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Cross-disciplinary Expert Perspectives of Sustainability and Resilience Planning

NIST Research Brief
NIST RB 5

January 2025

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Research Summary

It has become increasingly important for community planning to include resilience and sustainability concepts, given the onset of increasing weather and climate extremes and stressors. The definitions of resilience and sustainability continue to be somewhat ambiguous in current literature and policy; some see them as synonyms and use them interchangeably, while others see them as somewhat intertwined or completely independent of each other. This research looks at the interactions of definitions of resilience and sustainability across various physical, social, and environmental domains. By using survey data from experts working across diverse applications of resilience and sustainability, we analyze the connections between the domains, which can help encourage more efficient and effective efforts to address future hazards. Our findings suggest that when it comes to sustainability and resilience, experts perceive three main differences in (a) temporal application, with resilience being short-term and sustainability being long-term, (b) focus areas, with resilience as hazard-oriented and sustainability and ecosystem-oriented, and (c) their codependence.

Research Advancement Details

Communities face increasing risks of extreme disturbances and persistent stresses, such as extreme weather events, geologic hazards, and the effects of climate change (Marvel et al., 2023). Both resilience and sustainability are crucial in these contexts, as proactive investments in resilience planning offer increasingly cost-effective strategies for mitigating and reducing potential damage. Moreover, improving the quality of life in vulnerable communities—both in the present and for future generations, with respect to

environmental, social, and economic considerations—requires the adoption of holistic sustainability perspectives. Resilience and sustainability have been, and continue to be, critical concepts in the conversation surrounding community planning, yet there are gaps in knowledge and mutual understanding amongst different experts and sectors as it relates to the two concepts (Lizarralde et al., 2015). In current literature, some examples of sustainability definitions are the need to balance economic prosperity, social equity, and environmental quality (i.e. the triple bottom line), or the Brundtland definition of “the ability of a community to meet its needs without compromising the needs of future generations”. Resilience has also been defined in various ways—e.g., a system’s capacity, capability, or ability to anticipate, cope with, or adapt to contingencies (Weber).

A paradigm shift from looking at resilience and sustainability as independent characteristics of infrastructure, and the systems infrastructure supports, to valuing these characteristics together (including climate change mitigation and adaptation strategies) can help develop more effective and efficient planning options. Trade-offs may exist between sustainability and resilience objectives, such as climate adaptation and mitigation, economic and environmental costs, equity considerations, affordability and risk reduction, short and long-term consequences, and spatial variations and focus (Frey and Gasbarro, 2019). These complexities are exacerbated by uncertainties associated with risks and valuations across longer timeframes. Decision makers must act in this complex space to balance impacts across diverse actors with varying priorities and concerns, which requires using multiple disciplinary techniques and data sources (Marchese et al., 2018, Carissimi et al., 2023). Additionally, evaluating resilience and sustainability impacts resulting from multi-objective decisions is difficult because each is measured in different ways, and the knowledge necessary to fully capture this complexity is distributed over many domains of expertise (e.g. physical, social, and environmental).

Enabling cross-pollination across these often fragmented domains requires that experts develop shared knowledge to identify standardized planning & design rules that bring together sustainability and resilience oriented principles. Thus, analyzing expert perceptions of these two concepts can lead to greater clarity across these domains that are critical to strategies for mitigating damage from extreme disturbances and persistent stresses.

Using a data collection instrument (DCI), we collected data from individuals with cross-disciplinary expertise in the areas of resilience and sustainability. This DCI is titled “Trade-offs and Synergies in Designing for Resilience and Sustainability” and was approved by the NIST Institutional Review Board as Study #: EL-2021-0319. This DCI is provided in Appendix A.

The data gathered encompasses responses from 110 experts originating from a broad spectrum of areas of expertise. When it came to categorizing occupations, “Academia” encompasses full-time, assistant, and adjunct professors; “Researcher” encompasses government and academic researchers in various fields (e.g., engineering); “Nonprofit”

indicates non-profit work; “Government” encompasses local, state, and federal government; “Student” encompasses all levels of post-secondary study; and “Industry” encompasses work done under a business (e.g., consulting) [Fig. 1]. The data further includes each respondent’s previous personal and professional experience with sustainability and resilience – including perceptions of the two concepts – as well as demographic and cultural details.

