflective elements (e.g., time-lining, post-meeting survey, journaling)

Purpose: Project-related decision-making

- Structural elements (e.g., identifying and agreeing on appropriate roles of team members)
- Procedural elements (e.g., discussion and agreement on communication, project management needs, decision processes, conflict resolution)
- Administrative elements (e.g., identifying administrative needs, hurdles, solutions, accountability procedures)

Purpose: Delivering outputs from co-design phase

- (Joint) product development elements (e.g., proposal, report, videos, publications)
- Collaborative write-shops

Current Opinion in Environmental Sustainability

Purpose-driven engagement activities in the context of co-design. Moser (2016)

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The paper makes some specific notes on the choices of stakeholders to encourage transformational change (including agents of change, representatives of marginalised groups, actors and/or decision makers from places that are being challenged, or with different cultural socialization and personal perspectives). It also notes that one of the most frequently mentioned challenges was related to communication and the time-consuming process of finding a common language (i.e. disciplinary or practice-specific jargon). Indeed, the issue here went beyond this to finding agreement on a consensual framework for the research, on methods, priorities, against a background of different disciplines, ontologies and epistemologies. A specific communication challenges mentioned was the extended communication beyond those who were involved directly in the co-design process.

The paper reports that the research teams further mentioned challenges around building, deepening and maintaining engagement: trust building is essential but takes time. This implies that co-design processes had to be built for inclusivity and creativity, not just for efficiency and effectiveness in the sense of producing a joint output (in the case of this paper, research proposals).

It sets out the benefits of co-design, providing a useful list which includes:

- Enhanced understanding and advances in knowledge, on the topic and on co-design;
- Greater research collaboration, with more creative research proposals (and research) with improved conceptual/theoretical approach, cross-fertilization of ideas;
- Improved communication and improved relationships, with greater trust and enhanced networking;
- Better grounding (in reality) and increased reflectivity of researchers, with other ways of conceptualizing or looking at the world, improved understanding across different viewpoints and fields;
- Increased skills for collaborative work (facilitation, negotiation, engagement design);
- Increased motivation, encourage and stimulated by the challenges,
- Production of outputs, with peer-reviewed papers and non-academic outputs;
- Practical outcomes, including greater participation, better understanding, networks and greater access to policy spaces

Finally, the paper notes that the challenges of co-design point to the ongoing need to balance trade-offs and reconcile tensions between several areas. These include: between scientific rigor and an open, bottom-up design; between an emphasis on the advancement of science (and theory) for its own sake versus research with practical benefits in specific grounded realities; between the immediate needs of actors and the long-term focus on a more transformative agenda; between work at multiple scales

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with diverse geographies versus site specificity; and, finally, between funder requirements creating challenges around feasibility and cost versus the familiarity following familiar standard procedures.

6.1.8 Hegger et al. (2012)

Hegger et al. (2012) (*Conceptualising joint knowledge production in regional climate change adaptation projects: success conditions and levers for action*) develops an assessment framework for analysing the merits and limitations of joint knowledge production projects (co-production) and presents seven success conditions for joint knowledge production.

The paper deliberately avoids the term co-production, due to the multiple and differing uses of the term, and instead uses the term joint knowledge production, which involves *scientists, policymakers and sometimes other societal actors cooperating in the exchange, production and application of knowledge, taking place at the 'science–policy interface'*.

This approach has been advanced in the Netherlands and Germany, notably on regional climate change adaptation projects, and this paper argues a new framework is needed to evaluate these studies, i.e. to analyse and reflect on project experiences, thus facilitating social learning and adaptive management. This paper therefore develops an assessment framework for retrospective analysis of the success regional joint knowledge production project. To do this, they focus more on the process of joint knowledge production projects rather than on their products.

They identify criteria of salience, credibility and legitimacy (where salience relates to perceived relevance, credibility to the perceived adequacy of the knowledge produced and legitimacy to the extent to which knowledge production is unbiased, fair and reflects divergent values or viewpoints), but note that different actors will have different criteria and thresholds for these.

The paper then moves on to define seven success conditions for joint knowledge production in regional climate change adaptation projects:

- Actors: who participates? The paper outlines four principles for this.
    - First, the 'crucial' actors should be involved, i.e. those with an interest in the area under consideration; and that can provide expertise and practical knowledge. In this case, university departments as well as public policy bodies.
    - Second, actors need to be prepared to participate. Actors will not always and not in each stage of a project be willing to participate, for instance if they do not see themselves as a 'problem owner'.
    - Third, non-selected actors may be an important source of opposition, because of self-interest, or because of frustration about 'not being selected'.

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  - Fourth, in any collaborative process the number of actors needs to be limited to keep the process manageable
  - This highlights a trade-off between broadening the engagement process as much as possible (to arrive at socially robust knowledge) against the inherent limitations in how many actors can participate.

