CENTERS OF EXCELLENCE
IN AGRICULTURE, ENERGY AND WATER IN PAKISTAN:
A FEASIBILITY ASSESSMENT

FINAL REPORT

December 2011

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We regret any errors or inadvertent omissions, which are the sole responsibility of the Aguirre Division of JBS International, Inc. and its team.

Malcolm Odell
Washington, DC
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ACRONYMS

ABET	Accreditation Board for Engineering and Technology
ACI	American Concrete Institute
ADB	Asian Development Bank
AEDB	Alternative Energy Development Board
AEW	Agriculture, Energy and Water
AIT	Asian Institute of Technology
ASC	Area Study Center
AVRDC	The World Vegetable Center
BA	Bachelor of Arts
B.E	Bachelors in Engineering
BGS	British Geological Society
BOG	Board of Governors
BOO	Build, Own and Operate
BRSP	Baluchistan Rural Support Program
Bt	Bacillus thuringiensis
CABB	Center of Agricultural Biochemistry and Biotechnology
CASR	Center of Advanced Study and Research
CDC	Career Development Centre
CE	Civil Engineering
CEEC	Continuing Engineering Education Centre
CES	Center for Energy Systems
CEWRE	Center Of Excellence in Water Resources Engineering
CHE	Council of Higher Education
CIA	Central Intelligence Agency
CIIFAD	Cornell International Institute for Food, Agriculture and Development
CIMMYT	Center for Integrated Mountain Development, International Maize and Wheat Improvement Center
CM	Cubic Meter
CNG	Compressed Natural Gas
CNMR	Center for Nuclear Medicine and Research
COE	Center Of Excellence
COMSATS	COMSATS Institute of Information Technology
COTR	Contract Officer's Technical Representative
CRL	Centralized Research Laboratory
CRSP	Collaborative Research Program
CSF	Competitiveness Support Fund
CSM	Colorado School of Mines
CSU	Colorado State University
DAI	Degree Awarding Institution
DEC	Development Experience Clearinghouse
DFID	Department for International Development (UK)
DSO	Dam Safety Organization
DVM	Doctor of Veterinary Medicine
Ed.D.	Doctor of Education
EPC	Engineering, Procurement and Construction

EPP	Energy Policy Project
ERRA	Earthquake Reconstruction and Rehabilitation Authority
FAO	Food and Agricultural Organization
FAS	Foreign Agricultural Service
FATA	Federally Administered Tribal Areas
FODP	Friends of Democratic Pakistan
FSc	Faculty of Science
FWO	Frontier Works Organization
GAT	Graduate Admissions Test
GCISC	Global Change Impact Studies Center
GDP	Gross Domestic Product
GEF	Global Environmental Fund
GEM	Global Evaluation and Monitoring
GENCO	Generation Companies
GIS	Geographic Information System
GIZ	German Society for International Cooperation
GM	Genetically Modified
GoP	Government of Pakistan
GPS	Geographic Positioning System
GRE	Graduate Record Exam
HEC	Higher Education Commission
HED	Higher Education for Development
HEI	Higher Education Institution
HVAC	Heating, ventilation and air conditioning
IAWIND	Iowa Alliance for Wind Innovation and Novel Development
IBA	Institute of Business Administration
IBPKP	Indus Basin Program Knowledge Platform
ICA	International Cooperation Administration
ICBA	International Center for Biosaline Agriculture
ICIMOD	International Centre for Integrated Mountain Development
IEEM	Institute of Environmental Engineering and Management
IER	Institute of Education and Research
IFI	International financial institution
IRBM	Integrated River Basin Management
IP	Intellectual property
IPD	Irrigation and Power Department
IPM	Integrated Pest Management
IPP	Independent power producers
IRRI	International Rice Research Institute
IRSA	Indus River System Authorities
ISI	Institute of Scientific Information
ISO	International Organization for Standardization
IT	Information Technology
ITC	Information Technology Centre
IU	Indiana University
IUCN	International Union for Conservation of Nature

