

Challenges and Opportunities of International University Partnerships to Support Water Management

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Historically water scarce regions such as the Central Andes in South America are particularly vulnerable to changes in water supply and demand and are struggling to adopt a more participatory model of integrated water management. Inclusive engagement principles have been used successfully in many locations to improve agricultural and water management; however, there are several barriers to transference of similar practices to Latin America. For example, collaborative research arrangements between U.S. and Latin American universities are desirable to develop sustained research programs on appropriate integrated water management techniques, but institutional barriers and the lack of a culture of applied research and extension that is responsive to community needs may limit the effectiveness of research partnerships. Additional barriers to participatory management exist at the community level, including traditional limitations such as low institutional capacity, traditional gender roles, and authoritarian structure, as well as emerging issues related to changing rural livelihoods. This article examines opportunities and threats associated with an emergent partnership between Purdue University (Purdue) in Indiana, USA, and Universidad Nacional de San Agustín de Arequipa (UNSA) in Arequipa, Peru. It serves as the introduction to this Special Issue exploring water resources risks in Arequipa, Peru, as well as

potential barriers and strategies to support water management adaptation.

Globally, many drivers such as population growth, climate change, and changing income and consumer preferences are dramatically altering water resources management. In water scarce regions that rely on irrigated agriculture in particular, the intrinsic linkage between land and water management (Chen et al. 2018) means new sustainable management frameworks must be developed to minimize environmental impacts on both resources (Brack et al. 2017). However, in some countries the lack of technical knowledge, infrastructure, and human capacity means that well-intentioned sustainable management frameworks do not achieve the expected results in the management of water resources (Maestu 1997; Ortiz Acosta and Romo Aguilar 2016; Rivera-Marquez et al. 2017; Ruiz 2019). In Peru, although a complete revision of the national water policy in 2009 provides a general framework for the proper management of water resources, its application is limited (Robert 2019).

At the same time, Peruvian Canon Law No. 27506 provides a source of funding to enhance Peruvian water management infrastructure (Congreso de la Republica 2001). This law invokes a tax, collected by the State, on the economic exploitation of natural resources. According to Article 6.2, regional and local governments

should use funding from this tax exclusively for the financing or co-financing of regional and local impact infrastructure projects, and 20% of the tax can be transferred to public universities to invest in research that enhances regional development.

In response to on-going issues of environmental degradation, UNSA, a Peruvian public university, used the tax-derived financing from mining to establish a partnership with Purdue in the United States. Purdue was approached due to their experience in water resources management, especially for agricultural management, and their history of international extension, to foster applied research in Arequipa, Peru.

This unique collaboration has not been without challenges, but is also showing initial successes, and the purpose of this Special Issue is to provide a clear look at both. Our contributing authors explore not only institutional challenges in the formulation of the partnership, but also social challenges that impact participatory water governance. Collaborations are making technological advances and demonstrating the potential impact of applied research into water-related threats. To start, in this introduction the established legal framework governing environmental management is reviewed. To examine the partnership established between UNSA and Purdue to improve water management capacity in Arequipa, we analyze existing conditions, both internal and external, around which this partnership was developed and establish the opportunities and threats (challenges) which contribute to the implementation, improvement, and achievements of this unique partnership.

Universidad Nacional de San Agustín

UNSA is a public university in Arequipa in southern Peru. The university comprises three campuses, with 17 departments and 45 professional schools in the fields of humanities, natural sciences, social sciences, and engineering. Its mission is “to train competent and ethical professionals, with capacity for research and innovation generating scientific, technological, and humanistic knowledge, contributing to the sustainable development of the region and the country (UNSA 2020).”

Purdue University

Purdue University is the land grant university of Indiana, established through the Morrill Act in 1869, with its main campus in West Lafayette, Indiana, USA. The university is organized into 13 colleges and schools. It offers 200 undergraduate degrees and 70 master’s and doctoral degrees. It is known worldwide as a leading research institution. As a land grant university, the Purdue College of Agriculture has a three-part mission for teaching, extension, and research, as follows: “Purdue Agriculture will help make Indiana, our nation, and our world better through: Students prepared to make a difference; Research with purpose, leading to discovery with impact; Engagement/Extension that strengthens lives and livelihoods; An inclusive culture that supports excellence in all we do (Purdue 2020).”

Arequipa Nexus Institute

To raise technical and human capacity, the UNSA strategic plan included a goal to establish long-term collaborations to address the environmental, agro-economic, and social challenges that support sustainable management of water, soil, energy, food, and other resources in the Arequipa region, in Peru in general, and throughout Latin America. Thus, a thorough search was carried out throughout the world to identify potential collaborators, with the security of having economic funds from the mining Canon.