- Discourses, defined as 'ensembles of ideas, concepts and categories though which meaning is given to social and physical phenomena, produced through an identifiable set of practices'.
  - The process of defining 'the problem. The nature of policy problems will lead to different output from joint knowledge production projects. If the problem is well structured, there is more chance of actors agreeing on policy goals and means and they can aim at solving policy problems (with the converse for badly structured problems, and which may then need further ideas and concepts to progress). However, actors may have different problem perceptions or different ways to frame problems. Nonetheless, process of finding shared problem definitions can be influenced to some extent by managing expectations regarding the outcomes of a process.
  - The recognition of actor perspectives. Scientists, public policymakers, businesses, etc. have differing perspectives on the world and belong to communities with different epistemologies. This makes it important to address problem perceptions, but also the broader actor perspectives. Boundary objects can be used to address this, defined as concepts adaptable to different viewpoints but at the same time robust enough to maintain identity (boundary objects are also defined in the paper as mediators of narratives, with examples given of GIS maps or tools).

- Rules.
  - The division of responsibilities. The paper reports on a range of engagement, including participation, integration, negotiation and learning, noting there are degrees of cooperation. The paper outlines there is no single approach, and it will be appropriate to the context: however, an important issue is to be explicit and transparent about the level of cooperation intended.
  - Roles of researchers and of research-based knowledge. Within the co-production process, scientist can play different roles from pure scientists through to advocacy. The role will be determined partially by the degree of agreement and uncertainties around the problem. The role may involve provision of data but also provision of concepts (including boundary concepts or objects), to help understand problems, and their application in policy (and communication). The researcher can therefore act as mediators or process organisers that structure knowledge, rather than just knowledge producers. However, the paper identifies some caution: scientists can become issue advocates without being explicit.

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  - Reward structures. The paper explores what is the reward for researchers, policy makers and other societal actors for co-producing knowledge? For researchers, there is still the primary reward of paper publication, of more applied research: the paper thus argues for other forms of reward in relation to evaluation criteria. For public policy bodies and societal stakeholders, the rewards are the receipt of (perceived) useful knowledge.

- Resources. The paper outlines a number of resource aspects that encourage joint knowledge production. This includes boundary objects (see above) and facilities and forms for interfacing and sharing of knowledge (e.g. administrative support, places to meet). It outlines three spaces; physical space (e.g. meeting rooms); virtual space (e.g. computer networks), and mental space (e.g. common goals). It stresses the need for physical proximity as this is conducive for knowledge creation as face-to-face relations help to build relationships that enhance the sharing of knowledge.
- Joint knowledge production projects are in need of other resources than finance and formal authority. Fruitful collaboration of actors in the domains of science and public policy necessitates specific resources (boundary objects, facilities, organizational forms and competences) facilitating such communication as well as enough time to enable these processes.

Based on this a series of recommendations are made, reproduced below:

Proposition 1. The success of joint knowledge production projects is enhanced in cases in which the broadest possible coalition of actors is formed, within the practical and strategic limits present. This likely entails both in- and exclusion of actors.

Proposition 2. The chance that joint knowledge production is successful is enhanced in cases in which participating actors deliberate on the nature and denomination of the policy problem (whether un-, badly-, moderately- or well-structured) and the type of outcome expected (ideas, closure on problem definition, concepts, arguments or solutions), i.e. where there shared understanding of goals and problem definitions.

Proposition 3. Actors in joint knowledge production projects can be expected to have diverging and implicit perspectives on the world around them. The success of joint knowledge production will be enhanced if the different perspectives of stakeholders are recognised and taken into account. In this, boundary objects (concepts) can play a mediating role.

Proposition 4. The chance that joint knowledge production is successful is enhanced if actors decide, consciously and reflexively, which role to pursue in a project, how to define their identity in relation to the other actors, and to make their choices known to these other actors, i.e. there is organized reflection on division of tasks by participants.

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Proposition 5. The chance that joint knowledge production is successful is enhanced in cases in which the role of researchers and their knowledge is clear.

Proposition 6. The chance that joint knowledge production is successful could be enhanced through novel forms of reward structure, but more experience with such examples is needed.

Proposition 7. The chance that joint knowledge production is successful is enhanced through the availability of specific resources (boundary objects, facilities, organizational form and competences) facilitating communication between communities with different epistemologies.

Dimension	Expected success condition	Credibility	Salience	Legitimacy
Actors	1. Broadest possible actor coalition is present	↑ inclusion of place-based knowledge in science	↑ inclusion of place-based knowledge in science ↓ high complexity	↑ inclusion of various different perspectives in the knowledge production process ↓ need to reconcile many different knowledge interests
Discourses	2. Shared understanding of goals and problem definitions	↑ epistemological differences can be bridged	↑ knowledge resonates with needs as perceived by policy-makers and societal stakeholders	↑ actors believe that the right questions have been asked concerning the right problem
	3. Recognition of differences in actor perspectives takes place	↑ inclusion of different forms of knowledge in science	↑ inclusion of different forms of knowledge in science ↓ high complexity	↑ inclusion of various different perspectives in the knowledge production process ↓ need to reconcile many different knowledge interests
Rules	4. Organized reflection on division of tasks by participating actors takes place	No straightforward relationship assumed	↑ synergetic division of tasks	↑ mutual understanding of each other's interests and explication of assumptions that would otherwise remain implicit
	5. Role of researchers and their knowledge is clear	↑ enhanced trust in researchers (no "stealth issue advocacy")	↑ potential contribution of scientific knowledge is clear	↑ enhanced trust in researchers (no "stealth issue advocacy")
	6. Innovations in reward structures are present	No straightforward relationship as such, but willingness of actors to engage in JKP at all is likely enhanced		↑ more actors are rewarded for their participation in co-production
Resources	7. Specific resources are present	↑ enhanced mutual understanding of viewpoints and interests; learning each other's language; intimate human relationships; more efficient information transfer		

↑↑ = positive, ↓ = negative; ↓↑ = ambiguous.

