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Higher Education Capacity Building in Water Resources Engineering and Management to Support Achieving the Sustainable Development Goal for Water in Pakistan

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Dr. Steven J. Burian, University of Utah

Dr. Steven J. Burian has advanced water infrastructure resiliency and sustainability through research, led multi-disciplinary water initiatives, and inspired students with his passionate approach to engineering education. He earned a Bachelor of Science in Civil Engineering from the University of Notre Dame and a Masters in Environmental Engineering and a Doctorate in Civil Engineering from The University of Alabama. Dr. Burian's professional career spans more than 20 years during which he has worked as a design engineer, as a Visiting Professor at Los Alamos National Laboratory, as a Professor at the University of Arkansas and the University of Utah, and as the Chief Water Consultant of an international engineering and sustainability consulting firm he co-founded. He served as the first co-Director of Sustainability Curriculum Development at the University of Utah where he created pan-campus degree programs and stimulated infusion of sustainability principles and practices in teaching and learning activities across campus. Dr. Burian currently is the Project Director of the USAID-funded U.S.-Pakistan Center for Advanced Studies in Water at the University of Utah. He also serves as the Associate Director for the Global Change and Sustainability Center at the University of Utah where he facilitates interdisciplinary sustainability research initiatives. His research group has contributed new approaches for designing urban water infrastructure, innovative urban databases and water modeling techniques, sustainable solutions for distributed water-energy-food systems in cities, and practical adaptation strategies for water managers facing aging infrastructure, climate change, and other challenges. This research has been funded by NSF, EPA, NASA, DOD, DOE, USAID, National Labs, State Departments of Transportation, and Industry in the U.S. and several countries. More than 75 authored or co-authored peer-reviewed publications, 100 conference papers and project reports, and several software packages and databases have been produced from this research. Dr. Burian's enthusiasm for student learning has led to numerous teaching awards and the creation of new pedagogical approaches directed toward multi-institution collaborative learning. He has also sought to advance teaching effectiveness of engineering educators by serving as mentor at the American Society of Civil Engineers ExCEEd Teaching Workshop and as the developer of a variety of teaching and curriculum development workshops, including the recent Wasatch Experience at the University of Utah.

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HIGHER EDUCATION CAPACITY BUILDING IN WATER RESOURCES ENGINEERING AND MANAGEMENT TO SUPPORT ACHIEVING THE SUSTAINABLE DEVELOPMENT GOAL FOR WATER IN PAKISTAN

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ABSTRACT

Achieving the Sustainable Development Goals requires a multi-pronged approach, with a key element being the development of a trained Community of Practice to sustain the advances in the relevant sectors. The engagement of higher education as a catalyst in the development and capacity building of the next generation of professionals and citizens comprising the Community of Practice is essential to meet the challenges of poverty, climate change, and clean water and to sustain those advances past 2030. This paper describes a capacity building program funded by the United States Agency for International Development to partner the University of Utah, in the United States, with Mehran University of Engineering and Technology, in Pakistan, to create the U.S.-Pakistan Center for Advanced Studies in Water (USPCASW). The USPCASW program includes six core components of Curriculum Reform, Applied Research, Exchanges and Training, Governance, Gender Equity, and Sustainability. This paper describes the project, the activities for each component, and the multi-level assessment of the program, activities, and impact. The paper also highlights the overarching impact of the program and its alignment with achieving the Sustainable Development Goal for Water. Following the description of the program components and assessment, the paper concludes with a discussion of challenges and lessons learned.

INTRODUCTION

The United Nations (UN) introduced the Sustainable Development Goals (SDGs) in 2015 as the framework for the 2030 Agenda for Sustainable Development. The 17 SDGs build on the Millennium Development Goals (MDGs) introduced by the UN in 2000, and they seek to illustrate the universal approach needed to eradicate poverty and heal the planet[1]. Significant progress was made on the MDGs, but the SDGs seek to go further to address the root causes of poverty and the universal need for development that works for all people[2]. The SDG agenda recognizes that ending poverty must go hand-in-hand with strategies that build economic growth and addresses a range of social needs including water, education, and health etc. Governments alone cannot achieve these goals, unless their implementation is fully supported by all stakeholders which includes, citizens, civil society, private sector, and academia—just to name a few.

SDG 6 is to ensure Clean Water and Sanitation (https://sustainabledevelopment.un.org/sdg6) . It is estimated that nearly three-quarters of one billion people do not have access to clean water, and this number is projected to substantially increase in the future. Partly spurred by the MDG, more than 2 billion people have been provided access to improved water and sanitation since

1990; however, the quality of the drinking water does not typically meet minimum standards[2]. For example, in Pakistan, access to 'improved' drinking water increased to 91% in 2015, but the fraction that meets minimum drinking water guidelines (e.g., World Health Organization) remains below 12%. Water scarcity is intensifying in many countries, and is being exacerbated by population growth and climate change. For instance, 65% of the residents in the seven largest cities of India faced severe water deficiency as of 2005[3], and in Pakistan estimates by the Asian Development Bank indicate less than 1000 m^3 of water are available per person, which demarks the country as water scarce.

Pakistan committed in 2015 with the rest of the world to meeting the SDGs by 2030. Under the MDGs, progress in Pakistan was fair, with significant advances only made in 10 of 34 reported indicators. The reasons for missing the majority of the indicators included economic challenges, natural disasters (e.g., floods), conflicts, administrative and political changes, fading commitments from government and development partners, and late commitment at the sub-national level[4]. The Government of Pakistan, and the Planning Commission in particular, has made a strong commitment to the SDGs and is putting an action plan into place that engages national and provincial actors, international donors, non-governmental organizations, private enterprise, and the education sector.

