Decision Center for a Desert City

Strategic Management Plan

2015-2019

Abstract

Our mission is to develop a transdisciplinary network of scientists, students, and stakeholders cooperatively producing transformational solutions to inform evidence-supported strategies for water sustainability transitions for cities in the Colorado River Basin.

DECISION CENTER FOR A DESERT CITY
ARIZONA STATE UNIVERSITY

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PI and Director

I. Introduction

The Decision Center for a Desert City (DCDC) at Arizona State University (ASU) was established in 2004 with an investment from the National Science Foundation (NSF) through the Decision Making under Uncertainty (DMUU) program[1]. The research of this collaborative group has advanced fundamental knowledge about decision making under uncertainty in the context of water sustainability and urban climate-change adaptation. With new funding from NSF awarded in 2010, DCDC expanded and diversified its research agenda, trained a diverse new group of scholars, and engaged a wide range of stakeholders in the cooperative production of knowledge and action[2].

A recent synthesis of more than a decade of place-based and use-inspired research on decision-making under uncertainty conducted by DCDC identified several strategic insights (Larson, White, Gober, & Wutich, 2015). First, empirical research on complexities and uncertainty is essential to improved understanding of decision making related to climate change and other long-term environmental risks. Second, novel decision-support tools and transdisciplinary research approaches are needed to understand uncertainty, and such tools can help decision-makers identify alternative pathways and outcomes under high or increasing uncertainty. Third, empirical research and decision-support tools are improved by boundary organizations that bridge scientists and policymakers, enhance social networks, and enrich collaborative learning.

The integrated research, education, and outreach activities have advanced scientific understanding, trained a new generation of scholars, and informed policy- and decision-making processes, especially at the city and regional scale. The region's sustainability, however, remains uncertain. The Phoenix region, like other metropolitan areas that depend upon the Colorado River, continues to grapple with long-term drought, climate-change impacts, population growth, and complex social, institutional, and economic dynamics. In part because of these dynamics, transformational change remains elusive. What is needed are innovative approaches to understanding, simulating, and evaluating tradeoffs in complex urban systems; anticipating plausible and desirable futures; and developing and testing transition strategies toward urban water sustainability in the Phoenix region, the Colorado River Basin, and beyond.

Now, researchers, decision makers, and stakeholders in cities of the Colorado River Basin will be able to take greater advantage of DCDC thanks to a new $4.5 million NSF award[3]. The new award, the third made to DCDC in its more than 10-year history, brings the total NSF investment in the center to approximately $18 million. It will allow ASU to expand the geographic scope of DCDC's work beyond central Arizona to include cities dependent upon Colorado River water in states like Colorado, Nevada, and California to explore transformational solutions that will be necessary to sustain water supplies well into the future.

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[1] Grant No. SES-0345945, DMUU: Decision Center for a Desert City: The Science and Policy of Climate Uncertainty
[2] Grant No. SES-0951366, DMUU: Decision Center for a Desert City II: Urban Climate Adaptation
[3] Grant No. SES-1462086, DMUU: DCDC III: Transformational Solutions for Urban Water Sustainability Transitions in the Colorado River Basin

A. Project Abstract

This collaborative research group will generate the analytical framework and empirical results necessary to theorize environmental decision making under uncertainty for urban water systems. One main concern about environmental uncertainties for cities in the Colorado River Basin is the anticipated impact on water resources. Possible impacts, such as rising temperatures, changes in the amount and timing of precipitation, and increased variability, likely will reduce renewable surface and groundwater supplies and diminish water quality, leading to widespread but uneven risks. The projected biophysical impacts of environmental change are conditioned by and interact with land-use changes, population dynamics, economic development, and water-management decisions. Managing transitions toward urban water sustainability will require innovative approaches to water governance that are anticipatory, adaptable, just, and evidence-supported. This collaborative group includes a transdisciplinary team of social, behavioral, economic, and sustainability scientists working in close collaboration with stakeholders. A diverse group of undergraduate, graduate, and postdoctoral scholars will be educated and trained with a focus on key competencies in sustainability through real-world sustainability research and education experiences. The collaborative group will build and strengthen networks of scientists and decision makers that improve the relevance of scientific knowledge for decisions and foster social learning among diverse perspectives.

Drawing from use-inspired sustainability science and decision making under uncertainty, the investigators will address the overarching question**:**

Given environmental and societal uncertainties, how can cities dependent on the Colorado River Basin develop transformational solutions to implement water sustainability transitions?

This research program is comprised of four **Integrated Project Areas (IPAs)**:

1) <u>Regional environmental and land-use changes</u> as biophysical drivers that affect decision making;

2) <u>Actors, institutions, and governance</u> as socioeconomic drivers that affect decision making;

3) <u>Simulation modeling, visual analytics, and scenarios</u> for knowledge integration and exchange; and

4) <u>Evidence-supported transition strategies</u> toward sustainable water governance.

This approach enables the investigators to evaluate how urban water system decisions are affected by environmental and land use changes conditioned by and interacting with social, institutional, and economic processes; model, simulate, visualize, and explore alternative futures in complex social-ecological-technical systems; and conduct comparative studies to develop scientific knowledge with explicit consideration of specific contextual factors and generalizable patterns.

This plan articulates the center's mission, vision, and strategic goals and objectives, describes key milestones and performance metrics, and details evaluation protocol.

II. Vision and Mission

Our vision is a society transformed where urban water systems in the Colorado River Basin are resilient to climate change and generate equitable social and economic benefits while providing a range of ecosystem services.