Source Hegger et al. 2014.

6.1.9 Hegger et al. (2014)

A subsequent paper by Hegger et al. (2014) (*Toward successful joint knowledge production for climate change adaptation: lessons from six regional projects in the Netherlands*) carries out a comparative analysis of six Dutch adaptation projects using the framework above, i.e. the seven success factors.

The paper scores six adaptation projects. In relation to the success conditions, the "broadest possible actor coalition," "presence of innovations in reward structures," and "presence of specific resources" were most important. These conditions seem to be better met in the more successful projects.

Based on this, they propose two design principles for joint knowledge production: presence of broadest possible actor coalition, and presence of specific resources. They

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note that additional research is needed to determine the role of the other five success factors more precisely.

They report that what constitutes the broadest possible actor coalition depends not only on which actors are involved, but also on the mechanisms through which they are involved. Successful JKP is more likely in cases where actors make a conscious decision on the institutional location of the project around the research–policy nexus. They also conclude that success is more likely when the coordinating entity has characteristics of a boundary organization or knowledge broker. They also conclude that the most successful projects created a protected space for knowledge development, while establishing connections with ongoing policy processes.

With respect to specific resources, including facilities, boundary objects, and specific competencies increase the chance for success. While the exact arrangements were heterogenous, they include more than resources alone. They include the time inputs of actors, material arrangements (e.g. GIS maps, places to meet) as well as finances.

6.1.10 Groot et al. (2014)

Groot et al. (2014) set out some of the lessons from a detailed review of science practice interaction and practice orientated research for climate change adaptation in the brochure (*Productive Science-practice Interactions in Climate Change Adaptation*).

The report highlights this includes science-practice interactions between science and policy (developing adaptation policy), and between science and practice (implementing adaptation).

It reports that climate change and climate adaptation have features that make interactions challenging. Therefore, it stresses that practice orientated research may not be enough to take into account the culture, knowledge needs, vocabularies, constraints, roles and perspectives of policy makers and practitioners, in particular in the design and planning of the research. They therefore argue that practice-oriented research (for adaptation) needs to be complemented by and connected to more fundamental inquiry and concept development, which takes into account knowledge that has been developed in disciplinary sciences and on issues other than climate change adaptation.

The paper reviews the literature and provides some guidance for productive science-policy interactions (for adaptation), defined as exchanges between researchers and stakeholders in which knowledge is produced and valued as being scientifically robust and socially relevant. And especially if it leads to efforts by stakeholders to use or apply the research results in decision making or action.

It proposes that productive science-practice interactions should:

- Facilitate timely and coherent translation of research into policy options or advice;

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- Facilitate rapid uptake of research results by policy makers and/or practitioners;
- Alert policy makers and/or practitioners about emerging issues;
- Contribute to the scientific quality control process by allowing critical assessment of scientific outputs in light of users' needs and of other types of knowledge;
- Enhance strategic orientation of research in support of policies and societal issues;
- Allow for exchange and co-evolution of scientific, policy and practical knowledge, in a dynamic fashion;
- Fit within the political and institutional limits and pressures of policymakers, and resonate with their assumptions, exerting sufficient pressure to challenge them.

It usefully identifies three levels of engagement:

- Informing partners, in which scientists determine problem-oriented research questions and propose a strategy to address the problem. The proposal is then discussed with other parties (i.e. practitioners, stakeholders) to reach acceptance for the proposed strategy.
- Active exchange with partners, in which problem-oriented research questions are still mainly determined by the scientific community, but with regular exchanges with other parties from the start to develop a meaningful response strategy that will get support from the stakeholders.
- Joint development of research needs from the very beginning, in which all relevant parties are engaged actively in a process to jointly determine problem-oriented research questions and subsequently develop a strategy to address the problem ('co-production').

The guidance then proceeds through the steps in the productive science-practice interactions: start up: implementation and communication (and dealing with uncertainties).

In the start up phase, the guidance outlines the aim is to identify the users of the research and develop understanding about the context in which they are working and the decisions to be made. For a problem-oriented adaptation project, there is a need to identify all relevant users of the project output and to develop understanding about the political and organizational context in which they are operating, which can also lead to identifying groups of users with similar information needs.

The guidance highlights that climate change is usually one item on the decision makers' agenda, and not necessarily the most important. Climate policy and adaptation will, at least in part, be addressed by existing policy sectors and plans. There is therefore a need to understand the organizational context and how climate change adaptation is integrated in the policy agenda of the different sectors.