It is becoming apparent that to achieve the ambitious and comprehensive SDGs a many-faceted effort is required that involves capacity building not only in terms of technical skills but also soft skills such as effective communication and management. Indeed, in order to achieve the SDGs, higher education must do more than train a high quality workforce; it must both prepare and inspire highly skilled individuals to be innovators—and most importantly, agents of change—in their institutions and industries. But to nourish the momentum of change begun through its degree and research programs, higher education must be a catalyst for establishing a Community of Practice by stimulating cooperation among academia, business, and government, including providing opportunities for training and continuing education of the water sector and interconnected workforce. This can be achieved by aligning academic curricula and research—and the policies that support and guide them—with the specific skill sets and priorities needed to meet the emerging issues and challenges of the SDG era and beyond. Mainstreaming the SDGs in higher education and localizing the Communities of Practice can be facilitated through the establishment of Centers of Excellence that address SDG focus areas. Here we report on one such example of a center striving to leverage academia to achieve the water SDG in Pakistan.

The United States Agency for International Development (USAID) has long supported programs to build capacity in higher education in Pakistan in the areas of energy, water, and food security. Recently, the Center for Advanced Studies (CAS) program was launched by USAID and the Higher Education Commission of Pakistan (HEC) to strengthen a culture of applied research in Pakistan. The CAS program set up three centers: (1) Agriculture/Food Security at University of Faisalabad, in partnership with University of California, Davis, (2) Water at Mehran University of Engineering and Technology, in partnership with University of Utah, and (3) Energy at National University of Science and Technology, and University of Engineering and Technology, Peshawar, in partnership with Arizona State University.

This paper describes the U.S.-Pakistan Center for Advanced Studies in Water (USPCASW) approach to building the water research capacity in Pakistan to enable the training of the next generation of water Communities of Practice that will help Pakistan achieve the Water SDG. SDG 6 seeks to ensure access to clean water and sanitation for all[5]. The USPCASW partnership between the University of Utah (UU) and Mehran University of Engineering and Technology (MUET) is seeking to align all project components to help Pakistan achieve the six Water SDG targets:

6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

The next section begins by explaining the theory of change underlying the USPCSAW project and guiding its activities. It then introduces the project components and describes their alignment with the Water SDG targets. The subsequent section presents the multi-level assessment approach and results. The final section discusses the challenges and successes of the USPCASW project with particular reflection on the benefits of having a shared vision, using a multidisciplinary approach, focusing on creating agents of change, and finding ways to localize the Community of Practice to sustain the capacity building.

USPCASW OVERVIEW

Theory of Change

The theory of change driving the approach to capacity building at USPCASW draws on ideas developed by Forum for the Future, and others, about the importance of human, social, manufactured (physical), financial, and natural capital for sustainable development[6,7] (see Table 1). At MUET, capacity building activities focus on increasing human, social, physical, and financial capital in order to create a Center with enough capital stocks across all four types to continue,

post-USAID funding, to advance the Water SDG agenda in Pakistan, thereby increasing Pakistan's natural capital (see Figure 1).

Human capital generating activities include degree programs, training workshops, and exchange programs to develop faculty and student capacities across both technical and soft skills. Social capital generating activities include networking events, such as executive seminars, that bring together key stakeholders from academia, government, business, and civil society. Physical capital generating activities include the construction of a new building to house the Center at MUET, along with the establishment of several labs and a library. Finally, financial capital generating activities include external grant writing, collaborations with the private sector, fee-based workshops for water professionals seeking additional training, and other revenue generating actions. In many ways, however, human capital development in terms of developing the Center's endogenous capacity to increase the four capitals is the most fundamental element of this project because social, manufactured, and financial capital are ultimately derivatives of human and/or natural capital[7].

Table 1. The Five Capitals Model of Sustainable Development.

Type of Capital	Definition (adapted from Forum for the Future[6])
Human	knowledge and skills
Social	trust, relationships, networks, and institutions
Physical	buildings, infrastructure, and technology
Financial	shares, bonds, banknotes available for investing in other capitals
Natural	natural resources and processes

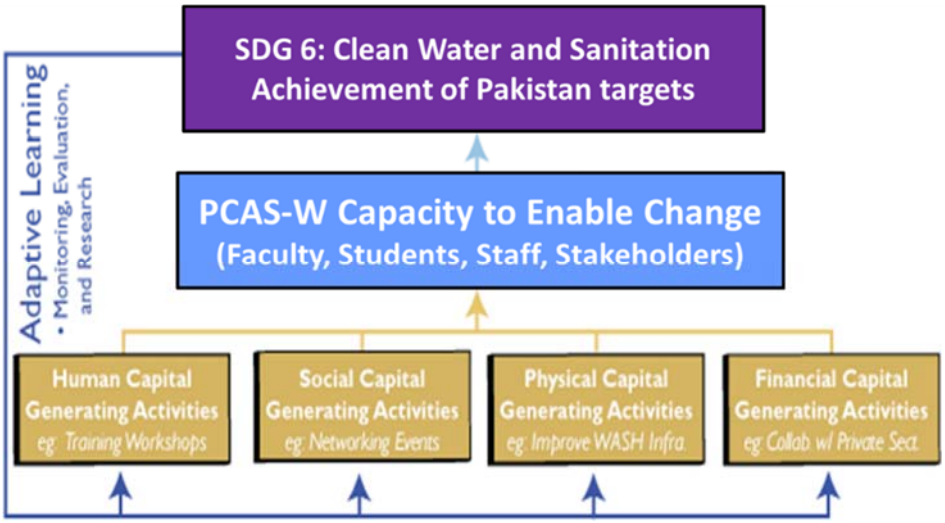

Figure 1. Theory of change guiding USPCASW.