Our mission is to develop a transdisciplinary network of scientists, students, and stakeholders cooperatively producing transformational solutions to inform evidence-supported strategies for water sustainability transitions for cities in the Colorado River Basin.

III. Project Organization

Strategic Goal 1: Assure effective management of the collaborative group, including mechanisms for integrating individual researchers and institutions into a cohesive team and selecting and integrating related research projects.

Strategic Goal 2: Assure continued operation of the collaborative group and its programs in the event of the absence or loss of key personnel and developing thorough procedures for succession and backup of personnel.

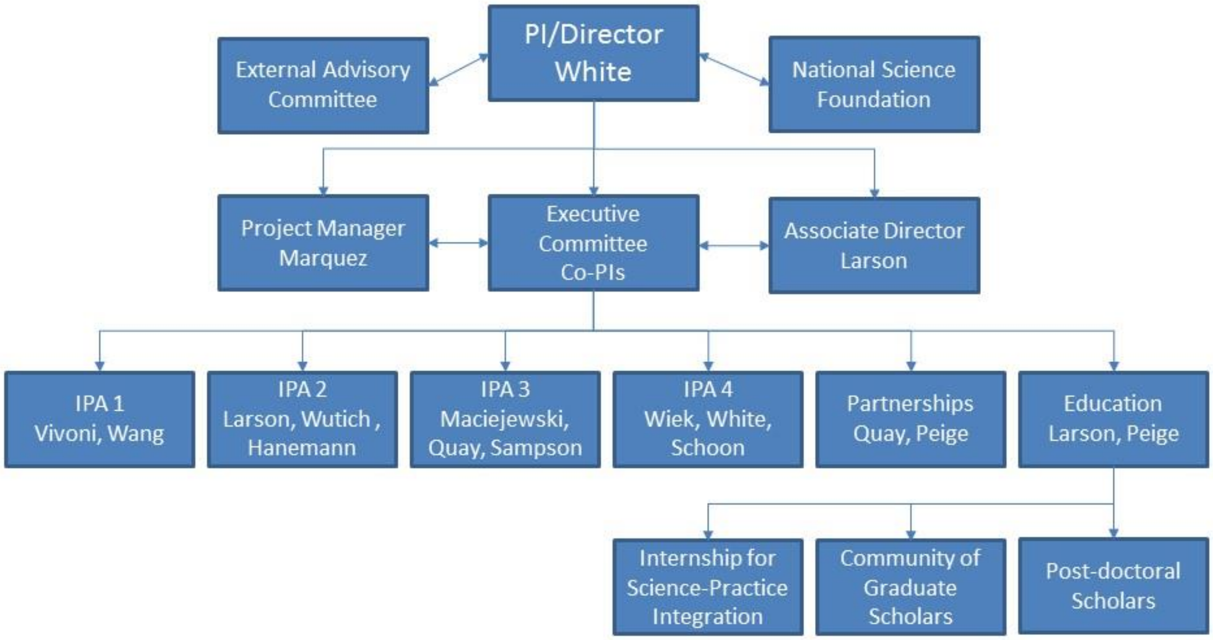
Administratively, the Decision Center for a Desert City at Arizona State University is a research unit of the Julie Ann Wrigley Global Institute of Sustainability[4] (GIOS), which has developed highly visible transdisciplinary research projects such as LightWorks, UREx Sustainability Research Network, and the Central Arizona—Phoenix Long-Term Ecological Research program. As the intellectual and administrative home for DCDC, GIOS offers the scientific and professional network and staff support (e.g., financial management, human resources) and facilities to support the collaborative group.

Our management team benefits from the administrative experience and long-established relationships among investigators, administrators, and stakeholders. Dave White, an environmental social scientist with the administrative experience and vision necessary to ensure efficient operation of the collaborative group, will serve as PI/PD. White served as senior project personnel 2004-2009, Co-PI and Associate Director 2010-2012, and PI and Co-Director 2012-2015. White will be responsible for intellectual achievements and broader impacts, serve as point-of-contact to NSF and GIOS, lead the Executive Committee, and oversee day-to-day operations of managing staff, travel, budget, and communications. Program Manager Liz Marquez, who has held the position since 2011, supports White and the Executive Committee. Kelli Larson, who has been Co-PI since 2012, serves as Associate Director and Director of Education and Mentoring.

A diagram of the reporting structure for the project shows how the Director, Associate Director, Executive Committee, Project Manager, and Project Areas Leads interact with one another, the NSF, and the External Advisory Committee (Figure 1).

[4] https://sustainability.asu.edu/

Figure 1 DCDC Organizational Chart



In the event that PI/PD White is unable or unwilling to lead the collaborative group, this responsibility would be transferred to Kelli Larson. In the unlikely event that neither White nor Larson could effectively perform the PI/PD responsibilities, Amber Wutich would be the logical next choice followed by Enrique Vivoni. Throughout the transition process, the appropriate ASU administrative authorities (e.g., GIOS Directorate, Senior Vice President for Knowledge Enterprise Development) and cognizant NSF program officer would be consulted.

A. Executive Committee

The Executive Committee is the central organizational unit for the collaborative group and includes the PI/PD, Co-PIs and Associate Director, and the Project Manager. The EC meets monthly, in person or by video- or tele-conference (Table 1). Together, these six individuals have ultimate responsibility for developing and maintaining the shared research, education, partnership, and assessment of the goals of the collaborative group. The EC is responsible for planning, implementation, and assessment of the collaborative group's activities, to include making recommendations to the Director for funding and resource allocation. The EC plays an active role in designing and carrying out the External Advisory Committee meeting. Executive Committee members maintain active communication with other IPA co-leads, senior project personnel, graduate students, undergraduate students, and collaborators.

