A ROADMAP FOR BUILDING CLIMATE RESILIENCE AT HIGHER EDUCATION INSTITUTIONS: A CASE STUDY OF ARIZONA STATE UNIVERSITY

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ABSTRACT

Over the past few years, more and more higher education institutions have pledged to achieve carbon neutrality and designed and adopted Climate Action Plans. Although many higher institutions are adopting climate action plans, few are integrating resilience principles and priorities, which are essential for understanding institutions' adaptive capacity for dealing with climate change. There is little existing research on how higher education institutions can implement climate resilience programs, behaviors, and policies into their planning process and campus-communities. To address this gap, this case study explores Arizona State University's process of designing and implementing a climate resilience plan and outlines best practices other higher education institutions can utilize to create their own climate resilience plan. We critically discuss the importance of climate resilience at the higher education level, outline steps necessary for designing an inclusive and holistic climate resilience plan, and provide examples of important techniques used to design the climate resilience plan.

KEYWORDS

climate resilience, higher education, sustainability, climate change planning

INTRODUCTION

Over the past decade, there has been an increase in the need for cities, businesses and communities to enhance their resilience to climate change impacts and natural disasters (Foster & Smith, 2015). Like local governments and businesses, higher education institutions face accelerating risks from climate disruptions, such as extreme heat and changing weather patterns. As "microcosms of the larger external community" that are responsible for "reinforcing desired values and behaviors in the whole community" (Cortese, 2013, pp. 19), universities have the potential to lead the design of innovative solutions to enhance the campus' and the surrounding community's resilience to climate threats. Despite this opportunity, most scholarly research has

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focused on resilience as it pertains to urban planning, individual resilience, resilient ecosystems, and disaster preparedness rather than resilience on university campuses (Storms, Simundza, Morgan, & Miller, 2015). A research study conducted by environmental and engineering consulting firm Haley & Aldrich surveyed colleges about resilience efforts and found that "94 percent of organizations face significant challenges, such as short-term budgetary constraints, not knowing where to start to integrate resilience into campus planning, and lack of best practices, that resulted in delaying resilience planning and deterring progress" (Holland, 2015, pp. 60). This case study aims to provide an example of how to implement resilience at a university campus despite various challenges such as budgetary constraints, confusion of where to start, and/or lack of guidance via best practices.

BACKGROUND

Role of Universities in Climate Resilience Planning

Universities are integral for galvanizing climate action and resilience planning by conducting baseline research and generating discoveries that often influence policy-making toward a sustainable future. Further, "universities' cutting-edge research, operational resources, and strong community partnerships make them uniquely suited to bring together elected officials, business leaders, and environmental advocates to forge a path toward a sustainable future" says former President Janet Napolitano of the University of California (Second Nature, 2018, pp. 4). In many cases, students at universities also serve as a driving force for resilience by organizing climate research projects, advocating for climate solutions, and providing feedback on current university operations as they pertain to sustainability. In the spirit of collaboration innate to the function of higher education, this article seeks to provide insight on how Arizona State University (ASU) is developing its climate resilience plans to address climate change and set an example for how universities can serve as climate resilient centers in their communities.

Arizona State University (ASU)—Commitment to Climate Action

ASU is one of the largest public universities in the United States of America. With metro campuses and locations in Phoenix, Mesa (Polytechnic campus), Tempe, and Glendale (West campus), Scottsdale (Skysong), Lake Havasu, Washington DC and Santa Monica, CA and nearly 200 online degree programs; ASU provides education to over 74,878 students and employs about 18,000 faculty, staff, and administrators. Even with such a large campus-community, ASU has made climate action a priority. In 2019, Arizona State University achieved carbon neutrality six years ahead of schedule (Tricoles, 2020). The university's commitment to climate action can be seen by its 174,664 installed PV panels, 66 electric vehicle charging stations, subsidization of 1.7 million one-way light rail trips and of Tempe neighborhood Orbit buses, and creation of an urban forestry program that has resulted in the planting of over 600 trees. Examples of climate action related research range from ASU's Sustainable Cities Network which was established to build sustainability capacity within local governments, to ASU's Center for Global Discovery and Conservation Science's mapping of the impact of the 2019 Pacific Ocean heatwave on Hawaiian coral reefs (D'Angelo, 2019). While climate action has been a university priority since President Michael Crow helped initiate the American College & University Presidents' Climate Commitment (ACUPCC) in 2006, the increasing need for enhancing climate resilience inspired President Crow to sign Second Nature's Climate Resilience Commitment in 2016, which sets targets and goals for climate resilience planning in higher education institutions.

Photos showcasing ASU's commitment to climate action including the university's zero waste efforts, PV solar installations, sustainable dining and transportation options.

Arizona State University and Second Nature

University Sustainability Practices (USP) was tasked by President Crow with creating the resilience framework in line with the goals of the 2016 Climate Resilience Commitment, which asks ASU to generate a resilience assessment alongside the climate action plan. According to Second Nature, the goal of the resilience assessment is to "provide a baseline of current resilience activities on campus and in the community, develop initial indicators of resilience through a multi-stakeholder process, and identify current vulnerabilities related to climate change" (Second Nature, n/a).

Before assessing the campus-community's resilience, it was important for the university to define resilience and establish guidelines for the resilience planning process. For the purposes of ASU's university-enterprise and its surrounding communities, USP defines resilience as increasing the ability to survive disruption and to anticipate, adapt, and flourish in the face of climate change. After defining resilience, USP moved to establish guidelines for resilience planning. In order to engage the ASU campus-community stakeholders and leverage specific operational expertise, USP adapted Second Nature's Resilience Planning Guidelines into 6 key steps:

1. Climate Futures Briefing and Brainstorming
2. Future Visioning Scenario
3. Climate Impact and Vulnerability Assessment
4. Resilience Capacity Assessment Matrix
5. Resilience Plan
6. Evaluation

To support resilience efforts, ASU partnered with Second Nature in a pilot project on resilience assessments—including just 6 higher education institutions—called the Climate Resilience in Urban Campuses & Communities (CRUX) initiative. The goal of the initiative was to develop a diverse collection of templated processes for the wider audience of Second Nature Resilience Commitment institutions to select from to aid in their own resilience planning.[5*]

As an embedded member of the community with a vested interest in its success, USP recognized the importance of creating and maintaining strong campus-community partnerships, especially when dealing with the cross-cutting issue of climate change. As such, USP partnered with South Mountain Community College, another of the six CRUX institutions, and employed an ASU graduate student who served both institutions to support the resilience planning process.