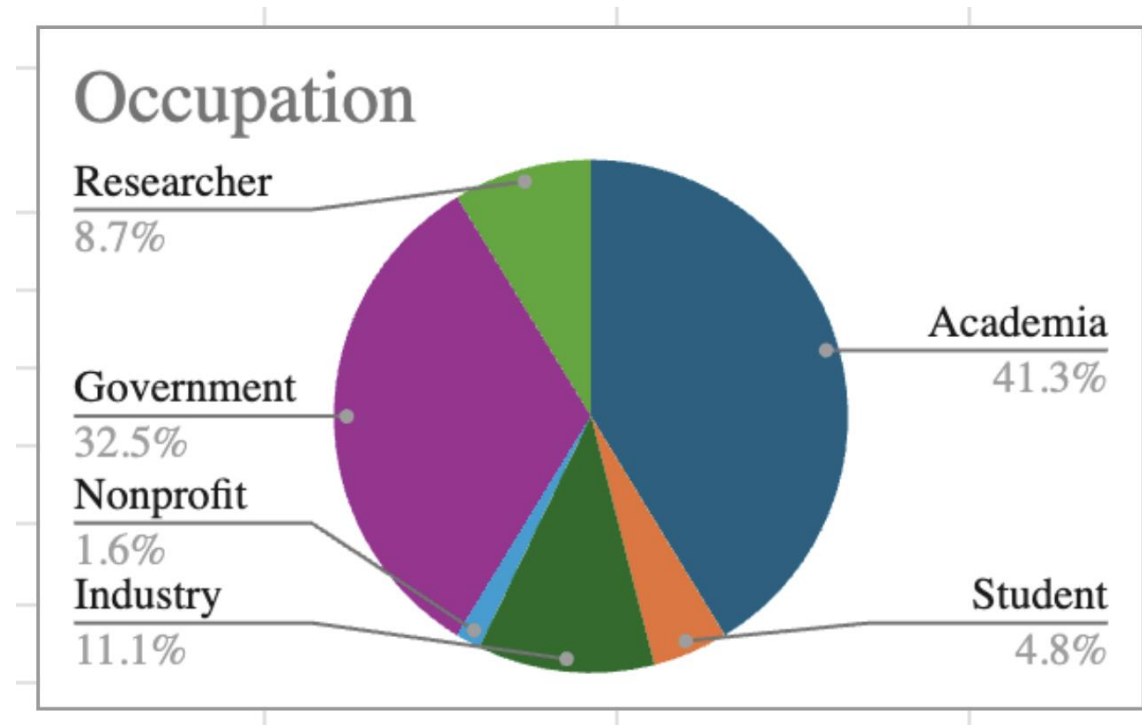


Figure 1. Breakdown of Respondents by Occupation

Through both qualitative and quantitative analysis of the survey data—including methods like thematic analysis and frequency analysis—we were able to reach broad conclusions about the way resilience and sustainability interact. This includes common associations made by experts when defining the concepts, words that belong to the concepts, and the contexts in which they are mentioned. Importantly, when evaluating the two concepts independently, most experts agree that sustainability is a goal while resilience is a necessity. However, when evaluating them together (e.g., looking for keywords that apply to both topics) the associations become more holistic with the word "systems". Additionally, personal data relating to the experts’ occupation was also collected, guiding our research on how occupation may affect the interaction between sustainability and resilience.

Discussion

Our analysis of survey results revealed overlaps in self-reported definitions of sustainability and resilience between experts of various fields. Most resilience definitions

collected (92.73%) focus on a system's ability to withstand and recover from a temporary disturbance or shock in a variety of contexts, with the most common being environmental, societal, and interpersonal. This finding is corroborated by existing literature, which suggests that resilience is flexible and concerns interaction with a system across various fields (Riepponen et al., 2023), enabling it to withstand short-term stresses and changes (Duchek, 2020). Interestingly, respondents coalesced around two main views on how the system functioned in relation to resilience in the long-term (after a shock). Forty percent of respondents mentioned a return to normalcy, while 36% mentioned a key aspect of a resilient system being that the system improved or adapted to become more resistant to similar shocks in the future [Fig. 2]. The association with adaptation is particularly interesting in tying resilience to sustainability; it suggests that resilience to short-term disasters contributes to the long-term resiliency of a system.