By integrating the six USPCASW project components with the Five Capitals Framework, a clearer picture of the inputs and outputs—and their indicators—required to create a sustainable center to thrive post-USAID funding has emerged, with corresponding indicators and targets. This has helped to clarify a few gaps (e.g., the need for administrative capacity building) and potential vulnerabilities (e.g., the sometimes difficult transition from student to professional). In particular, it has highlighted the need to create a tighter link between the project's capacity building activities and outputs and the longer-term objective of the Center as contributing to water security for Pakistan. Aligning this integrated approach to capacity building and institutional development within higher education with the pursuit of the water SDG is a critical step in this direction and illustrates the potential role of higher education generally for advancing the SDGs. The next sub-section presents the activities to support the development of the four capitals at USPCASW.

USPCASW Project Components

This section describes the six USPCASW project components and explains how they are being aligned with the Water SDG. The activities of USPCASW are designed to support achieving objectives in each project component. But, there are numerous cross-cutting activities that support multiple (and in some case all) project components. The following description of components highlights a few of the project activities. More details about USPCASW and its activities can be found at its web sites hosted at the University of Utah (http://water.utah.edu/) and MUET (http://water.muet.edu.pk/).

Component 1. Governance. The goal of this component is to develop policies, procedures, and practices to effectively govern USPCASW and affiliated institutions. To enable this component and other component actions to be implemented, the UU established a Project Management Unit (PMU) at MUET. The designated Chief of Party manages the PMU providing day-to-day oversight and guidance to facilitate implementation of the project components in Pakistan. The PMU supports UU at MUET to establish effective faculty and student policies and to make decisions aligning with those policies. The Chief of Party has extensive experience working with the MDGs and now SDGs, which is being used to help guide the USPCASW management and decision making to support achieving the Water SDG. *A key action by UU that underlines the need for improved quality in human capital development at MUET has been establishing a transparent meritocracy that rewards faculty for excellence in teaching and research (see Appendix for table outlining the connection between the four capitals and the key project activities).*

Component 2. Curriculum Reform. The goal of this component is to modernize the curriculum by creating new degree programs in important areas for water in Pakistan and improving teaching. Two graduate degree programs, Hydraulics, Irrigation, and Drainage (HID) and Environmental Engineering (ENVENG) have been revised and two new degree programs, Integrated Water Resources Management (IWRM) and Water Supply, Sanitation, and Hygiene Sciences (WASH Sciences) have been introduced. *To support Curriculum Reform and the delivery of these four programs, a Course Mentoring Program has been created to build teaching capacity of individual professors and overall advance human capital development in Pakistan higher education*. This

activity pairs an experienced instructor from MUET with a mentor at the University of Utah or one of the supporting institutions (e.g., Colorado State University, University of Nevada, Las Vegas, City College of New York) to work through the structured development of a course and improvement of teaching skills. To ensure the program can sustain the high quality being established, a process for continuous assessment and improvement is being implemented that follows the approach used to accredit engineering programs in the United States.

To guide the degree programs, 10 student learning outcomes have been introduced:

1. Apply knowledge, skills, and modern techniques and tools in the water profession.
2. Formulate and conduct experiments, as well as analyze and interpret data.
3. Design a system, component, or process responding to development challenges and the demands of public and private stakeholders to meet desired needs within realistic constraints.
4. Apply sustainability and resilience concepts in the context of water problems to develop solutions for Pakistan and the world.
5. Communicate effectively in written and oral forms in professional and public settings.
6. Judge decisions based on sustainable development principles.
7. Discuss contemporary issues of culture, gender, and being a global practitioner in the context of water and environmental challenges and solutions.
8. Effectively manage and lead in the water sector.
9. Inform public discourse and policy making related to water.
10. Exercise high ethical standards and professional responsibility.

The outcomes highlight the need for sustainability and sustainable development principles to be infused throughout the curriculum, which is the approach used for the USPCASW degree programs. In addition, there is specific SDG content delivered through a weekly seminar, specialty courses in each program, and co-curricular activities sponsored by the USPCASW.

Component 3. Applied Research. The goal of the USAID CAS program and therefore USPCASW is to improve the applied research culture in Pakistan leading to advances in support of sustainable water, energy, and food security systems. The USPCASW Applied Research component builds on the other components and creates an environment with opportunities to conduct research having significant impacts on water engineering and management practice, policies, and decision making. Attention has been placed on the need to establish integrating projects, termed "flagship" projects to provide the opportunity for researchers to have home project to which they can contribute, be exposed to research leadership opportunities, and deliver research products that combine with the products of others in a logical and synergistic way. The three flagship projects currently being supported by USPCASW are listed in Table 2. The PWDR project is directly aligned with the Water SDG, and will be a product that keeps the USPCASW centered on assessing and guiding applied research culture in Pakistan and its alignment with achieving the SDG. The other two projects seek to provide national 'living' laboratories (one a place-based physical infrastructure system and the other a digital infrastructure system) to support stakeholder-driven experimentation that can lead to advances in achieving specific targets of the Water SDG. The

shared vision of achieving the SDGs also provides a framework to assess the project components and identify areas that need to be addressed. In the case of the research flagship projects, there is a need for the development of integrated efforts to address targets 6.3 (water quality) and 6.6 (ecosystems).

Table 2. USPCAS-W "Flagship" projects.