ASU CAMPUS-COMMUNITY CLIMATE RESILIENCE PLANNING TIMELINE

Based on Second Nature's Resilience Planning Framework and the resilience planning guidelines, USP developed the following timeline for enhancing the university's climate resilience and fulfilling the resilience commitment:

Year 1—Climate Futures Briefing, Pilot Future Scenarios Workshop, Vulnerability Assessment, and Resilience Capacity Matrix at ASU West Campus

- Convene broad stakeholder group to be briefed on regional climate change expectations
- Coordinate Resilience Task Force working group on West Campus to complete initial Visioning Exercise
- Identify main climate threats facing the ASU community via the workshop
- Design the base of the Resilience Capacity Matrix

Year 2—Climate Future Scenarios Workshops, Vulnerability Assessment, and Resilience Capacity Matrix for entire ASU campus-community

- Coordinate working groups on Tempe, Polytechnic, and Downtown campuses and complete visioning exercises on all 3 campuses
- Host vulnerability workshops to identify the current resources and capacities compared to future needs for enhancing resilience
- Develop Resilience Capacity Matrix based on results from all workshops

Year 3—The Climate Resilience Plan

- Establish initial climate resilience plan indicators and metrics based on the Resilience Capacity Matrix
- Create targets for achieving all indicators

Year 4—Begin Implementation of the Climate Resilience Plan and Design Evaluative Measures

- Design measures for evaluation and actions to expand research and educational experiences relative to resilience
- Begin implementation of climate resilience plan

5.* It should be noted that the CRUX initiative would not have been possible without funding provided by the Kresge Foundation

CLIMATE FUTURES BRIEFING, PILOT FUTURE SCENARIOS WORKSHOP, VULNERABILITY ASSESSMENT, AND RESILIENCE CAPACITY MATRIX AT ASU WEST CAMPUS

USP chose the ASU West Campus to serve as the pilot location for testing the resilience planning process and protocol because it has a smaller population, straight-forward operations, and is uniquely embedded into the community compared to the other ASU campuses. The work completed at ASU's West campus provided the groundwork for designing the ASU campus-community wide Vulnerability Assessment that led to the creation of the Resilience Capacity Matrix and overall resilience plan.

Climate Futures Briefing and Brainstorming

To determine key climate stresses that will impact the ASU campus-community, the Arizona State Climatologist was consulted and invited to present to a broad stakeholder group at a kick-off resilience brainstorming session in March, 2017 at ASU West. The following climate change expected impacts for the region were described by the State Climatologist, which informed the subsequent Visioning Workshops, Vulnerability Assessments, and Resilience Capacity Matrix:

- Increased Extreme Heat and Urban Heat Island Effect
- Changing Precipitation Patterns and Severe Drought
- Heavy Monsoon Rains and Increased Flash Flooding
- Extreme Weather and Increased Dust and Electrical Storms

The stakeholder brainstorming session also generated the decision to hold visioning sessions as a first step to engage and inspire stakeholders at the beginning of the process.

Future Visioning Workshop Procedure and Implementation at ASU West

An important component of sustainability planning is designing sustainable future states to frame transformational sustainability solutions, such as a climate resilience plan. Future visioning offers a compelling way to make climate change explicit to local communities, propose possible solutions, and enhance the participation of stakeholders in designing new policies and processes for building a sustainable future in line with future goals (Sheppard et al., 2011). By identifying preferred future goals through a visioning process, it is possible to design strategies that head towards them, build capacity, and create climate resilience at the same time.

The ASU West Campus visioning workshop was held in July 2017 and included staff, faculty, students, local government leaders, and community leaders including members of Habitat Humanity, the Tiger Mountain Foundation, and the Arizona Department of Environmental Quality.

To conduct the visioning exercise, ASU split the stakeholder group up into two groups. Each group was asked to vision 25 years into the future at ASU–Resilient Campus. Stakeholders' backgrounds pertained to one of four selected primary sectors of campus climate resilience: infrastructure, society and equity, environment, and mission services. Each group was told the following:

> Imagine 25 years into the future. You are giving a campus tour of ASU–Resilient Campus. Participants include your future children and/or grandchildren. Before the tour starts, you explain a key aspect of the university's mission: to facilitate an inclusive campus-community environment that mitigates climate impacts while demonstrating preparedness and

adaptive capacity in the face of uncertainty. As you guide participants through campus, make 3 specific stops to highlight resilience attributes relative to your professional sector/expertise: infrastructure, society and equity, environment, and mission services. At your stops, describe the campus setting, the surrounding environment, what people look like, the campus-community relationship, programs being implemented, and what story the campus is trying to tell.

To guide and inspire participants in the visioning process, each group was provided a series of key criteria for developing visions (Figure 1) and questions for consideration pertaining to each sector as it relates to campus-community climate resilience.

FIGURE 1. Key criteria for developing quality visions. Vision criteria were developed based on research from Arnim Wiek and David Iwaniec titled "Quality criteria for visions and visioning in sustainability science"(Wiek and Iwaniec, 2014).

Why do we vision?	Visualize what future campus should be versus what it could be
How do we vision?	Start from tabula rasa (blank slate) instead of existing campus
What do we vision?	Tap into your imagination, think outside the box
Should our vision be realistic?	Creative, unconstrained, free, idealistic, open, innovative, not necessarily realistic

The following table provides the questions given to the attendees to consider resilience in each predetermined sector:

Society and Equity	Mission Services
How is equality woven throughout the social fabric of campus and the surrounding community? How does the campus interact with the surrounding areas? What type of student housing is available, and are there any healthcare programs implemented? Where does the food come from and how accessible is it? Is reliable transportation available to all campus and community members?	What is the relationship between campus and the surrounding community? What makes the relationship special? Are there any specific strategies for recruitment that address climate concerns? Are there innovative research opportunities available? How is ASU continuing to deliver its academic mission?
Infrastructure	**Environment**
How is energy managed—where does it come from? What is the primary water source and are there any specific water strategies implemented? What does the waste infrastructure look like, and how is waste sorted and processed? Where are people spending their time? How do people travel between spaces?	What does the environment look like on and around campus? Are there any specific plant and/or animal species that are abundant? Are there any positive impacts on the surrounding environment? How is the campus connected to the "environment-at-large"?

