



PLANNING AND EVALUATING THE SOCIETAL IMPACTS OF CLIMATE CHANGE RESEARCH PROJECTS:

**A guidebook for
natural and physical
scientists looking to
make a difference**

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FOREWORD

As scientists, we aim to generate new knowledge and insights about the world around us. We often measure the impacts of our research by how many times our colleagues reference our work, an indicator that our research has contributed something new and important to our field of study. But how does our research contribute to solving the complex societal and environmental challenges facing our communities and our planet? The goal of this guidebook is to illuminate the path toward greater societal impact, with a particular focus on this work within the natural and physical sciences.

We were inspired to create this guidebook after spending a collective 20+ years working in programs dedicated to moving climate science into action. We have seen firsthand how challenging and rewarding the work is. We've also seen that this applied, engaged work often goes unrecognized and unrewarded in academia. Projects and programs struggle with the expectation of connecting science with decision making because the skills necessary for this work aren't taught as part of standard academic training.

While this guidebook cannot close all of the gaps between climate science and decision making, we hope it provides our community of impact-driven climate scientists with new perspectives and tools. The guidebook offers tested and proven approaches for planning projects that optimize engagement with societal partners, for identifying new ways of impacting the world beyond academia, and for developing the skills to assess and communicate these impacts to multiple audiences including the general public, colleagues, and elected leaders.

We would like to thank our colleagues in the Climate Assessment for the Southwest (CLIMAS), the Southwest Climate Adaptation Science Center (SW CASC), the Northwest Climate Adaptation Science Center (NW CASC), and the Great Lakes Integrated Sciences and Assessments (GLISA) for inspiring this work and for their contributions to making our communities and environments healthier and stronger, even as we face the challenge of climate change.

Sincerely,

*Alison Meadow
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A background image of a glacier, showing white ice and blue water, is visible on the left side of the page. The title 'INTRODUCTION' is in a teal color.

INTRODUCTION

As scientists, we aim to generate new knowledge and insights about the world around us. We often measure the impacts of our research by how many times our colleagues reference our work – an indicator that our research has contributed something new and important to our field of study. Considering the challenges facing our society and environment, this type of impact is no longer enough. Many researchers are seeking ways to have greater and more direct impacts on communities and our environment by helping solve complex challenges such as climate change.

But how can we structure our research to contribute directly to solving the complex social and environmental challenges facing our communities and our planet? This guidebook offers techniques to help researchers plan to increase their impacts beyond academia as well as document and evaluate those impacts. In order to identify and describe the impacts that may be generated by research, we use a set of five impact types that range from creation of new connections between researchers and partners in broader society to tangible, beneficial changes in social and/or ecological systems (i.e. socio-ecological systems). Collectively, we refer to this range of impacts as societal impacts.

The framework we present is applicable to all types of academic research. However, we specifically tailored this guidebook for physical and natural scientists working in the field of climate change. Global society is in a moment where swift and intentional action is needed, but it seems difficult to know which actions will be most effective and for whom. The environmental and societal challenges associated with climate change are diverse and complex. It is necessary to understand how climate research can most effectively guide climate action, where it has been most successful doing so, and reveal the types of action that are currently missing.

This guidebook is formatted into three main parts. In the first part we provide background information about the societal impacts of research. In the second part, we present a framework for planning for and assessing the societal impacts of research, including worksheets and case studies. The third part contains a series of appendices that provide additional context for the information in this guidebook.

PART 1.

Introducing Societal Impacts

Why consider the societal impacts of research?

The harmful social and environmental impacts associated with global warming and climate change present urgent and complex challenges for humankind. These challenges have encouraged natural and physical scientists to make their research more responsive to communities, resource managers, and policy makers. Many researchers choose the profession because they see possibilities for generating new knowledge to benefit the environment and society. However, academic researchers are not always supported by their institutions or departments to engage with societal partners, produce research outputs for public audiences, or conduct applied research.

Funders and universities are starting to pay more attention to the ways that academic research generates positive impacts for society – in economic terms and far beyond. In much of Europe, the United Kingdom, and Australia, universities are required to report on their societal impacts as part of the requirements to receive federal research funding. In the U.S., the National Science Foundation (NSF) includes broader impacts criteria in its

funding calls, which require applicants to describe their plans to achieve impacts beyond the production of high-quality research. For example, applicants may develop activities that connect their fundamental research efforts to empowering people and improving their quality of life.¹ Other federal funding programs also expect researchers to engage with decision makers in the course of producing “actionable” or “usable” knowledge. The Department of the Interior’s Climate Adaptation Science Center network is one example; the National Oceanic and Atmospheric Administration’s long-running Regional Integrated Science and Assessment program is another. Both programs award 5-year grants to academic institutions that can demonstrate skill and experience in producing science about climate variability and change that can be directly linked with resource management and policy making. Crafting a societal impacts plan and an evidence-based assessment of project impacts can improve your chances of receiving funds from agencies that prioritize societal and broader impacts.

¹ See for example NSF Dear Colleague Letter 21-059, A Broader Impacts Framework for Proposals Submitted to NSF’s Social, Behavioral, and Economic Sciences Directorate.



Larger issues of trust and accountability are also in play in considering societal impacts. Academic researchers can help build relationships of trust between universities and their surrounding communities through public engagement and problem-solving at a local scale. The Association of Public and Land Grant Universities' recent report, *Public Impact Research: Engaged Universities Making the Difference*, makes the case that using public impact research along with fundamental research, "communicates powerfully to the public the value of university research and could help restore public trust in our institutions." Researchers contribute to their university's trust-building work through effective engagement and by documenting impacts in local, regional, or international communities.

At the scale of individual researchers, societal impacts have not often been included in academic assessments for promotion and tenure. This trend, however, is changing. For example, Purdue University now includes promotion and tenure criteria that is specific to engaged scholarship.² Other efforts have been made to broaden academic performance metrics beyond the restrictive focus on publications, citations, and grants and include measures of societal relevance and impact.³ A well-crafted and well-supported statement on the societal impacts of research can be integrated into performance review and promotion packets as an example of outreach and service.⁴

2 Abel, Steve, and Rod Williams. 2019. *The Guide: documenting, evaluating and recognizing engaged scholarship*.: Purdue University, Office of Engagement.

3 See for example:

Alvesson, Mats, Yiannis Gabriel, and Roland Paulsen. 2017. *Return to meaning: A social science with something to say*: Oxford University Press.

Foster, Kevin Michael. 2010. Taking a stand: Community-engaged scholarship on the tenure track. *Journal of Community Engagement and Scholarship* 3 (2):20.

Hicks, Diana, Paul Wouters, Ludo Waltman, Sarah De Rijcke, and Ismael Rafols. 2015. Bibliometrics: the Leiden Manifesto for research metrics. *Nature News* 520 (7548):429.

4 See Appendix D for more information regarding concerns about the role of societal impacts in academic performance reviews.



What are Societal Impacts?

Societal impacts are the ways that research, and the process of conducting research, influences the world beyond the academic realm.

While often in the climate and environmental sciences, we aspire to long-term and large-scale impacts like measurable risk reduction or changes in ecosystem health, these kinds of impacts take substantial time to develop and are dependent on a wide range of variables, such as the ability of societal partners to enact new policies or practices. For example, a forest may not be demonstrably more resilient to fire in the span of 2-3 years—the length of a typical research grant. Likewise, a city may not know if it is more resilient to storm surges until the next time a large storm hits. However, there are a range of nearer-term impacts that occur along a pathway to long-term and large-scale impact that can tell us about the ways in which our research is helping to make beneficial changes.

In this guidebook, we present five categories of societal impacts. However, we focus on four that are more likely to manifest on short- to medium-term timescales. We can observe and document these impacts and use them as indicators of the likelihood of future socio-environmental impacts. Throughout this guidebook, you will see most of our discussion involves the first four categories, but we will occasionally reference the fifth (socio-environmental impacts) as part of the larger context of impacts evaluation.

FIVE CATEGORIES OF SOCIETAL IMPACTS



Instrumental applications

your research led to tangible changes to plans, decisions, practices, or policies



Conceptual impacts

your research contributed to changes in people's knowledge about or awareness of an issue



Capacity building impacts

your research contributed to enhancing the skills, expertise, or resources of an organization or group of people








Connectivity impacts

your research led to new or strengthened relationships, partnerships, or networks that endure after the project ends



Socio-environmental impacts

changes to social and/or ecological systems, such as improvements in health and well-being or in ecosystem structure and function, that result from actions taken because of your research.

Societal impact categories	Example in practice #1	Example in practice #2
<p>Instrumental impacts</p> <p>Changes to plans, decisions, practices, or policies</p> 	<p>"We worked with the staff of the local wildlife management agency throughout this research. When it came time for them to update their species management plan, they cited our report and journal article in the plan. They also asked both myself (PI) and my Co-I to review their plan to ensure that the research findings were explained accurately."</p>	<p>"The state Department of Transportation used our research findings regarding drought and the sources and patterns of dust storms, which have caused numerous highway casualties, to apply for federal funds to improve highway signs, warnings, and road markings. Funding was approved; new infrastructure was installed in 2017."</p>
<p>Conceptual impacts</p> <p>Changes in people's knowledge about or awareness of an issue</p> 	<p>"Health professionals who participated in this project reported that they understood the science behind regional temperature projections much better than when the project started. Two of these professionals took the initiative to present the findings of our research to an internal group in their health center, in order to explain the research methods and findings to their colleagues."</p>	<p>"Results from our paleoclimate project, conducted with a federal agency, provided new insight into how temperatures impact streamflow and drought in the Colorado River basin. During subsequent meetings, water managers explicitly discussed how they could apply this insight into new techniques for water management."</p>
<p>Capacity building impacts</p> <p>Enhancing the skills, expertise, or resources of an organization or group of people</p> 	<p>"Three graduate students, from backgrounds often under-represented in STEM fields, participated in this project. They gained data collection, analysis, and project management skills, participated in the writing of four academic papers, and all three were accepted into post-doctoral climate research programs."</p>	<p>"We provided municipal planners with data about flooding impacts on their city. We worked with them in several workshops and phone calls to ensure the data were clearly presented and addressed the planning needs of the city. Our partners have said they already feel more confident and capable when discussing flooding with city residents."</p>
<p>Connectivity impacts</p> <p>New or strengthened relationships</p> 	<p>"A group of city planners met for the first time at a workshop we held as part of our project. After the workshop, this group began meeting regularly to collaborate on a funding proposal for their city. They continue to invite me [the researcher] to attend their meetings, and I do on a regular basis."</p>	<p>"In 2015, utility employees identified several climate and environmental risks that could impact their operations. Our research team provided them with tailored data and analyses to address their concerns. A year later, utility employees contacted us again to propose collaborating to develop scenarios for carbon reduction. has turned into an ongoing new project."</p>
<p>Socio-environmental impacts</p> <p>Changes to social or ecological systems, such as improved health and well-being or ecosystem structure and function</p> 	<p>"Our research team modeled the likelihood of future heatwaves in our region. After working with us on the research project, the City revised its extreme heat response protocols. We now have 10 years of data on heat-related deaths in the city which show a significant decline, despite the fact that we've had more and hotter heatwaves during this same 10-year period."</p>	<p>"We worked with local residents to develop a reforestation plan, using findings from previous research. The residents got funding from the City for the project and they planted over 200 trees. Over the last three years, residents noticed that several bird and mammal species had repopulated the area. The reforestation plan is bringing back biodiversity to the region."</p>