Through the work of the Core Foundation, the connection between UNSA and Purdue was achieved with a mission to provide transformative solutions for great challenges in the sustainable management of Arequipa’s resources. In 2017, through high-level coordination, Tomas Díaz de la Rubia, Chief Scientist and Chief Executive Officer of Discovery Park at Purdue, and UNSA Rector Rohel Sánchez, laid the foundations for the collaboration. In March 2018, the Arequipa Nexus Institute of Food, Water, Energy and the Environment was launched. The vision of the Nexus Institute is “to be a vibrant, educational, and innovative research ecosystem where transformative solutions to the great challenges facing Arequipa, Peru, and Latin America are

explored.” Its mission is to “Increase the capacity and strategic collaborations required in the long term to address environmental, agro-economic, and social challenges that provide support for the development of adaptive, profitable, and sustainable food-energy and water systems in the Arequipa region of Peru.” The initial phase resulted in funding ten three-year projects addressing the interdependent topics of food, energy, water, and the environment. The largest of these projects, led by the authors, addresses Sustainable Water Management in the Arequipa Region. Each project involves professionals from both Purdue University and UNSA.

Water Regulation in Peru

In general, water resources management is included in the national environmental policy established for Peru through D.S. No. 012-2009-MINAM (Ministerio del Ambiente 2009). The first objective of this national environmental policy is the protection of biodiversity, due to the richness of flora and fauna in Peru. This does not prevent extraction of all the natural resources in the nation, but criteria must be adjusted to protect biodiversity, consistent with a sustainable development paradigm, which, defined simply, is the use of resources without harming resource use by future generations. In contrast to a nature conservation approach, which prohibits human or economic activity on the land, or a purely resource extraction approach, the sustainable development approach views Peru’s natural resources and biodiversity as a public good which can be managed to provide long-term value chains (Nobrea et al. 2016). While achieving true sustainable development may be utopian, this framework establishes minimum values that must be maintained. For example, though it may not be possible to return irrigation water to the same quality and quantity as before using it, environmental standards provide an acceptable threshold for maintaining initial characteristics.

Sustainable development has three principles, which correspond to the economic, the social, and the environmental (Enkerlin Hoefflich et al. 1997; Badii 2004). These principles must be prioritized to maintain balance among them, and the breakdown

of this balance can provoke social conflicts. If, for example, the environmental side is prioritized by neglecting the social and economic aspects, there will be protests from groups that are affected by the measures considered.

The Water Resources Law no. 29338 regulates both management of water quantity and water quality (Congreso de la Republica 2009). Use is prioritized as follows: protection of biodiversity, population use, agricultural use, mining and industrial use, and other activities. A water balance is used to determine the amount of water allocated for each purpose. Ecological flow, the minimum amount of water needed to safeguard the biodiversity in a given basin, is used as part of that water balance. The National Water Authority (ANA) is responsible for calculating and maintaining this water balance.

Water quality is regulated through two environmental management policies, the Environmental Quality Standards (ECA; supreme decree 004-2017-MINAM), which establish the maximum amount of a pollutant expected to be present in the water as a receiving medium for different uses. A second instrument is the maximum allowable limits (MPPs), which correspond to the maximum load of contaminants that can be released to receiving waters as point discharges. MPPs are set for each type of release and controlled by the different ministries, so each ministry sets its own permissible ceilings. Of the two management instruments mentioned, the environmental quality standard (ECA) is the most important (Ministerio del Ambiente 2017).

Both ECAs and MPPs set values for various physicochemical, microbiological, heavy metal, and agrochemical parameters. Laboratory or field analyses of water quality samples related to these parameters must be conducted by laboratories that are certified by the National Institute of Environmental Quality (INACAL). These are generally associated with the certification of the international standard ISO 17025.

Methods

A Strength, Weakness, Opportunity, and Threat (SWOT) analysis was applied to analyze the conditions of the partnership established between

UNSA and Purdue to improve water management capacity in Arequipa. SWOT analysis provides a methodology for evaluating what is working well and what is limiting progress in the partnership (Community Toolbox 2020). Both internal factors, i.e. strengths and weaknesses, and external factors, i.e. opportunities and threats, were analyzed, as follows:

- Strengths – Areas of competence which are under the control of the Nexus Institute. These characteristics indicate a high level of performance, providing advantages or benefits and possibilities in the future.
- Weaknesses – Areas of low performance that are under the control of the Nexus Institute and that slow achievement of the objectives.
- Opportunities – Factors over which the Nexus Institute has no direct control, which can contribute to the achievement of objectives.
- Threats – Factors that cannot be controlled directly by the Nexus Institute, but which impair achievement of objectives. Threats pose a risk to the functioning of the partnership.