At the conclusion of the workshop, all of the visions were shared and analyzed to produce a final vision that is coherent, shared, and plausible (Appendix 1)—which are key characteristics of any sustainability vision (Wiek and Iwaniec, 2014).

Upon completing the future visioning exercise at ASU West, the most common vision themes were:

- The campus blends and acts in harmony with the surrounding community and ecosystem. The boundaries between campus and community are blurred and porous.
- Through partnerships with local governments, businesses, and corporations, the University acts as a 'resilience hub' for the local community providing inclusive access to education (defined more broadly than traditional degree-granting higher education), resources, and technology.
- Food, energy and water are produced and used sustainably through a variety of innovative practices that promote local, circular, closed-loop resource systems.

Vulnerability Assessment and Resilience Capacity Matrix at ASU West

After the visioning process was complete, the ASU West working group met monthly with staff from USP to conduct a Vulnerability Assessment. Each meeting focused on a different sector of the overall framework:

- **Society and Equity** refers to campus systems designated to meeting the basic needs of the ASU campus-community. Universities often function as community hubs where the lives of students, faculty, and staff are brought together. As a community hub, ASU campuses must include access to climate resilient housing, food, water, and healthcare and basic access to ASU for the well-being and safety of all students, faculty, and staff.
- **Mission Services** refers to continuing to meet ASU's fundamental goals as a comprehensive public research university in the face of climate change. To further its university mission ASU must build resilient research discovery, financial planning, academic excellence, university accessibility, social fabric, and sustainability literacy within ASU's campus-community.
- **Infrastructure** refers to the physical systems and facilities of ASU including energy, water, waste, buildings, landscaping, and transportation within the campus-community. Ensuring climate resilient infrastructure is vital for the future of ASU to continue as climate change presents greater extreme environmental conditions that these structures must withstand.
- **Environment** refers to the campus-community ecosystem. This includes ensuring responsible water use, robust biodiversity, and natural landscaping is used across ASU's campuses to create naturally resilient systems in every campus environment.

At each meeting, the group evaluated campus planning areas for their sensitivity to climate change impacts, as well as inherent adaptive capacity, culminating in an overall vulnerability score of low, medium or high. At the conclusion of the meeting series, USP presented the final Vulnerability Assessment to be reviewed and signed-off on by the group.

The Vulnerability Assessment then informed and evolved into a Resilience Capacity Matrix (Figure 2 in Appendix) that included sectors, planning areas, indicators of resilience, metrics, adaptive capacities, and vulnerabilities pertaining to each climate impact as outlined below. The matrix also facilitated generating a list of potential opportunities for implementing new measures to enhance resilience.

- **Sectors:** a key strategic area
- **Planning Areas:** a key objective
- **Indicators:** demonstrates achievement of climate resilience in a given planning area for mitigation and management of climate event impacts
- **Metrics:** measures indicator progress and highlights data collection opportunities for measuring resilience
- **Adaptive Capacity/Strengths:** Existing resources pertaining to each planning area
- **Vulnerability:** Barriers and challenges pertaining to each planning area

This process provided base level indicators and discussion topics for all of the other ASU campuses.

EXPANDING FUTURE VISIONING AND THE VULNERABILITY ASSESSMENT TO ALL ASU CAMPUSES

The pilot workshop at ASU's West campus provided a variety of insights for engaging the broader ASU campus-community. Insights include: 1) Engage stakeholders at every step, 2) It was impossible for USP to provide baseline metrics/indicators for all sectors, 3) Establish a shared understanding of what climate resilience is and why it is important, and 4) It would be more effective to create the capacity matrix on a sector by sector basis in which attendees were assigned a sector based on their expertise.

In an attempt to utilize these lessons learned as a means of engaging a broader stakeholder group on an expertise level and creating a shared understanding of climate resilience, University Sustainability Practices decided on a six workshop (two at each campus) strategy instead of a monthly meeting strategy used at ASU West. The first workshop focused on identifying and designing the shared future vision of each stakeholder and the second workshop focused on completing the Vulnerability Assessment at each campus. The key vision elements from all future vision workshops can be seen below:

- Blurring the line between the campus and the community
- Desert-adapted landscaping with ample shade, ecological services, and water harvesting
- Inter-communal housing with shared services including healthcare
- Improving the connection with nature through design and construction
- Emphasis on health and wellness through a variety of strategies and tactics
- Water capture and reuse to minimize wasted water
- Improving the connection with the local community by acting as a community hub or center
- Reduced congestion through innovative transportation solutions
- Education may be provided in whole new ways that bring new ways of managing campus and campus infrastructure

- On-campus food production that helps decrease dependence on outside food but also improves the connection between consumer and food sources

After the future visioning workshops concluded, USP hosted a second workshop to conduct the Vulnerability Assessment, which identified the campus-community's weaknesses, strengths, vulnerabilities, and the assets that the campus-community holds relative to climate change impacts. To capture vulnerability, USP designed a table for workshop attendees to fill out for each sector, including the climate stresses, projected impacts, and what level of impact the individual perceived the predicted climate stress would have on that sector (Figure 3). All of these tables were collected at the end of the workshop sessions and combined by USP into one cohesive Vulnerability Assessment document where the impact scores were averaged and rounded to the nearest whole number.

COMPLETING THE CAMPUS-COMMUNITY RESILIENCE CAPACITY MATRIX

The vision elements and Vulnerability Assessment set the stage for the creation of the ASU Cross-Campus Community Resilience Capacity Matrix. The matrix was created through a process known as backcasting. Backcasting is an interactive planning tool in which a successful future state is imagined by various stakeholders (as done in the future visioning workshop), followed by the question "what do we need to do today to reach that sustainable future state?" (Kanter et al., 2016). The main difference between backcasting and forecasting is that the latter generates a variety of futures from a common present while the former generates various pathways to a single desired future state (Kanter et al., 2016). Thus, backcasting can be seen as a problem-solving approach that enables stakeholders to set priorities, create and rank a variety of solutions, and identify specific steps that need to be taken in order to reach their shared desired future state.