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The paper recommends that a needs assessment can help this, in which researchers and boundary workers closely interact with the potential users to find out which data and information they require for supporting adaptation decision making. When information and data needs have been clarified, it is useful to map the data and information that is already available.

To align knowledge supply and demand, the paper outlines it is essential for researchers and boundary workers to start projects with an open discussion with all relevant users on the climate data and information needs and how to accommodate these. To avoid generation of information and data which are finally not being used, it is important to ask the 'why question' behind the 'what question'. Such probing questions will help to understand how the climate data or information will be used in practice, or in the policy or decision-making process.

In the implementation phase, the process of interaction needs to be actively organized, supported and structured by using suitable methods. This includes a range of methods/techniques: Serious gaming; Strengths, Weaknesses, Opportunities and Threats (SWOT); Multi Criteria Analysis; Group model building; Scenario building workshops; and Touch table.

Reflecting the literature above, it highlights the benefits of making the project focus on concrete or tangible outputs and solutions. It also highlights the need to strike a good balance between practical relevance, legitimacy and scientific reliability of knowledge. As with other literature, it also recommends an iterative approach: developed and implemented stepwise, re-visiting the problem description and if needed re-adjusting the problem formulation.

It also describes the need to sustain participation over time, noting the time this takes is often underestimated. There tends to be less interaction and user involvement during the knowledge production phase itself (following the design at the start and the results and use at the end). It is therefore useful to plan a number of checkpoints in between – to help the different participants to keep in touch with the developments and help keeping the topic on the policy and practice agenda.

Given the time involved in co-production, it highlights that it can be useful to identify a set of concrete products (such as a roadmap, a scenario analysis, a development plan, a pilot case study or a modelling exercise) which can be jointly worked at and co-produced.

For the communication phase, the brief highlights the need to develop a common language. To do this necessitates regular face-to-face contact and exchanges. This needs to go beyond just agreeing joint vocabulary.

It provides some recommendations for communicating research results to decision makers:

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- Do not provide too much information. Avoid lengthy research reports and ensure the language is brief and to the point and avoid scientific jargon.
- Develop a common language to communicate effectively between policy and science: this can use professional knowledge brokers.
- Use plausible scenarios of the future relevant for policy formulation (over a range of spatial scales).
- Use visualizations (after testing) and employ user panels to assess proposed visualisations or other interactive communication methods.
- Communicate in terms of information packages linked to current and future policy challenges.

The guidance also has a section on uncertainty, providing a set of recommendations:

- Discuss uncertainty with policy makers and practitioners and provide them with recommendations for dealing with it (either deal with uncertainty, reduce uncertainty before making a decision, or revise that uncertainties are so large and act as a barrier to a decision).
- Agree on how to characterize climate change uncertainties, noting that policy makers will express uncertainty differently to scientists.
- Communicate uncertainty adequately, avoiding overly complex approaches.
- Support decision making by acknowledging uncertainties rather than trying to reduce them.
- Advise policy makers and practitioners on how they may deal with uncertainty.

A further publication (Hollaender and Groot, 2014) sets out the sequence of steps for advancing practice orientated research as follows:

- Identify users of research, including diversity of users;
- Develop understanding of work context, organisation, roles, objectives;
- Develop understanding of decisions;
- Identify opportunities for research to feed into decision making process;
- Assess end-use needs (needs assessment);
- Facilitate knowledge co-development;
- Produce concrete and tangible outputs;
- Ensure communication mechanisms.

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6.1.11 OECD (2016)

OECD (2016) (*Tools to mainstream adaptation into decision-making processes, Climate Change Risks and Adaptation: Linking Policy and Economics*) provides some practical lessons for engaging with policy makers. It highlights a number of useful points:

- Climate change policy does not occur in a vacuum, and it is essential to understand and integrate mitigation and adaptation within the existing socio-institutional landscape. This is particularly important since climate change will often be one of many policy objectives, and not necessarily the dominant one.
- Pragmatism is essential as any approach (or support, advice or tool) needs to fit with the resource, time, capacity and expertise available for policy or project analysts, otherwise there is a danger that it will not get used. This may mean a focus on providing information that is good enough, rather than perfect, particularly given the complexity of climate change.
- An important component of the policy practice process is to find relevant entry points, that is, to identify opportunities in the national, sector or project planning process where climate considerations can best be integrated. This requires an understanding of the existing policy and institutional framework as well as relevant national or sector development priorities. It is also important to consider how these linkages cascade through to implementation, as well as how they are located within the institutional and political contexts. These entry points will differ across sectors and national contexts (and between mitigation and adaptation).
- A key consideration is to align climate decisions to the policy and institutional landscape, and consider existing processes or guidance, such as project cycle steps and appraisal documentation already in place. This will be country, sector and even organisation specific, this cautions against the development of generic tools and approaches.
- The stage at the decision-making process when climate chance is considered is critical. It is important to ensure that the information is produced early enough in the process to influence the decision, or that are targeted at key windows or "intervention opportunities" (Ballard, 2014). This is particularly important when there are long-lived decisions or defined policy opportunities for change. For some decisions or investments, critical windows of opportunity to influence decisions may be very narrow.
- In practical terms, the path from identifying potential entry points through to implementing policy or measures is challenging. It requires the involvement of a diversity of users and stakeholders, finding relevant champions, building partnerships and providing support networks.
- As climate policy moves from theory to practice, barriers often make it more difficult for individuals, businesses and governments to plan and implement – especially for adaptation actions. These include economic, political economy and

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governance challenges. These barriers can result in less efficient or less effective adaptation, missed opportunities and/or higher costs.

