International Cooperation on Border Problem Solution

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Abstract *- An existing Ph.D. Program in environmental science and engineering began a review of its directions and future, leading to a new mission, vision, and strategic plan. As part of that process, the comparative advantages enjoyed by the program were explored. A key advantage is its location on two borders: one is a border with another country and the other is a border with another state. The existing curriculum had been in place for over ten years without modification, and environmental problem solving requires significantly more interdisciplinary behavior than exhibited in that curriculum. In addition, there is a need to establish a niche for the program while also encouraging even more cross-border collaboration. This process is leading to development of a new curriculum intended to focus on border issues to include borders anywhere in the world. This direction also provides many opportunities for collaborations between universities in differing countries (and/or states) while providing the prospect of allowing movement towards best practices in education, engineering, and policy. Since solutions at any border are interdisciplinary in nature, much can be learned from the interactions between disciplines, governmental agencies, and laws and policies. Often, the focus at borders is on political issues, but environmental issues and resulting health and quality of life issues can provide common ground for collaboration on some issues. The intent of this curriculum is to identify those elements and approaches that are common to many borders, along with definition of design constraints and issues that may differ. Different curricular tracks are being developed.*

Index Terms *– Curriculum, borders, interdisciplinary*

BACKGROUND

An existing Ph.D. Program in environmental science and engineering began a review of its directions and future, leading to a new mission, vision, and strategic plan. As part of that process, the comparative advantages enjoyed by the program were explored. A key advantage is its location on two borders: one is a border with another country and the other is a border with another state.

The existing curriculum had been in place for over ten years without modification, and environmental problem solving requires significantly more interdisciplinary behavior than exhibited in that curriculum. In addition, there is a need to establish a niche for the program while also encouraging even more cross-border collaboration. This process has led to ongoing development of a new curriculum intended to focus on border issues to include borders anywhere in the world. This direction also provides many opportunities for collaborations between universities in differing countries (and/or states) while providing the prospect of allowing movement towards best practices in education, engineering, and policy. Since solutions at any border are interdisciplinary in nature, much can be learned from the interactions between disciplines, governmental agencies, and laws and policies.

One can think of many borders that exist around the world. Often, the focus is on political issues, but environmental issues and resulting health and quality of life issues can provide common ground for collaboration. The intent of this curriculum is to identify those elements and approaches that are common to many borders, along with definition of design constraints and issues that may differ.

Compounding solutions to environmental problems at any border are political issues; regulatory agencies; existing laws and policies; infrastructure differences; cost structures (labor, equipment, energy) that are different on each side of the border; currency exchange rates; licensure differences; operating permit differences; environmental regulations and level of enforcement; acceptable and common design practices; data that, when available, often are different in spatial and temporal dimensions and frequency of reporting;, available government and industry resources to solve problems; and transnational companies and their impact. All these topics are embedded within different cultural and social constructs that are fundamental to development of sound policies. When the term “policy” is used, it should include (1) formal policies codified in regulations or law, (2) practices between governments that are not codified into regulations, (3) practices involving NGO’s and citizenry that have some continuity, and (4) any other activities that define the actual solution to environmental problems on a specific border.

Of course, each situation has physical complications as well, including different geographies, different atmospheric conditions, different mixes of industry and other sources, as well as different health and related areas of potential harm.

The curriculum design is based on earlier national curricular conversations. Of particular usefulness are results on integrated curricula from the Foundation Coalition augmented by the author's experience with that coalition and other integrated programs. These form the basis for expected outcomes and assessment practices. In addition, critical success factors have been adopted to measure program success, including the numbers of borders studied, collaborations with other countries, and publications focused on border issues. This curriculum is expected to further dialogues and advances in common licensure, design best practices, and shared policies.

This curriculum revision is in part a result of an ongoing strategic planning process. A review of basic elements of that process will help see the linkages to the desired curriculum. Some of those items reported are still in transition.