The development of the Resilience Capacity Matrix was informed by a series of two additional one-hour long backcasting workshops with the leadership teams and ASU staff members at each campus known as the Green Devil Network (GDN). The new design reduced disconnect between staff and the Climate Commitment and confusion among staff about what Climate Resilience means. This approach also increased social cohesion between departments and produced complete resilience assessments at each ASU campus. The design of these workshops followed the process outlined by the Nature Conservancy's Community Resilience Building Workshop.

The purpose of the workshops was to summarize the outcomes of the Vulnerability Assessment and produce a resilience assessment that would guide resilience efforts across the ASU Campus Community. Part one of the workshops focused on the importance of a resilience assessment and introduced the capacity matrix as a tool for completing the assessment. During this workshop participants were each assigned one planning area within the matrix (e.g. housing, biodiversity, energy, food, health, etc.) to individually complete based on their self-identified expertise. Part two of the workshop series involved splitting participants into groups based on the section of the matrix they were assigned and/or self-identified with. Each group collectively discussed their section and reported out a final version to the group at large, allowing comments from the other groups. After the conclusion of the workshop series at each

FIGURE 3. This is an excerpt of the Vulnerability Assessment tables filled out by each individual.

Sectors/units	Current & projected climate condition relevant to system	Current stress	Projected impacts due to climate changes	Projected changes in combined climate& non-climate stress	Degree of impact 3+ = high, 2+ = medium 1+= low
Population body - ASU body	Higher temperature Extreme events (greater intensity & frequency of microbursts & dust storms)	Managing high density of pop (e.g events) Meeting increased demands (e.g. energy) Emergency preparedness plans	High volume outdoor events during warmer summer months likely to cause heat stroke, dehydration, emergency visits, mass exodus that will vary by age group	Population increase Energy demands increase Safety demands increase	High
Facilities & Infrastructure - Student housing	Higher temperature More arid conditions Extreme events Urban heat island	Safety thru well-lit areas, thermal comfort, Meeting increased demands for energy Meeting increased demand for water use	Warmer temperature will increase frequency & intensity of energy demands for cooling during both day & night; Demand for shade structures; cooling stations demand increase	Cooling demand increase Shade structure demand increase Air conditioning demand increase	High
Grounds - Campus grounds (arboretum)	Higher temperature More arid conditions Drought Extreme events	Maintenance of grounds for aesthetic and legal bases.	Warmer temperature will increase frequency & intensity of water for irrigation. Cleaning cost of extreme events such as micro-bursts	Irrigation demands Increase Maintenance cost not known	Low & uncertain
Energy & Utility Supply	Higher temperature More arid conditions Drought Extreme events Urban heat island	Managing current status Maintenance costs Meeting increased demands Planning for future demands Coordination with utility companies Expansion of renewables Purchasing power agreements	Warmer temperature will increase frequency & intensity of stress on utility & energy demands; Exceedance of threshold temperature of units likely with warmer temperature both during day & night. Greater air conditioning usage Greater lighting needs as campus expands Greater water demands as campus expands Expansion for renewable energy such as solar	Overall higher energy demand for cooling, heating Maintenance and distribution costs increase Upgrades & retrofits increase Renewables demand increase Infrastructure upgrades increase Emergency preparedness updates more frequent	High
Water & Wastewater	Higher temperature More arid conditions Drought	Managing current status Maintenance costs Meeting increased demands of water for wastewater systems	Changes in intensity & frequency of precipitation may increase stress on supply & distribution systems Water quality due to turbidity after dust storms	Water demand for population, research & maintenance increase Emergency preparedness for storms updates more frequent	Medium
Food systems	Higher temperature Arid conditions Prolonged drought	With emphasis on local food & local growers means variable impacts Higher cost of local food Cooling & transportation costs	Warmer temperature, prolonged drought and intense precipitation all have significant impact on food production with possible water delivery cutbacks. Local food supply will be affected due to their perishable nature Higher refrigeration costs to keep food fresher Higher energy costs anticipated for production, supply and distribution of food.	Higher refrigeration costs Higher food production costs Higher food cost in general	High
Transportation, Pavement & Parking (Built environment)	Higher temperature Extreme events Urban heat island Flash floods	Meeting increasing demand for shade for parking Meeting increasing demand for walkways Meeting increasing demands of bike pathways Meeting increasing demands for foot traffic	UHI on ASU's built environment including parking garages, pavement walkways and buildings and transportation stations is increasing during night. Greater dust & storm frequencies is demanding weather safety alerts Efficiency reduction of solar PVs.	Demand for shaded Structures Cooling stations Cooler walkways Flashflood incidences Dust storms frequency	High

campus, the resilience team at USP put together the final Resilience Capacity Matrix complete with a built-in Vulnerability Assessment (Figure 4 in Appendix).

ASU'S CLIMATE RESILIENCE PLAN

Recognizing that simply having a Resilience Capacity Matrix is not enough to create change toward a climate resilient future, USP designed a two-part initiative for integrating resilience into the ASU-enterprise system that addresses both short-term and long-term climate change impacts. The initiative includes two main documents:

1. Climate Resilience Emergency Management Plan
2. Climate Resilience Enterprise Planning Framework

The documents are each framed around the structure of the Resilience Capacity Matrix:

- **Sectors:** a key strategic area
- **Planning Areas:** a key objective
- **Indicators:** demonstrates achievement of climate resilience in a given planning area for mitigation and management of climate event impacts
- **Metrics:** measures indicator progress
- **Targets:** sets a time frame and goal for achieving an indicator

The Climate Resilience Emergency Management Plan outlines indicators and metrics based on two main climate events likely to impact ASU due to its geographic location: extreme heat and drought. This plan outlines specific actions, indicators, metrics and targets to address the immediate climate impacts associated with these events. Other impact areas may be added at a later date.