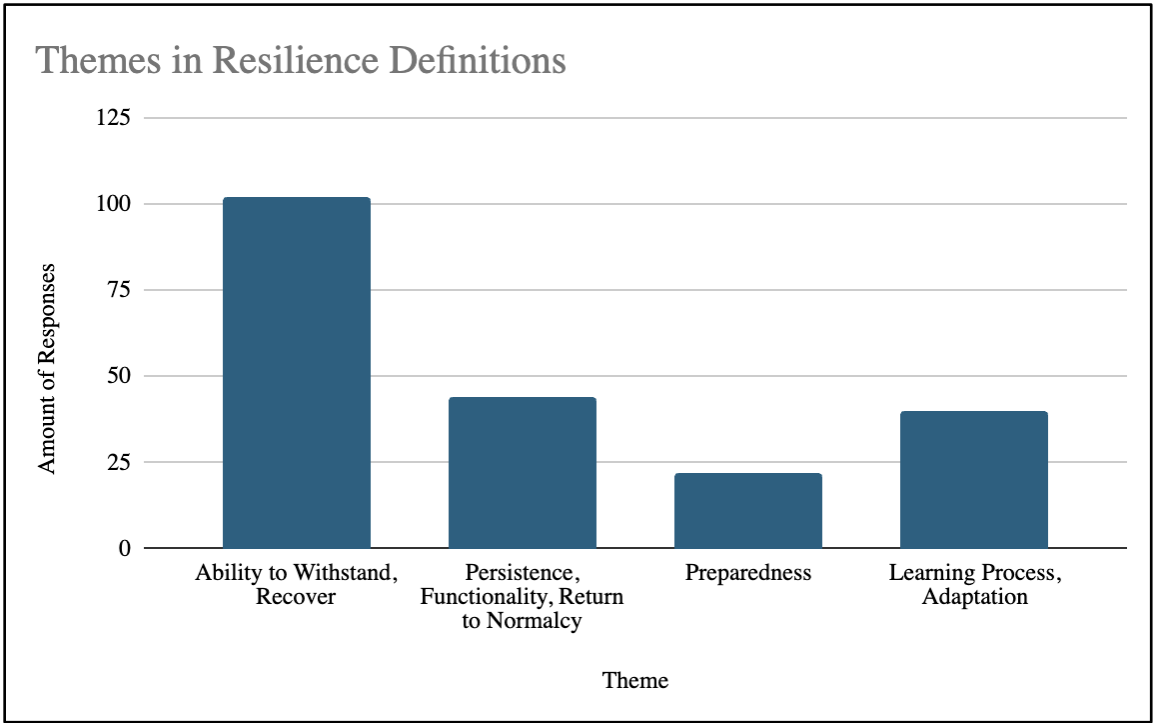


Figure 2. Themes in resilience definitions

Similar to resilience, the majority of responses for sustainability definitions (78/110 or 71%) mentioned the idea of prioritizing long-term viability and keeping a system functioning for future generations. A thematic analysis identified *long-term viability*, *harmony*, *conservation*, and *self-sustaining* as the most prominent themes in the responses [Fig. 3]. Specifically, many respondents included the phrasing "the ability of a community to meet its needs without compromising the needs of future generations," citing the United Nations' Brundtland Report (Brundtland, 1987). The difference in time frame between the two concepts aligns with existing literature, with resilience being perceived as short-term and sustainability as a longer-term concept, with both being active (Marchese et al., 2018).