Comparative Advantages

Any organization needs to begin its planning process by understanding any forces that give them an advantage against competition. For this case, the Environmental Science and Engineering (ESE) Ph.D. Program under consideration is housed at the University of Texas at El Paso (UTEP). Reviewing the current situation led to the following perceived comparative advantages:

- Location on border
- Location in highly Hispanic population
- Arid region: extreme environment, energy needs, population density gradients
- Homeland Security emphasis
- World's largest inland desalination facility
- Defense industry concentration in region
- Health disparities that are different in a border region

GUIDING PRINCIPLES

Experience has indicated that the guiding principles (sometimes called core values) should be stated before the mission (what the organization does) and the vision (where the organization plans to be in the future). The guiding principles are effectively how the organization does its work. The following elements surfaced as appropriate to the guiding principles.

Our program will engage students with faculty who are focused on:

- Real world problem solving;
- High-quality research that builds success through interdisciplinary lines of investigation;
- Timely dissemination of knowledge;
- Excellence in teaching and student career development.

We will promote diversity, internationality, and creativity and lateral thinking ability at multiple levels.

Our success will be measured through the successes of our graduate students, development of our program, and our involvement in and leadership of scientific, engineering, policy and management, and education and outreach activities aimed at advancing understanding of environmental change and how society will need to adapt.

MISSION

The mission statement reflects the purpose of the organization. In this case, the program selected a statement that carries forward the guiding principle emphasis on students and their success as graduates.

To prepare the next generation of leading environmental problem solvers.

- Participants conduct research to understand the present and future state of the Earth System
- Participants study how society will need to adapt in order to sustain ecosystem goods and services and human health and well being
- Our program is rigorous
- Our program focuses on environmental problems that span or are relevant to international or state/provincial border regions

Accomplishment of this mission includes but is not limited to research activities associated with: Toxicology, Waste management, Ecosystem structure and function, Conservation biology, Provisioning of ecosystem goods and services, Alternative energies, Air and water quality, Human health and well being, Environmental engineering, Sensor and cyber-

infrastructure development, Environmental policy and management, Environmental hazard risk and management, Environmental Education and Awareness, Environmental change, Earth system science, and Environmental management

VISION

At this point, program deliberation focused on identifying the future direction of the program. Constant reference to the comparative advantages cited earlier lessened the chance that the program would look like all other programs. The vision must also be stated in such a way that progress toward it can be measured. Otherwise, it simply becomes a motto or similar statement. The vision selected was as follows:

Our vision is to become a local to global leader in environmental science and engineering education and problem solving, particularly in situations concerning border regions.

We will meet this vision through the following objectives:

- Recruitment of a diverse and outstanding interdisciplinary team of innovative and energetic research and teaching faculty and graduate students;
- Improvements to our research and teaching facilities;
- Attainment of funding to support novel research and educational opportunities;
- Collaboration with international, federal, state, local, institutional and non-profit organizations;
- Development of an integrated interdisciplinary program that researches, monitors, assesses, and better educates the general public about environmental change and sustainability;
- Development of improved environmental management and policy guidelines and other advisory mechanisms.
- A suite of innovative educational and career development activities that improve lateral thinking ability, interpersonal and interdisciplinary communication skills, and the career potential of our program participants.

KEY STRATEGIC DIRECTIONS

Reaching the Vision will require improvements in some key areas. These Key Strategic Directions will each have implementing objectives and tactical work plans developed to create plans to make progress. A few notes are included on each to clarify the intent. Further details of the plan will not be presented here in order to focus attention on approaches to border issues.

CRITICAL SUCCESS FACTORS

There need to be a vital few things that are regularly measured to show progress toward meeting the vision. Among those being considered are the following, which will ultimately be reduced to about five in number:

- Numbers of borders on which work done
- Number of international students
- Where we are doing work
- Publications
- Presentations
- Grants / funding
- Numbers of students
- Numbers and qualifications of applicants
- Numbers of interdisciplinary interactions on campus

The numbers and value of interdisciplinary interactions is expected to be tracked and portrayed by use of sociogram tools developed in the social psychology field. Of course, involvement in research teams working on interdisciplinary problems is the best way to development of interdisciplinary skills, although these can be clearly enhanced by other curricular elements.