The Climate Resilience Enterprise Planning Framework (Figure 5) uses this structure to provide a framework for long-term planning to be integrated with and inform ASU enterprise planning. This document is based on the Capacity Assessment Matrix and is comprised of the same sectors from the Vulnerability Assessment workshops:

Society and Equity refers to campus systems designated to meeting the basic needs of the ASU campus-community. Universities often function as community hubs where the lives of students, faculty, and staff are brought together. As a community hub ASU campuses must include access to climate resilient housing, food, water, and healthcare and basic access to ASU for the well being and safety of all students, faculty, and staff.

Mission Services refers to continuing to meet ASU's fundamental goals as a comprehensive public research university in the face of climate change. To further its university mission ASU must build resilient research discovery, financial planning, academic excellence, university accessibility, social fabric, and sustainability literacy within ASU's campus-community.

Infrastructure refers to the physical systems and facilities of ASU including energy, water, waste, buildings, landscaping, and transportation within the campus-community. Ensuring climate resilient infrastructure is vital for the future of ASU to continue as climate change presents greater extreme environmental conditions that these structures must withstand.

Environment refers to the campus-community ecosystem. This includes ensuring responsible water use, robust biodiversity, and natural landscaping is used across ASU's campuses to create naturally resilient systems in every campus environment.

FIGURE 5. The layers of the Climate Resilience Enterprise Planning Framework.

Targets will be established as data is collected to measure these metrics to set standards and time frames for achieving climate resilience within these sectors.

This framework is a living document and is to be regularly reviewed by a committee for collecting metric data, evaluating progress towards meeting targets, and updating indicators and metrics to accurately meet ASU's needs in continuing to build climate resilience. As the framework is updated, linking climate resilience targets with opportunities to use ASU campuses as living laboratories should be explored to further academic excellence and framework robustness. Next steps for implementing the framework include selecting a Climate Resilience Committee to review the resilience plan and outcomes bi-annually and engaging with stakeholders to begin implementation of the plan.

EVALUATION MEASURES

Evaluation and continuous measurement of progress is essential to ensure ASU fulfills the Climate Commitment. Consistent with the requirements of the Climate and Resilience

Commitments, ASU submits annual progress reports on resilience efforts and greenhouse gas emissions to Second Nature. This annual reporting allows USP to assess its current impact, track its resilience efforts, learn from other universities' reports, and update its strategies for ensuring climate resilience. The process for reviewing the plan and metrics includes bi-annual evaluation by a campus-community resilience task force composed of faculty, staff, and community organizations/members.

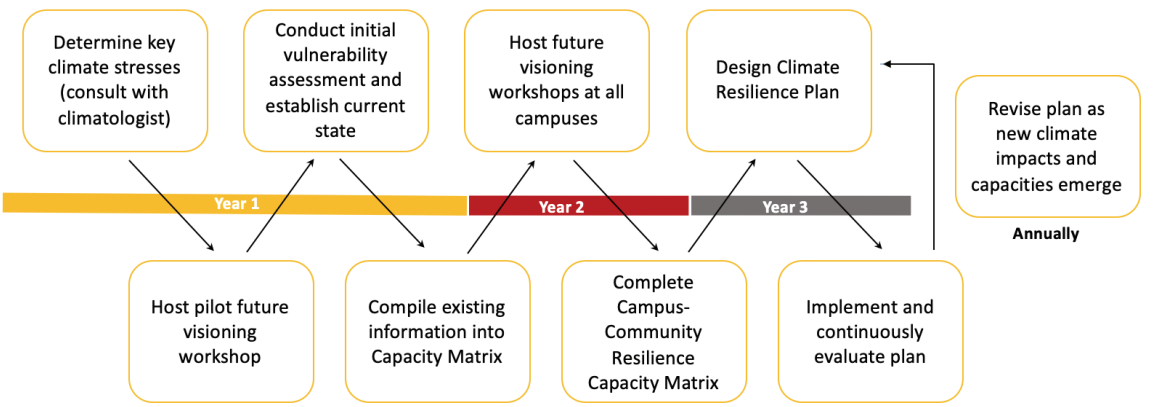
Additionally, USP will continue to submit an annual report to the Association for the Advancement of Sustainability in Higher Education's (AASHE's) Sustainability Tracking, Assessment and Reporting System (STARS), which is an internationally recognized third party sustainability assessment tool for higher education institutions. The STARS report provides a detailed and comprehensive breakdown of ASU's sustainability and resilience efforts, including learning outcomes, campus as a living laboratory, support for sustainability research, transportation, waste, energy, food, affordability, well-being, community partnerships, supply chain and biodiversity.

LESSONS LEARNED

When thinking about how to weave resilience into campus-community lifestyles, it is important to keep the following seven components in mind:

1. Demonstrate the immediate need—Connect resilience to everyone's day job the best you can, get support from leadership
2. Create ownership through future visioning—Allow as many people as possible to be involved with the future visioning process so all ideas and needs are incorporated, leading to a robust, holistic, inclusive vision
3. Break down resilience into bitesize tasks—Redesign the effort commitment for the individual participant to be more accommodating to their schedule and break the project into parts
4. Utilize existing resources—Don't let perfection get in the way of progress, work with what you have, identify what you don't, and prioritize
5. Build collaborations and hire students—Collaborations with local government agencies, community organizations, and students has been critical

FIGURE 6. USP's Climate Resilience Plan Timeline.



6. Integrate resilience planning into the campus strategic planning process—Resilience planning should incorporate campus planning terminology and engage staff in order to maximize traction, impact, and eventual merging.
7. Define institutional boundaries—Recognize when it's within the institution's jurisdiction to monitor and manage resilience and when the institution is acting as one of many stakeholders in a larger planning process.

Reflecting on ASU's Climate Resilience Plan Process, it is much easier to see the strategy USP employed to achieve the climate resilience vision. The following diagram illustrates USP's final process for integrating climate resilience into the university's practices (Figure 6).