- These includes market failures, as well as policy, behavioural and governance failures (Cimato and Mullan, 2010). Addressing these barriers is critical to climate policy. The consideration of these from the start of the policy process is important.

It also highlights some useful differences between mitigation and adaptation, and public and private decisions, that are relevant for COACCH.

- Mitigation and adaptation both aim to reduce the risks associated with climate change, albeit with different approaches. However, mitigation and adaptation policy decisions differ strongly, in terms of governance, aggregation level and decision makers (Watkiss et al., 2015). In practice, decisions on adaptation and mitigation are taken by different actors, operating across different sectors and on different scales and, importantly, managing different budgets.
- The "problem structure" of adaptation is different from mitigation. Mitigation is a global public good with a long-time dimension, whereas adaptation is relatively short-term and involves both public and private actors. The climate benefits of mitigation are global, while its costs and ancillary benefits arise locally. In most cases, both the costs and benefits of adaptation accrue locally and nationally. This has implications for governance as well. Decisions on adaptation and mitigation are taken at different governance levels and inter-relationships exist within and across each of these levels (Klein et al., 2007). Mitigation is primarily driven by international agreements and ensuing national public policies, possibly complemented by unilateral and voluntary actions, whereas most adaptation involves private actions of affected entities, public arrangements of affected communities, and national policies.
- For investment and private decisions, there is an added layer in that the primary appraisal approach is financial, not economic. The financial appraisal aims to assess the return on investment of options. This is a complementary approach to the economic analysis and approaches the issue from a different perspective, maximizing towards the individual, and excluding societal costs and benefits (such as external costs related to the environment). This means that the financial appraisal is undertaken from the view of an implementer with only private interests. It estimates the internal rate of return (IRR), which is a metric to evaluate projected cash flows and assess the feasibility of a project or investment. The costing is focused on market prices, and includes relevant taxes and charges (which are excluded in the economic analysis).
- Note that for some stakeholders (such as the European Banks) both a financial and an economic analysis is undertaken for investments. While there is a need to demonstrate a financial return (for loans) there is also the use of economic criteria to select projects with high economic benefits, which can be then offered concessionary loans.

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6.1.12 Mauser et al. (2012)

Mauser et al. (2012) (*Transdisciplinary global change research: the co-creation of knowledge for sustainability*) provides a useful framework for co-creation, shown below, with three main steps.

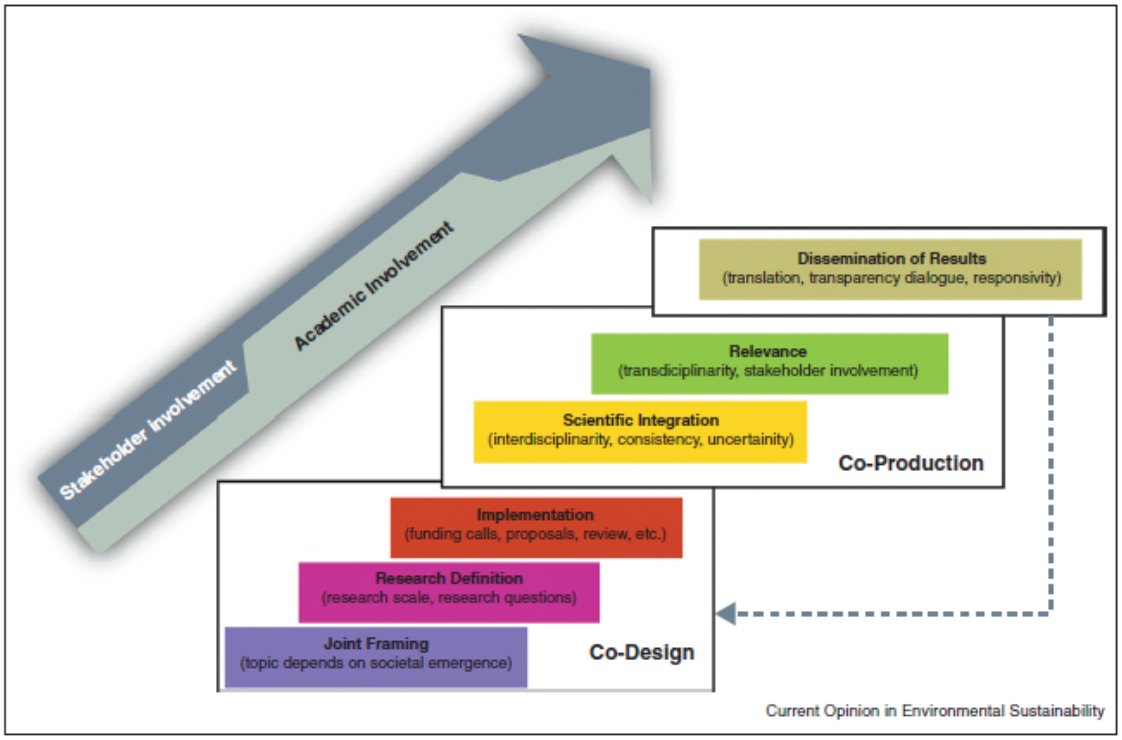

Figure 5. Framework for interdisciplinary and transdisciplinary co-creation.