As the curriculum evolves and implementation and review occur, the critical success factor metrics will enable assessment of the approach to the desired vision. Further reports in the future will enable the reader to make their own judgment as to its success.

RESEARCH AREAS AND CURRICULAR TRACKS

It may be helpful to describe some potential research areas that may be important in border situations, or at least have differences when applications are made in border locations. Those chosen for presentation here are those with active faculty at UTEP and/or within its numerous international collaborators. In initial discussions, twenty-seven UTEP faculty were identified as active in the areas cited blow. They represent many disciplines, including engineering (civil, electrical, and mechanical), communications, computer science, biology, chemistry, geology, physics, economics, health sciences, political science, environmental law, and business. The following sections will detail work in which border studies can be a part of traditional areas.

In curricular revision, the ESE Program is moving toward tracks within the program that roughly align with the areas to be presented. Each student will be advised and develop a specific curriculum based on his or her background and objectives. For this reason, there may be students who do not fit one of the specific tracks noted here. In addition, it is expected that the tracks will change over time to accommodate growth and changes within the field.

Current tracks either already created or anticipated include the following: energy science and engineering, air science and engineering, environmental change and observation, environmental policy and economics, and water and desalination. There are also several important topics that cut across all these areas, including health, computational techniques and modeling, and sociological and cultural aspects of border populations.

The Movement of Air Pollutants across Borders

National borders cannot contain or constrain the atmosphere on any scale, from local to planetary. On the global scale, atmospheric emissions from the rapidly industrializing nations of Asia create a brown pall over and are changing the climate of the entire region. Asian dust, sometimes polluted with industrial emissions, is a major source of fine aerosol in western North America and may (perhaps only a matter of time) cause U.S. Clean Air Act exceedances on the Pacific Coast from solely Asian sources. Meanwhile, the eastern North American sulfate haze can impact Europe, and African dust builds up soils and asthma caseloads in the Americas. Pollutants from Asia and South America respectively are deposited on Arctic and Antarctic ice caps, potentially changing their rate of melting and speeding up the effects of climate change.

On a much smaller scale, as metropolitan areas develop along borders to take advantage of the economic opportunities that frontiers provide, air contaminants move freely across national boundaries at the whim of the wind and topography, disregarding any security measures to maintain those boundaries. On the US- Mexico border in the Paso del Norte region, industrial emissions and fugitive dust from both nations impact the environmental health of residents of the other, although prevailing winds and disparities in environmental standards and enforcement dictate a greater impact on the US side from Mexican emissions. Similar situations are seen in many other metropolitan areas along the US- Mexico border (Ambos Nogales, Calexico- Mexicali, etc.). Dust from Chihuahuan Desert dust storms in the El Paso area can even be transported across the Canadian border! UTEP faculty members have long been involved in studies of air quality on the border. For example, Civil Engineering faculty members signed an agreement with the Border Environmental Cooperation Commission (BECC) to study air pollution resulting from vehicles queuing at border crossing locations.

The movement of air contaminants across borders has implications for international and homeland security as well. CBRNE (chemical, biological, radioactive, nuclear, or explosive) agents may be deliberately or accidentally released by anthropogenic action in one political entity and move across borders into other nations. This scenario must be considered in military and security planning. UTEP's location, resources, and multinational connections have placed it in an ideal location, geographically and resource-wise, to be a nexus of cross-border air transport research. As indicated above, faculty in departments across several many colleges have been collaborating with each other on issues of local and regional transport of air pollutants. For example, UTEP faculty work with colleagues at *El Colegio de Frontera Norte* and the *Universidad Autonoma de Ciudad Juarez* in our neighbor city across the river, as well as with a number of other Mexican universities from Chihuahua City to Mexico City, our Canadian colleagues, and experts in other nations investigating this common problem . to develop a better understanding of movement across borders and necessary and effective control measures. In addition, they could work to better understand the signature (and hence source) of various aerosols.