The SWOT analysis can be used to find interactions between internal and external variables, which inform approaches to continuing the partnership, also known as a TOWS analysis (Dyson 2004). These approaches are as follows:

1. Success approach – using a **strength** to enhance an **opportunity**;
2. Reaction approach – using a **strength** to control a **threat**;
3. Adaptation approach – using an **opportunity** to control or adjust a **weakness**; and
4. Survival approach – mitigating the effect of a **threat** by being aware of a **weakness**.

SWOT Analysis of the Nexus Institute

Strengths

The initial strengths of the Nexus Institute are shown in Table 1. One of its greatest strengths, and the reason that Purdue was approached by UNSA, is the *experience of Purdue faculty members* in conducting and publishing research in the agricultural, food, natural resources, and life sciences. In 2015, Purdue was ranked among the

top five universities in the world associated with agriculture and forestry, the categories most related to water management (TOPUNIVERSITIES 2020). The ten Purdue leaders on these projects have over 200 years of combined academic experience, in disciplines ranging from natural resource social science, water, soil and food science, to engineering and technology. They have received numerous recognitions for excellence in research both internal and external to the university, including the 2009 World Food Prize.

Support of university administration allowed for the creation of the Nexus Institute, which provides funding and a collaboration framework for sustainable water management in the Arequipa region for at least three years. An additional strength is that the UNSA mission “to train competent and ethical professionals, with capacity for research and innovation generating scientific, technological, and humanistic knowledge, contributing to the sustainable development of the region and the country” *is aligned with sustainable development* (UNSA 2020). Sustainable development is based on the management of natural resources, including water.

Weaknesses

The primary weakness of the collaboration is the *limited involvement of UNSA faculty*. Faculty positions in Arequipa are complex, and many faculty divide their time between more than one position, often serving at multiple universities. To avoid potential conflicts of interest, only faculty working solely at UNSA were eligible to participate in the Nexus Institute. This, together with numerous time constraints and other requirements, greatly limits participation by UNSA faculty. For example, the Sustainable Water Management project includes six faculty from Purdue, but only three UNSA faculty members are officially recognized as part of the project (University Council resolution number 0692-2019).

In addition, *language barriers have limited communication* between professionals at both universities, as very few faculty know both English and Spanish. Language knowledge was not a requirement for proposal submission, and Purdue faculty were told that UNSA faculty would be taking intensive English classes, which has

Table 1. SWOT and TOWS analysis of the Purdue-UNSA partnership.

	Strengths: <ol style="list-style-type: none"> 1. Experience of Purdue members 2. Support from university administration 3. UNSA mission aligned with sustainable development 	Weaknesses: <ol style="list-style-type: none"> 1. Little involvement from UNSA professionals 2. Language barrier 3. Lack of technical experience from UNSA professionals
Opportunities: <ol style="list-style-type: none"> 1. Canon Law, provides financing 2. Interested government agencies 3. Interested users 	Success: <p>S1-O1 Developed proposals and received funding from UNSA to develop research on water resources in Arequipa</p>	Adaptation: <p>O1-W2 Provide language training to all participants O1-W1/W3 Marketing of technical training for UNSA professionals</p>
Threats: <ol style="list-style-type: none"> 1. Change of UNSA administration 2. Change in environmental regulations 3. Insufficient access to technology 4. No incentives for UNSA professionals 	Reaction: <p>S3-T1 Fulfillment of the UNSA mission through the partnership enhances the reputation of the UNSA faculty to their new administration</p>	Survival: <p>T3 Train users with available technology T4 Generate economic or other incentives for UNSA professionals</p>

not happened. Furthermore, *UNSA professionals have limited experience* in projects related to water resources management, especially in using computer modeling tools.

Opportunities

Taxes collected from mining as part of the *Peruvian Canon Law* provide a reliable source of research funding for the Nexus Institute and related projects (Congreso de la Republica 2001). This partnership has also received *great interest from government agencies* through agency visits by Nexus members. Both universities have engaged with *groups interested in the development of adequate water management*, and research findings will be shared by developing tools and hosting workshops and trainings to improve water resources management.

Threats

The *term of leadership of the current UNSA administration* ends in December of 2020, which could affect stability and funding of the partnership. Future management of the Nexus Institute will depend on the next elected administration.

In Peru, *environmental regulations have been constantly changing*, putting the design of decision-making tools at risk, especially those that take into account MPPs and ECAs.