CONCLUSION

Creating a campus-wide climate resilience plan is no small task for any university, and certainly not for an institution of ASU's size. Transitioning from short-term operations planning to long-term resilience planning required the creation of ownership through a shared vision, diverse stakeholder engagement, and recognition of both ASU's strengths and weaknesses when it comes to dealing with the impacts of climate change. USP recognizes that the resilience plan is in no way perfect. However, it serves as a starting place for the perpetual process of building and maintaining climate resilience. In the future, USP's goal is to integrate Resilience Plan elements into long-term campus master plans and strategic planning processes to ensure the campus-community can continue to bounce forward in the face of an uncertain future. It is also hoped that the efforts and lessons learned can serve as a guide for other institutions to use and improve upon in designing their own climate resilience plan.

For more information on USP's resilience process or access to more detailed examples, please contact Arizona State University's University Sustainability Practices at usp@asu.edu.

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APPENDIX

Final Vision Example (ASU West)

Imagine arriving at a campus that acts as an extension of the surrounding community and environment. Rather than exist as separate spaces, they exist as a harmonious whole perfectly in tune with one another. People flow freely between these spaces affirming the lack of any divisive borders or boundaries. Walking through the community, there is a certain positive energy felt as you realize you are actually within the campus. You get the feeling this is less of an institution and more of a hub for the community with education as the grounding principle.

As you move through campus, the smell of creosote hangs in the air and a roadrunner dashes in front of you on the hunt for food. Your eyes follow the bird as it runs into a beautiful park with a visitor's center. This space is very green and enveloped by shade trees. The visitors' center is built into the ground and constructed from recycled materials. Starting inside you notice the lighting is provided solely by LED lights complimented with biophilic design. A student worker approaches and greets you.

She suggests visiting her top three favorite sites on campus to understand what this university is all about: the Community Garden, the Campus Health Center, and the Recreation Hall. She puts special emphasis on the oasis located in the middle of the Rec Hall as she hands you an iPad like device with an interactive map for reference during your tour. You notice the Community Garden is only a few steps from the visitor's center and decide to stop there first. Before you reach the garden, you notice an unusual receptacle that turns out to be a waste bin that automatically sorts waste into appropriate categories. Snapping a quick picture on your super smartphone to share with friends, you move into the garden.

A large array of people are working on various tasks. Among them are community members, staff, and numerous students. Speaking with a local resident, you learn that much of the green waste produced from the garden, along with food waste from the Rec Hall and community, is converted to energy. This and solar are the primary energy sources for the micro-grid that powers the campus and community. Water is provided solely by wells and rainwater harvesting. In addition to traditional food crops, you observe some odd plants and inquire further. An individual who identifies herself as part of the T'ohono O'odham tribe shares that these are native plants that have been used as food for thousands of years by her tribe and others from the region. She notes there is a Native Food Kitchen at the Rec Hall that offers prepared meals and classes on how to make these crops into tasty, nutritious meals.

Before continuing on to the Campus Health Center, a retired Facilities Management Director explains the abundance of student workers is partly due to their receiving tuition credit for garden work. Tuition is based entirely around campus and community work. Three hours of garden work per week pays for a class. Students can also work within their field of

study for tuition credit. For example, Child Development students can work in the Daycare to earn classes.

For each field of study there are corresponding jobs allocated to students. This helps bridge the gap between research and application while allowing for innovation and creativity. Walking into the Health Center you learn the Daycare, Fitness Center, Retiree Center, Dental Clinic, and Family Medicine Clinic are just a few of the specialty student practices available free to all members of the campus-community. To mitigate congestion and waiting lists, the Health Center utilizes video chat to have virtual appointments with doctors and specialists.

In the hall leading to the Fitness Center you see a poster on the wall about heat-related illness. It illustrates that since 2017 the number of individuals afflicted with heat-related illness has dropped significantly as a result of more stable power and greater access to natural cooling stations. The micro-grid has significantly reduced blackouts. In the rare event of a blackout there are multiple backup batteries that store large quantities of energy. This coupled with the Recreation Hall's vast oasis, ensure people have consistent access to cooling during extreme heat events. This reference to the vast oasis is very intriguing and you decide to make that your last stop.

Once at the Fitness Center you see that before and after using the exercise equipment students are swiping their ID cards. Asking a young man finishing up on the treadmill, he informs you the exercise machines are connected to the micro-grid and each activity produces energy. The amount of energy each individual contributes is cataloged via a points system on their ID card. These energy points can then be utilized in various ways and prizes are awarded to the top contributors each month. He also notes that students' work hours are logged to their IDs as well.

Leaving the Health Center and walking toward the Rec Hall, it dawns on you this campus lacks any parking structures. People commute exclusively by public transit, driverless cars, or alternative methods such as bicycles and skateboards. Ironically, a driverless car drops off a group of people right in front of you. Introduce yourself, you learn the group consists of two students, a community member, and the Vice Provost of the university. They were all picked up from their residences in a nearby neighborhood. Such intercommunal living is a welcomed surprise that says a lot about the University's commitment to social equity.

Your excitement peaks as you reach the Rec Hall. Before going in you notice the natural beauty of the building's exterior. A brilliantly designed system of rain harvesting devices that all seem to direct water toward a central tank, which you assume feeds the oasis. There are solar panels strategically placed for optimum sunlight along with swaths of plant species that are superior in carbon sequestration. Inside the Rec Hall the natural beauty continues with an impressive display of vines and tropical plants eloquently woven into the interior design. For a brief moment you wonder if you are still outside. Then a large screen catches your eye. It details the layout of the building along with a schedule of classes and events. An impressive array of classes and events, there is everything from swimming lessons to gardening classes to Native American cultural classes, along with art galleries, concerts, plays, film festivals, etc. Each function is free and open to all members of the campus-community. Almost all of them are produced or led by students. There is another large screen a few feet over that details the current class schedule for students. The first thing you notice is that classes are offered throughout most of the day and night. Many of the classes listed are marked as hybrid virtual classes. Confused by what this means you inquire with a student walking by.