These categories do not represent all possible types of societal impacts.⁵ However, they provide a foundation for exploring the societal impacts of climate-related research. If your research generates impacts that do not fit in one of these five categories, you can still use the framework presented in this guidebook to identify and document your research impact and insert your own impact categories as appropriate.⁶

Impact categories are not hierarchical – one is not more important than another. They all represent meaningful results from the process of conducting research. Impacts may interact within and across categories and will often amplify each other. For example, a network established to connect researchers and policymakers may improve relationships and trust among network members. Within the network, policymakers feel free to ask key questions, consider new data, and ultimately become sufficiently confident in the research to include it in a new environmental policy. All the impact categories can contribute to beneficial socio-environmental changes. They are worth tracking to understand the changes that have already occurred; they also indicate the likelihood that more changes are coming.

⁵ Other frameworks can be found in:

Pedersen, David Budtz, Jonas Følsgaard Grønvad, and Rolf Hvidtfeldt. 2020. Methods for mapping the impact of social sciences and humanities—A literature review. *Research Evaluation* 29 (1):4-21.

Reed, Mark S. 2018. *The Research Impact Handbook*. 2nd ed: Fast Track Impact.

Edwards, David M, and Laura R Meagher. 2020. A framework to evaluate the impacts of research on policy and practice: A forestry pilot study. *Forest Policy and Economics*. 114: 101975.

⁶ See Appendix A for further discussion about categories of societal impacts.



How do researchers generate societal impacts?

There are several pathways that connect research to societal impacts. Often, they flow through the following steps:



#1. You do robust, credible, and relevant research.



#2. That research connects to society.



#3. Societal partners use that research.

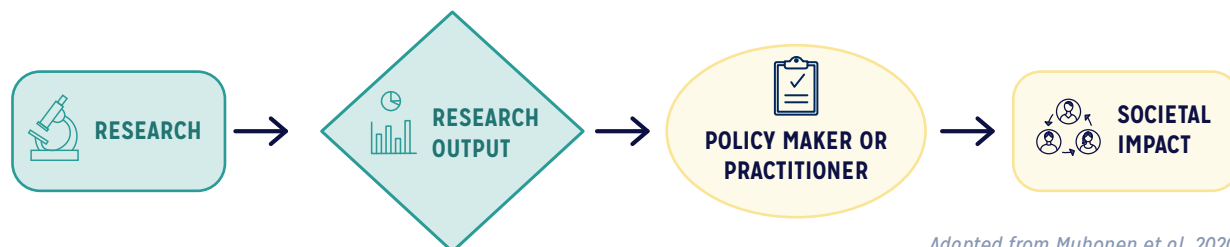


#4. That research changes something in the world.

It is in Step #2 – how research connects to society - that a number of different pathways toward generating societal impacts open up. We introduce a few of these pathways below.

Indirect Connections between Research and Research Users

One pathway involves indirect connections between researchers and research users. Perhaps someone comes across your research findings in a book, journal article, or report and uses it to address their needs. They might cite these research findings in a management or policy document. Along the indirect pathway, the researcher and the person using research findings never interact in person. Indirect pathways are sometimes referred to as a “classical pipeline” or “loading dock” model.⁷



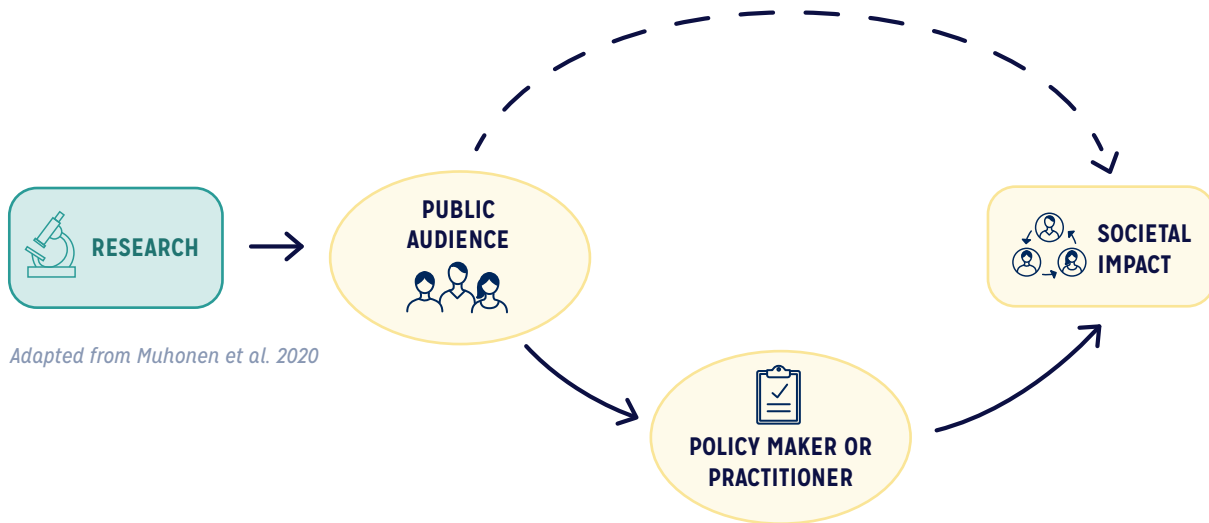
Adapted from Muhonen et al. 2020

⁷ Read more about the “classical pipeline” pathway in: Muhonen, Reetta, Paul Benneworth, and Julia Olmos-Peñuela. 2020. From productive interactions to impact pathways: Understanding the key dimensions in developing SSH research societal impact. *Research Evaluation* 29 (1):34-47.

Read more about the “loading-dock” model in: Cash, D. W., J. C. Borck, and A. G. Patt. 2006. Countering the loading-dock approach to linking science and decision making - Comparative analysis of El Nino/Southern Oscillation (ENSO) forecasting systems. *Science, Technology and Human Values* 31 (4):465-494.

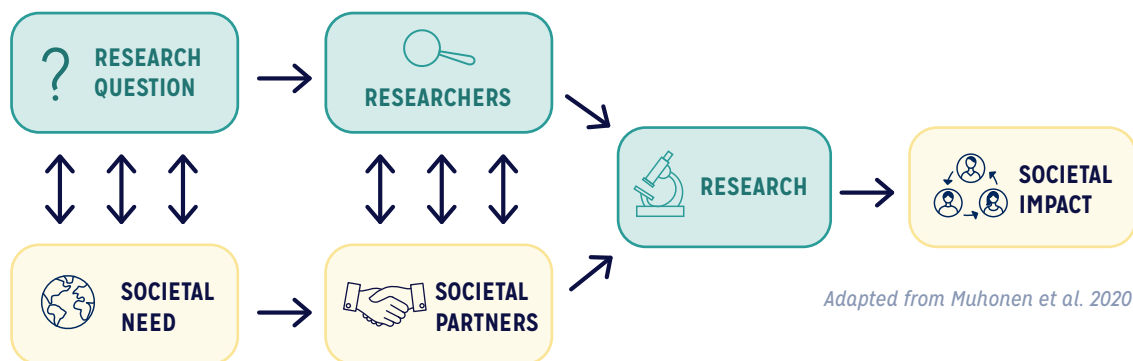
Connecting through Public Engagement

A second pathway involves public engagement activities like giving talks to the general public or having your research appear in news media, social media, or popular media like podcasts. In this case, members of the public may choose to use your findings in their lives and the information might be conveyed from the general public into a policy or practice use, such as if citizens advocate for a particular governmental action.



Direct Engagement Between Researchers and Societal Partners

A third pathway involves direct engagement between researchers and societal partners over the course of a project. These partners might include natural resource managers, policy makers, or those responsible for managing the impacts of climate change within their community, city, region, or country.



This guidebook focuses mostly on this third pathway – direct interaction between researchers and societal partners throughout the research process. This pathway stems from decades of evolution in socially-engaged research practices, which are more consistently effective in generating research that is useful to and used by society.⁸ This approach might involve interactive activities such as: researchers and societal partners jointly developing research questions and project design, conducting fieldwork together, collectively analyzing data, and producing co-authored outputs, such as papers or reports.

Who are societal partners?



In this guidebook, we use the term “societal partners,” or “partners” for short, to refer to people who are engaged in a research project but live or work outside of the formal, academic research enterprise. Other common terms for this group of people include practitioners, decision makers, stakeholders, and community partners. Our use of the term societal partners indicates that the people engaged in the research process, and those who are affected by the research, are active participants in the research effort—not passive recipients of the research outcomes.

Although engaged research approaches are the most effective in moving research into use, these approaches come with some challenges. They tend to be more time and resource intensive, which imposes some “costs” on participants in terms of their own time, energy, and resources. This is true for both researchers – who also need to devote time and energy to their academic impacts – and for societal partners – who also need to devote time and energy to their own work and life responsibilities. Often, societal partners are asked to participate in multiple research efforts due to their unique perspectives or experiences. It is important to be aware of partner burn-out⁹ and researcher stress.¹⁰ Some of these additional “costs” can be mitigated through careful project planning and ensuring adequate research funding and time.