Flagship Project	Description	Water SDG Targets
Pakistan Water Development Report	PWDR will be a compilation of analysis of the current state and pathway to achieving Water SDG in Pakistan	All targets addressed
MUET Clean Water Project	The CWP is establishing a Community of Practice to design, build, and operate a water supply system to deliver potable water to the MUET campus and adjacent communities	6.1, 6.2, 6.3
Indus River National Water Management Model	This project seeks to create a hydroinformatics platform to link a WEAP model of the Indus River and data science tools for water management operations and policy analysis	6.4, 6.5, 6.6

The flagship projects are being supported in a scaffolding structure by individual researcher and student thesis projects. A Small Grants Program has been created to support the development of projects that align with the flagship projects AND the Water SDG. *To support the underlying human, social, and financial capital of the MUET researchers to implement the USPCASW Applied Research component, joint research groups have been established that bring together researchers from MUET and other institutions in Pakistan with collaborators from the University of Utah and its supporting institutions (e.g., Colorado State University, University of Nevada, Las Vegas, City College of New York).*

Component 4. Exchanges and Training. The goal of the exchange and training program is to support the creation of a "complete" water engineering and management professor, one with human capital supporting technical competency in teaching and research and the non-technical skills and global competencies to build relationships and influence change. More than 50 faculty members at the University of Utah and supporting institutions contribute to supporting the training and exchange programs. Quarterly missions to Pakistan led by the University of Utah team are conducted to deliver workshops and seminars, engage in strategic business meetings, and support MUET faculty, personnel, and students in individual and small group meetings and activities. The USPCASW has also initiated an exchange program for faculty and students to visit the University of Utah and receive integrated training in applied research, non-technical skills, and global competencies. Similar to the previously described components, the emphasis on the exchanges and training is the Water SDG. For example, the recent mission had joint research group meetings where alignment of research with the Water SDG was emphasized, a curriculum streamlining meeting that assessed the degree programs and their alignment with the Water SDG, and an Executive Seminar on Achieving the Water SDGs in Pakistan. *The exchanges and training activities support development of all four capitals, with an emphasis on human.*

Component 5. Gender Equity. The importance of engaging under-represented groups to achieve solutions in the water sector cannot be overstated. It is the same in Pakistan as in the United States – increasing the participation of women and other under-represented groups in water engineering is essential for creating the most effective and sustainable actions. This cross-cutting component of USPCASW is seeking 50% participation of women across all activities. This expectation is consistent with the USAID target and aligns with SDG 5, Gender Equality. The USPCASW program has focused on establishing the supporting environment at MUET to attract, retain, and empower women in the degree, research, and training programs. Specific measures taken MUET include the establishment of a Gender Policy (http://www.muet.edu.pk/circulars-notifications/gender-policy-statement) and the creation of a concept for a Women's Resource Center. *Both of these efforts provide a foundation to introduce strategic initiatives that further advance the development of human capital with the inclusion and empowerment of women in USPCASW project components and in the Pakistan water sector.*

Component 6. Sustainability. The goal of the Sustainability Component is to advance networking and fundraising in support of sustaining USPCASW as an institution and collection of programs beyond the duration of USAID funding. This component includes activities to build national and international networks (social capital), to acquire external funding through grants and contracts (financial capital), and to generate revenue through training and technology and venture commercialization activities. For example, USPCASW provides training to irrigation district personnel and others in areas to support advancement of the Water SDG, such as target 6.4 on water efficiency. A business plan is currently being created that will identify the necessary external revenue needed and align that revenue generation with achieving the water SDGs. Approaches are also being developed to assess the impact of USPCASW programs toward achieving the Water SDG in Pakistan.

In the broader application of the USPCASW, the strategy is to apply the six project components to develop a community of 'dedicated institutions' through repeated processes of "twinning", where each step transfers skills and knowledge from one catalytic organization to new candidates. The goal of this approach is to empower Communities of Practice to take ownership of the service and enable local systems to deliver inputs needed to maintain results and deliver impacts beyond the initial capacity building. In this way, the project employs a "train-the-trainer" strategy at the institutional level to build the capacity of 'dedicated institutions' to support sustainable activities addressing SDG 6 targets in local communities, and to *catalyze* a viral process that enables sustainable systems to multiply from site to site. In this approach, the University of Utah is working as the **catalyst** with the local "catalyst-in-training", MUET, which more generally could be a University, an NGO, a government agency, local Service Providers (SP), or other key stakeholders in the identified Community of Practice. The catalyst seeks to (a) build capacity of the actors, (b) facilitate data management and ongoing dialogue among the actors in the community, and (c) build capacity of the local University, or other identified entity, to serve as the next catalyst in a new district. In the next step, the 'local catalyst' organization is then poised to take on the catalytic role with the support of the University of Utah and a broader supporting team.

The USPCASW project places a major emphasis on harnessing in-country universities in this process, not only as potential catalysts where appropriate, but also as **multipliers**. *We believe that there is a disconnection and underutilization of local universities in developing and supporting the four capitals essential for long-term success of sustainable development programs, which can also lead to long-term cost savings*.

ASSESSMENT

The assessment of the project is planned for three levels: inputs (activities), outputs (capacity building of catalyst and Community of Practice), and impact (SDG6 targets). Given the early stages of the project, the approach and only preliminary results from the multi-level assessment of project inputs and outputs, and assessment of indirect and direct impact (achievement of SDG6 targets) are presented in this section.

Inputs

Monitoring of inputs includes quantity and quality. An annual workplan is constructed to coordinate the inputs and set targets for amount, reach, and quality of activities supporting each project component. Several activities were noted in the component descriptions above, and full USPCASW Annual Workplans listing all activities are available on the project web site (http://water.utah.edu/).

The activities are individually and in some cases collectively monitored to determine the number of participants, the contact duration, participant satisfaction, and so on. The compilation and reflective assessment of the inputs is reported quarterly to USAID and incorporated annually into a larger report. Those reports are available at the project web site (http://water.utah.edu/).

Currently there are 86 students enrolled in the four graduate degree programs. Students in the HID, ENVENG, and IWRM programs have completed their first year of courses and a second cohort of students (and a first cohort of WASH Sciences) has started. Students have initiated their thesis research projects, and the first cohort of MS students is scheduled to graduate in 2017.