The Executive Committee is responsible for the selection, prioritization, allocation of resources, and integration of research projects. During the preparation of the NSF-DMUU proposal, the PI and co-PIs cooperatively developed the research plan and associated budget, which provides the framework and blueprint. These initial priorities and resource allocation decisions were made to ensure sufficient funding for each project area to accomplish the research, education, and partnership goals. Each year, the Executive Committee will evaluate the progress and products of each project area to review and adjust if necessary the allocation of funds to ensure the collaborative group meets the goals detailed in the proposal and this strategic management plan. Each year the Executive Committee will receive an update from each project area with specific action plans including goals, objectives, tasks, timelines, and responsible individuals. The External Advisory Committee, NSF program officers, and university administration will provide additional input.

Table 1 DCDC Executive Committee

Name	Academic Unit	Role
Dave White	School of Community Resources and Development	PI/PD
Kelli Larson	School of Geographical Sciences & Urban Planning and School of Sustainability	Co-PI/Associate Director
Enrique Vivoni	School of Earth and Space Exploration	Co-PI
Michael Hanemann	W. P. Carey School of Business	Co-PI
Amber Wutich	School of Human Evolution and Social Change	Co-PI
Liz Marquez	Decision Center for a Desert City	Project Manager

B. External Advisory Committee

The External Advisory Committee is composed of scientific and technical experts from diverse academic disciplines and decision-making institutions and will meet annually to review and advise the collaborative group. The EAC provides a summary report to DCDC and the NSF with specific recommendations to guide the research, education, and partnership programs as well as management activities of the collaborative group.

Table 2 DCDC External Advisory Committee

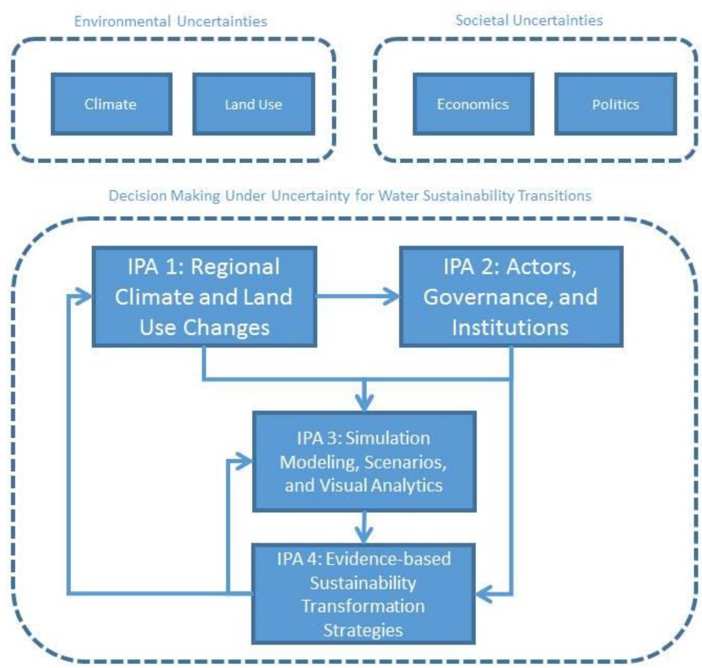
Name	Institution
William Easterling (Chair)	Dean, College of Earth and Mineral Sciences, The Penn. State University
Thomas Buschatzke	Director, Arizona Department of Water Resources
Lisa Dilling	Fellow, Cooperative Institute for Research in Environmental Sciences, University of Colorado – Boulder
David Feldman	Chair, Department of Planning, Policy and Design, University of California at Irvine
Catherine L. Kling	Charles F. Curtiss Distinguished Professor, Department of Economics, Iowa State University
Linda Mearns	Director, Institute for the Study of Society and Environment, National Corporation for Atmospheric Research
Fernando Miralles-Wilhelm	Professor and Executive Director, Earth System Science Interdisciplinary Center, University of Maryland
Kathryn Sorensen	Water Services Director, City of Phoenix

IV. Management Plan for Research

Strategic Goal 3: Conduct fundamental research that results in improved understanding of decision making related to climate change and other long-term environmental risks, and that is grounded in the relevant theoretical frameworks in the social and behavioral sciences as well as other appropriate science and engineering fields.

Strategic Goal 4: Develop novel interdisciplinary theoretical frameworks to advance knowledge about environmental decision making under uncertainty for urban water sustainability transitions.

Figure 2. Integrated analytical framework for theory of decision making under multiple uncertainties to inform water sustainability transitions in the CRB.



We will organize our collaboration around four integrated project areas (IPAs), as illustrated in Figure 1. We will use a suite of linked biophysical process models that simulate climate change, urbanization, land use, and hydrological processes in the CRB to produce a set of climate and land-use scenarios (**IPA 1**).
To understand social and institutional opportunities and constraints for sustainability transitions, we will conduct a multi-city social, economic, and institutional analysis—including a residential survey study of risk perceptions, attitudes, and behaviors, interviews of local and regional decision makers, and an economic analysis of residential water use (**IPA 2**). The outcomes of the simulated regional biophysical processes (**IPA 1**) and social, economic, and institutional analyses (**IPA 2**) will be incorporated as inputs, constraints, parameters, and policy options for socio-hydrological urban water-systems modeling and scenario analysis, with a multi-platform visualization (e.g., web interface and immersive decision theater) (**IPA 3**).