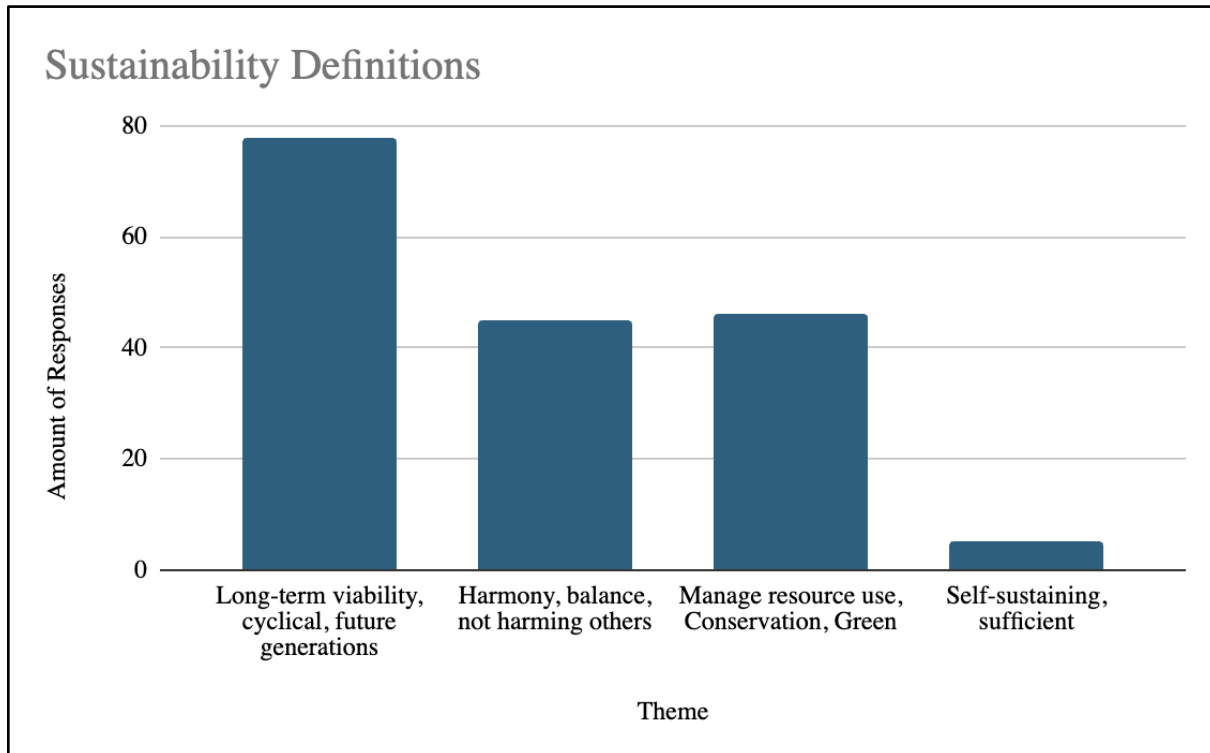


Figure 3. Themes in sustainability definitions

We also asked respondents to generate keywords and associate them with the topics of resilience, sustainability, or both. We found that the most common words associated with resilience orient the concept around a disaster—like “recover,” “adapt,” and “robustness” [Fig. 4]. The temporal aspect to these words suggest resilience is crucial in the short- and medium-terms. When it comes to sustainability, the word associations were more long-term—for example, “longevity”—and focused on broader thematic concepts, like “environment,” and “economics” [Fig. 5]. When both themes were taken into consideration, the associations most often evaluated systems as a whole, with common words being “adapt”, “system”, and “environment”.

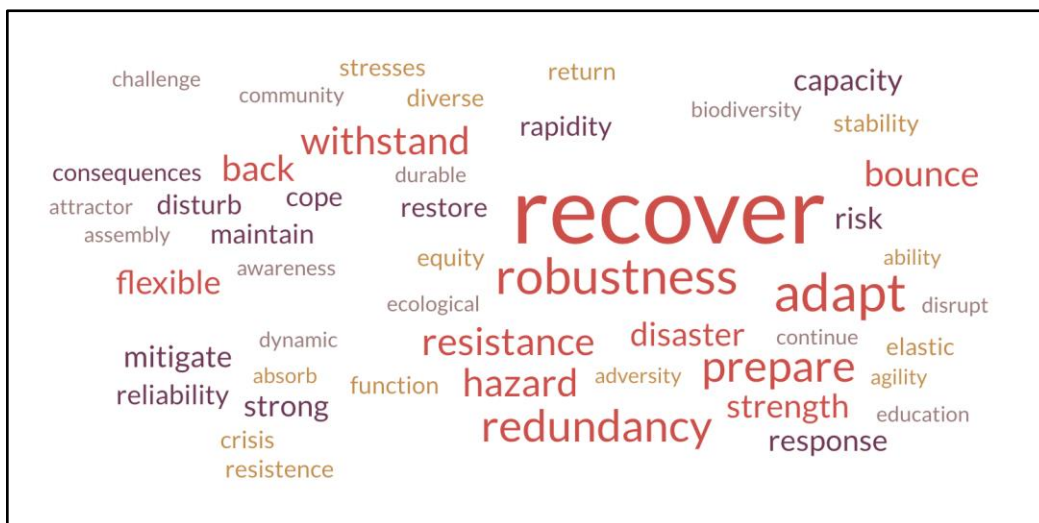


Figure 4. Word cloud of words (by number of mentions) associated with resilience

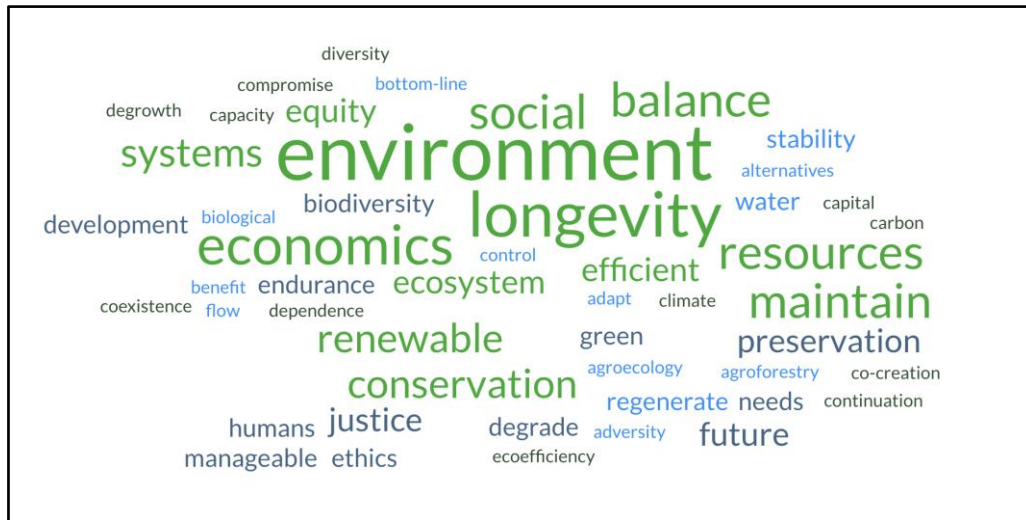


Figure 5. Word cloud of words (by number of mentions) associated with sustainability