IWASRI	International Water Logging and Salinity Research Institute
IWMI	International Water Management Institute
IWMA	International Water Management Association
IWREM	Institute of Water Resources Engineering and Management
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
JPMC	Jinnah Postgraduate Medical Center
KIU	Karakoram International University
KPK	Khyber Pakhtunkhwa, formerly Northwest Frontier Province
kW	Kilowatt
LEAD	Leadership for Environment and Development
LOI	Letters of Interest
LUMS	Lahore University of Management Sciences
MA	Masters of Arts
MAF	Million Acre Feet
MBA	Masters of Business Administration
MD	Medical Doctor
M.E	Masters in Engineering
M.Ed.	Masters of Education
MENA	Middle East and North Africa
MIT	Massachusetts Institute of Technology
MOU	Memorandum of Understanding
MRL	Material Research Lab
MSc	Master of Science
MTDF	Medium Term Development Framework
MUET	Mehran University of Engineering and Technology
MUISTD	Mehran University Institute of Science Technology And Development
MW	Megawatt
NAEAC	National Agricultural Education Accreditation Council
NBS	NUST Business School
NCATE	National Council for Accreditation of Teacher Education
NCEG	National Center of Excellence in Geology
NCEPC	National Center of Excellence in Physical Chemistry
NIUIP	National Institute of Urban Infrastructure Planning
NDP	National Drainage Program
NED	NED University of Engineering and Technology
NEPRA	National Electric Power Regulatory Authority
NESPAK	National Engineering Services of Pakistan
NfP	Not-for-profit
NGO	Non-Governmental Organization
NTC	National Telecommunication Corporation
NTDC	National Transmission and Despatch Company
NUST	National University of Sciences and Technology
NWFP	North-West Frontier Province
NYT	New York Times
O&M	Operation and Maintenance

OGRA	Oil and Gas Regulatory Authority
ORIC	Office of Research, Innovation and Commercialization
OSU	Oregon State University
PAEC	Pakistan Atomic Energy Commission
PARC	Pakistan National Research Council
PAS	Pakistanis at Stanford
PCEPT	Professional Competency Enhancement Program for Teachers
PCRET	Pakistan Council for Renewable Energy Technologies
PCRWR	Pakistan Council for Research in Water Resources
PEC	Pakistan Engineering Council
PESCO	Peshawar Electric Supply Company
PFI	Pakistan Forestry Institute
Ph.D	Doctor of Philosophy
PHEA	Pakistan Higher Education Assessment
PHEC	Pakistan Higher Education Commission
PIEAS	Pakistan Institute of Engineering and Applied Sciences
PJAAEVS	Pakistan Journal of Agriculture, Agricultural Engineering, and Veterinary Sciences
PJAS	Pakistan Journal of Agricultural Sciences
PKRs	Pakistani Rupees
PL	Public Law
PMD	Pakistan Meteorological Department
PNEC	Pakistan Navy Engineering College
PNRL	Pharmaceutical and Neutraceutical Research Lab
PSC	Pakistan Study Center
PSF	Pakistan Science Foundation
PSO	Pakistan State Oil
PV	Photovoltaic
PVJ	Pakistan Veterinary Journal
PVMC	Pakistan Veterinary Medical Council
QAU	Quaid-I-Azam University
QEC	Quality Enhancement Cells
QMS	Quality Management System
QUEST	Quaid-e-Awam University of Engineering, Science & Technology Nawabshah
R&D	Research and Development
RA	Research Associate
RAF	Royal Air Force
RDF	Rural Development Foundation
RS	Remote Sensing
SaciWATERs	South Asia Consortium for Interdisciplinary Water Resources Studies
SAFWCO	Sindh Agricultural and Forestry Workers Coordinating Organization
SAU	Sindh Agriculture University
SBKWU	Sardar Bahadur Khan Women's University
SCEE	School of Civil and Environmental Engineering
SDPI	Sustainable Development Policy Institute
SEECS	NUST School of Electrical Engineering and Computer Science