⁸ See Appendix B for more information on socially-engaged research practices.

⁹ Young, Nathan, Steven J Cooke, Scott G Hinch, Celeste DiGiovanni, Marianne Corriveau, Samuel Fortin, Vivian M Nguyen, and Ann-Magnhild Solås. 2020. “Consulted to death”: Personal stress as a major barrier to environmental co-management. *Journal of environmental management* 254:109820.

¹⁰ Cvitanovic, Christopher, Mark Howden, RM Colvin, Albert Norström, Alison M Meadow, and PFE Addison. 2019. Maximising the benefits of participatory climate adaptation research by understanding and managing the associated challenges and risks. *Environmental Science & Policy* 94:20-31.

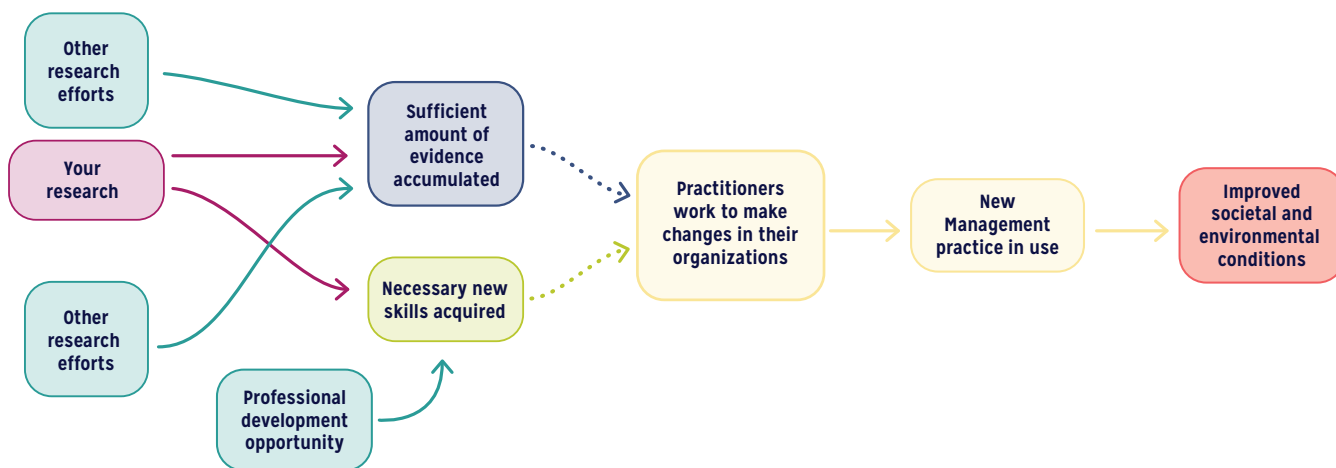
Contribution or Attribution?

Although it can be tempting to try to connect a research effort to a new policy or to an environmental change, generating societal impacts from research is rarely a straight line. It is not always (quite rarely, really) possible to attribute a change in policy, practice, or in the socio-ecological system directly to one particular research finding or project. Multiple factors influence whether research is used and what impact it has for the intended users. Perhaps your partners realize they need to build more internal capacity before being able to move forward with a new plan. Or, as is often the case, the organization's decision-making framework may require evidence from multiple sources before feeling confident in taking action. Sometimes, a perfectly planned and executed project does not result in anticipated changes due to factors outside of your control, such as budgetary constraints or changes in leadership.

Although it is not always possible to attribute specific impacts to individual projects, it does not mean that a project has not been successful. More often, research has been a contributing factor – or one of several factors – in creating change. While a singular research project or finding is not typically the sole factor in generating an impact, we can still illustrate how and in what ways it contributed to the impact. Contributing to change is a positive outcome and should be reported as such.

In a contribution model, like the one below, you might see that your research was one part of the process of making changes in practice that ultimately contributed to improved environmental conditions.

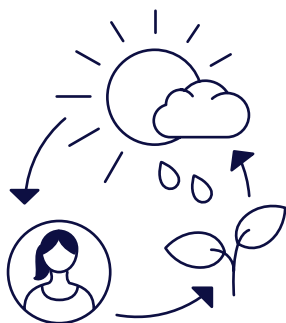
How Research Contributes to Societal Impacts



First, your research might be one of several projects examining the phenomenon in question. A management agency is likely to require several sources of evidence before it is willing to consider a change in practice. Therefore, having your research as part of that evidence is crucial to the process. Second, a change in practice may require agency staff to develop new skills. The agency may seek that training from another source and that source becomes another contributor to the impact. When the new evidence and training is combined, the agency may be more able and willing to make the change in practice. However, work still must take place within the agency to craft new policy language, move it through internal decision channels, and secure appropriate funding – all of which require significant effort and know-how on the part of agency personnel. In this example, that change in practice eventually leads to improved environmental outcomes. The conceptual model below illustrates how one research project is part of a larger system that supports a change in practice and, ultimately, a change in environmental conditions. While your research project may not be solely responsible for changes in practice, policy, or socio-environmental conditions, using a contribution model like this one helps demonstrate how your work has contributed to those greater impacts.”



11 See Appendix C for more information about the challenges of documenting societal impacts.



PART 2.

Societal Impacts Planning and Assessment Frameworks

The process for identifying and documenting research impacts presented in this guidebook is built on an outcome-oriented logic model framework.¹² Logic models have similar basic components, but do not always look the same. They can be adjusted to apply to projects and programs in multiple ways. Logic models are not rigid; they are flexible tools that can be used in a variety of ways. A general way to understand logic models is that they offer a comprehensive explanation of how and why a desired change is expected to happen in a particular context. This framework invites researchers to make explicit connections between project resources, activities, outputs, and how these lead to specific impacts or changes.

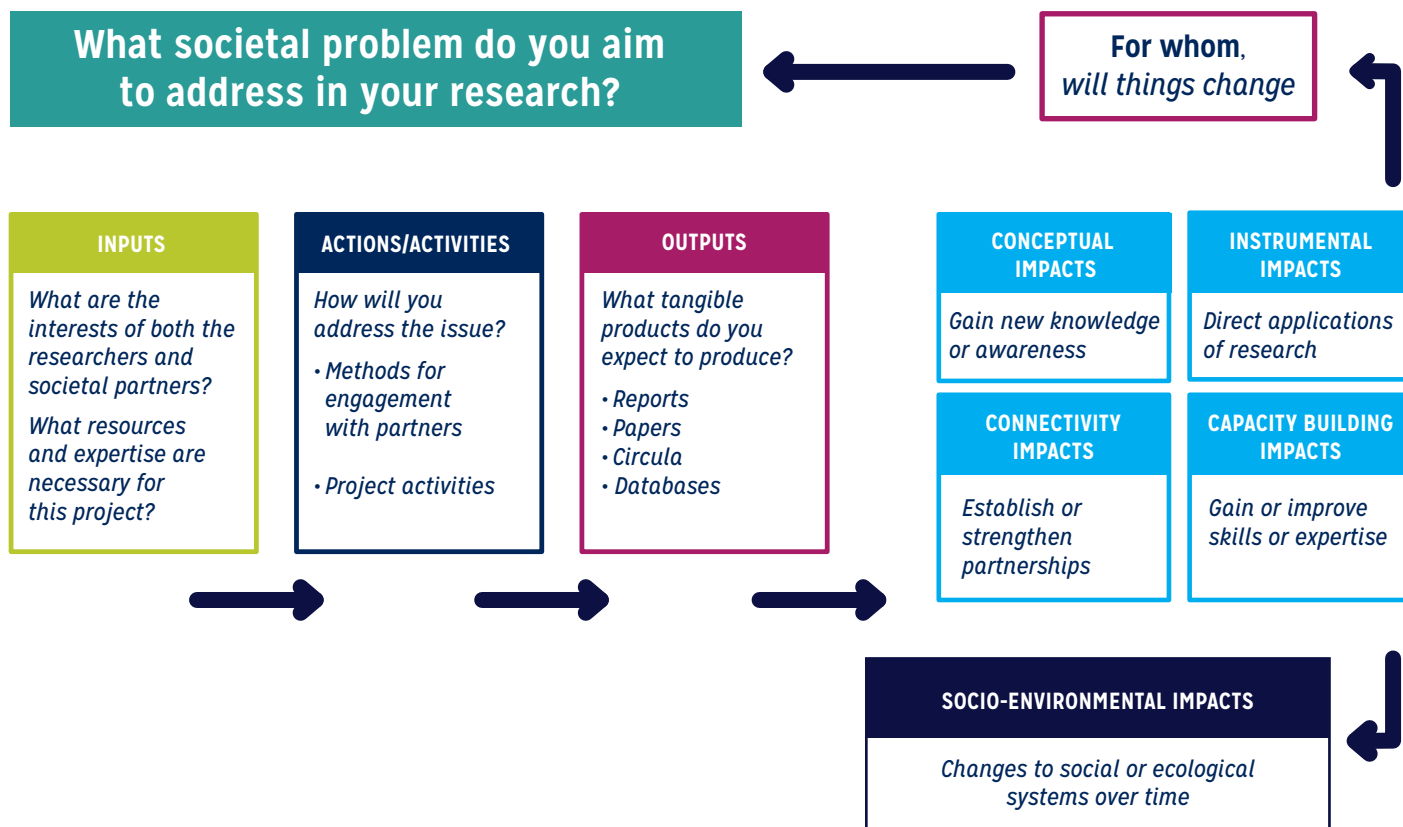
In this section, we present two applications of the logic model framework. The first variation is meant to guide researchers who are in the planning and design stages of a project. The second variation is geared toward researchers who are in the middle or final stages of a project and want to document impacts that have already occurred. To illustrate how this framework functions, we will work through both variations separately and apply them to a case study example about coastal flooding and sea level rise.

2.1 Framework for Project Planning and Design

Generating societal impacts requires re-thinking the way research projects are designed. For example, the degree to which societal partners are involved (or not) at various steps of the research process will determine the types of impact.¹³ Used during research planning, design, and proposal writing stages, the following logic model framework encourages researchers to think through and explicitly connect what they anticipate doing and producing during their project, to the societal impacts they anticipate achieving at the end of their project.