Mauser et al. 2012.

The first phase is centred on co-design, with integration between stakeholders and decision makers from the relevant societal sectors to develop a viable research issue. The paper outlines that the process of co-design starts with the joint framing of sustainability challenges faced by society, then the translation into a definition of the required knowledge (and thus research definition). This is seen as the input to implementation through, e.g. research funding calls. The paper highlights that during the co-design phase stakeholders and academic participants work in a coordinated, integrated way to establish a common understanding of the research goals, to identify the relevant disciplines, participants and the integration steps and to agree on the roles the different groups have.

The second phase consists of co-production of knowledge. The focus is on scientific integration and during this phase integrated research is conducted, noting continuous exchange between participating scientists and stakeholders. There is a focus on interdisciplinary working, aligned to the overall needs of the project, with dialogue between stakeholders and scientists to ensure the societal relevance of the research.

The last step consists of the co-dissemination of the results among the different societal groups. This includes publication in accessible format, providing

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comprehensible and usable information for different stakeholders. The discussion of results also leads to new research questions, which initiates a new transdisciplinary research cycle.

The paper also provides some challenges to this process that must be overcome:

- Develop new processes and skills: Integration requires strong process-oriented skills (inter-personal, communication and facilitation), as well as organizational and managerial competencies, that are not always available and may require professional support or training.
- Deal with inertia to change: Integration requires critical reflection on the role of science in global sustainability and on the limitations of business-as-usual research. This, in turn, requires an openness to change, which is not necessarily easy or comfortable for those involved.
- Clarify roles, responsibilities and rules of engagement: Integration is research coordination, and different actors will have varying levels and forms of involvement in different parts of the process. This requires clarity about roles and responsibilities, about who makes decisions when, and about how to appropriately safeguard scientific integrity and relevant standards of quality.
- Establish integrated institutions: The disciplinary based practices and structures of existing research are not conducive to integrated efforts, and need to be supplemented with new, integrated structures.
- Develop support systems: Academic reward and career advancement systems, do not lend themselves to integration.
- Remove persistent inequalities: In terms of access to power and resources, as well as research capacities, there are persistent inequalities in science, which are a challenge to the deeper levels of collaboration that integration calls for.

To address these, the paper recommends,

(i) the design and implementation of new support and management structures,

(ii) the development of a diversity of skills for managing integration processes, including the necessary reward structures, and

(iii) adjustments to funding mechanisms, including selection and evaluation procedures.

6.1.13 Other papers and guidance documents

Durham et al. 2014 provides useful guidance on stakeholder engagement, even though it is focused on biodiversity (BiodivERsA Stakeholder Engagement Handbook: Best practice guidelines for stakeholder engagement in research projects). This also uses a three-stage approach, with co-design, co-production and co-dissemination, as shown in the figure below. Like many studies in this review, it considers that research and co-production needs to demonstrate credibility, relevance and legitimacy.

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It also has useful examples for engaging with stakeholders at different parts of the process, i.e. tools and methods for i) opening out ii) exploring, and iii) deciding.