Border Policy and Economic Development

UTEP has numerous faculty members who are involved in this area, including those connected to its well-recognized Institute for Policy and Economic Development (IPED). In the past, IPED researchers have addressed water issues and resource depletion in border areas and have expressed a great interest in border environmental issues and in working with STEM students to understand the policy and legal implications of such issues. For example, IPED researchers are looking at legal reform in Mexico and what such reform means to the border. ESE students can benefit from learning about the role of scientists in the evidentiary settings of a new court system. IPED and the University College also have expertise in comparative public policy and administration as well as in economic impact modeling focusing on the border region.

IPED also offers a 15-hour graduate certificate program in Intelligence and National Security that may appeal to some ESE Ph.D. students who wish to examine the nexus of border security and the environment. Fences alone are a prime example of ecological damage in arid regions, and sensors and other monitors have great impacts on wildlife and flora in northern border domains. The militarization of the border in many areas of the world also creates considerable environmental harm.

Finally, IPED has extensive ties to international partners with expertise in dealing with border issues, including:

Yarmouk University and the Tafila Technical University, both in Jordan, are engaged in studies of water issues in the Middle East. Through these partnerships UTEP has enrolled for Ph.D. students from Jordan, including one in the ESE program.

The Universidad de Brasilia has a unit like IPED and does extensive work on the northern border of Brazil. IPED is also establishing a exchange programs with UnDB and the Pontifical Catholic University in Rio de Janeiro.

Through IPED, UTEP has signed an MOU with the International University for European Studies, a European consortium. IPED is also proposing an expanded exchange program with the Institute for International Sociological Studies (ISIG) at the Universite d'Trieste that will involve the creation of a new journal on Border Issues.

Social Vulnerability and Environmental Hazard Risk Assessment across Borders

Losses due to environmental hazards have escalated in recent decades leading to a reorientation of emergency managers away from a focus on immediate post-disaster response toward loss reduction through mitigation, preparedness, and long-term recovery [4],[5]. Effective mitigation requires spatial assessment of risk, involving identification of the hazards likely to affect a given place and the vulnerability of the people likely to be affected and the development of risk reduction measures that are effective across a multitude of hazard types. Spatial approaches for the assessment of vulnerability to environmental hazards have been developed and applied to local contexts at sub-national scales. However, fine-scale spatial assessment models are lacking in settings where hazard events have the potential to generate cross-border impacts [2]. Governance varies between countries sharing borders; however, border regions share critical commonalities, including air and water resources. Students conducting research in this area can fill an important gap in knowledge by developing risk assessment models and applications for cross-border contexts based on multi-sited work.

An operational definition of the term *risk* (R) is necessary for any risk assessment. In the geographical literature on environmental hazards, risk has been defined as the combination of people's varying exposure to a biophysical *hazard* (H) and their differential social *vulnerability* (V), i.e., their capacity to prepare for, respond to, and recover from a hazard event [5]. The relationships between these three terms may be represented in the form of the "pseudo-equation": $R = H * V$ [5]. A critical point is that even a high magnitude hazard event poses no risk when it occurs in the absence of a vulnerable population. Conversely, a vulnerable population – such as one that lacks access to protective resources – experiences no risk if there is not a probability of a hazard event occurring in their presence. Based on this definition, risk can only be assessed by considering the intersection of biophysical and social dimensions of risk in particular places [1],[3],[5].

A basic methodological challenge for cross-national risk assessment is that many datasets have spatial coverage that stops at international boundaries. In such contexts, developing and disseminating knowledge of societal risks to environmental hazards requires integrating datasets from multiple countries. While access to secondary data usable for cross-national risk assessment is challenging, UTEP faculty in sociology have experience in this research area, having collaborated with international partners on several risk analysis projects. The specific methods utilized in this research area are diverse, ranging from GIS techniques for the spatial characterization of environmental hazards and social vulnerability; data transformation for comparability across scales and borders; spatial econometric modeling; and interviews and focus groups with emergency managers, policy makers, and at-risk residents. In sum, this area will allow students to integrate advanced biophysical metrics (e.g., air pollution models) with sociodemographics in the assessment of key dimensions of risk to environmental hazards, which will contribute to a basic understanding of human-environment relations while informing policy and management efforts for risk reduction in border regions.