Eight University of Utah led missions have been conducted to provide training and mentorship to faculty and students from MUET and other higher education, government, and non-government institutions. There have been more than a dozen training workshops, symposiums, and conferences on topics such as grant writing, water management modeling, computer programming, effective teaching, and more. In sum, more than 365 person-days of faculty members from the University of Utah and supporting institutions have been dedicated to training in Pakistan.

Collectively, these inputs are seeking to develop human, social, physical, and financial capital among MUET faculty and students and more broadly in the Pakistan water research community. Outputs from these activities are starting to be realized, as described in the next sub-section.

Outputs

The measurement of outputs of the project include typical academic analytics (number of courses developed, number of applied research projects started, number of journal articles published, etc.) and capacity building metrics of the local institution (MUET) and the targeted Communities of Practice (Hyderabad water, Sindh Irrigation and Drainage Authority).

Figure 2 presents progress toward achieving targets for selected project indicators within the six key components of the project. The graphics shows the percentage of the total goal (i.e., life of project target) that was complete by end of each calendar year (with the exception of publications, which are tracked based on academic year and thus 2016-2017 numbers are not yet available. The graphic indicates the emphasis of project activities has been curriculum reform. The number of new courses and teaching training workshops has led to accomplishing the educational targets quite early in the project. The students and alumni is now the emphasis as MS students will begin to graduate in 2017. Also visible in the indicators on Figure 2 is the emphasis placed on governance and establishing bodies, policies, and procedures for effective and sustainable governance of a Water Center. Data on indicators similar to Figure 2 will be monitored as the Communities of Practice begin to advance.

This figure is helpful in seeing where our efforts have been spent in 2016 versus 2015, as well as showing which areas require focus in 2017. Curriculum continues to be an area where a lot of work was needed and major strides have been made. Research progress has struggled to gain momentum, but there are good reasons to expect that the significant investment in building research capacity through workshops and exchanges will bear fruit in the upcoming year. With awards pending for two additional rounds of small grants, we will likely meet the target. The exchange program also started in 2016 and will continue to grow through 2017, as well as strides being made in completing internships with the students. Governance bodies were largely established in 2015, with the remaining pieces still in progress. The move toward 50% inclusion of women has continued, but recruitment and retention remain challenging. Sustainability issues continue to be one of the most challenging areas for the project. While connections have been made and many plans are beginning to move forward, finalizing the partnerships and external funding proves to be a slow process. The team remains optimistic with numerous opportunities being pursued.

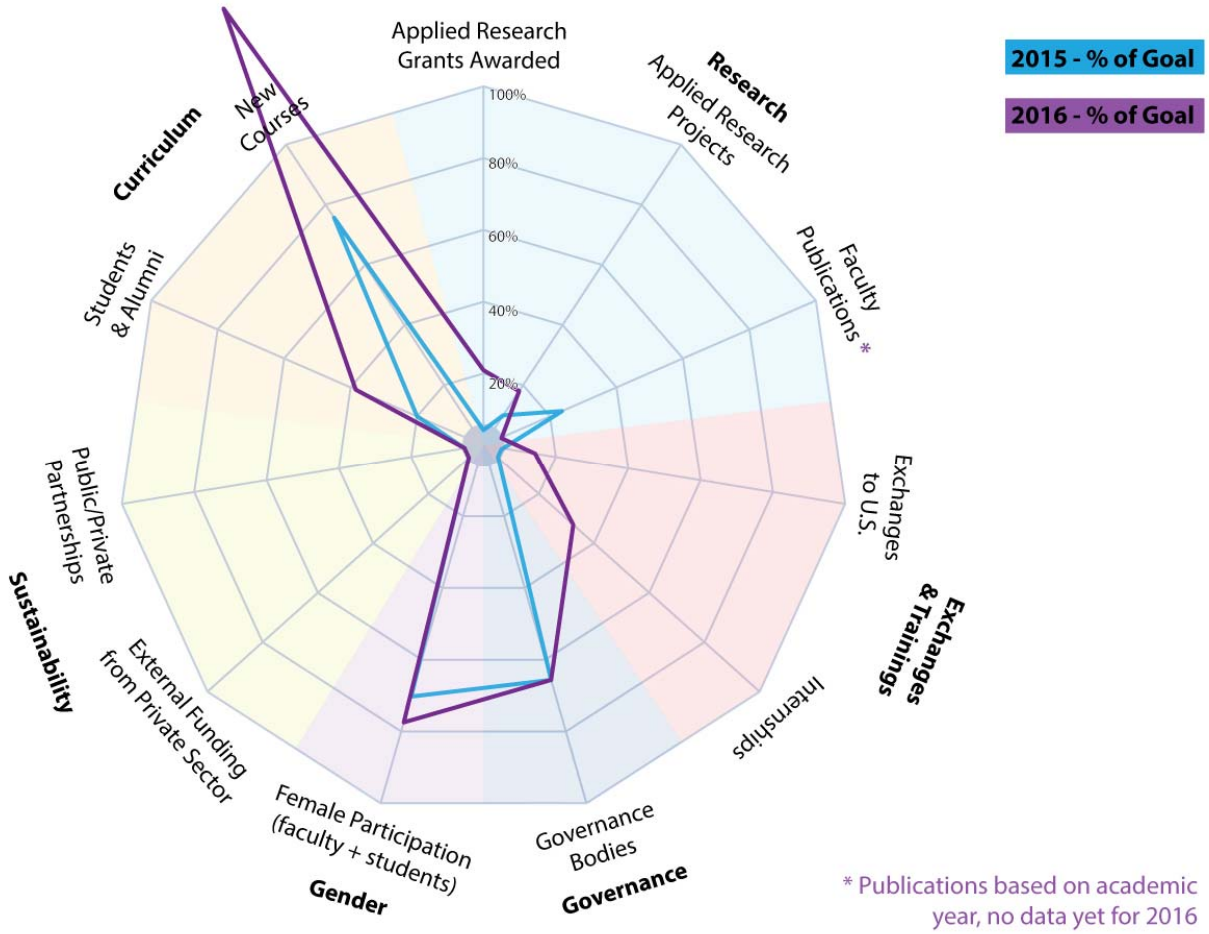

Figure 2. Progress toward achieving output targets in six project components for the partner institution (MUET).