SFG	Strategic Foresight Group
SGH	Salivary gland homogenates
SHYDO	Small Hydel Development Organization
SIDA	Sindh Irrigation and Drainage Authority
SNGPL	Sui Northern Gas Pipelines Limited
SOAR	Strengths, Opportunities, Aspirations and Results
SOP	Standard operating procedure
SOW	Scope of Work
SPDC	Seed Production and Development Center
SRSP	Sarhad Rural Support Programme
SZIC	Sheikh Zayed Islamic Center
TAMU	Texas Agricultural and Mechanical University
TIPAN	Transformation and Integration of the Provincial Agricultural Network
TISS	Tata Institute of Social Sciences
TNAU	Tamil Nadu Agricultural University
TO	Task Order
TRB	Transportation Research Board
TVA	Tennessee Valley Authority
UAF	University of Agriculture, Faisalabad
UC	University of California
UCLA	University of California – Los Angeles
UET	University of Engineering and Technology
UK	United Kingdom
UMich	University of Michigan
UNC	University of North Carolina
URI	University of Rhode Island
USCID	U.S. Committee for Irrigation and Drainage Professionals
UNDP	United Nations Development Program
UNESCO-IHE	United Nations Educational, Scientific and Cultural Organization- Institute of Water Education
UNEP	United Nations Environment Program
UNICEF	United Nations Children's Fund
UNLSP	United States National Science Linkage Program
UNLV	University of Nevada at Las Vegas
UPesh	University of Peshawar
US	United States
USACE	United State Corps of Engineers
USAID	United States Agency for International Development
USBR	United States Bureau of Reclamation
USC	University of South Carolina
USD	Unites States Dollars
USDA	United States Department of Agriculture
USEFP	United States Educational Foundation in Pakistan
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USTDA	U.S. Trade & Development Agency

USU	Utah State University
WAPDA	Water And Power Development Authority
WASID	Water And Soils Investigations Division
WB	World Bank
WSU	Washington State University
WWF	World Wildlife Fund

Map of Pakistan

EXECUTIVE SUMMARY

Background

The purpose of this assessment is to provide the United States Agency for International Development (USAID) with information to serve as the basis for collaboration with the Higher Education Commission (HEC) of Pakistan. This collaboration will work to increase institutional capacity of selected Pakistani universities in certain geographic and sector areas through the development and support of Centers of Excellence (COE). The three COE sector areas are: Agriculture, Energy, and Water. The JBS Team (hereafter 'the Team'), consisting of four U.S. and five Pakistani experts, visited seven universities in three provinces, Sindh, Punjab, and Khyber Pakhtunkhwa, as well as in Islamabad, which have recognized expertise in provision of higher education in the areas of agriculture, energy, and water. Pakistan has 19 public and eight private engineering, science and technology universities and Degree Awarding Institutions (DAI) as well as five agriculture universities and one university in animal and veterinary sciences. These institutions have experienced substantial growth and improvement during the past decade. Due to focused resources and attention on the engineering and scientific disciplines from the HEC since 2002, the number of doctoral dissertations in these fields has increased almost ten times. Agricultural sciences have received significant investment and witnessed a revival of research. Two of the Engineering universities, National University of Sciences and Technology (NUST) and University of Engineering and Technology (UET), Lahore are among the top 500 universities of the world, and two universities, NUST and Mehran University of Engineering and Technology (MUET), are certified by the International Organization for Standardization (ISO).[1]

Despite extensive support from USAID and the gains achieved since 2002, higher education enrollment rates today remain extremely low, even when compared with other developing countries in the region. Less than 5 percent of the 17 to 23 age group are enrolled in any form of higher education as compared to Nepal (5.1%) and India (approximately 10%).[2] An increased ability to address natural resource management needs and to meet citizens' increasing requirements in agriculture, energy, and water would constitute a materially positive response to the development needs of Pakistan.

Mission of Centers of Excellence

Drawing on the Team's Scope of Work and guidance from HEC and USAID, the Team undertook this feasibility assessment to examine the higher education sector from the perspective that proposed Centers of Excellence should address the following issues:

- Promote innovation and public-private synergies leading to 'transformative growth' in the agriculture, energy, and water sectors over the next 10 to 30 years;
- Create related educational networks through the higher education sector for Pakistan's advancement and well-being;
- Foster institutional capacity development with identified roles for involvement of the U.S. higher education sector;
- Build bridges among academia, industry and government to take advantage of top-quality higher education;
- Produce cutting-edge research and engage in entrepreneurship activities;
- Provide guidance in policy formulation to the Government of Pakistan; and

[1] The International Organization for Standardization (ISO) is an international standard-setting body composed of representatives from various national standards organizations. The organization promulgates worldwide proprietary, industrial and commercial standards.
[2] World Bank. (2011). *Project appraisal document on a proposed credit in the amount of SDR 192.2 million to the Islamic Republic of Pakistan for a tertiary education support project.*.