¹² See W.K. Kellogg Foundation <http://www.wkkf.org/knowledgecenter/resources/2006/02/WK-Kellogg-Foundation-Logic-Model-Development-Guide.aspx>

¹³ Shirk, Jennifer L, Heidi L Ballard, Candie C Wilderman, Tina Phillips, Andrea Wiggins, Rebecca Jordan, Ellen McCallie, Matthew Minarchek, Bruce V Lewenstein, and Marianne E Krasny. 2012. Public participation in scientific research: a framework for deliberate design. *Ecology and society* 17 (2).



PROBLEM STATEMENT

What societal problem do you aim to address in your research?

Write out the specific societal or environmental issue that your research addresses. It should speak to the broader issue that your research will inform. Most likely, it will be different from your actual research questions or objectives. In your statement, include who is affected by this issue.

Floodsville Project Problem Statement:

A tropical storm caused major flooding in a neighborhood of the City of Floodsville. Ocean water breached the existing coastal wall, leading the city's planners and emergency managers to question whether they had the most accurate projections for sea level rise. They need to up-to-date sea level rise information so they can make better informed policies and decisions for the future of the city.

INPUTS

- **What resources are available or necessary to conduct your research?**
- **What are the interests of both the researchers and the research partners?**

Describe the inputs that you have available or that you will need to conduct your research. Your inputs will vary depending on the type of project you are conducting. Fundamental resources include time and funding. Consider the human resources needed to carry out your research, including skills, types of knowledge, and expertise. Describe the members of your research team (including yourself) and the expertise, knowledge, and skills each person offers to the project. If you do not already have a research team established, write down the types of members you will seek out. Once your team is established, each member should think through their individual motivations for participating in the research. What kinds of societal impact goals motivate each research team member? How will they contribute toward those impacts? The financial and human resources available and the motivations of the research team will drive the research design, as well as the project's activities, outputs, and impacts.

Floodsville Project Inputs:

Human resources needed:

- Climatologist with skill in climate modeling, experience with sea level rise
- GIS specialist to map model projections
- Floodsville City official with knowledge about city policies and the climate adaptation plan and connections to city planners and emergency managers
- Neighborhood Association representative where flooding occurred
- Social scientist to gather qualitative data about residents' experiences

Physical resources needed:

- Funding for climate modeler, GIS specialist, social scientist, neighborhood association representative
- Time from city officials who participate in the project
- Time from community members who participate in the project

Motivations, objectives, and interests of the research team:

- Climatologist: to apply their modeling knowledge to a specific societal issue
- GIS specialist: to fulfill their contract, but wants to help solve the City's issue
- City official: to ensure safety for the future of the City
- Community member: to ensure safety for neighborhood residents
- Social scientist: to engage with local community members and help inform a better adaptation plan

ACTIVITIES

- ***What activities will you do to address the broader societal issue?***
- ***Do your proposed project activities incorporate the project inputs and the interests of your research team?***

In the activities section, focus on the infrastructure of your project, which may include things such as: a calendar timeline of your proposed activities; the research methods you will use; a description about how you and your research team plan to interact and communicate throughout the project; or describing the responsibilities of each member of the research team.

Floodsville Project Activities:

This two-year project will include two main components of research:

1. Risk assessment: analyzing current climate models for sea level rise for the region around Floodsville. The climatologist will run the model analyses and produce downscaled climate projections. She will coordinate with the GIS specialist to construct risk maps for the region based on these analyses.
2. Qualitative analysis of people's experiences with the flood and future plans to deal with flood risk. The social scientist will coordinate with the community representative and the Floodsville city official to develop protocol for focus groups with the neighborhood association and with city planners and emergency managers. Three focus groups will occur with the neighborhood association and three will occur with the city planners and emergency managers in the first year.

The entire research team will meet monthly throughout the project to discuss updates and coordinate next steps. Between regular meetings, team members will communicate via email and phone as necessary.

At the end of the project, the research team will present findings and recommendations for the city's adaptation plan to city officials, planners, and emergency managers. We will also present our findings at a neighborhood association meeting.

OUTPUTS

- **What do you plan to produce through your research?**

In this section, write out the tangible research outputs that you and your team plan to produce over the course of your project. These outputs may include several different types of products, such as: data analyses and models; public outreach materials; white papers and peer-reviewed articles; teaching curricula or training materials; reports tailored to specific audiences; websites; or fact sheets. As you outline this section, think about when you want these outputs to be completed, keeping in mind that some of them may fall outside of your anticipated timeline.

Floodsville Project Outputs:

1. Climate model analysis
(Completed in 6 months)
2. Risk map of Floodsville region
(Completed by end of Year 1)
3. Policy recommendations for City's Adaptation Plan regarding sea level rise
(Completed in 18 months)
4. Fact sheet report for neighborhood where flooding occurred (printed and available on City website; completed by end of Year 2)
5. Peer-reviewed paper submitted
(completed 1 year after end of project)



IMPACTS

- ***What do you expect to change as a result of your activities, your interactions with the public and your research partners, and your outputs?***
- ***For whom will things change or who will change because of your research?***

In this section, think through the types of impacts you anticipate having through your research project. Your impacts section does not need to be comprehensive, but it should contain a list of attainable goals. As we know, research projects often do not proceed as intended. Not all research projects will yield outcomes in all categories. Achieving one impact may depend on accomplishments in other impact categories. At the end of a project, you may also discover several unanticipated impacts.

We suggest starting with the first four of the five categories of impact we introduced earlier in this guidebook, which include:

- Conceptual impacts – new knowledge or awareness gained
- Connectivity impacts – partnerships established or strengthened
- Capacity building impacts – skills or expertise strengthened or acquired
- Instrumental impacts – direct applications of research

As you work through your anticipated impacts, define who your societal partners are, such as: resource management agency representatives, policy makers or government officials, community members, industry professionals, students, or members of the general public. As part of this section, you might also consider the demographics of the people who will be impacted by your research. Will your research impact the audiences that you aim to reach?

Floodsville Project Impacts:

Conceptual impacts

- City officials, planners and emergency managers have a better understanding of future flood risk and sea level rise; they also understand the experiences of the residents whose neighborhood was flooded
- Neighborhood residents have increased awareness about why the recent flooding happened and the future impacts they might face
- Researchers have a better understanding of the city planning processes and experiences of flooding in the city

Capacity building impacts

- City residents feel better equipped to prepare for future flood risk
- City officials feel equipped to discuss climate projections and make decisions to address future flood risk

Connectivity impacts

- Connect city officials with neighborhood residents
- Increase connections between emergency planners and city managers – currently there is little communication between these agencies.

Instrumental impacts

- Inform Floodsville's new multi-hazard mitigation plan regarding flood
- Inform emergency management policies to deal with future flood risk

Socio-ecological impacts (long-term aspirations)

- As sea-level rise occurs, Floodsville does not experience any further flooding
- Floodsville saves significant amounts of money by implementing actions from their hazard mitigation plan

PLANS TO COLLECT EVIDENCE OF CHANGE

- *How will you know that your research changed things for people?*

Your research design should incorporate plans to systematically collect pieces of evidence that corroborate the impacts of your research. Some research projects will require external evaluation, which can generate high quality data from formal surveys, interviews, and even randomized control trials. However, societal impacts evidence can also be collected by research team members and societal partners. These sources of evidence might include: feedback from partners in the form of emails, letters, or conversations you are able to document; reference to your work in a management/policy document; or feedback from the general public.

Floodsville Project Evidence of Change:

- Citations in Floodsville's Multi-Hazard Mitigation Plan
- Emails and discussions with City officials, planners, and emergency managers and with neighborhood residents
- Solicit feedback via survey at final project meetings with City officials, planners, and emergency managers and with neighborhood residents

REVIEW YOUR PLAN

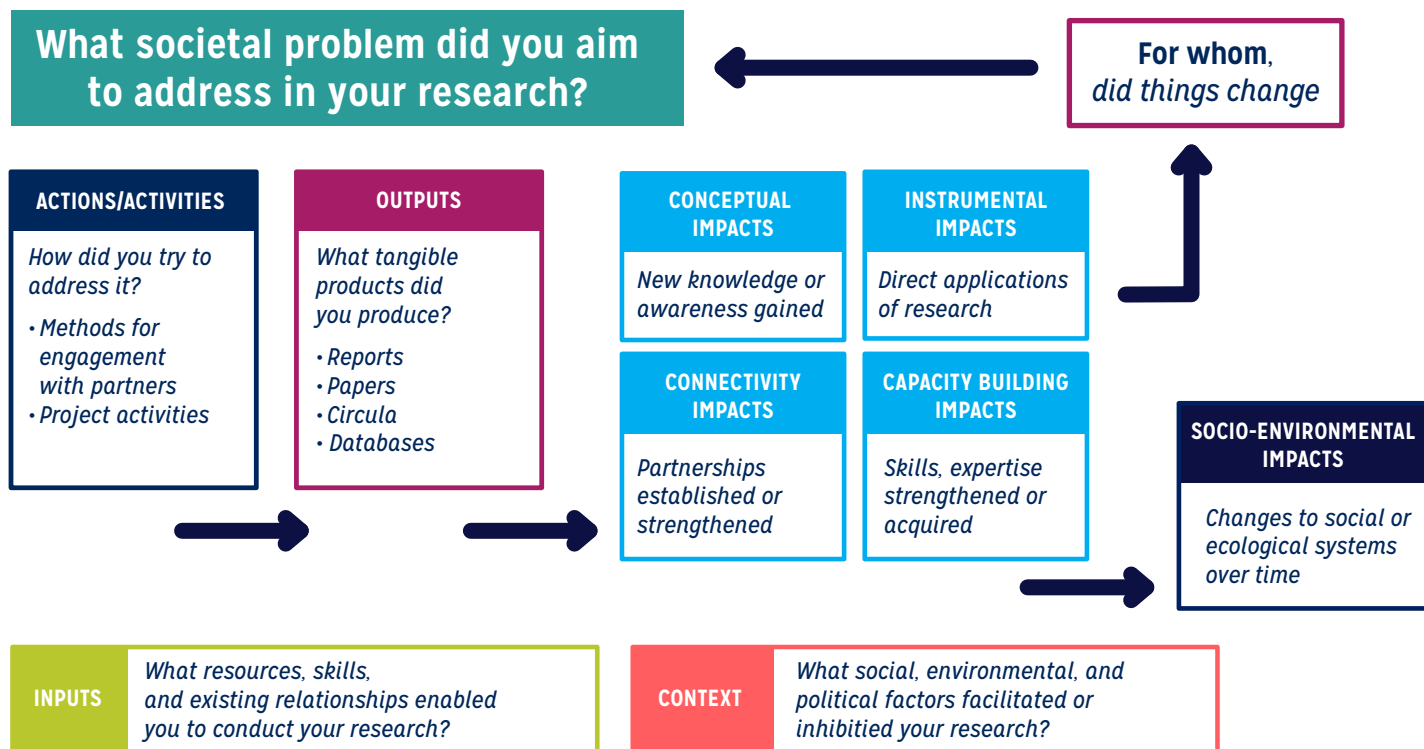
Once you have completed outlining each piece of your project framework, review your plan to see if each step logically flows into the next step. Make sure your inputs relate to your project activities; that activities relate to outputs; that your outputs relate to your anticipated impacts; and that impacts address the original interests and motivations of the research team. Write a quick summary about how your impacts address the societal problem you are trying to inform with your research.