In **IPA 4**, we will create an inventory of transformational solutions to water governance, identify transition points, design transition strategies, and evaluate real-world transition experiments and modeling simulations (with **IPAs 1 & 3**). With input from all IPAs, we will conduct cross-city, comparisons to evaluate context-specific and transferable transition strategies. Throughout the project, the collaborative group will leverage and expand DCDC's network of relationships with stakeholders, developed over more than a decade of sustained engagement, to co-create opportunities to facilitate sustainability transitions in the region.

A. IPA 1: Regional Environmental and Land-use Changes

The goal of IPA 1 is to understand the impacts of climate and land-use changes in the Colorado River Basin on the urban water systems embedded in the region. This will be performed through the integration of models of the biophysical and anthropogenic drivers (regional climate change and urban expansion) with the environmental systems (atmospheric and hydrologic components) that regulate and modify urban water supply in the presence of socio-institutional feedbacks. Innovations will be conducted in the numerical tools used to simulate climate and land-use change conditions at the scale of the Colorado River Basin and the identified cities (i.e., Phoenix, Las Vegas, and Denver) that are dependent, to varying degrees, on the regional water supply. In addition, the current state-of-the-art in terms of climate and land use/urban growth scenarios obtained from international and national efforts, but tailored with input from regional stakeholders, will be assessed in the numerical modeling framework. Our primary scientific contribution is to develop a new multi scale framework where the integration of numerical models and impact scenarios can more explicitly account for social actors and policy-making.

Key milestones include:

- Evaluation of urban expansion scenarios and their implementation for the Colorado River Basin with the Weather Research and Forecasting model.
- Evaluation of CMIP5 climate change scenarios for Colorado River Basin and options for downscaling.
- Regional analysis of evapotranspiration and land cover change effects on the regional hydrologic and atmospheric cycle.
- Gridded, hourly meteorological dataset at 6-km resolution for Colorado River Basin.
- Regional land cover change scenarios including urban growth.
- Regional CMIP5 scenarios.
- WRF model version with updated urban canopy scheme.

B. IPA 2: Actors, Institutions, and Governance

The goal of IPA 2 is to understand the role that urban residents, institutions, and economic dynamics play in water sustainability transitions and transformational solutions. This IPA will undertake three core research activities. The first will be to improve understanding of the factors that influence metropolitan water demands in order to promote more sustainable use of urban water, with focused economic analyses in the residential and commercial sectors of major cities. The second will be to examine the causes and accomplishments of recent efforts to innovate in the governance and water allocation of water from the Colorado River: what has been achieved, how did this come about, what remains to be done, and how might that be accomplished? The third will be to compare and contrast the existing provisions for sustainable water governance and urban climate adaption across three major metropolitan regions of the CRB; here, special focus will be placed on groundwater management in Colorado and Arizona, and the new sustainable groundwater initiatives being considered in Nevada and California.

Key milestones include:

- A workshop on lessons from recent innovations in governance and allocation of Colorado River water.
- A social network analysis of collaboration across water management institutions in Phoenix, Denver, and Las Vegas.
- A workshop on new developments in methodology and data for identifying factors conducive to changing urban water use.
- A survey of residents' risk perceptions and future preferences for alternative scenarios regarding urbanization and water governance in Phoenix, Denver, and Las Vegas.
- A workshop on successes and failures in promoting sustainable groundwater in Arizona, Colorado, Nevada, and California.
- An institutional analysis of water sustainability transitions and transformational solutions in Arizona, Colorado, Nevada, and California.

C. IPA 3: Simulation Modeling, Visual Analytics, and Scenarios

The goal of IPA3 is to develop a credible assessment framework in which stakeholders from regions reliant on water from the CWB can assess salient external physical drivers and governmental policy drivers relevant to water sustainability issues. This goal will focus on the co-production of model drivers and policy scenarios coupled with a visual analytics interface to enable stakeholders to explore, compare, and learn about water sustainability drivers and the uncertainty inherit in these drivers. Of keen interest is enabling the exploration of how climate and land-use change scenarios impact urban water systems and how can we communicate these impacts and uncertainties effectively to stakeholders.

Key milestones include:

- A needs assessment for the assessment framework based on the physical drivers being identified from IPA1 and IPA2, the strategies identified by IPA4, and the uncertainty associated with these.
- An initial version of the assessment framework will be created through participatory development with the research team and stakeholders.
- Development of scenarios driven by discussions with IPA1, IPA2 and IPA4 which will include a discussion of uncertainty to be represented in the scenarios as well as output metrics to be used to assess the scenarios.
- Integration of scenario (advanced scenario analysis, planning, assessment, and comparison) tools into the assessment framework.
- Assess transitioning strategies developed as part of the scenario exploration within the assessment framework.

D. IPA 4: Evidence-supported Transition Strategies

The goal of IPA 4 is to develop a theoretically informed understanding of sustainability transitions for urban water systems in the Colorado River Basin from interdisciplinary perspectives and to enhance the capacity of cities to develop, implement, and evaluate transformational solutions. This will be accomplished through a comprehensive review and identification of innovative transition strategies, modeling simulations, and real-world transition experiments. One major contribution of IPA 4 will be a foundational dataset (repository or inventory) of transformational solutions that differentiates between innovative means (education, incentives, transition policies) and ends (final policies, governance regimes, practices, technologies). Both modeling simulations and real-world transition experiments will provide evidence for the effectiveness and efficiency of proposed and implemented means and ends to inform decision making under uncertainty.