- Attract the highest quality students and faculty.

Methodology

This feasibility assessment for Centers of Excellence examines the identified institutions based on the five criteria included in the definition of a COE highlighted by USAID.[3] These criteria were developed into six components that guided the Team during the investigation. They included: 1) quality of education, 2) research, 3) infrastructure and technology, 4) university partnerships, 5) institutional organization and administration, and 6) student profiles.

The selected universities encompassed the following:

Agriculture: University of Agriculture (UAF), Faisalabad, and Sindh Agriculture University (SAU), Tando Jam;

Energy: University of Engineering and Technology, Peshawar, the National University of Sciences and Technology, Islamabad; and

Water: Mehran University of Engineering and Technology, Jamshoro, and the Centre of Excellence in Geology, University of Peshawar (UPesh), and the additional institution, the Centre of Excellence in Water Resources Engineering (CEWRE) at the University of Engineering & Technology (UET), Lahore.

The assessment, undertaken in Pakistan from November 10 to December 8, 2011, consisted primarily of qualitative data collection, supplemented by the collection of programmatic information in-country from each of the seven universities. A wide variety of stakeholders who are both participants and end-users or potential end-users of higher education services were interviewed to ensure that a diversity of perspectives was taken into consideration.

As a final analysis procedure, the team conducted Stakeholder Matrix and Strengths, Opportunities, Aspirations, and Results (SOAR) analyses by sector, and reviewed university capacities through a unique scoring matrix. SOAR, a strength-based approach, was used in questionnaires, interviews with stakeholders, and team discussions to identify and tap into each institution's existing strengths and assets and to guide stakeholders to envision potential opportunities for achieving future measureable results and impacts.

Constraints of the Study

The Team was able to complete these capacity assessments in spite of several constraints. Security issues and 30-day visa limitations in Pakistan played a major role in restricting the technical teams' time and travel around the country to the selected universities. While the teams were able to spend over two weeks in the field, visiting each of the universities for between two and four days with security protection, such escorted travel, by necessity, required intense planning and coordination, eliminating spontaneity in meetings and in speaking with relevant stakeholders, and shortening the actual observation and interaction time at each site. Contact with individuals in communities, including

[3] Centers of Excellence, as defined by USAID for the purpose of this assessment, commonly have access, quality, and relevance components that qualify them as providers of a first-rate higher education (such as cutting-edge curricula, production of competitive advanced academic degrees, world class faculty, top level students, visionary leadership, latest technology, etc.). At the same time, possession of similar high-quality components should neither be the sole criteria for ranking a Center of Excellence nor should mask an individual institution's ability to offer singular good quality education opportunities that specifically address country needs. This issue is particularly relevant in light of the request in the RFP to explore the possibility of Pakistan Centers of Excellence becoming U.S. accredited institutions. In striving for improved education provision against an international scale of excellence, the universities selected for this assessment should endeavor to become a top-quality institution, i.e., a center of excellence, while at the same time, ensuring that they continue to focus on the unique needs in Pakistan.

students, community leaders, parents, and farmers, was severely limited, which is reflected in the lack of information from such groups in the data. In addition, in spite of the COE initiative being a high USAID priority, the timing for the assessment needed to be pushed back multiple times, causing the assessment schedule to undergo many changes, including interruptions from national holidays. Delays necessitated changes in the consultant team roster. In addition, while the assessment team and the reason for the assessment were generally very well-received by the Pakistanis involved, current political issues between the United States and Pakistan may have influenced the opinions shared through interviews.

Cross Sector Findings

Quality, Governance, Gender, and the Private Sector

Reviewing the status of higher education in terms of governance and equity, the Team identified a number of strengths of the higher education system, including the enthusiastic interest of universities in becoming a COE with USAID support. Those interviewed placed a high value on American education, including its system, institutions and pedagogy. There was broad appreciation as well of the expansion in access to higher education over the last eight years under the leadership of the HEC, an expansion that included heavy investment in engineering, agriculture, and education and information technology. The universities studied clearly demonstrated enhanced capacity to use new inputs in terms of both human and technical resources and a commitment to quality education through ISO certification, and accreditation and self-assessment using an established system of Quality Enhancement Cells (QEC) supported by HEC. The Team also noted an increasing number of women students and faculty, although both numbers and proportions are still low in Engineering and Agriculture. Within this context of growth to address development, higher education will need to serve as the home base for a series of Policy Think Tanks with strong social science components that promote high-level strategic dialogue on higher education policy and support gender equity, quality, transparency and accountability within the Agriculture, Energy, and Water sectors.