Floodsville Project Design Review:

This project will provide up-to-date projections for sea level rise in the region around the City of Floodsville. By working with city officials, planners, and emergency managers, as well as gathering evidence with neighborhood residents, our project will provide insight into how people cope with flood-related disasters and will help them prepare for, and hopefully prevent, future flood risk.

2.2

Societal Impacts Framework for Impact Assessment and Project Reflection



PROBLEM STATEMENT

- **What societal problem did you aim to address in your research?**

Summarize the specific societal or environmental issue that you addressed in your research in one or two sentences. It will likely be different from your actual research questions or objectives. In your statement, include who was affected by this issue.

Floodsville Project Problem Statement:

A tropical storm caused major flooding in a neighborhood of the City of Floodsville. Ocean water breached the existing coastal wall, leading the city's planners and emergency managers to question whether they had the most accurate projections for sea level rise. They wanted to up-to-date sea level rise information so they could make better informed policies and decisions for the future of the city.

ACTIVITIES

• *What actions did you take to address the broader societal issue?*

In this section, state your research methods briefly. Then provide a description of how you interacted or communicated with societal partners through your research.

Floodsville Project Activities:

- Downscaled climate and sea level rise projections to the scale of Floodsville and the surrounding region.
- Attended 4 meetings with city planners and emergency managers during the winter and spring of 2017. We presented our research (using maps) at each meeting and engaged in discussions with decision makers about the research process as well as implications of our findings.
- City officials called us regularly throughout their planning process to confirm their understanding of the research (March – November 2017).
- Attended two community association meetings focused on the flood event and community plans for flood relief (summer 2017). Answered questions about projections of future flood events linked to sea level rise.
- Conducted two focus groups with community members (one with 10 participants and one with 8), one focus group with city planners (5 participants), and one with emergency managers (8 participants). All occurred in spring and summer 2017. These focus groups helped us understand the scale of analysis that was most helpful to all three groups, how to present the data, and made us more aware of questions and concerns of the community members.
- Provided city officials and community members with detailed maps and summaries of our analysis during a presentation with each group (December 2017).



OUTPUTS

• *What did you produce through your research?*

Briefly describe your research findings. Then write out the tangible research outputs you produced. If you anticipate producing more outputs (such as a peer-reviewed article) note that here as well. Your outputs could take many forms, such as: data analyses and models; public outreach materials; white papers and peer-reviewed articles; teaching curricula or training materials; reports tailored to specific audiences; websites; or fact sheets.

Floodsville Project Outputs:

Findings: We found that the City's current sea wall was not high enough for the current sea levels or future levels. We provided estimates to inform the height of a new wall.

Products:

- Downscaled climate projections for the Greater Floodsville region.
- Maps of projected sea level rise in the region – maps comply with FEMA data standards for easy use in planning documents.
- Presentations summarizing research findings provided to city planners.
- Two-page factsheet, aimed at community audience, summarizing the research and addressing questions and concerns raised by community members at meetings.
- A peer-reviewed publication has been submitted.

IMPACTS

- *What changed as a result of your activities, your interactions with the public and your research partners, and your outputs?*
- *For whom did things change or who changed because of your research?*

In this section, identify what your project activities and outputs did for your societal partners. Think through how your activities led to certain outputs, and how your activities and outputs contributed to change. In reviewing your original research design, did you have the type of impacts you anticipated? Did you have any unanticipated impacts?

Begin your description of impacts with one of the impact categories we introduced above: conceptual impacts – new knowledge or awareness, connectivity impacts – partnerships established or strengthened, capacity building impacts – skills or expertise strengthened or acquired, and instrumental impacts – direct applications of research.

Identify for whom things changed because of your research. This list may include resource management agency representatives, policy makers or government officials, community members, industry professionals, students, or members of the general public. You might also consider the demographics of the people who were impacted by your research. Did your research impact the audiences that you aimed to reach?

IMPACTS CONTINUED

Floodsville Project Impacts:

Conceptual impacts:

- Our research team received emails from city council about their increased understanding about the risks of sea level rise.
- Community members asked increasingly in-depth questions about the impacts that they might face, and used this to think about new ways they would prepare for floods

People impacted: Floodsville community members from a neighborhood that had historically been underfunded for infrastructure improvements by the Floodsville city government; Floodsville city councilmembers.

Capacity building impacts:

- A city council member used our Powerpoint presentation files to give a presentation to another city that was recently flooded.
- Floodsville City Government gave staff members time to learn GIS skills from our research team in our lab facilities, which helped them to be able to map the projections. This was a new skill set for the staff.

People impacted: Floodsville city government staff members.

Connectivity impacts:

- We built new relationships with city planners and community members.
- Our existing relationships with emergency managers were strengthened.
- The city planners invited us to do a new project about implementing green infrastructure.
- Our research team continues to get requests from the city for presentations.

People impacted: Floodsville community members; Floodsville city planners and emergency managers; members of the project research team.

Instrumental impacts

- The new projection maps were used in the city's new multi-hazard mitigation plan.
- The city's multi-hazard mitigation plan was accepted by FEMA.

People impacted: Floodsville city government officials.

Long-term socio-ecological impacts (assessed using long-term evaluation process)

- 25 years later, sea level rise of 1 meter occurred, but flooding of the town was avoided
- Floodsville saved \$5 billion USD by implementing actions from their hazard mitigation plan

EVIDENCE OF CHANGE

- *How do you know that your research changed things for people?*

Here, you can cite evidence that shows how your research was used or how things changed because of your research. Some examples of evidence include:

Feedback from your partners

- Formal (letters of recommendation or partnership)
- Informal (email or phone calls)

Reference to your work in a management/ policy document

- Citation to support statements
- Research findings forming the basis of policy document
- Citation in management reports or publications

Feedback from the general public

- Audience surveys
- Emails or other engagement from public
- Media interviews/reference to your work

Formal evaluation of your work

- Randomized control trials
- Pre-post tests
- Surveys/interviews of partners

Floodsville Project Evidence of Change:

- City of Floodsville Multi-hazard Mitigation Plan. 2018. Floodsville Department of Emergency Management.
- City of Floodsville Long-Range Infrastructure Plan. 2018. Floodsville Department of Planning.
- Documents available online at: floodsvillestoppedflooding.gov
- Emails from community members and government employees
- Qualitative data from a survey distributed to city employees and community members

PROJECT REFLECTION AND REVIEW

- ***What resources and factors enabled this project and your research impacts?***
- ***What components of the research were effective and which ones were not as effective?***

Once you have completed outlining your research impacts, you may want to reflect on the parts of your project that were effective and those that were not effective. Write down some of the resources you had available that enabled your research. Think about the environmental, social, and political factors that helped or hindered your research. Some examples include:

- Process oriented factors – the way the problem was framed; project management; the way findings were disseminated; outputs matched partner needs
- Inputs – key skill sets, funding, and resources of the research team
- External factors – the political, economic, or social context supported, or did not support, action or change

Floodsville Project Review:

Overall, our project turned out to be effective. After the flood, the City looked back at their hazard mitigation plan regarding flooding and decided to update it. They want to keep in touch about future updates to sea level rise projections. Residents in the neighborhood that experienced flooding feel prepared to deal with future risk and have more trust in the city's multi-hazard mitigation plan to reduce their future risk.

Some of the inputs that helped enable our project include:

- *The knowledge and capacity on our research team to provide projections*
- *Funding for research and engagement with partners*
- *Existing relationships between researchers and Floodsville City Emergency Managers*

Some of the context that enabled our project include:

- *A flood event happened which galvanized action in the city*
- *Community members were motivated to address the issue*
- *The city made it a priority to update their hazard plans*



Documenting Impacts - Worksheets and Case Studies

This section contains worksheets filled with guidance and additional case study examples to help you plan and document your own research impacts. The first set of worksheets pertain to the Societal Impacts Framework for Project Planning and Design. The second set of worksheets are based on the Societal Impacts Framework for Impact Assessment and Project Reflection.

Societal Impacts Worksheet for Project Planning and Design Guidance Document

[Click here to download your own worksheet template for project planning and design in Google Drive.](#)

PROJECT TITLE:

Societal or Environmental Issue:

What societal problem do you aim to address in your research?

- Summarize your problem statement in 1 - 2 sentences
- Different from your research questions and research objective
- Address who is affected by this societal problem

Inputs

What resources are available or necessary to conduct your research?

What are the interests and motivations of each member of your research team?

- Describe the resources that you have available or will need to conduct your research
- Define your research team, and the skills, types of knowledge, and expertise each member offers to the project
- Identify the societal impact goals that motivate each research team member to be part of the research project

PROJECT CONTINUED:

Anticipated Activities

What actions will you take to address the societal issue?