She explains this means the classes may have students from different parts of the country or world that join the class via video chat. Not only are there students from all over the world

in your classes, some students are actually in other parts of the world. You ask if this has the negative consequence of impersonal communication and lack of a real connection with virtual class mates. She clarifies that because their physical presence is in the room and they are able to communicate face to face, the relationships between students and teachers maintain the value of physical interaction. As she leaves you, she enthusiastically mentions the oasis and how you must stop there. The excitement continues to grow. Instead of going straight there, you decide to stop by the shopping mall section of the building. Just outside the mall is the food court. There are a variety of restaurants and styles of food. A plaque at the entrance reads that all of the food found here was produced within the campus-community via sustainable agriculture. Some students quickly grab something to eat as they walk to a class, while a group of retirees sit and are waited on during a break in their Osher lifelong learning classes. All the utensils and packaging are made from compostable materials. Your ears pick up delightful music and you notice toward the center of the space where students are playing instruments. The beautiful notes travel with you to the shopping area.

Here lies an extensive network of stores and services: clothing, school supplies and books, electronics, and repair shops. There are even some stores with unfamiliar items and technologies. Investigating one such store you discover the products were developed by Environmental Engineering students and are still going through testing and fine tuning. They can be purchased at much lower prices than the final product. A small tablet grabs your attention, and a student worker explains that this device can analyze any food item and display the ingredients and nutritional value in less than a second. Fascinated, you decide to pass, knowing the results of some of your daily foods may be alarming. Maybe next year.

As you stroll on you realize that this space makes the majority of people's wants and needs available locally, avoiding unnecessary travel or online purchasing. Even the food is produced on campus and is easily accessible to everyone in the campus-community. With that thought, your stomach growls a little and you decide to stop back by the food court for a meal. You pick up a burrito that contains native tepary beans and other plant-based proteins. You consider eating here in the company of the student musicians. However, the thought of enjoying your burrito in the oasis takes precedence and you move quickly in its direction.

Located in the middle of the building, the oasis is easily accessible from anywhere in the Rec Hall. At your quickened pace you almost steam past a statue of a bonsai tree dedicated to the individuals who designed and constructed the building. Amazingly the entire project, from design to construction, was completed by students. While marveling at this you pick up the sounds of birds chirping and running water. Overwhelmed with anticipation, you finally step foot inside the oasis.

An absolutely stunning array of massive trees, waterfalls, ponds, lush foliage, vines, insects and wildlife, etc. as far as you can see. Instantly you notice how much cooler the temperature is inside and you can feel the abundance of oxygen in the air as you take a deep breath. Throughout the landscape there are groups of people studying, reading, relaxing, meditating, and enjoying this magnificent space. You completely understand the enthusiasm people have for this place and are delighted to have chosen this as your last stop.

You locate an odd-looking chair close to a pond and sit down to devour your burrito. A nearby student introduces himself and asks if the chair is comfortable. A bit confused, you respond that it is. He explains that the chair is part of a research project that is exploring the use of mushroom mycelium as building material. The chair you are sitting on is made entirely of mycelium. Shocked, you inspect the chair more thoroughly paying attention to the texture

and color. You even put your nose close to it and sniff it. To your surprise it doesn't smell and feels quite sturdy. He goes on to say that the primary reason for attending this university was because of its deep connection to the surrounding environment and community, coupled with the opportunity to conduct cutting edge research and actually apply it. This is the type of university that will be able to survive and adapt to a changing climate, because this is more than just a school. It is a testament to the capability of human beings to live in harmony with each other and our earth as a whole.

With that, the student leaves you. Sitting in your mycelium chair, eating food produced a short walk from this desert oasis, you reflect on what the student had just said. His statements about campus were echoed throughout your tour. This really is a special place that, through its dedication to higher education, has mitigated its negative impacts on the environment, prepared the entire campus-community for extreme climate events, and ensured its ability to thrive under any circumstances. This is a resilient campus.

FIGURE 2: ASU West's Initial Capacity Assessment Matrix

Sector	Planning Area	Current and Projected Climate Stresses and Impacts: Higher Temperatures and Urban Heat Island Effect	Changing Precipitation Patterns and Drought	Heavy Monsoon Floods and Lightning	Increased Wind and Severe Dust Storms	Indicators	Measure	Adaptive Capacity and Strengths	Vulnerability	Priority
Society and Equity	Housing	Low-income community/students lack adequate cooling, increased cooling costs increase housing costs, increase maintenance and repairs	Inadequate water supply for landscaping and lawns, swimming pools	Sustained damage, roof collapse, leaks, power outage, increased costs	Sustained damage, increased costs	Safe and affordable housing in the neighboring community	· Average percent of income spent on housing costs annually by neighboring community members (data limited)	· Census data indicates neighborhoods immediately surrounding campus to be of > $45,000 annual household income	· Fluctuating economic conditions beyond the University's control (HIGH) · Census data show some neighborhoods within 5 mile radius of campus to be < $35,000 annual household income	1
							· Percent of the population that is homeless or living in informal settlements by neighboring community members (data limited)	· 5 homeless shelters within 5 mile radius of campus, potential to use. (HIGH)	· Many funding demands and limited resources (MEDIUM)	
							· Number and severity of crime in the neighboring community	Phoenix and Glendale police departments (MEDIUM)	· Fluctuating crime activity primarily driven by "outside drivers" (LOW)	
						Emergency shelter for extreme climate and weather events	· Adequate facilities to accommodate the campus and community during extreme climate events (e.g., extreme heat, flooding)	· Thunderbird campus for emergency housing, high schools may serve as Red Cross shelters	· Only one heat refuge center at Glendale Public Library · No plans in place to use campus as place of refuge	
							· Adequate systems (staffing, transportation, etc.) and funding to accommodate the campus and community during extreme climate events			
						Resilient housing for the campus & community	· Percent of campus-community that reside in housing (on/off campus) that is climate-adapted (efficient, flood-safe, storm-safe, etc.)	· Two student residence halls (Las Casas and Casa de Oro) · Energy efficiency programs offered by utilities and others	· Residence Hall costs per student are increasing	
	Food	Heat intolerant crops no longer viable in-state, out-of-state, and internationally	Drought intolerant crops no longer viable in-state, out-of-state, and internationally	Sustained damage to crops	Sustained damage to crops	Food security (when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.)	· Number of neighboring communities categorized as food deserts	· Most surrounding neighborhoods are considered food secure by ADHS	· ADHS lists 13 neighborhoods within 5 mile radius as food deserts	
							· Average percent of income spent on food annually (students/faculty/staff & neighboring community)	· Students spend about $5000 per academic year on food		
							· Income spent relative to dietary quality (data limited)			
							· Availability of culturally appropriate food on campus and in neighboring community (data limited)	· Three grocery stores within mile radius · Campus has 8 restaurants, a dining hall, and a market · Borderlands produce rescue a couple times a year · IRC garden 3 miles away	· No community garden on campus and none in surrounding community	
						Resilient Food Production and Supply	· Percent of food crops produced for AZ that are heat resistant and water efficient			
							· Percent of food crops produced for AZ that are healthy			
							· Percent of food crops produced for AZ in an ecological responsible manner			
							· Number of days AZ could feed itself if cut off from exporters, and number of days it would take to transition to sustainable local food system		· Less than 1% of food locally sourced · Tried CSA program for students 6 years ago and was unsuccessful · No farmer's markets in 5 mile radius	
							· Average cost of AZ staple foods			
							· Total MTCDE from food consumed in AZ (production, transportation, and waste)			
							· Percent of public demand for resilient food			
	Health	Greater heat related illness (heatstroke, heat exhaustion, heat cramps, etc.)	Greater potential for dehydration	Increased risk of drowning, waterborne illnesses, and flood damage	Increased respiratory and allergy issues, increased risk of soil borne illnesses like valley fever	Happiness and well-being	· Average level of perceived happiness among students, faculty, and staff		Is there a survey on perceived health and happiness - (check with student health/advisors)	
							· Average level of perceived happiness among neighboring communities			
						Adequate access to healthcare	· Percent of the campus-community with affordable health insurance	· Student health care option	· Student health care can be more expensive than marketplace · Student health insurance is limited to certain providers	
							· Percent of people that can afford required/necessary medical treatments			
							· Percent of people who have adequate transportation for health services		· Number of people that do not make medical appointments due to transportation	