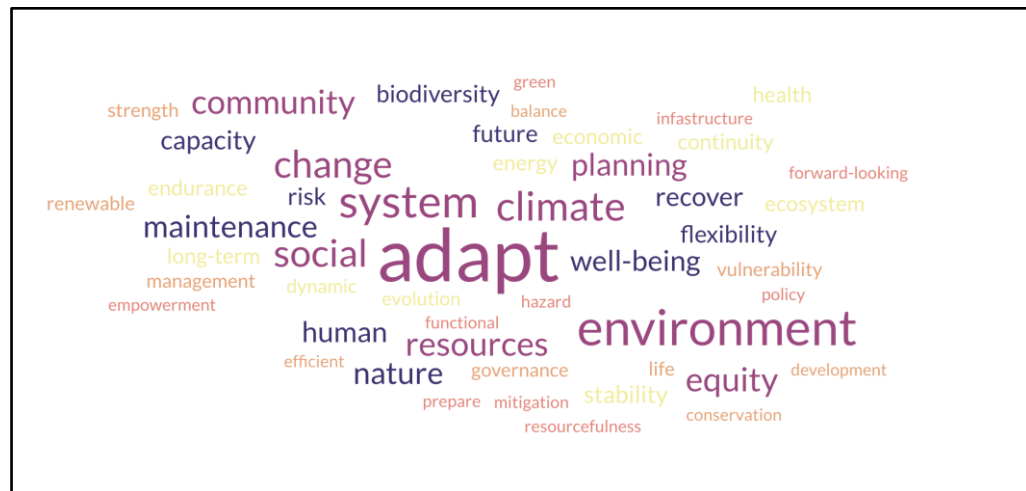


Figure 6. Word cloud of words (by number of mentions) associated with both sustainability and resilience

This study also collected experts' responses to a Venn diagram selection that best encompassed their understanding of the relationship between resilience and sustainability [Fig. 7]. Their selections are shown in Figure 8, with respondents categorized by occupation. Out of 110 respondents, in occupations with over 10 respondents, there were the most in academia (e.g., professors) and government (e.g., UN, policymaking, etc.). Regardless of occupation, a plurality of experts chose option B, which depicted that sustainability and resilience are independent but not mutually exclusive. This is an important consideration and is in alignment with existing studies that argue that the two topics cannot be thought of as entirely interdependent, as tradeoffs may exist (i.e., short-term resilience actions may have long-term sustainability implications) (Frey and Gasbarro, 2019). Therefore, a balanced integration of sustainability and resilience frameworks, keeping in mind that they are malleable concepts, is integral (Roostaie et al., 2019).