- State your research methods
- Outline roles and responsibilities for each member of the research team
- Describe how the research team will engage and communicate with one another during the project
- Outline the activities that will take place throughout the project

Anticipated Outputs

What do you plan to produce through your research?

- Observations and data
- Tangible research outputs might include:
 - Public Outreach Materials
 - Models/Datasets
 - Reports for Partners
 - Fact Sheets
 - Websites
 - Peer-reviewed articles
 - Curricula
 - Others

Anticipated Impacts

What do you expect to change as a result of your activities, your interactions with partners, and your project outputs?

- Conceptual outcomes - new knowledge or awareness gained
- Connectivity outcomes - partnerships established or strengthened
- Capacity Building outcomes - skills, expertise strengthened or acquired
- Instrumental outcomes - direct applications of research

For whom do you expect things will change?

Evidence of Impact

How will you know that things have changed?

- Describe your plan to collect, document evidence of change. Some examples include:
 - Feedback from your partners
 - Reference to your work in management or policy documents
 - Feedback from the general public
 - Formal evaluation of your work

Societal Impacts Worksheet for Project Planning and Design

Case Study Example

PROJECT TITLE:

The Influence of Temperature and Soil Moisture on Colorado River Water Resources

Societal or Environmental Issue:

The U.S. Southwest is an arid region and is becoming hotter and drier due to climate change. Climate model-based temperature projections indicate Colorado River streamflow reductions of 20 percent by 2050 and 35 percent by 2100. Approximately 40 million people in the western U.S. and northwestern Mexico rely on Colorado River water for domestic, industrial, and agricultural uses.

This project aims to better understand how temperature has influenced Colorado River water resources. Water resource managers who work in the Colorado River Basin will use this information to inform resource management plans and operations, which has implications for people, cities, and ecosystems across the Southwest.

Inputs

To develop the proposal, we have engaged with a group of Colorado River basin water managers who have assisted in directing research questions and ensuring the project is relevant to resource management. This group of water managers will form an advisory board to guide the analysis and generation of research products through interaction with the science team. The members of the advisory board have long-standing relationships with members of the science team from previous research engagements. They are interested in using the research findings for their own purposes, and are informing the project design, but are not interested in collecting or analyzing data.

The science team will be collecting and analyzing the data and communicating findings to the advisory board. The science team is an interdisciplinary group with expertise in climatology, paleoclimatology, hydrologic modeling, and climate projection analysis, with extensive experience working with resource managers. The members of the team want to apply their expertise to address water management issues in the Southwest. One member of the team will be using part of this research for her dissertation.

This project has funding for 2 years.

Anticipated Activities

- Engagement activities include:
- quarterly meetings with the advisory board
- email and phone calls between science team and advisory board members as needed
- a final project workshop with water resource managers

The science team will meet monthly to discuss project updates and will communicate as needed by phone and email.

The Influence of Temperature and Soil Moisture on Colorado River Water Resources

Anticipated Outputs

- Analysis of instrumental data
- Analysis of tree-ring chronologies
- Soil moisture model
- Project website, kept up to date as research is completed
- Quarterly reports to advisory board
- Presentations to academic audiences
- Workshop with water resource managers
- Final report for water resource managers
- Academic publication

Anticipated Impacts

- Inform decision making and planning for water management and conservation measures, by providing information about the roles seasonal precipitation, temperature, and antecedent moisture conditions
- Raise awareness of possible impacts of warming temperatures on drought and expected runoff now and in the future
- Increase awareness about how to use tree-ring data for future planning, recognizing that the past is not an analog for the future
- Increase awareness about the climate connections between winter precipitation and fall and spring temperatures in the Colorado River Basin

Evidence of Impact

- Annual interviews with members of the advisory board about the research process and how they have used or plan to use project findings
- Interviews with members of the science team about the research process, research findings, and implications of their findings
- Feedback from workshop participants via online survey
- Evidence from emails and feedback from advisory board about use of information

Societal Impacts Worksheet for Project Reflection and Impact Assessment Guidance Document

[Click here to download your own worksheet template for project planning and design in Google Drive.](#)

PROJECT TITLE:

Summary Statement of Impacts

Return to this section after you have completed the rest of the worksheet.

Summary of the Research

What societal problem did you aim to address in your research?

- Summarize this problem statement in 1 – 2 sentences
- This is likely to be different from your research questions and your research objective
- Be sure to address who is affected by this societal problem

Project Engagement Activities

What actions did you take to address this issue?

- State your methods briefly to give a sense of the kind of research you did
- Provide a description of your approach to societal engagement

Research Outputs

What did you produce through your research?

- BRIEFLY describe your research findings
- Tangible research outputs:
 - Public Outreach Materials
 - Models/Datasets
 - Reports for Partners
 - Fact Sheets
 - Websites
 - Peer-reviewed articles
 - Others

PROJECT CONTINUED:

Details of Impacts

What changed as a result of your activities, your interactions with partners, and your outputs?

- Conceptual Impacts - new knowledge or awareness gained
- Connectivity Impacts - partnerships established or strengthened
- Capacity Building Impacts - skills, expertise strengthened or acquired
- Instrumental Impacts - direct applications of research

For whom did things change?

Evidence of impact

Examples of evidence of change

- Feedback from your partners
 - Formal (letters of recommendation or partnership)
 - Informal (email or phone calls)
- Reference to your work in a management/policy document
 - Citation to support statements
 - Research findings forming the basis of policy document
 - Citation in management reports or publications
- Feedback from the general public
 - Audience surveys
 - Emails or other engagement from public
 - Media interviews/reference to your work
- Formal evaluation of your work
 - Randomized control trials
 - Pre-post tests
 - Surveys/interviews of partners



Societal Impacts Worksheet

Case Study Example Document

PROJECT TITLE:

Climate Change and Regional Fish Management

Summary Statement of Impacts

We worked closely a coalition of natural resource managers to identify the cumulative impacts of climate change, habitat degradation, and invasive species on an important fish species in this region. Based on this research, the coalition was able to prioritize funding for management of this species. In addition, a federal resource management agency used the findings to inform its decision to build a physical barrier to protect the key species from an invasive competitor.

Summary of the Research

This project used a novel modeling approach to develop multi-species climate change vulnerability assessments, which offer the ability to relatively rank and prioritize populations of multiple sympatric species. We concluded that climatic drivers, which are damaging the species' habitat, as well as introduction of an invasive species are contributing to the loss of the focal species in the region.

Project Engagement Activities

The lead researcher worked closely with the coalition group. The coalition's mission is to support the management of ecologically significant species in this region through building awareness and sharing best practices between and among federal and state natural resource management agencies in the region. The researcher attended coalitions meetings approximately 3 times each year during the project (2016 – 2018) and co-convened a workshop with the coalition (Summer 2018) where they elicited feedback from other regional resource managers about early project findings.

The researcher and the coalition leaders communicated regularly by phone and email, at least every month. The coalition team members remarked on how often the researcher attended their general meetings.

Research Ouputs

- Several scientific papers analyzing the extent to which the focal species is affected by invasive fish species in the region and the rate of habitat degradation expected due to climate change.
- Maps of currently stressed and fragmented habitat areas.
- Maps of areas likely to become more stressed in the future due to climate change impacts.
- Maps of presence of focal species and invasive species.
- All maps were integrated into an existing decision support tool used regularly by resource managers in the region.

Climate Change and Regional Fish Management continued

Details of the Impacts

- The management coalition used our research findings as part of its decision to prioritize funding for management of the focal species. They reallocated available resources to their efforts to restore habitat in the region.
- A federal agency used the findings to inform its decision to build a physical barrier at one key location (identified through our work) to protect the focal species from its invasive competitor.

Sources that corroborate the Impacts

- Regional Aquatic Species Management Coalition Strategic Plan 2018 – 2023.
- Federal Agency Species Management Plan 2019.
- Environmental Impact Statement regarding placement of physical barrier at No Invasives Creek. 2018.



PART 3.

Additional Context and Information

Part 3 contains four appendices that provide additional context and information about several of the topics introduced in this guidebook. The appendices are intended to dive deeper into the academic literature on societal impacts, engaged research approaches, and research evaluation for readers who wish to explore these topics in greater detail.

Appendix A: Exploring Societal Impacts Categories

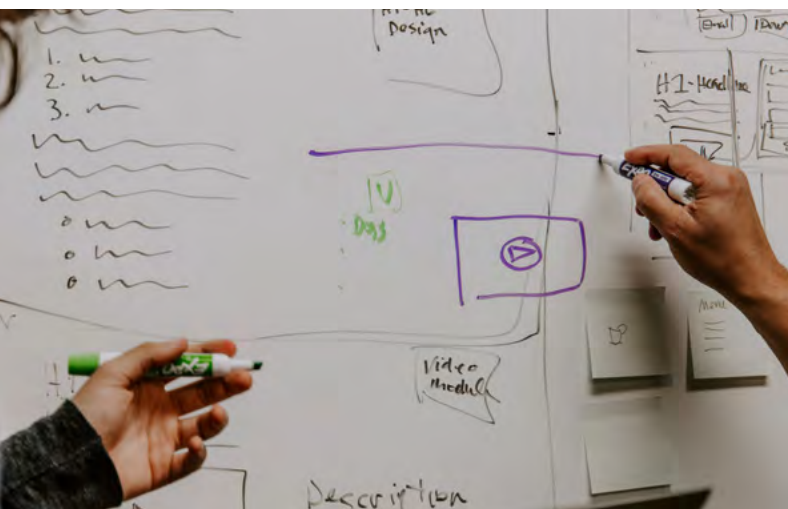
A number of different impact categories have been developed for use in different contexts. Many people use a common core of impact types but refine or add new categories to better suit a particular use. There are good reasons to rely on a common typology, such as the ability to compare and contrast projects, programs, and organizations, and to provide consistency over time to measure progress in achieving impact goals. However, because the societal benefits accruing from research are highly context-dependent (i.e. different communities, decision makers, or policy makers need different things), retaining the ability to demonstrate impacts in ways that reflect the true societal benefits is important. Below we summarize some of the common impacts definitions in order to provide options and ideas for researchers looking for appropriate descriptions of their work.