The governance structure for the COEs will be the most critical issue contributing to the success of the initiative. Thus, at the outset of this COE initiative, the Team recommends that HEC perform a vital coordinating function to seek the most viable institutional framework and governance model for the long-term sustainability of the COEs. The HEC must facilitate this stakeholders' dialogue with prominent participation of a wide variety of stakeholders at the outset to determine the most viable, practical, and sustainable approach for the COE initiative at the national and university level.[4]

COE Directors will need significant private sector experience to leverage initial USAID funding to attract resources from the private sector within the first three years. Consensus will be needed around a practical, streamlined governance model that minimizes bureaucratic constraints, assures financial and academic autonomy, provides for transparency and accountability, and attracts and retains the highest quality students and faculty among talented young men and women. For input to this consensus-oriented dialogue, the Team recommends that at least one-third of all Boards of Governors, Committees, faculty and students be women and that new COEs move actively toward achieving 50 percent female enrollments as a key component of their long-range strategic planning.

Agriculture: Calling for a Paradigm Shift Linking Energy and Water

Despite impressive achievements and academic progress among agriculture universities, the need is there for a true paradigm shift in agriculture education and research that focuses directly on the needs of small and medium farmers, including pursuit of innovation in credit/market linkages, intermediate and

[4] The governance dialogue may want to include consideration of a name for COEs that does not carry the history of existing COEs in Pakistan; among the names suggested by the Team is *"Center for Advanced Study and Research"* (CASR).

appropriate technology, sustainable farming systems, and value-added interventions that link fully with water and energy concerns. Further attention must also be given to adaptive research related to existing farming systems, including development of mangroves, *Jatropha,* and other agroforestry and forestry systems that are well-adapted for Pakistan's vast high salinity areas. UAF and SAU are keen to develop new and expand existing partnerships with leading U.S. universities, to secure long-term research funding from the Punjab and Sindh Governments, and to assist the COE to develop productive linkages with institutions in other countries across the Indus Valley region and around the world that have similar interests and mandates.

Energy: Policy over Technology

Crucial findings in this sector are that issues around energy are much less technical than policy- and management-related. Specifically, energy policy is not being addressed in Pakistani universities where crucial social sciences are largely absent or neglected. Major disconnects exist between universities and the energy industry and between universities and communities. Thus an Energy COE must serve the nation as an Energy Policy Think Tank with strong connections to industry and U.S. universities and organizations in energy research and policy, especially in the areas of power sector governance, mini-hydel, bioenergy, solar, wind, energy efficiency, and fossil fuel plant performance. The sector should also have linkages with the Agriculture COE in the area of biofuels, in particular *Jatropha* cultivation and biodiesel production.

Water: An Emerging Crisis

The Water Team's most important finding is that a water crisis is at hand in Pakistan, with the population growing exponentially while available water per capita is dropping dramatically. Clearly, as with Agriculture and Energy, policy issues frequently trump technological constraints, evident in both the floods and droughts of recent years. Old but ingenious irrigation systems have shown remarkable resilience, but have been overwhelmed by larger issues of water management that are due as much from man-made as from natural disasters. Key recommendations for COE priorities point to a focus on the following:

- *Addressing Policy Constraints* to avert an emerging water/population crisis;
- *Practical* education and training in water resources;
- *Research relevant* to country needs;
- *Effective* outreach to promote dissemination of knowledge and results of research;
- *Links* to U.S. water-resources universities;
- *Forums* to promote cooperation for regional and transnational management of water, energy, and agricultural resources.

Private Sector: Engine for Growth and Innovation

The private sector, hitherto largely ignored by the world of higher education, is Pakistan's engine for both growth and innovation. Enhanced, vital partnerships with industry will be critical to the success of each of the COEs. Important gaps to be filled include recognition that faculty strengths are often theoretical rather than practical and need-oriented**.** Curricula, training, and research are not yet oriented towards the needs of farming communities, value chains and industry, or the major socioeconomic and environmental issues facing the country. More ground-truthing and rapid technological updating are needed, together with support for entrepreneurship and the creation of more incubators to bring the private sector into universities.