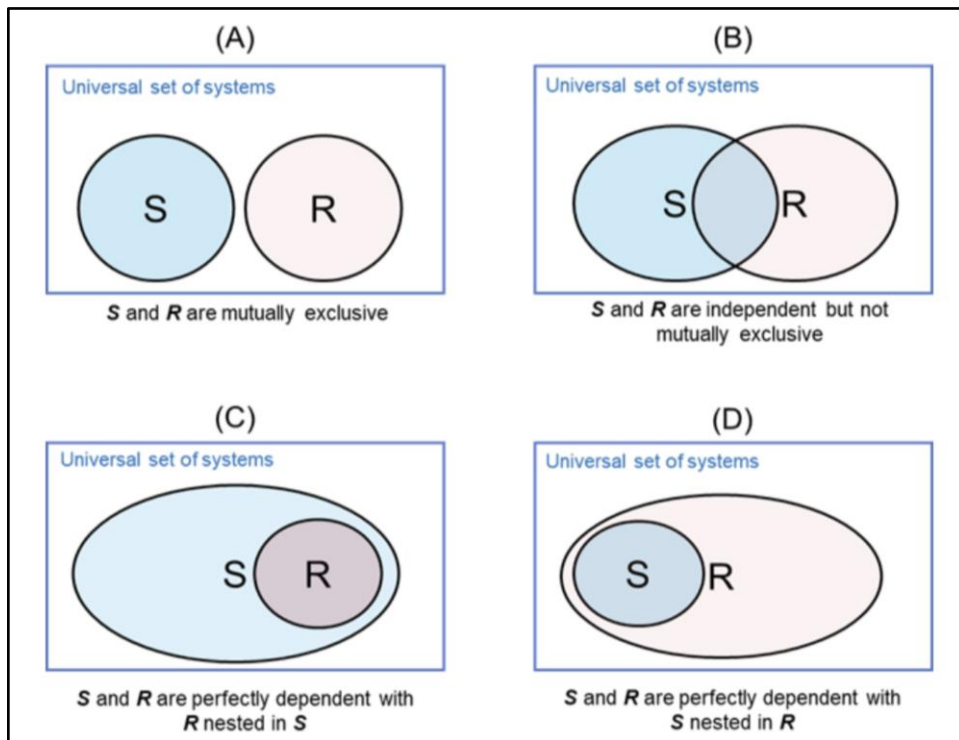


Figure 7. Venn Diagrams included in the survey, where S is sustainability and R is resilience

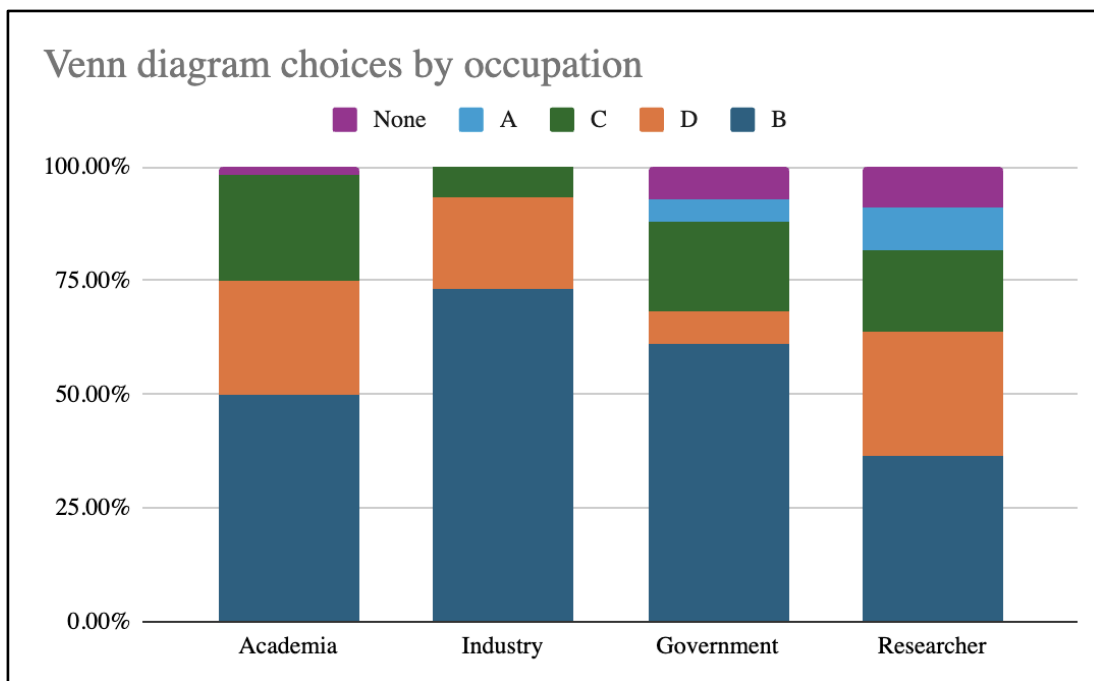


Figure 8. Venn diagram choices separated by occupation

Our research suggests experts perceive three main differences between sustainability and resilience, those being differences in (a) temporal application, with resilience being short-term and sustainability being long-term, (b) focus areas, with resilience as hazard-oriented and sustainability and ecosystem-oriented, and (c) their codependence. Our research is based on survey data from experts based in North America; and therefore, does not include more diverse international perspectives from experts in other countries.

Potential next steps for research include exploring the contrast present in definitions of sustainability. Some responses were centered around human activity, whether in the present or future (i.e., issues concerned with the ability of a system to meet human needs and maintain those functions, like in the economy, society, or natural resources for the next generation), while other responses looked at measuring sustainability in terms of how humans affect other species (e.g., sustainable built systems not having a large negative impact on others). The axis which perceptions of sustainability are oriented around are important areas for future investigation, as it can help guide how policy makers view the priorities of industry.

Conclusions and Future Work

We were able to discern that across occupations (e.g., academia, government, etc.), the vast majority of respondents view sustainability as a goal and resilience as a necessity, and believe that both concepts are somewhat codependent on each other. The results ultimately focused on occupation, although our research collected data on experts from various fields and domains. Similar definitions and applications are corroborated by the existing literature in various fields, like supply chain management and organizational management. Possible future areas of research include looking at resilience and sustainability across a) timeframes, as the impacts of sustainability are primarily seen in the long term, and b) spatial scales, since resilience and sustainability have varying implications in both a narrow (e.g., individual and local) and broad (e.g., organization-wide, national, international) scale. Additional research may also assess the importance that experts place on resilience and sustainability as independent topics, which can direct priorities in policy making spheres.