A standard typology, that emerged from policy studies (Weiss 1973; Pelz 1978), and has been applied to societal impacts assessments (Walter, Davies, and Nutley 2003; Meagher, Lyall, and Nutley 2008; Meagher and Martin 2017), focuses on two core categories of impact:

- Instrumental impacts - direct impacts of research on policy and practice decisions where a specific piece of research is used in making a specific decision or in defining the solution to a specific problem
- Conceptual impacts - complex and indirect ways in which research can have an impact on the knowledge, understanding, and attitudes of policy makers and practitioners.

Kuruvilla et al (2006) designed the Research Impact Framework as a tool to assist researchers in documenting their own impacts and added two additional impacts that has also previously been described by Weiss (1998): Mobilization of support - research findings provide persuasive evidence to back ongoing and proposed policy activities or raise awareness and support for new policy-making. Also termed symbolic or justification by Pelz (1978).

Wider influence - research impacts that lead to a wide change or transformation of accepted beliefs and practices, beyond the use or impact to a specific, direct societal partner.



Meagher and Martin (2017) expanded impacts categories to include impacts with an indirect, but still traceable influence, on use of research findings:

- Capacity building impacts - training and/or developing collaborative abilities
 - Enduring connectivity - establishment of long-lived external relationships
 - Attitude or cultural change - increased willingness to engage in knowledge exchange activities, on the part of individuals, institutions, or organizations.
-
- The National Science Foundation (NSF) includes “broader impacts” as a key component of research it funds. NSF’s categories tend to emphasize improvements to the broader science enterprise through:
 - Full participation of women, persons with disabilities, and underrepresented minorities in STEM
 - Improved STEM education and educator development at any level
 - Increased public scientific literacy and public engagement with science and technology
 - Development of a diverse, globally competitive STEM workforce
 - Increased partnerships between academia, industry, and others
 - Enhanced infrastructure for research and education

The list of NSF impact examples also includes:

- Improved well-being of individuals in society
- Improved national security
- Increased economic competitiveness of the United States

Process as an Indicator of Impacts

Researchers also recommend evaluating the process of engagement as a key indicator of the likelihood of generating impacts (see Appendix B for a more detailed discussion of this process). The Social Impact Assessment Methods for research and funding instruments through the study of Productive Interactions (SIAMPI) framework was developed by Spaapan and van Drooge (2011) to evaluate the return on investment of European Union-funded research. They recommended documenting productive interactions between researchers and societal partners in three categories:

- Direct interactions - ‘personal’ interactions involving direct contacts between humans, interactions that revolve around face-to-face encounters, or through phone, email or videoconferencing (i.e. research findings and processes are conveyed directly between researchers and societal partners).
- Indirect interactions - contacts that are established through some kind of material ‘carrier’, for example, texts, or artefacts such as exhibitions, models or films (i.e. research findings are transferred through a report, article, or other media).
- Financial interactions - when potential partners engage in an economic exchange with researchers, for example, a research contract, a financial contribution, or a contribution ‘in kind’ to a research program.

Similarly, Ford et al. (2013) link the likelihood of impacts to the extent to which the research has been intentionally co-designed with decision makers. They note that all types of research, including basic or fundamental science as well as applied or action-oriented science, have the potential to influence policy, inform decisions, and alert the public to potential problems; but only “usable science” – or research that is explicitly designed to contribute to decision making processes and have the characteristics of pertinence, quality, and timeliness – does so directly.

Impacts in Context

All research impacts are context-dependent (Boaz, Fitzpatrick, and Shaw 2009; Mach et al. 2020); they will differ depending on the project goals, sector, processes, and participants. Thus, while maintaining a common core of impacts categories is valuable for consistency and comparison, allowing for flexibility in reporting structures is crucial to ensure that the impacts most important to societal partners are prioritized. For example, Reed (2018) presents a more fine-grained list of impact categories, intended to help researchers plan and document their own impacts. In addition to his categories for capacity/preparedness, understanding and awareness, attitudinal, and policy (which align well with capacity-building, conceptual, and instrumental impacts), he suggests:

- Economic – monetary benefits arising from research
- Environmental – benefits from research to genetic diversity, species or habitat conservation, ecosystems, and ecosystem services
- Health and well-being – research that leads to better outcomes from the health of individuals, social groups, or public health.
- Cultural – changing in the prevailing values, attitudes, beliefs, discourse and patterns of behavior

A caveat to using pre-defined categories: Fazey et al. (2014) and Wiek et al. (2014) point out that while it is possible to anticipate some impacts, it is important to be open to unanticipated or unintended outcomes. Unexpected results can provide additional insights into the possibilities for future impacts.

Summary

There is some coalescence around a common core of impact categories, particularly in frameworks developed for use by European research institutions, who are more likely to have mandated reporting of societal impacts. This common core – instrumental, conceptual, capacity-building, and connectivity – can be beneficial when seeking to compare research projects, program, and organizations or when seeking to track progress in meeting impact goals over time. However, in order to accurately capture the impacts from diverse research and investigators, maintaining flexibility within frameworks is important. Space should be maintained for unanticipated or unexpected impacts or for describing impacts that do not immediately fit a pre-defined category. Exploring alternative impacts categories can help researchers identify the breadth of categories they may generate and provide ideas for framing and describing impacts.

Appendix B: Socially Engaged Research

As noted throughout this guidebook, one pathway to generating societal impacts is through direct interactions between researchers and societal partners throughout the research process. This pathway stems from decades of development in the theory and practice of socially-engaged research.

In the U.S., the conceptualization of how science brings about innovation and social change can be traced back to the post World War II era when the first clear articulation of non-war federal science policy was put forward by Vannevar Bush (Guston 2001). The vision that Bush formulated in a report to President Truman—*Science, the Endless Frontier* (1945)—emphasized the need for government support for science to continue during post-war times. Research and technology, he believed, would spur innovations in health, agriculture, national security, and other forms of public welfare. But Bush also emphasized that the “freedom of inquiry must be preserved. As long as universities are vigorous and healthy and their scientists are free to pursue the truth wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it to practical problems in Government, in industry, or elsewhere” (1945).

This vision of science policy was originally developed to maintain scholarly independence from government or corporate influence (Dennis 2015). It assumes that discoveries made by academic experts will be delivered to members of society who will use the results to inform policy, practice, and technology (Cash, Borck, and Patt 2006). However, the model does not explain how scientific results will be delivered, consumed, or used. Evidence has accumulated to indicate that when research is separated from its intended users (such as in the loading-dock model described by Cash et al. 2006), it is not often used in practice and policy. For example, Bornmann et al. (2016) found that only 1.2% of climate science research produced between 1980 and 2014 was cited in international climate policy documents.

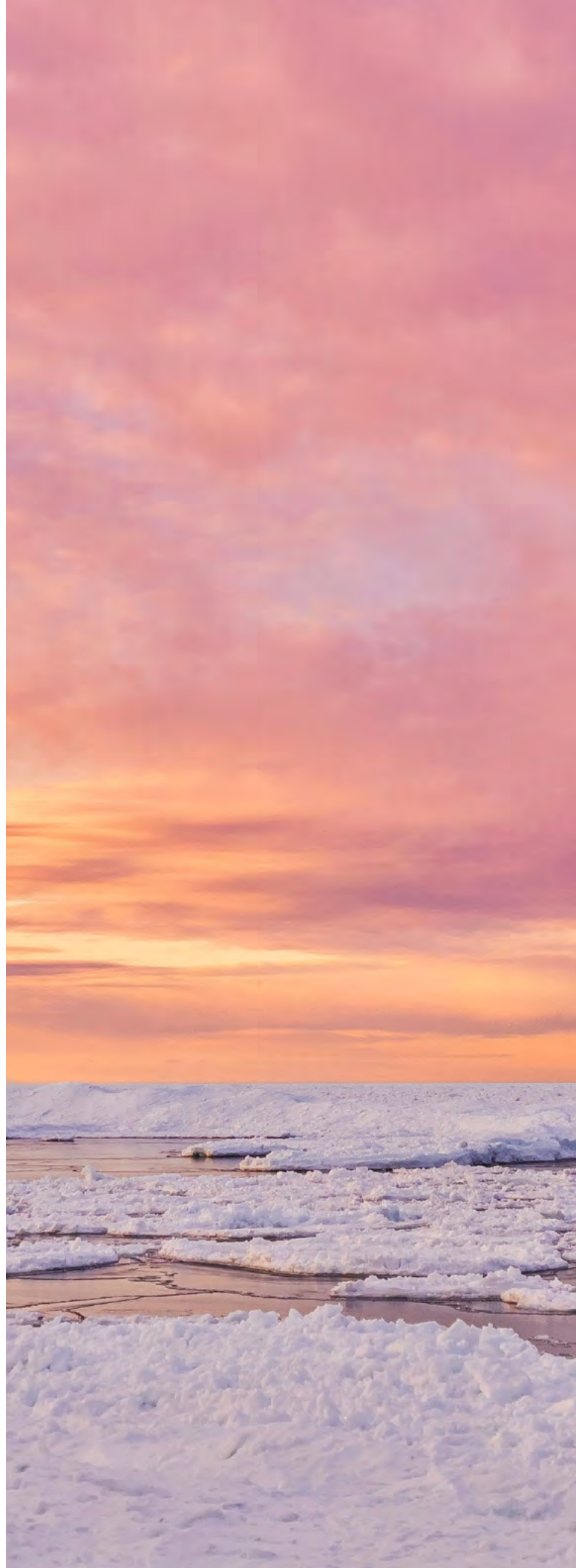
In response to this gulf between research and practice, new modes of research have evolved. These new modes can be broadly categorized as socially engaged research. Various approaches and methods within this vein include action research (Lewin 1946; Greenwood and Levin 2007); post-normal science (Funtowicz and Ravetz 1993); Mode 2 knowledge production (Gibbons et al. 1994; Nowotny, Scott, and Gibbons 2001); boundary work (Guston 2001; Cash et al. 2003); knowledge coproduction (Jasanoff 2004; Lemos and Morehouse 2005); transdisciplinarity (Pohl 2008; Jahn, Bergmann, and Keil 2012); transformational sustainability science (Kates et al. 2001; Wiek et al. 2012); social learning (Wenger 2010; Pahl-Wostl et al. 2007); and useful science or usable knowledge production (e.g. Dilling and Lemos 2011; Clark et al. 2016; Mach et al. 2020). See the table below for brief descriptions. These frameworks converge and diverge in terms of agenda and approach. However, they all make one thing clear: ***physical and social scientists must collaborate with people outside of the academic realm if they want their research to inform policy or create societal and environmental change.***