Key milestones include:

- Repository/inventory of transformational water solutions (system-wide), structured into innovative means (education, incentives, transition policies) and ends (final policies, governance regimes, practices, technologies), reviewed by expert panel.
- Outline of key components of overall transition / transformation strategies, reviewed by expert panel.
- Modeling simulations for ex-ante testing of transformational water solutions, reviewed by expert panel.
- Identified experimental settings based on ex-ante testing and expert panel suggestions
- Suite of experiments on innovative water solution means (education, incentives, transition policies) and ends (final policies, governance regimes, practices, technologies), producing evidence for effectiveness and efficiency, reviewed by expert panel.
- Summative, ex-post review of the experiments, validated by expert panel.
- Revised and generalized transition / transformation strategy, based on the empirical evidence gathered through the experiments, reviewed by expert panel.

V. Management Plan for Education

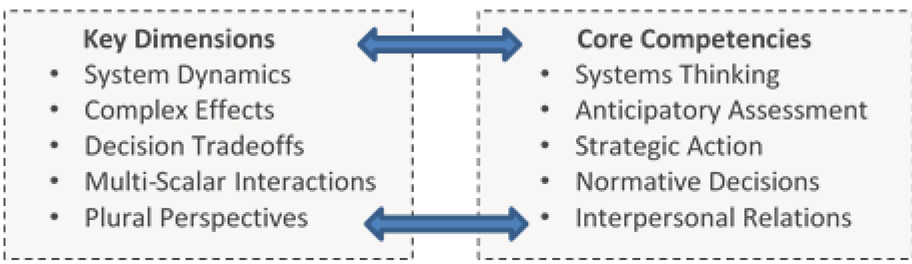
Strategic Goal 5: Educate and train a new generation of diverse scholars with a focus on key competencies in sustainability through real-world sustainability research and education experiences.

Strategic Goal 6: Provide meaningful education and training experiences for students, teachers, and other individuals.

Strategic Goal 7: Mentor undergraduate and graduate students, along with post-docs, to enhance interdisciplinary research and professional skills that are essential for collaborating across different domains of science and practice.

Complementing the research program, Co-PI and Associate Director Kelli Larson will lead the education programs with support from Katie Peige, the education and community outreach coordinator. Our education programs will develop competencies in sustainability (Wiek et al. 2011) through real-world sustainability research and education experiences (Brundiers and Wiek 2011; Brundiers et al. 2010). Wiek et al.'s competencies include systems thinking, anticipatory assessment, strategic action, normative decision making, and interpersonal relations (Figure 2). These competencies emerged from an extensive review of the scholarly literature, following from the complex characteristics of sustainability challenges; these involve the need to understand the: 1) interactions and feedbacks between human/social and environmental/biophysical systems; 2) complex effects resulting from system dynamics, often in the form of unintended consequences, cascading impacts, non-linear relationships, etc.; 3) tradeoffs inherent in decision making, wherein one positive outcome may be gained at the expense others; 4) multi-scalar dynamics and forces that play out across local to broader scales, as well as across past, current, and future temporal scales; and 5) plural perspectives involving varied and often divergent values and viewpoints among stakeholders, in addition to the diverse knowledge domains that influence and inform sustainability. The five dimensions will provide a framework for examining urban water sustainability transitions under uncertainty. The associated competencies can be organized into three clusters: 1) *strategic-knowledge*, which integrates systemic, anticipatory, normative, and action-oriented competencies; 2) *practical-knowledge*, which links knowledge to action; and 3), *collaboration*, which involves the skills needed to work in teams encompassing diverse knowledge communities and stakeholder groups.

Figure 3 Framework for integrating sustainability competencies and challenges in education programs



A. Postdoctoral Students

Our postdoctoral mentoring plan focuses on professional and career development, encompassing the six core competencies outlined by the National Postdoctoral Association (NPA): 1) discipline-specific conceptual knowledge; 2) research skill development; 3) communication skills; 4) professionalism; 5) leadership and management skills; and 6) responsible conduct of research. We will guide each postdoctoral scholar ("postdoc") through a structured process of interdisciplinary engagement and collaboration. Each postdoc will complete an Individual Development Plan for Postdoctoral Fellows, derived from the NPA. This IDP ensures that the postdoc and his/her mentor develop a shared strategy for training and career advancement. They will provide biweekly updates to the faculty mentor and undergo an annual performance self-assessment as well as formal evaluation by PI/PD White.

- <u>Orientation to People and Facilities at ASU</u>: Postdocs will receive a tour of facilities and an overview of research initiatives in social, behavioral, and economic sciences; sustainability sciences; and related areas. They will be included in events in the home academic department and invited to seminars, meetings, and workshops with visiting scholars.
- <u>Orientation to Specific Research Endeavor</u>: Postdocs will be introduced to the research team, which will share key research documents and relay information about research policies and practices.