Two major highlights are worth noting in the area of governance. First, the monitoring and evaluations changes have been very helpful in focusing the projects energies, as well as working toward better alignment in tracking between MUET and the U. The Four Capitals framework has also been beneficial in describing the program. Second, the National Water Research Network in Pakistan will be incredibly valuable both for building relationships for the Center, as well as for creating stronger channels for disseminating research and finding areas of needed focus on water issues.

The fourth new degree program, WASH Sciences, also began enrolling students in 2016. Students participating in the WASH program will have a deep understanding of the social, economic and cultural factors driving water and sanitation-related behaviors, and the factors influencing community dynamics. They will be able to design systems, guide policy, and support implementation of programs to provide clean drinking water and sanitation services.

The Center also continues to build and refine the Course Mentoring Program (CMP). This program uses a twinning process to pair instructors at MUET with highly skilled faculty in the U.S., and other countries, to help in refining their course contents, as well as encouraging pedagogical advances. In offering these semester-long, one-on-one relationships—facilitated through an online learning management system to all of MUET's faculty, we are bringing courses up to the necessary levels of quality much more quickly than would be possible with traditional workshops and trainings alone.

We are also very pleased to have begun moving the research program forward with 12 research seed grants awarded to researchers in Pakistan, and 9 of those are receiving technical assistance from research partners at the University of Utah and supporting institutions. For the small grants program, MUET has established a process for the seed grant evaluation that includes advertisement, guidance for proposal preparation, and administering an independent peer-review process modeled after the National Science Foundation panel approach. This process has evaluated more than 250 proposals to date.

As Table 2 listed, three flagship research projects have been initiated with initial results expected in 2017. In particular, the Pakistan Water Development Report will bring valuable water research and information to decision makers across Pakistan. The first issue will include ten chapters and is focused on meeting the SDGs on water in Pakistan. An important advancement in research in year two has been the alignment with Sustainable Development Goal 6 on Clean Water and Sanitation. The curriculum programs already aligned well, but the re-organization of the research groups has provided a critical shared vision to enable focused collaboration and direct tangible impact on well-being in Pakistan.

The exchange program is also moving forward with 27 completed full-semester exchanges and the process now in place to continue bringing faculty and staff to the University of Utah, Colorado State University, and other supporting institutions for training in 2017. The exchange participants have received technical training on the sorts of equipment that will be available in the new labs at MUET, along with valuable skills in communication, networking, substantive knowledge, and cross-cultural interaction, contributing to the development of human, social, physical, and financial capital.

Sustainability continues to be one of the more challenging areas for the project. To help move things forward, we brought several Senior Advisory Board members from the University of Utah to visit Pakistan. This allowed for high level networking and increased support for the project, both in Pakistan and in Utah. The project also joined in and helped create several new organizations focused on water issues in Pakistan, including the Standing Committee on Business-Academia Collaboration.

Overall, the project is making significant progress across all the key areas and has a clear vision of which areas need additional focus in the future. As the major programs have all been brought online in years one and two, there is capacity for focusing on areas that have seen slower movement, such as getting the Women's Resource Center at MUET operational and moving

forward with sustainability goals. One idea already in the works for 2017 to help increase industry connections is an industry partnership specific call for research grant proposals. Staffing is also being reexamined in areas where it might be possible to increase efficiency by breaking up positions within the PMU and bringing on additional administrative staff at the U to better support the ongoing programing. Table 3 summarizes the progress to date.

Table 3. Summary of Progress

COMPONENT	LIFE OF PROJECT TARGET	PROGRESS TO DATE
Governance	Governance Structure - Project Management Unit - Senior Advisory Board - Board of Governors - Council on Research & Policy - HEC-CAS Advisory Committee Policies & Procedures for Continuing Excellence - Faculty Activity Report - Student Handbook - Faculty Handbook - Revised M&E Plan	Mostly Achieved - Achieved - Achieved - Achieved - In Progress - In Progress Mostly In Progress - Achieved - In Progress - In Progress - In Progress
Curriculum Reform	At Least 3 Degree Programs 20 Revised/New Courses 250 Graduates Curriculum Reform Structure	Achieved - 4 Programs (7 Degrees) Achieved - 32 Revised/New Courses In Progress – 96 Students Enrolled Achieved - Course Mentoring Program
Applied Research	50 Applied Research Projects 28 Small Grants Awarded	In Progress – 9 Total Projects In Progress – 6 Awards Granted
Exchanges & Training	250 Faculty/Student Exchanges to U.S. 50 Internships	In Progress – 27 Exchanges Completed In Progress – 16 Internships Completed
Gender Equity	50% Female Participation (Faculty + Students) Gender Equity Plan (GEP) Established Women's Resource Center Established	In Progress – 29% Female Participation Achieved – GEP Adopted Campus-Wide at MUET In Progress – Inauguration Ceremony Held
Sustainability	Water Sustainability Network Established $1 Million Generated from Private Sector 5 Public-Private Partnerships (PPPs) Sustainability Plan 50% Employment of Graduates in Water Sector	In Progress – Pakistan Water Research Network Established Limited Progress – Mostly Networking Limited Progress – Mostly Networking Limited Progress NA – First Cohort Graduates Summer 2017