Socially engaged research concepts

<i>Research concept</i>	<i>Description</i>	<i>Exemplary citations</i>
<i>Action research</i>	Research primarily defined and driven by stakeholders. Researchers support, facilitate, and provide technical input. Objectives aim to effect change in a stakeholder community.	Lewin 1946; Greenwood and Levin 2007
<i>Post-normal science</i>	Motivated by societal issues and needs rather than researcher curiosity. Relies on participation of a 'peer community' that extends beyond scientists.	Funtowicz and Ravetz 1993
<i>Mode 2 knowledge production</i>	Contextualized by the societal factors surrounding a particular issue and characterized by the inclusion of multiple types of knowledge and research partners.	Gibbons et al. 1994; Nowotny et al. 2001
<i>Boundary work</i>	Aims to solve real-world issues through dialog and collaboration across the 'boundaries' between scientific experts and decision makers.	Guston 2001; Cash et al. 2003
<i>Knowledge coproduction</i>	Iterative engagement between researchers and nonacademic partners will produce innovative, scientifically-robust, and useful knowledge for real-world applications.	Jasanoff 2004; Lemos and Morehouse 2005
<i>Transdisciplinary research</i>	The integration of multiple types of expertise and knowledge is necessary to address a common issue.	Pohl 2008; Jahn et al. 2012
<i>Transformational sustainability science</i>	Incorporates knowledge from outside academia into research processes to support the creation of sustainable social systems.	Kates et al. 2001; Wiek et al. 2012
<i>Social learning</i>	Social processes help create mutual understandings between two or more parties, through which individual and societal transformations can occur.	Wenger 2000; Pahl-Wostl et al. 2007
<i>Useful science, usable knowledge</i>	Research conducted to produce knowledge that is useful, usable, and actually used by societal members.	Dilling and Lemos 2011; Clark 2016; Mach et al. 2020

Socially engaged research is more effective than indirect research pathways in transitioning research into policy and practice and generating societal impacts. By virtue of the direct engagement between researchers and societal partners, and incorporating partners' perspectives and knowledge into the research process, the research better fits the decision contexts in which it will be used (Mach et al. 2020). The process of engagement helps to build relationships and trust between societal partners and researchers (Kothari et al. 2011), which makes it more likely that partners will find the research credible and usable (Cash et al. 2003; Lacey et al. 2018; Association of Public and Land-Grant Universities 2019). The research findings are more accessible to societal partners both conceptually, because the research process does not occur in a black box (Jasanoff and Wynne 1998), and physically, because the findings are do not sit behind academic pay-walls (Cvitanovic et al. 2019). A principle of socially engaged research is that it should include multiple knowledges and values (Norström et al. 2020; Reed and Meagher 2019). This inclusive process helps to make the outputs and outcomes more applicable and acceptable to societal partners, particularly those who have historically been excluded from both research and decision making processes (David-Chavez and Gavin 2018; Association of Public and Land-Grant Universities 2019).

Studies of the outcomes of socially engaged research show that the approach is particularly strong in terms of fostering learning (conceptual impacts), strengthening community (connectivity impacts), and using research findings in policy or practice documents (instrumental impacts) (Cvitanovic et al. 2019; Jagannathan et al. 2020). As we note throughout this document, although expectations for long-term socio-environmental change are embedded within many discussions of socially engaged research (Jagannathan et al. 2020), those changes are harder to generate in the short- and medium-term and are harder to identify and trace in the longer term.



Appendix C: Challenges of Impacts Assessment

There are two main sets of challenges associated with evaluating research impacts. The first set has to do with the nature of knowledge generation and the use of knowledge and information. The second set deals with the methodological barriers to identifying and quantifying the full range of possible impacts emerging from research.

Knowledge Generation and Information Use

The nature of knowledge generation and use poses significant challenges for tracing clear lines from a particular research project to societal impacts. There is often a significant time lag between when research results emerge to when practitioners adopt new practices (Bell, Shaw, and Boaz 2011; Penfield et al. 2014; Spaapen and van Drooge 2011). For example, in medical research, this lag can be up to 17 years (Moore et al. 2016). The lag can be attributed to several factors, such as whether an organization is prepared to integrate new knowledge; the level of uncertainty surrounding new knowledge; and the pertinence of the new knowledge to the specific needs of the practitioners (Ford, Knight, and Pearce 2013; Green et al. 2009; Oh and Rich 1996). The need for an organization to be ready to use new information – and the need for new information to be ready to use – and the resulting time lag makes it more difficult to trace the influence of one particular piece of research on a decision or action (Bell, Shaw, and Boaz 2011; Boaz, Fitzpatrick, and Shaw 2009; Penfield et al. 2014; Spaapen and van Drooge 2011; Wiek et al. 2014). Researchers can use contribution analysis to gauge the extent to which research has influenced practitioner decisions. Using a contribution framework allows researchers to acknowledge the complexities involved in creating societal change, while also pointing to the ways that individual research efforts (and researchers themselves) help the process of change (Morton 2015). In addition to contribution analysis, using multiple categories of impact, including the categories presented in this guidebook, is an effective approach to identifying the ways a research project helps influence new thinking and behaviors while acknowledging that systemic change (whether social or ecological) may require additional time and inputs.

Methodological Barriers

Collecting tangible pieces of evidence can sometimes be straightforward – for example, if an organization cites your research findings as justification for a new policy change. In other cases, identifying less-tangible impacts can pose some methodological challenges to those unfamiliar with using qualitative data. Conceptual impacts, such as changes in understanding or attitude, are most likely to be identified through qualitative assessment methods that allow project participants to reflect in an open-ended fashion on their experiences. Unanticipated or unexpected impacts are also more likely to be identified through open-ended qualitative inquiry (Spaapen and van Drooge 2011; Meagher and Martin 2017).

Addressing these methodological challenges will depend on the resources and time available for evaluation (Bell, Shaw, and Boaz 2011). Rigorous qualitative data collection and analysis can help to identify impacts and understand the context in which they were generated. The most common societal impacts reporting frameworks, the Research Excellent Framework (UK), the Standard Evaluation Protocol (Netherlands), and the Australian Engagement and Impact Assessment all use a case study approach to collecting impact reports. Case studies are reviewed by panels of experts, usually made up of a mix of researchers and societal partners. While more time consuming than quantitative assessments, these qualitative approaches provide a more realistic and richer understanding of the role of research in societal change.

Another methodological challenge is related to the time lag issue discussed above. Because it can take several years for research to move into use and impact, details about how and why it was able to generate such impacts, particularly questions related to engagement processes and participation, may be lost along the way (Bell, Shaw, and Boaz 2011; Wiek et al. 2014). Over time, memories

fade or events are re-interpreted by participants and it can be challenging to reconstruct the details of particular projects and decisions. It can also be challenging to secure the participation of researchers and practitioners in evaluation processes, particularly after projects have ended and the participants have moved on to other matters (Wall, Meadow, and Horangic 2017; Wiek et al. 2014). These challenges can be overcome through on-going and embedded evaluation approaches that follow projects throughout their lifetimes and maintain contact with participants.

Finally, the lack of baseline data on how and under what conditions and at what frequency research has specific societal impacts hinders our ability to evaluate project success (Penfield et al. 2014; Jagannathan et al. 2020). This challenge may be self-correcting as interest in societal impacts grows and more data is generated about the current state of impacts

Appendix D: Concerns about Societal Impacts Evaluation

As societal impacts reporting and evaluation has gained traction, it has also raised some concerns within the research community. A societal impacts approach to academic evaluation represents a significant shift for many institutions and researchers. Instead of being evaluated solely on the scientific rigor and significance of their work, it requires demonstrating the significance of their research outside of the academic realm.

Some researchers have expressed concern that emphasizing societal impacts will effectively devalue basic research and divert resources away from research that is focused on “blue skies” questions and grand scientific challenges (Chubb and Reed 2018; Watermeyer and Chubb 2019; Stern 2016). In a similar vein, some are apprehensive that evaluation of their research impacts will threaten their academic freedom by allowing external forces to have more control over research agendas. Some researchers, for example, express concern that government-funded evaluations of government-funded research may be a tool to suppress research critical of government policies. Their concern may be related to fears about breaking

down the boundaries between science and society in ways that some researchers perceive will dilute the integrity of scientific research (Cvitanovic et al. 2019). However, this critique perhaps overlooks the fact that funding agencies have always had significant influence on research agendas, and that societal values and interests have always influenced which scientific research is valued, funded, and undertaken (Greenwood and Levin 2007). These concerns are not raised solely by the introduction of societal impacts measures.

A more practical concern is the societal impacts reporting may be required on top of current evaluation practices. Most academic researchers are evaluated based on the academic impacts of their work – as measured by the number of publications and citations. The accuracy and appropriateness of these academic metrics have been challenged on multiple fronts (Adler and Harzing 2009; Alvesson, Gabriel, and Paulsen 2017; Hicks et al. 2015), but they have proved quite durable thanks to their relative ease of use. Given the importance of academic metrics, the move to societal impacts reporting can feel like an added burden – and one with little payoff if the effort is not directly linked to formal performance evaluation or promotion and tenure policies.

Societal impacts evaluation and reporting does not seek to supplant research excellence. Quite the opposite – societal impact practices recognize that the foundation of societal impacts is high quality research. Engagement with societal partners, often a key component in generating societal impacts, does not negate the need for rigor in scientific methods or processes (Cvitanovic et al. 2019; Greenwood and Levin 2007). Societal impacts reporting provides opportunities for researchers who do socially engaged research to be recognized and evaluated based on a more accurate portrayal of the work they do – research that involves scientific rigor plus additional time and resources for direct engagement with societal partners. Societal impacts reporting can become less of an additional burden on researchers once the practice is fully integrated into academic performance measures. It will help ensure that researchers receive credit for the work of generating societal impacts and the work of documenting, evaluating, and reporting them.

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