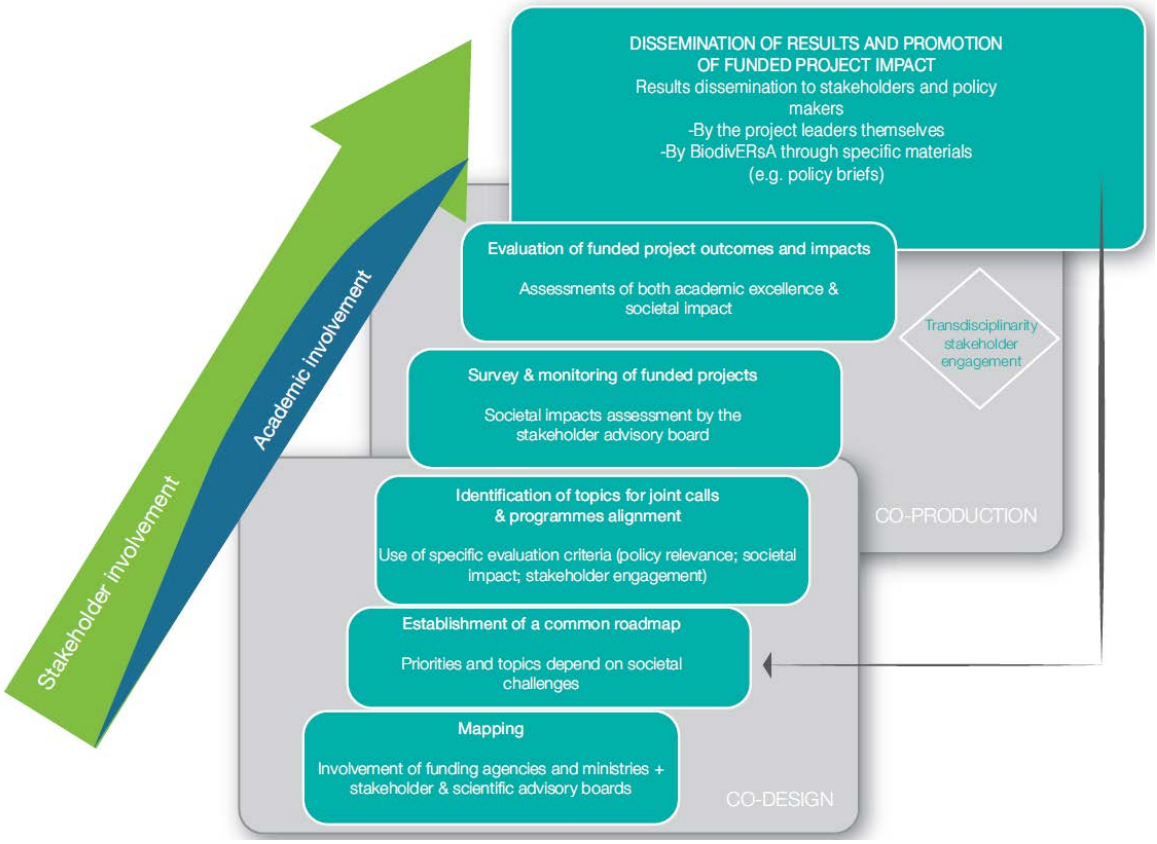

Figure 6. Approach to engage stakeholders and promote science-policy dialogue. Durham et al. 2014

Pohl et al. (2010) (*Researchers' roles in knowledge co-production: experience from sustainability research in Kenya, Switzerland, Bolivia and Nepal*) provide some discussion of interactive knowledge production, drawing on four examples of knowledge co-production. They highlight three basic roles through which sustainability researchers can meet the challenges of knowledge co-production: reflective scientist, intermediary and facilitator, and how these can address the challenges of co-production.

The N8 Research Partnership (Campbell et al., 2016) undertook a study to explore new models of 'co-production' (*Knowledge That Matters: Realising the Potential of Co-Production*). The report draws on the findings of pilot projects to examine the benefits and opportunities as well as the challenges and constraints of co-production approaches. The report states that co-production represents a qualitatively different form of research, and therefore the frameworks and criteria required to assess effectively the merits of proposals. The report draws together the lessons from the research programme to propose a series of recommendations, to assist in the effective implementation and development of co-production methodologies. These are split

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into those for research funders and those for academic institutions. These are more targeted at commissioning co-produced research, and the changing needs for researchers (including training).

There are also a number of co-design toolkits around (e.g. Boyd et al., 2010) that provide practical tips in specific contexts (notably health) which include useful guidance on engaging partners.

6.1.14 Tyler, 2013: Tips for working with policy makers

A commentary (Sutherland et al. 2013) set out 20 issues that policy makers should understand for interpreting scientific claims. The scientific robustness of the COACCH project means these are of less relevance, though some issues (differences and chance variation, dependencies) are important for extreme events and others (bias, sample size, etc.) are important for the new primary studies. In response, the UK Parliamentary Office of Science and Technology (POST) set out 20 things that scientists need to know about policy-making (Tyler, 2013)). This provides some useful practical tips. The most relevant of these are reproduced below.

- Making policy is difficult. Many policy decisions are not straightforward and public policy is more complex than it seems, involving a wide range of inputs, complicated interactions with other policies, and varied and unpredictable outcomes. Simple solutions to complex problems are rarer than most people think.
- No policy will ever be perfect. Whatever the decision, the effects of policy are almost always uneven, involving trade-offs between groups.
- Policy makers can be expert too. Scientists often consider themselves as the experts who engage with policy makers, but many policy makers are experts too (don't assume that you are the only expert in the room).
- Policy makers are not a homogenous group. "Policy maker" is at least as broad a term as "researcher". It includes government officials ranging from senior to junior, generalist to specialist, and to those in connected agencies and regional government, as well as all the people who might not directly make the decisions, but as advisers can strongly influence them.
- Policy makers are people too. Policy makers are people who, despite extensive training and the best of intentions, will sometimes make bad decisions and get things wrong, or may choose to act in their own interests.
- Policy decisions are subject to extensive scrutiny. It is regulated by professional guidelines, a variety of checks and balances, and scrutiny that comes from a wide range of institutions and angles.
- Starting policies from scratch is very rarely an option. While academics often recommend what to do if you were designing the system from scratch. But in practice, solutions need to evolve from within the existing system and they also need to be pragmatic.