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Appendix A: Complete Survey

Trade-offs and synergies in designing for Resilience and Sustainability

Consent Text:

You are selected to participate in this research study given your professional expertise. In this project you will answer survey questions, generate individual concept maps, and discuss your perspectives and disciplinary understandings of relative trade-offs and synergies in designing for resilience and sustainability.

Your responses will lead to greater clarity across these domains that are both critical to strategies for mitigating damage from extreme disturbances and persistent stresses, such as extreme weather events and continued climate change impacts. In this study you will be asked questions about your background, field of expertise, and understanding of resilience and sustainability concepts. Please know that there are no right or wrong answers to any of these questions, we just want your experience and opinions.

The concept mapping activity will be completed, individually, through online workshops and take no more than one hour of your time. Because the workshops will each include multiple participants, other participants will hear your questions and comments. The workshops facilitators will try to limit discussions with you about the specific content of your concept map to one-on-one discussions in breakout rooms to protect confidentiality. There will be an optional focus group to which you can participate, where the group's aggregated concept map will be presented for validation and further discussions.

If you feel uncomfortable answering any of the questions, you can skip them, or stop participation at any time. Your participation is voluntary and without compensation. If you decide to participate in the study, you may withdraw your consent and stop participation at any time without penalty.

Your responses will never be linked to your individual identity. Instead, findings will be attributed to characteristics associated with your background and field of expertise. The deidentified information collected in this study may be shared with researchers at the National Institute of Standards and Technology (NIST) or with researchers outside NIST. The information that you provide may be used in future research. Any future research will ensure to protect the confidentiality of the information we gather from you. We do not anticipate any risks from participating in this study.

We hope to gain more knowledge on how sustainability and resilience are conceptualized to better guide allocation of resources that can help researchers, practitioners, and government refine planning for future extreme weather and climate change associated impacts.

To consent, please click “Yes” and complete this brief optional survey. At the end of the survey, you can schedule a time to complete the concept mapping activity.

- ☐ **Yes, I agree to participate in this study**
- ☐ **No, I decline participation in this study**

Brief Survey: Trade-offs and synergies in designing for Resilience and Sustainability

A Federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with an information collection subject to the requirements of the Paperwork Reduction Act of 1995 unless the information collection has a currently valid OMB Control Number. The approved OMB Control Number for this information collection is 0693-0078. Without this approval, we could not conduct this information collection. Public reporting for this information collection is estimated to be approximately eight minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the information collection. All responses to this information collection are voluntary. Send comments regarding this burden estimate or any other aspect of this information collection, including suggestions for reducing this burden to the National Institute of Standards and Technology at: 100 Bureau Drive, Gaithersburg, MD 20899, Attn: Dr. Jennifer Helgeson, Associate Program Manager for the NIST Community Resilience Program, NIST Engineering Laboratory; or contact at jennifer.helgeson@nist.gov.

Section 1: Definitions and keywords

1. In your own words define RESILIENCE. Please write a short definition.
2. In your own words please define SUSTAINABILITY. Please write a short definition.
3. Please provide up to 10 keywords for resilience and/or sustainability (Please add a minimum of five keywords).
4. Please organize your keywords into the following categories (you can drag and drop):