- Development of Individual Development Plan (IDP): This plan will follow the process that NPA established to identify skills and strengths that the postdoc wishes to develop and will outline steps to accomplish that plan.
- Personal Research Time: We will require postdocs to spend a fraction of each week's time on their personal research objectives identified in the IDP.
- Participation in Research Team Meetings and Seminars: We will expect postdocs to present research findings in written and verbal forms on a regular basis, and they will receive constructive feedback from team members to improve communication and presentation skills.
- Career Search and Development: Postdocs will receive regular feedback from project PIs, ASU faculty, and staff concerning job application materials, interview seminars, and job-offer negotiations.
- Participation in formal workshops: Typically run by ASU's Office of Knowledge Enterprise Development (and mandatory for all ASU staff funded by external grants) workshops focus on research funding, grant-proposal writing and budget preparation, and training on research ethics, lab safety.
- Teaching Opportunities: We will encourage postdocs to pursue opportunities to teach, or co-teach, ASU graduate and undergraduate courses.
- Proposal-Writing Opportunities: We will strongly encourage postdocs to contribute to writing of grant proposals in collaboration with PIs, with other faculty members.
- Presenting Research Results in Professional Settings: We will support postdocs to travel to conferences to present research findings and participate in workshops and sessions. We will encourage them to participate in regional, national, and international scholarly organizations in their fields of endeavor.
- Mentoring Opportunities: We will encourage our postdocs to mentor undergraduate and graduate students from ASU and other institutions.
- Involvement in Education and Outreach: Postdocs will have opportunities to interact with diverse, non-academic audiences through programs that take research into schools and public forums, including Water/Climate Briefings, Internship for Science Practice Integration, and Advanced Water Educators Workshops.

B. Community of Graduate Scholars

The Community of Graduate Scholars (CGS) is a yearlong, one-credit course—to be guided by Co-PI Larson—that gives our Graduate Research Assistants (GRAs) the opportunity to become leaders in interdisciplinary approaches to research, decision-making, and community engagement. Each CGS student works on a research team with their faculty advisor; this work provides them with the intellectual depth necessary to contribute to DCDC's research. Meanwhile, the GRAs regularly gather to examine the relationships among the different project areas and to learn how articulate their scholarly work in transdisciplinary settings. The program is structured to build dialogue, thought, and action across disciplines as well as across the science and policy spheres. Through the CGS seminar, students become familiar with the issues, perspectives, and language of the researchers within DCDC, as well as with issues that emerge from interdisciplinary collaborations and initiatives that link knowledge to action. Finally, the graduate RAs develop mentoring skills by helping their fellow students through peer-review exercises and discussions about challenges they face throughout their research and educational endeavors. In the coming years, the CGS will also interact with undergraduate students in the ISPI program by providing input on the undergrads students' research and final poster presentations.

C. Internship for Science-Practice Integration

The Internship for Science-Practice Integration, led by Kelli Larson and Katie Peige, places undergraduate students with partner agencies to carry out use-inspired research projects that have policy relevance to the host agency. Program partners that host the DCDC interns include government agencies as well as non-profit organizations, such as the Arizona Department of Water Resources, various municipal water divisions (e.g., Phoenix, Tempe, Goodyear, and Gilbert), The Nature Conservancy, and The Audubon Society, among others. The program runs during the spring semester of each academic year, where students enroll for a three-credit hour course. Beyond the ten hours of work they do for their internship, the students integrate their practical internship work into a research project in the context of the ISPI course. The course focuses explicitly on developing research and professionals skills by guiding the student through: writing a prospectus, executing data analysis, developing a visual poster of their results, and ultimately, communicating their results to their peers, faculty, and stakeholder who attend our end-of-the-year symposium that celebrates the achievements of our undergraduate interns and graduate scholars.

D. K-12 Education

Decision Center for a Desert City, Arizona Project WET, and the University of Arizona's Water Resources Research Center will continue to work together to host K-12 educators each summer and provide them with teaching methods and new ideas related to sustainability, water, and climate change. We will continue working with teachers to pilot and refine teaching modules associated with WaterSim.

In addition to ongoing K-12 activities, DCDC will enhance our efforts on *Citizen Science and Citizen Engagement* initiatives. These efforts will build upon a recently initiated citizen science project funded by ASU through the Office of Vice President for Entrepreneurship & Innovation. This initiative will target high school students and teachers and develop tools for classroom use including WaterSim. Students will use inquiry processes to study research design and gain ecological and procedural knowledge, as well as knowledge about human-environment interactions. All modules/curriculum will meet AZ Science and Social Studies Standards and the Next Generation Science Standards, with a focus upon systems thinking and using systems models and incorporate aspects of the sustainability competencies. We will employ standard evaluation techniques using pre- and post-testing, and surveys for formative and summative evaluation of K-12 educational activities.

VI. Management Plan for Partnerships

Strategic Goal 8: Administer a boundary organization to enhance the linkages between science and policy and foster social learning among stakeholders in support of sustainable urban water governance.

Strategic Goal 9: Facilitate interactions among researchers and decision makers in order to help frame basic research and increase the capabilities of decision makers to make sound decisions over multiple time scales as well as disseminating any tools and other products of value to stakeholders and other interested groups.

Strategic Goal 10: Enhance communication, outreach and media products with a priority to increase followers and quality of engagement.

Since inception, DCDC has been committed to enhancing societal benefits of science and technology, focusing on the co-production of knowledge and products such as scenarios, models, simulations, and credible, relevant maps. Our partnership activities are designed to build social networks to enhance knowledge use and exchange and foster social learning in support of adaptive resource governance. Ray Quay, DCDC's director of stakeholder relations, leads the partnerships programs. Quay, who holds a PhD in Planning and has 20 years of experience in municipal planning and water services departments, is supported by Katie Peige, community and outreach coordinator, and Liz Marquez, DCDC program manager.

The specific strategies for achieving the strategic goals for partnerships include regular Water/Climate Briefings and periodic Science/Policy Collaborative Workshops to reconcile science and policy priorities; data sharing agreements to maximize scale-dependent comparative advantages; modeling, simulation, and visualization for knowledge integration; and co-production of boundary objects such as scenarios and decision support systems. To foster communication and media outreach, we will maintain an active website[5], Google Scholar page[6], social media presence[7], and online video library[8]. DCDC participants regularly comment on water, climate, and decision research for print, video, and online media in local, national, and international outlets.