Impact

Impact is difficult to measure in this type of capacity building project when the overarching mission is water security in Pakistan, which is operationalized to helping Pakistan progress towards achieving the targets of SDG6. We have been developing approaches to monitor the project impact on SDG6 in two ways – first to measure indirect impacts on SDG6 in the form of activities building capacity to address SDG6 targets. For example, we have assessed the coverage of SDG6 targets in curriculum and research. The 2016 assessment of the four degree programs sought to determine whether coursework and thesis projects provided opportunities for students to gain knowledge about the Water SDG targets and to develop skills to solve real-world problems addressing the SDGs in Pakistan. The results shown in Figure 3 illustrates that overall USPCAS-W addresses the six targets of the Water SDG, but each individual degree track does not provide comprehensive coverage. This is an identified area to continue to address in the future to further infuse Water SDG coverage, especially how to translate to actions from graduates and the professional communities they enter. At the completion of the program, student learning in outcomes tied to SDG6 will be assessed.

SDG Water Targets	IWRM	HID	ENVENG	WaSH Sciences
Drinking Water	√		√	√
Sanitation & Hygiene			√	√
Water Quality	√		√	
Water Efficiency	√	√		
IWRM	√	√	√	√
Ecosystems	√		√	

Figure 3. Four degree programs coverage of Water SDG targets.

The summary results from the 2016 review of four USPCAS-W joint research groups is shown in Figure 4. There remain numerous opportunities for modifying the research groups to provide better coverage of the Water SDG targets. The expectation is for all joint research groups to have linkages to all Water SDG targets.

SDG Water Targets	Agriculture Water Management	Hydroinformatics and Decision Support System	Water Quality	Water Governance
Drinking Water			√	
Sanitation & Hygiene			√	
Water Quality			√	
Water Efficiency	√	√		√
IWRM	√	√		
Ecosystems				√

Figure 4. Four USPCAS-W joint research groups and their current alignment with Water SDG targets.

Beyond the monitoring of the first level impact indicators, we also intend to measure the direct impact the project activities have as the Communities of Practice implement accomplishments that address SDG6 targets. For example, the MUET Clean Water Project will provide clean drinking water to at least 5,000 people.

DISCUSSION

Due to the comprehensive set of activities comprising the USPCASW project, a thorough review of all components and assessment is not possible. Therefore, the focus of the previous parts of the paper was to present the project in the context of achieving the Water SDG in Pakistan. In this section, we more broadly consider the USPCASW project and briefly review a few key challenges and lessons learned as the project has been developed.

Two key challenges stand out at this time. First, ***creating programs that can be sustained and can continue to seek to raise the level of quality requires a culture shift***, in addition to funding. A sustainability/business plan is being created that must address acquisition of funds and resources to support the human and physical infrastructure and programs of USPCASW. But equally as important is identifying approaches to inculcate proven practices in faculty, students, and administrators that lead to an institutional and personal attitude to pursue excellence, a system that ensures accountability, and policies and support for continuous assessment and improvement processes. And then to expand this to the broader Communities of Practice being created.

The second key challenge experienced to date is expanding a capacity building program from one entity to others, such that it can be a national program. All universities have a natural tendency to be local and regional in their scope because of their physical location. Even institutions that have a national and international reputation still employ a local workforce and address local problems and engage with the local community more frequently (this is the same in the U.S. as it is in Pakistan). In the context of achieving the country-level Water SDG, this factor is a major

challenge. Even more so in a country such as Pakistan that has entrenched Provincial tendencies for higher education. The approach of the University of Utah to address this challenge has been to emphasize training the trainers such that the change being made at MUET can then be made at other institutions with the University of Utah serving as the catalyst in the next Community of Practice through USPCASW-led training activities.

There are a few lessons learned from the initial setting up of the USPCASW that can help other capacity building programs. First, the decision to establish a shared vision has been instrumental in creating a solidified faculty, rather than a collection of independent operators. The focus on achieving the targets of the Water SDG in Pakistan as the shared vision has helped to not only coalesce existing faculty, but also to strategically identify new faculty and resource needs. It has provided a clear message for the center, and in terms of meeting the program objective of applied research it has given a national level agenda. Although the water SDG provides concrete goals, targets, and indicators to work towards, a remaining challenge is using evidence to demonstrate the USPCASW impact on achieving the water SDG targets in Pakistan (e.g., research projects, policy/business/government/academia/civil society collaborations, or alumni as agents of change).

A key lesson learned about using the SDGs as a Shared Vision of the USPCASW is the need for an interdisciplinary approach. The USPCASW program was created by a team with representatives from engineering, economics, law, geoscience, public health, education, social science, and earth science. This breadth of expertise has crafted an interdisciplinary training program that incorporates the breadth of expertise needed as a foundation for practicing in the water sector. This has been implemented in the curriculum programs through a common set of courses and infusing interdisciplinary content throughout the curriculum.

Another lesson learned in the initial setting up of the USPCASW programs has been the critical need for developing non-technical skills and global competencies to enable the technical training to have the greatest impact. Without the ability to recognize the need for and influence change of practices, institutions, policies, and public perceptions the technical knowledge and skills being elevated in MUET faculty, administrators, staff, and students will not achieve its fullest potential. The current emphasis of USPCASW is to increase the attention to training non-technical skills and global competencies in the exchange and curriculum programs and to develop applied research projects that investigate and develop these attributes.