Relevant to
Sustainability

Relevant to
Resilience

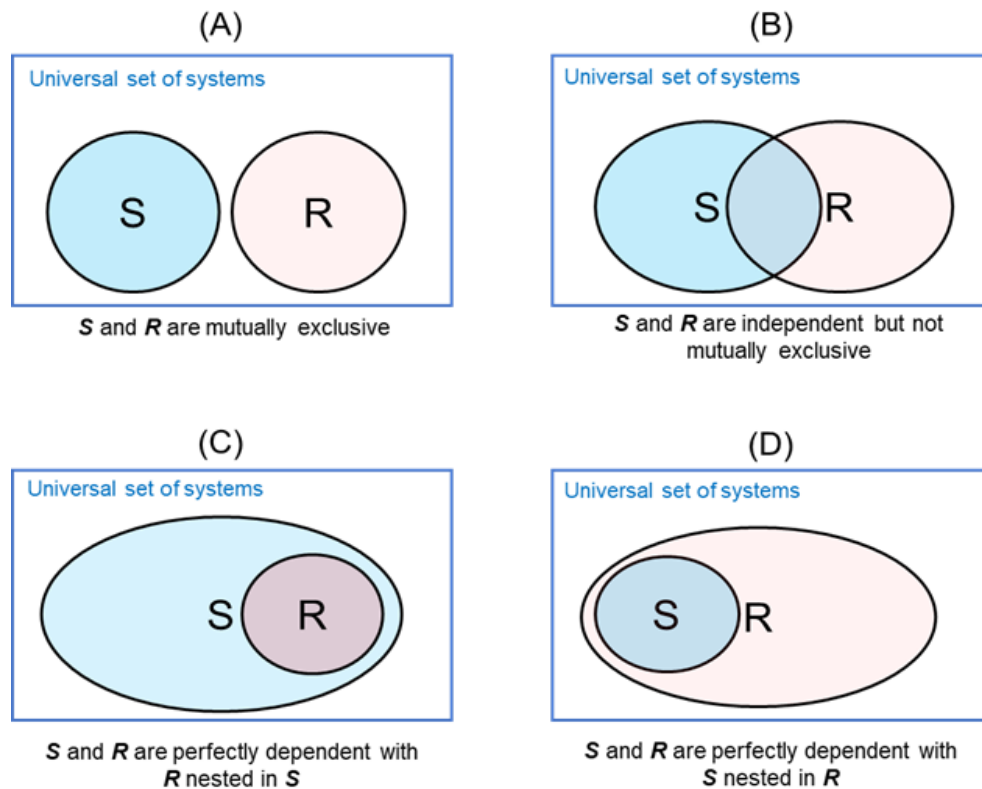
Relevant to both
Resilience and
Sustainability

Section 2: Sustainability and Resilience relationships

1. Which of the following statements do you agree with most? Select only one.
 - a. resilience of the system is necessary, but not sufficient, for sustainability
 - b. resilience of the system is sufficient, but not necessary, for sustainability
 - c. resilience of the system is neither necessary nor sufficient for sustainability
 - d. resilience is both necessary and sufficient for sustainability

2. Do you agree or disagree with the following statements?
 - a. Systems that are resilient may not be sustainable T/F/unsure
 - b. Systems that are not resilient are not sustainable T/F/unsure
 - c. Systems that are not sustainable may be resilient T/F/unsure

3. Which of the following diagrams most accurately describes the relationship between resilient and sustainable systems? (Notes: **R** = Resilient systems and **S** = Sustainable systems)



E) None of the above (Please explain)

Section 3: Demographics, Discipline, Edu background, profession

1. Please confirm your preferred email address:

2. Which of the following categories most accurately describes your current position(s)? Select all that apply

- Student (undergraduate)
- Student (Graduate)
- Teaching/Research assistant
- Postdoctoral researcher
- Adjunct professor
- Associate professor
- Private industry
- Consulting
- Government (Federal)
- Government (State)
- Government (Local)
- Other. Please specify:

3. Which of the following categories most accurately describes your area(s) of formal expertise? Select all that apply

- Performing arts
- Visual arts
- History
- Languages and literature
- Law
- Philosophy
- Theology
- Anthropology
- Archaeology
- Economics
- Geography
- Political science
- Psychology
- Sociology
- Social work
- Biology
- Chemistry
- Earth science
- Space science
- Physics
- Computer science
- Mathematics
- Agriculture
- Architecture and design
- Urban planning / Town planning
- Business
- Divinity
- Education
- Engineering and technology

- Environmental studies and forestry
- Ecology
- Family and consumer science
- Human physical performance and recreation
- Journalism, media studies, and communication
- Library and museum studies
- Medicine and health
- Military sciences
- Public administration/policy
- Other. Please specify.

4. How many years have you been working on issues related to resilience and/or sustainability?

[Enter a number]

Please explain how your work is related to resilience and/or sustainability.

5. How much of your work do you consider to be interdisciplinary in nature? (interdisciplinary indicates that you work with at least one person from another discipline, or the work produced blurs lines between disciplines)

- None at all
- A little
- A moderate amount
- A lot
- A great deal

6. What spatial scale does the majority of your work address? Please select one.

- single building
- single infrastructure system
- building clusters
- local/municipal level
- state or territory
- national
- international
- Other. Please provide additional details:

7. Please provide some examples of how you apply principles of sustainability and resilience in your personal life?

8. Do you belong to a professional organization with a focus on resilience and/or sustainability?

9. In which region of the world have you spent the majority of your adult life (18+ years of age)?

Thank you for your time and participation.

If you would like a copy of your responses emailed to you, please click “yes” below.

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Publication History

Approved by the NIST Editorial Review Board on 2025-01-06

How to Cite this NIST Technical Series Publication

Helgeson JF, Xue K (2025) Cross-disciplinary Expert Perspectives of Sustainability and Resilience Planning. (National Institute of Standards and Technology, Gaithersburg, MD), NIST Research Brief (RB) NIST RB 5. <https://doi.org/10.6028/NIST.RB.5>

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