VII. Management Plan for Broadening Participation of Underrepresented Groups

Strategic Goal 11: Engage in activities to broaden the diversity of the science and engineering workforce.

The Decision Center for a Desert City values diversity and is committed to broadening participation of underrepresented groups in the science and engineering workforce. Our commitment to broadening diversity is supported by the institutional commitment of Arizona State University to representation and inclusion. The university's pledge to diversity is codified in the ASU Charter[9], "ASU is a comprehensive public research university, measured **not by whom it excludes, but by whom it includes and how they succeed**; advancing research and discovery of public value; and assuming fundamental responsibility for the economic, social, cultural, and overall health of the communities it serves." ASU is the largest and one of the most diverse public universities in the country. From 2002-2014, minority undergraduate

[5] http://dcdc.asu.edu
[6] https://scholar.google.com/citations?hl=en&user=h2jqgykAAAAJ
[7] https://twitter.com/DCDC_ASU
[8] https://vimeo.com/user9066498
[9] https://president.asu.edu/about/asucharter

enrollment increased from 18% to 27% and minority graduate enrollment increased from 15% to 23%[10]. According to *Diverse: Issues in Higher Education Magazine*, ASU ranks[11]:

- #1 in the U.S. – Native American doctorates awarded – all disciplines
- #2 in the U.S. – Native American master's awarded – engineering
- #7 in the U.S. – Hispanic doctorates awarded – all disciplines

There is a variety of strategies necessary to prepare a STEM workforce in general. As noted by the National Academy of Sciences (NAS) report *Expanding Underrepresented Minority Participation*[12], particular attention is necessary to promote a diverse workforce: "However, there are issues that are specific to underrepresented minorities, in general and in STEM, focused on preparation, access and motivation, financial aid, academic support, and social integration." Our approach to broadening the diversity of the science and engineering work force through DCDC flows from the *ASU Diversity Plan: Building Blocks for Success through People, Programming and Policies*[13].

First, we seek to represent the diversity of our broader communities in the composition of our students, faculty and staff (people). Specific strategies include early outreach to underrepresented students; proactive recruitment activities that yield diverse pools of qualified applicants in order to generate a competitive pool of finalists; and engagement of current staff members of underrepresented groups in recruitment and mentoring.

Second, we take account of the current diversity in place and/or lacking in the planning and design of our activities (programming). Specific strategies will include requirement for all participating faculty and staff involved in HR decisions to complete the Diversity and Recruitment Certification Training[14] in the Human Resource arena (including the implementation of employee training models that take into account the needs and advantages associated with diversity, and general diversity training for all staff, faculty, and administrators to meet the needs of a diverse student body); development and evolution of our educational courses with diversity content; promotion of pedagogical strategies that encourage student involvement and facilitate respect for diverse perspectives; incorporation of diversity as a core element of post-doctoral mentoring and graduate research assistant training; commitment to diversity and inclusion call for systematic and ongoing review of all outreach publications for text and images that are representative.

Third, we review our policies and procedures to promote equity and success for all members of the collaborative group (policies). Specific strategies include the systematic collection and reporting of data rates by gender and ethnicity, and other relevant categories.

[10] https://diversity.asu.edu/bythenumbers
[11] https://diversity.asu.edu/
[12] https://grants.nih.gov/training/minority_participation.pdf
[13] https://diversity.asu.edu/sites/default/files/Diversity_Plan.pdf
[14] https://provost.asu.edu/files/shared/academic_recruitment/Diversity_Presentation_10_2_2011.pdf

VIII. Data Management Plan

A. Institutional Infrastructure

The Informatics and Technology team at ASU's Julie Ann Wrigley Global Institute of Sustainability will provide data-management support for the life of this project. This team provides a data-management framework to support various research endeavors. This framework provides the policies, procedures, and technologies necessary to support data collection, data curation and archival, dataset discovery and access, and to promote data synthesis and analysis across disciplines. GIOS encourages common standards for data archiving and documentation to ensure the consistent quality of published research data products.

Data-management needs are supported by the director, a database specialist, an applications programmer (aided by student programmers), and a specialist in Geographic Information Systems. Additional technical and web-development resources support the activities of this core group. The Informatics and Technology team guides researchers with respect to project management, data collection and metadata preparation.

GIOS provides a computing solution based on virtual Linux servers, with storage space on Netapp filers (network attached storage) for all its affiliated projects via ASU's Engineering Technical Services (ETS). The research databases and web servers are hosted on these virtual machines, which bring the advantages and economies of scale of professional IT facilities to both small and large research projects. As well as providing significant computing resilience, the ETS server facility allows staff to maintain proper backups of the stored data, thus meeting short-term data-protection needs. All data systems and web applications are password-protected and ASU staff perform regular security sweeps, searching for vulnerabilities or unusual behavior. The local network supports 1Gb/s connectivity; high-bandwidth connectivity is through ASU's connections to the Internet2 backbone. Over 6Tb of resilient storage space is allocated for research data. We address long-term data protection through regular technology transfers to maintain current standards for hardware and software. This strategy minimizes the risk of data loss through media or format obsolescence.