There are many locations in Arequipa where we would like to involve users in sustainable water management decisions, but users have *insufficient access to technology*, including the lack of access to smart phones or Internet.

Finally, there are *not adequate incentives for UNSA professionals* to be involved in the project, mainly because collaboration involvement increases workload, but does not provide an increase in compensation.

Approaches - TOWS Analysis

Combining the first strength and opportunity of the Nexus Institute led to initial *success*, which was the development of proposals that received funding from UNSA for water resources research in Arequipa (Table 1). Our strengths also allowed the team to *react* to an external threat, to increase awareness amongst local agencies of the sustainability mission of UNSA, and on-going research efforts to improve sustainability.

However, collaboration weaknesses require the Nexus Institute to *adapt* in two main areas with the help of external opportunities, as highlighted in Table 1. First, a system could be established to encourage the participation of more UNSA faculty in the Nexus Institute. This could include marketing to non-members that technical training is available for UNSA professionals if they participate in the collaboration. In addition, intensive language training should be provided and required for professionals from both universities.

Finally, where team weaknesses intersect with external threats, the collaboration must go into *survival* mode. Better economic incentives and relief from teaching requirements for faculty from UNSA would encourage more participation, thus funding may have to be sought. Also, there is a clear need for training stakeholders to better use technology available and overcome limits to access, which would help fulfill UNSA's mission and engage these groups, particularly in water management.

Evidence of Collaboration Success

This Special Issue documents some of the initial successes that have resulted from the initiation of the Nexus Institute to build research capacity to investigate issues of sustainable water management in Arequipa, Peru. The authors use a range of approaches, incorporating social science concepts, science, and technology, to better understand and address the challenges of water management in the region. This series of papers, all from participants in the Nexus Institute, give those involved in similar international collaborations a resource for identifying potential pitfalls and opportunities for achieving desired outcomes.

In the first paper, Mazer et al. establish a framework of collaboration principles to be used to evaluate international university-led research partnerships, and offer practical guidance on overcoming obstacles early on, amid an imperfect partnership. This work provides practical advice for the establishment of new university-led research partnerships.

Moraes et al. explore the limitations of conducting research in a data poor environment, through an evaluation of the existing water

resources monitoring network in Arequipa. The weather, stream discharge, and water quality networks are evaluated with respect to their ability to support water and agricultural management decision making and provides an evaluation of data available for further analysis.

The third and fourth papers give examples of applied research into the use of technology to improve water management. Guevara et al. describe a pilot water irrigation framework utilizing wireless communication and a sensor network for regulating water flow in a drip irrigation system to improve irrigation efficiency in Arequipa. Looking at the water distribution system for public-supply, Dawood et al. developed an assessment framework for potable water systems based on 3D modeling of pipe failure. The developed model can be used by municipal engineers as a screening tool to prioritize maintenance needs. Together, these two papers illustrate the potential of smart technology to improve the sustainability of water management.

An important aspect of water management in a dramatically changing region such as Arequipa is the impact of human-environmental change on people. The next two papers incorporate aspects of stakeholder engagement to address issues of environmental change. Brecheisen et al. incorporate historic imagery dating back to the 1960s into accessible formats to inform public conversation on the environmental impacts of land use change, glacial retreat, and a need for wetland preservation. Also, through analysis of historic change, Mazer et al. develop maps of urban flood hazards in Arequipa to inform municipal agencies and communities on the changing nature of the hazard.

The final paper in this issue discusses the capacity of local citizens and agencies to utilize the technology and information made available to be involved in water management. Popovici et al. describe the challenges associated with coproduction of knowledge, decisions, or policies with local community members in the context of changing rural livelihoods. Utilizing focus groups and semi-structured interviews, they determined that increased migration, market integration, and reliance on regional institutions for water and crop management undermine the effectiveness of coproduction efforts. Not included in this Special

Issue, but in review for publication in JCWRE Issue 172, Bowling et al. discuss the limitations of government agencies tasked with public education in developing, evaluating, and distributing water management information and tools. Based on interviews, focus groups, and small break out groups, they provide a vision for university-led water engagement centers that can provide a venue for applied research and public engagement in Arequipa.

The water resources challenges facing regions such as Arequipa are complex. A legacy of resource extraction and greatly expanded export agriculture threaten water quality and increase competition for scarce water resources. A large gradient between rural and urban livelihoods leads to disparities in access to technology and information, and even the ability to engage in water management decisions, which government agencies do not have the resources to overcome. It is our hope that the cases in this Special Issue provide insight, not only into the challenges facing water resources management, but also highlight some of the ways in which university partnerships can contribute to more effective and sustainable water management globally.

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