FIGURE 4. Example of the Food Planning Area within the Society and Equity Sector of the Resilience Capacity Matrix.

Sector	Planning Area	Current and Projected Climate Stresses and Impacts				Indicators of Resilience	Metrics of Progress	Adaptive Capacity (Strengths)	Vulnerability (Weaknesses)	Priority
		Increased Extreme Heat and Urban Heat Island Effect	Changing Precipitation Patterns and Severe Drought	Heavy Monsoon Rains and Increased Flash Flooding	Extreme Weather and Increased Dust and Electrical Storms					
	Housing	· Greater difficulty adequately cooling housing in summer (particularly, but not exclusively, low-income community and students · Increased cooling costs · Increase housing costs · Increased maintenance and repairs · Increased need for emergency shelters	· Inadequate water supply for landscaping, turf and swimming pools	· Sustained damage · Roof collapse and leaks · Power outages · Increased costs · Increased need for emergency shelters	· Sustained damage · increased costs · Increased need for emergency shelters · Disproportionately impacts off-campus lower income community and students	Safe and affordable housing in the neighboring community	· Average percent of income spent on housing costs annually by neighboring community members (data limited) *(Census data show some neighborhoods within 5 mile radius of campus to be < $35,000 annual household income & Census data indicates neighborhoods immediately surrounding campus to be of > $45,000 annual household income)*	· Programs to drive investments in neighboring communities · Efforts are underway to develop new housing opportunities (DPC) · Efforts are underway to develop partnerships with local entities to enhance housing (DPC) · ASU has an opportunity to lead by example for sustainable housing in AZ · Designated family housing (Poly)	· Limited housing availability in the community that is appropriate for ASU (Poly) · Rent and cost of living is rising · Limited land availability and/or land available is expensive (Tempe, DPC) · Currently at housing capacity (DPC)	1
							· Percent of the population that is homeless or living in informal settlements by neighboring community members (data limited) *Per AZDES, in 2016 3,244 people were counted homeless during annual PIT count (county wide)*	· Student Advocacy and Assistance programs offer support for homeless students · 5 homeless shelters within 5 mile radius of campus, potential to use. · City of Phoenix Human Services dept. rental/financial assistance · Multiple organizations dedicated to addressing these issues	· Many funding demands and limited resources · Current programs currently stressed as is - wonder about capacity during a stress time (DPC) · Current efforts could be more effective (DPC)	3
							· Number and severity of crime in the neighboring community	· Police departments' cooperation with ASU · Block Watch and Neighborhood Watch groups in most neighborhoods · Crime Prevention Programs	· Fluctuating crime activity due to drivers external to the campus community such as the overall state of the economy. · Difficulties with staff police departments · Gentrification trends can exacerbate crime (DPC, Tempe)	4
						Emergency shelter for extreme climate and weather events	· Adequate facilities to accommodate the campus and community during extreme climate events (e.g., extreme heat, flooding)	· ASU facilities for emergency housing, high schools may serve as Red Cross shelters · Emergency Response Team (ERT) in place and ready.	· Only one heat refuge center at Glendale Public Library (West) · Limited staff and resources & ever-changing challenges · Limited facilities available for such purposes · Population density poses potential additional challenges (Tempe, DPC, West)	1
							· Adequate systems (staffing, transportation, etc.) and funding to accommodate the campus and community during extreme climate events	· Emergency plans are in place but specific details have not been assessed (more data needed)	· Lacking specific data - emergency and evacuation plans can underestimate climate impacts · Limited funding, challenges funding "the probable"	1
						Resilient housing for the campus & community	· Percent of campus-community that reside in housing (on/off campus) that is climate-adapted (well-insulated to thermally "coast" during power outages, efficient, flood-safe, storm-safe, etc.)	· At ASU West - Two student residence halls (Las Casas and Casa de Oro) - limited responsibility · Tempe & Poly are expanding housing opportunities on/off campus (Poly: Century Hall Phase 2)	· Residence Halls may not be outfitted for climate hazards (no green building certifications) (West) · Lacking community data, but can assume the vast majority of homes are vulnerable to some climate hazards · Aging facilities and infrastructure · Roadways could flood during events, making access difficulties and creating stresses to systems (Poly) · Significant commuter university (West, Poly)	1