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- There is more to policy than scientific evidence. Policies are not made in isolation. First there is a starting point in current policy, and there are usually some complex interactions between policies at different regional scales: local, national and international. Law, economics, politics and public opinion are all important factors; scientific evidence is only part of the picture that a policy maker has to consider. Most of the major policy areas that consistently draw criticism from scientists are far more complicated than just scientific evidence: climate change falls into this category.
- Economics and law are top in policy advice. When it comes to advice sought by policy makers, economics and law are top. Scientific evidence comes further down the pecking order.
- Public opinion matters. Many of the most important public policy decisions are made by people who were directly elected, and most of the rest are taken by people who work for them. Public opinion is a critical component of the policy process. The public is directly involved in many planning decisions and public opinion is a consideration. Complex policy areas are all heavily influenced by public opinion.
- Policy makers do understand uncertainty. It is commonly asserted by scientists that policy makers prefer to be given information that is certain, and that policy makers don't understand uncertainty. However, politicians are surrounded by and constantly make formal and informal assessments of uncertainty and government civil servants are expert at drawing up policy options with incomplete information (noting complete information is almost never at hand). That said, policy makers do not like information with so many caveats that it is useless.
- Policy and politics are not the same thing. Policy is mostly about the design and implementation of a particular intervention. Politics is about how the decision was made. Policy is mostly determined in government, where the politics is focused by ministers.
- Policy and science operate on different timescales. When policy makers say that they need information soon, they mean within days or weeks. If scientists want to engage with policy they need to be able to work to policy makers' schedule. Asking policy makers to work to a slower timetable will result in them going elsewhere for advice.
- It is also advisable to make your advice concise.
- There is no such thing as a policy cycle. Much of the applied science literature talks about "the policy cycle". This usually starts with an idea, moves through a sequence of research, design, implementation and evaluation, which then feeds back into the start of the cycle. In practice it is a lot more complicated. Policy making is iterative; the art of the possible.
- Policy makers aren't interested in science per se. A few are, but on the whole, policy makers tend to be more interested in research evidence to inform policy

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making. Policy makers care about research evidence insofar as it helps them to make better decisions.

- 'We need more research' is the wrong answer. Policy decisions usually need to be made pretty quickly, and asking for more time and money to conduct research is unlikely to go down well. Policy makers have to make decisions with incomplete so they get frustrated with researchers who are unable to offer an opinion without first obtaining funding for a multi-year research programme. This does not mean that more research isn't often needed; it is, but that this is the wrong answer to a policy maker seeking scientific advice.

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7. Appendix 2: Questions for Practice Orientated Research

Several studies in the literature identify questions to help progress practice orientated research.

Beier et al. (2016) set out a series of general framing questions:

- What is the issue at hand? What questions are being addressed? What topics are included or excluded from consideration?
- What decisions are being made? Are they flexible or limited in scope?
- Who will use the scientific information (including downstream uses) and how will they use it?
- In what form, process, or product will the data be most useful to the users?
- Given that decisions must be made before the science can be "settled," what is a realistic expectation of what is possible and useful within the available time and budget?
- What is necessary to make data accessible to all projected users? Who will own the data or other products? Where will the products reside?
- What would success look like for all parties?
- What alternatives are available to achieve success? What is gained or lost by pursuing one alternative over another?
- What variables does the decision maker care about? What resolution of data? What spatial extent? What level of precision is realistic, achievable, and adequate for the decision? If such precision is not feasible, should the project be abandoned or modified?
- What is the planning time horizon? Is this horizon appropriate for the purposes agreed on by the stakeholders?
- How will uncertainty be addressed? To what extent can multiple projections (e.g., emission scenarios, general circulation models) bracket uncertainty?

Vincent et al. 2017 identify a series of decision driven questions, i.e. to help the co-design process:

- What problem or decision are we trying to address with the research?
- Do we know enough about user needs?
- Do we know enough about the context in which the research (outputs) will be used?
- How are the target decisions in the relevant sector made, and how will the research inform this?
- Who makes decisions (that are influenced by climate change)?

They also provide questions to ask stakeholders to determine interest:

- To what extent does the climate affect their planning and decisions?
- What interest do they have in climate risk and climate change?
- What information do they want from you?
- Who else might be influenced by their opinions?

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- Who else do they think should be play a role in co-producing knowledge?

With respect to early interview, Vincent recommend the following questions (adjusted here for the climate change context)

- What are the biggest challenges that you face? What role does the climate play in that?
- How does/has weather and climate affect(ed) your activities (in the past)?
- What weather and climate information do you use? (and where is it from?)
- For what purpose do you use this information for? What decisions does it inform?
- Are there limitations to the information that you use? (i.e. is it available for the appropriate time and spatial scale; do you understand it fully; does it provide the information that you need to make decisions?)
- What information would you like to be available? How would you use it?

ECONADPT (2016) identified initial survey questions such as:

- What decisions are they are making?
- What methods do they currently use to make decisions?
- What information sources they consult?
- What time frame do these decisions get made in?
- What sorts of methods and/or data in what format would help make better decisions?
- What time frame would they need these in order for them to be useful?

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