In terms of *intellectual merit*, contributions to vulnerability science will be made through the development of cross-border models for spatial assessment of environmental hazards that integrate social and biophysical components of risk. In terms of *practical merit*, the dissemination of knowledge of environmental risks to the wider community will contribute to the development of policies that will reduce risks to environmental hazards in border regions.

Water and Energy Solutions

Water is a concern at many borders, especially in arid regions. The Center for Environmental Research and Management (CERM) has had a long relationship with Friends of the Earth Middle East (Israel, Jordan, and Palestine) and other Middle East entities and has conducted contract work in the region through the US State Department. UTEP has also initiated the

Center for Inland Desalination Systems (CIDS) with significant funding from the Governor's Emerging Technology Fund and the UT System. CIDS is designed to take advantage of the El Paso Water Utilities desalination plant, the largest in the US and the largest inland desalination plant in the world. Desalination offers a possible solution in arid regions, but there remains the question of the high level of energy use by these plants. In fact, it is possible that generating power to run the facilities could use significant water elsewhere (for cooling, for example). Therefore, the energy group at UTEP is prepared to study energy sources and uses in these plants to enable a thorough review prior to implementation as part of a border water solution. Interestingly, while not actually a border issue, CIDS is working on establishment of desalination in Libya.
Movement of water through aquifers that underlie borders, as well as potential contamination of those aquifers, is critical to border environmental management. UTEP's experience regionally has positioned it with several faculty members who have studied both subsurface movement and surface-subsurface water interactions.

Borderlands Systems Ecology and Information Management

UTEP has a well-established and successful Systems Ecology Laboratory (SEL). (www.sel.utep.edu). SEL leads or is engaged in a range of mostly NSF-funded research, engineering and education activities. Specifically, these focus on:

Understanding environmental change and plant and ecosystem structure and function in extreme environments, namely the Arctic and the Chihuahuan Desert.

Developing novel technologies, cyberinfrastructure, and local to international collaborations that improve capacities for monitoring, assessing and predicting future states of environmental change.

Creating educational and life changing opportunities for the next generation of environmental scientist, especially students from underrepresented groups.

SEL's research, education and training activities span the Arctic and Antarctic, the US-Mexico Chihuahuan Desert border and local to international collaboratories and include active collaborations with colleagues spanning multiple colleges, programs and departments at UTEP. Research foci outlined below represent research activities for ESE students who will be mentored in SEL at UTEP.

The ecology of disease ~ For many of the worlds' borders, social, economic and other disparities contribute to disparities in disease occurrence, and human health and well being. Many of these impact both countries and can be managed more effectively through improved environmental management practices, which can be identified through studies focusing on the ecology of disease. ***The ecology of introduced species*** ~ Differences in environmental management, conflict in environmental management strategies, and increased connectivity in borderland regions can result in the increased rate of transfer and establishment of introduced species. In some cases, this can lead to environmental degradation, security concerns, social justice issues, and health issues (e.g. pollen induced asthma), stressing the need for improved introduced species research, policy, and management solutions. ***Restoration ecology***~ Restoration of ecosystems such as wetlands not only provide improved ecosystem goods and services (e.g. reduced erosion, increased prevalence of pollinators of crops, removal of industrial waste and effluent), but also provide important power-neutral international foci for social, environmental and geopolitical communication, exchange of good will, and a highly visible and measurable indicator of success and hope. ***The ecology of introduced species*** ~ Differences in environmental management, conflict in environmental management strategies, and increased connectivity in borderland regions can result in the increased rate of transfer and establishment of introduced species. In some cases, this can lead to environmental degradation, security concerns, social justice issues, and health issues (e.g. pollen induced asthma), stressing the need for improved introduced species research, policy, and management solutions. ***Restoration ecology***~ Restoration of ecosystems such as wetlands not only provide improved ecosystem goods and services (e.g. reduced erosion, increased prevalence of pollinators of crops, removal of industrial waste and effluent), but also provide important power-neutral international foci for social, environmental and geopolitical communication, exchange of good will, and a highly visible and measurable indicator of success and hope. Rem***ote sensing and environmental monitoring in borderlands*** ~ Successful environmental assessment and management require a fundamental underpinning of knowledge that has been built from empirical analysis of data. Comparable environmental data collection methodologies are commonly lacking across international borders. Remote sensing technologies from satellites, unmanned aerial and ground vehicles and static sensor networks have the capacity to provide scalable and integrative solutions for improving data acquisition in such settings. Mechanistic understanding of changes in land cover, biodiversity, air and water quality can be quantified using such datasets, improving the basis for enhanced communication and environmental problem solving across international borders. ***Cyberinfrastructure for Borderland Environmental Science and Management*** ~ Free access to data, information and knowledge across international borders builds capacities for informed and transparent decision making and empowers people from different countries, multiple disciplines and social groups. Web based mapping applications and information systems in combination with other cyberinfrastructure empower society, decision makers and other entities by providing access to data and information that