In summary, USPCASW is a 5-year project that was awarded funding in December, 2014. Much has been established since then, and much remains to be accomplished. We have the vision for a sustainable USPCASW program, and it is fundamentally based on building the four capitals (human, social, physical, and financial) at USPCASW. This paper summarized the project components and the alignment with achieving the Water SDG. USPCASW has had several early successes and lessons learned that are shaping its activities into the future. There are many other important early lessons learned, including: using applied policy research to strengthen science-policy interface; implementing measures to promote high standards of academic and research culture; connecting academic and research programs to market and industry needs; and

strengthening governance at all levels. As USPCASW progresses, discoveries made, and impacts realized more details will be reported to the water development and education community to support the many efforts ongoing around the world.

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REFERENCES

[1] United Nations. (2015). General Assembly notes, accessed August 13, 2016. http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

[2] United Nations Development Programme. (2016). Accessed August 13, 2016. http://www.undp.org/content/undp/en/home/sdgoverview/post-2015-development-agenda.html.

[3] Shaban, A. (2008). *Water poverty in urban India: A study of major cities*. Seminar Paper, UGC-Summer Programme (June 30-July 19, 2008).

[4] Government of Pakistan (2013). *Pakistan Millennium Development Goals Report 2013*. Planning Commission, Islamabad, Pakistan.

[5]United Nations. (2016). Sustainable Development Goals, accessed Agusut 13, 2016. http://www.un.org/sustainabledevelopment/water-and-sanitation/#.

[6] Forum for the Future (n.d.). The Five Capitals Model – A Framework for Sustainability, accessed August 15, 2016. https://www.forumforthefuture.org/sites/default/files/project/downloads/five-capitals-model.pdf

[7] Parkin, S., Sommer, F., and Uren, S. (2003). Sustainable development: Understanding the concept and practical challenges. *Proceedings of the Institution of Civil Engineers, Engineering Sustainability*, 156(ES1): 19-26.

Appendix: Examples of project activities to generate human, social, physical, and financial capital in support of ensuring water SDG impact of USPCAS-W.

Project Components	**Examples of activities to generate outputs in terms of…**				**Anticipated SDG Impact of Project Components**
	Human Capital *knowledge, skills*	**Social Capital** *shared norms, values, social networks*	**Physical Capital** *buildings, technology*	**Financial Capital** *money to invest in other capitals*	
Governance	-Administrative workshops and meetings -Tacit knowledge exchange through close working relationships	-Promote a "culture of excellence" (for example, by establishing a transparent meritocracy for faculty retention and promotion) -Establish policies and procedures for good governance of USPCAS-W (e.g., student and faculty handbooks)	-Construct new building to house USPCAS-W at MUET -Create web-based database for monitoring and evaluation	-Secure funds for operation and maintenance of all of the Center's facilities as well as ongoing implementation of critical activities	Good governance will create a more resilient Center better able to withstand shocks to its system, thereby providing ongoing support to advancing Pakistan's water security in the face of economic, social, and climatic changes.
Curriculum Reform	-Teaching effectiveness workshops -Ongoing faculty discussions for curriculum reform	-Course Mentoring Program to develop courses and improve teaching through pairing faculty from different institutions -Establish policies and procedures for ongoing curriculum assessment and improvement	-Improve classrooms, labs, and library -Improve course delivery through online learning management systems	-Secure funds for ongoing improvement of curriculum and teaching - Secure funds for upkeep and updating of curriculum-related infrastructure	Modern, interdisciplinary, and experiential curriculum will prepare students to address Pakistan's water challenges as professionals in the water sector.
Applied Research	-Technical workshops -Research proposal writing workshops -Flagship projects	-Nationwide Small Grants Program -Create research networks (e.g., Pakistan National Water Research Network) -Establishment of incentive structure to reward faculty for research contributing to achieving water SDG	-Improve labs and library -MUET Clean Water Project → campus as a living lab	-Raise funds through external research grants - Secure funds for upkeep and updating of research-related infrastructure	Technological, analytical, and social innovations will help achieve targets for water SDG.

Exchanges & Training	-Semester Exchange Program for Pakistani Faculty and Students -Missions to Pakistan to conduct workshops and seminars	-Collaborate and network with water researchers and professionals from different countries -Cultural activities (e.g., museum visits) and social activities (e.g., potlucks) for visitors to U.S. as well as visitors to Pakistan	-Establish of Visiting Faculty Hostel at MUET -Develop distance / online education infrastructure	- Secure funds to continue exchange program -Raise funds through fee-based training workshops offered nationally	Holistic professional development will prepare faculty and students to be agents of change for water SDG.
Gender Equity	-Gender equity and women's empowerment workshops -Gender mainstreaming across project activities	-Establish Gender Equity Policy and implementation committee -Establish supportive professional environment for both women and men	-Secure physical space for the establishment of Women's Resource Center	-Secure budget to operationalize Women's Resource Center and support its activities	Faculty and students will be well-positioned to support gender mainstreaming in their places of work and in the design and implementation of water solutions.
Institutional Sustainability	-Sustainability planning meetings	-Create diverse, cross-sector networks to link academia, business, civil society, and government (e.g., Standing Committee on Business-Academia Collaboration on Water) -Establish Alumni Association -Establish quality assurance policies and protocols	-Establish database of potential funders and donors	-Generate funds through strategic business plan	Sustained quality of education and research at USPCASW will ensure ongoing production of skilled graduates and innovations for water sustainability.
Anticipated SDG Impact of Increased Capital Stocks	Faculty and students with knowledge, skills, and experience to drive innovation for achievement of water SDG.	Interdisciplinary, cross-sector, cross-cultural networks—supported by robust social norms of collegiality, transparency, and merit-based rewards—to increase rate of SDG-relevant innovation.	Physical and technological infrastructure for high quality education and cutting-edge research is put to use in achieving specific water SDG targets.	Pursuit of Pakistan's water SDG does not depend on foreign aid; therefore its pursuit will continue until all targets are achieved.	