B. Data Collection and Processing

DCDC will gather a diverse array of biophysical and social-science data to be used for researching and modeling: regional climate and land-use changes; actors, institutions, and governance systems; simulation modeling, scenarios, and visual analytics; and evidence-based sustainability transformation strategies. Data will include: climate and hydrologic information (emissions scenarios from CMIP5 and IPCC AR5, urbanization scenarios, precipitation, air temperature, stream flow, water-use records); geographic and demographic information (historical land use, land-cover classifications, NDVI, classifications from other remote sensing imagery, census data); individual response social data (survey questionnaires, interviews); group response social data (focus groups, observations, social media); documents (planning and policy documents, public records).

C. Research Information Management

GIOS is developing a new research information-management system to enable project and dataset information to be entered throughout the research project. This research wiki is available to researchers on demand and is intended to facilitate effective management of research data and associated information. This approach reduces the work load "bulge" that occurs if these tasks are left until late in the research cycle. Once completed, these research records along with their associated datasets may be submitted for archival and eventual publication.

D. Dataset Incorporation and Archival

Support is provided to researchers by informatics personnel to convert source data into datasets suitable for archiving and dissemination. Each project makes a contribution towards this effort as reflected in the project budget. A wide range of data can be archived, including project datasets, student project data, models and simulation outputs, and supporting third-party data. Tabular data are stored in non-proprietary formats. Spatial data and imagery are stored in their native formats. In addition, all submitted data are subjected to basic quality control procedures before inclusion in the archives. Data packages are managed via a dataset inventory database, which tracks submission and publication workflows.

Metadata are encoded either in the Ecological Metadata Language (EML) and/or Dublin Core. Both these standards well established, being widely accepted across multiple disciplines. The research team for this project will provide complete metadata for each dataset to be archived to maximize the potential re-use of data. Metadata files are versioned to reflect updates or corrections.

A separate document archive holds many journal articles, posters, reports, and white papers in electronic format (pdf). Our image archive includes photos taken during research activities and images of graphs and maps. Both the document and image archive are directly accessible by our researchers. All electronic resources except for copyright-protected journal articles may be accessed through this archive.

E. Data Policy

Based on a history of collaboration with the LTER network, GIOS has adopted the LTER General Data Use Agreement as a standard across all projects and implements a two-tiered data-access policy, with most data being made publicly available. Only copyright-protected, third-party data, and selected human-subject data are not public. Some human subject datasets, however, have been stripped of identifying information and are publicly available through our data catalog.

Long-term monitoring data are normally made available to our researchers as soon as they are entered and to the public within two years of collection. Investigator- and student-supplied data usually become available after publication of results. Non-public data are available to our researchers via read access to the archives on the central storage, through individual database access, or via custom queries requested through the Informatics team.

F. Data Discovery and Access

By default, data are published via the ASU Libraries' Digital Repository[15], a web-based portal that accesses metadata and datasets from underlying repositories. Tabular data are presented to the user as comma-separated value files; a format selected because of its portable nature. Spatial data are supplied as compressed packages to reduce transmission requirements. In addition to this data source, published data associated with larger projects may also be presented via independent discipline-specific repositories.

IX. Evaluation and Assessment of the Strategic Management Plan

The goal of the DCDC evaluation and assessment plan is to promote organizational learning and adaptive management of the collaborative group. This will be accomplished through ongoing monitoring, conventional formative and summative evaluation, and social capacity metrics. Evaluation and assessment of federally-funded research centers has traditionally focused on outcomes tied to incentives built into university systems such as the number of researchers trained, research proposals submitted, grants awarded, and books, chapters, and journal articles published. The DCDC will employ these traditional measures to assess performance. The collaborative group's activities will also be evaluated by the External Advisory Committee, composed of diverse academic disciplines and stakeholder organizations concerned with decision making under uncertainty.

In addition to traditional performance metrics and advisory committee feedback, and institution focused on cooperative production of knowledge and action should also consider other metrics, such as increased capacity in social networks and relevance and impact of scientific knowledge. Therefore, evaluations will also assess the extent which DCDC activities build social capital and adaptive capacity by broadening networks of researchers and practitioners, and enhancing salience and policy-making relevance of scientific knowledge. Finally, using in-depth observation and process tracing techniques, DCDC activities will be evaluated for their impact on sustainability transitions in the Colorado River Basin. Combining outcome-based and social capital evaluation yields a superior measure of the value of knowledge created and the social process by which the knowledge is produced and valued.

[15] http://repository.asu.edu/

Table 3 Strategic Goals and Annual Performance Metrics

Strategic Goals	Performance Metric	Year 1	Year 2	Year 3	Year 4	Overall
3, 4	Foundational Datasets	3	2	3	2	10
3, 4	Model Versions	1	1	2	2	6
3, 4	National and International Presentations	12	12	12	12	48
3, 4	Peer-reviewed Publications	15	20	25	30	90
3, 4	Leveraged Funding	$500K	$1M	$1M	$1.5M	$4M
8, 9, 10	Technical/ Policy Reports	2	4	4	4	14
1, 2	Annual Reports	1	1	1	1	4
1, 2	External Advisory Committee Meetings	1	1	1	1	4
5, 6, 7, 11	Post-doctoral Researchers	1		1		2
6, 11	International Visiting Scholars	1		1		2
5, 6, 7, 11	Graduate Research Assistants	4	6	6	6	22
8, 9, 10	Collaborative Workshops	2	2	2	2	8
8, 9, 10	Water/Climate Briefings	6	6	6	6	24
8, 9, 10	Water Educators Workshops	1	1	1	1	4
5, 6, 7, 11	ISPI Students	12	12	12	12	48
1, 2, 5, 11	Diversity and Recruitment Certifications	10	20	5	5	40
8, 9, 10, 11	Social Media Followers	500	600	700	800	800

X. References

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