span borderlands, disciplines, management units just to name a few. This is especially the case if these systems are built on well-developed ontologies and work flows with provenance.

PARTNERSHIPS AND COLLABORATIONS

This program is intended to prepare graduates to work with policy makers to base border environmental policies on sound science and engineering principles and research. This will be accomplished through a combination of sound research and integrative coursework. For example, in the policy courses, linkages will be made to other border institutions. Students will be able to communicate with counterparts on other borders to calibrate their thinking and approaches, enabling a true comparison of the effectiveness of policies in different border situations. Linkages will be sought where students at two universities can develop projects within the jurisdiction of the sister institution. For example, students in an institution with a focus on the Israel-Jordan border could conduct a study relevant to the US-Mexico border, while UTEP students study the same policies, approaches, etc on the Israel-Jordan border. Class members will serve as resources for their counterparts at the other institution, critiquing each other's findings. Use of Web 2.0 tools, such as wikis, will be employed to foster continuing dialogue.

There will be a two-way exchange between UTEP and other border institutions. On the one hand, UTEP students and faculty members will spend time on the border in other settings, working in concert with local institutions, NGO's, and appropriate governmental agencies. The program will also attempt to enhance the educational experience by bringing both students and leaders from other sites, wither physically or through distance means.. Students will be recruited to come in cohorts to UTEP not only to pursue studies relevant to their border situation but, by integration with UTEP students, to enrich experiences of both sets of students. In addition, funding is being sought to create Scholars-in-Residence who will spend time at UTEP teaching classes and directing research on border environmental issues.

Linkages will be made to any existing programs that can enhance the ESE student experience. For example, UTEP's Master's degree in Communication has been extended through a partnership with RARE Conservation. Through the partnership conservation practitioners who are in the process of learning how to create, implement, and evaluate communication campaigns to address environmental concerns can take identical courses at four sites (in Indonesia, China, Mexico, and the US).

As this initiative evolves, we hope to garner increased collaborators and partners around the globe. We further hope to assess the benefits to students in the program as well as for hose in border regions.

REFERENCES

[1] Burton, I., Kates, R., & White, G. (1993). *The environment as hazard, 2nd edition*. Guilford Press: New York.

[2] Collins, T., Grineski, SE., & Romo, L. (2009). "Vulnerability to environmental hazards in the Ciudad Juárez (Mexico)-El Paso (USA) metropolis: A model for spatial risk assessment in transnational context". *Applied Geography*. DOI: 10.1016/j.apgeog.2008.10.005

[3] Cutter, S. (1996). "Vulnerability to environmental hazards", *Progress in Human Geography*, *20*(4), 529-539.

[4] Cutter, S., Mitchell, J., Scott, M. (2000). "Revealing the vulnerability of people and places: A case study of Georgetown County, South Carolina", *Annals of the Association of American Geographers*, *90*(4), 713-737.

[5] Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2004). *At risk: Natural hazards, people's vulnerability and disasters, 2nd edition*. Routledge: London.

[6] White, G., Kates, R., & Burton, I. (2001). "Knowing better and losing even more: The use of knowledge in hazard management", *Environmental Hazards*, *3*(3-4), 81-92.