Findings and Conclusions

Overall, the assessment team found that a set of carefully focused and limited interventions aimed at selected institutions of higher education and involving relevant stakeholders can have a very significant impact, not only on higher education, but also more broadly across Pakistan's social, legal, economic and political spectrum. The institutions reviewed in this assessment can benefit greatly from pairing with U.S. universities to improve management systems, curricular relevance, instructional methodology, outreach and partnering with stakeholders, and the upgrading of faculty capacity in both technical fields and the social sciences.

The Team presented several options that USAID could consider as the basis for a Summative Framework for Centers of Excellence:[5] (1) three *stand-alone* COEs, building excellence in Agriculture, Energy and Water; (2) three *sector-specific Core COEs with Affiliates*, building collaboration among COEs and affiliated universities in Pakistan; or (3) a *multi-sectoral COE network* that builds collaboration in the Indus Valley Watershed among COEs, affiliated universities, regional universities, and international organizations. Among these options, the Team recommends that the COE initiative start with Option 2, breaking down silos and building a strong interdisciplinary and interactive network for collaboration among the seven institutions within a 10 to 30-year vision of a region-wide Indus Valley Watershed initiative. The Team's assessment indicates that working toward such a regional framework has the potential to provide direct benefits to Pakistan. Such a long-range vision also can forge linkages among neighboring governments, universities, research institutes and international organizations concerned with broad issues of climate change, and the closely integrated issues of water management, agriculture, and energy across the Indus Basin, which are essential for sustainability.

Recommendations

The Team recommends that three sector-specific COEs with four affiliated universities be the backbone of a broader vision of an Indus Basin Program Knowledge Platform to evolve over the next 10 to 30 years. The outcome of the Team's feasibility assessment is the identification of the following institutions as best positioned to host a Center of Excellence:

- *Agriculture*: University of Agriculture, Faisalabad
- *Energy*: National University of Sciences and Technology, Islamabad
- *Water*: Mehran University of Engineering and Technology, Jamshoro

With a vision that incorporates broad institutional collaboration for sustainable development, the Team strongly recommends support for affiliated COEs in the selected areas to create a COE initiative that brings together important expertise from:

- Sindh Agriculture University, Tando Jam
    - Biosaline agriculture and agroforestry, climate change
- University of Engineering and Technology, Peshawar
    - Energy efficiency, mini-hydel
- University of Peshawar
    - Geology
- Centre of Excellence in Water Resources Engineering, University of Engineering and Technology, Lahore
    - Hydropower

[5] Within Pakistan's legislative and educational environment, a 'Centre of Excellence' program has been in existence since 1974, with mixed outcomes; the Team therefore recommends that this initiative adopt the term "Centre for Research and Advanced Studies" within Pakistan.

To facilitate the institutional and human capacity development needed for all COEs, the Team identified at least 16 U.S. universities ready, willing, and able to join the COE program, including several that already have links and joint programs in Pakistan upon which to build.

Recommended funding should be at the level of a minimum of USD 7 million per COE per year. Higher education and this COE model, in particular, provide an attractive investment opportunity for the U.S. Government that lends itself to accountability, transparency and long-term sustainability through the development of enduring partnerships with U.S. universities. Providing support at the highest level can maximize the development of a strong framework for attracting:

- Complementary funding from other USAID and Embassy programs,
- Matching/supplementary funding from HEC and national and regional governments for further faculty training, research, and infrastructure and facility development, and
- Focused Fulbright funding for Agriculture, Energy, and Water.

The Team further recommends that:

- A major proportion of allocated funding target human resource development as well as outreach to and partnerships with farmers and the private sector.

These investments in creating Centers of Excellence will help to lay a foundation for a network that has the potential to involve regional universities across the Indus watershed, as well as other regional and international institutions such as the World Bank, Asian Development Bank, Global Environmental Facility, International Center for Integrated Mountain Development, International Maize and Wheat Improvement Center (CIMMYT), International Center for Agricultural Research in the Dry Areas, International Food Policy Research Institute, International Water Management Institute and Tata Institute of Social Sciences (Mumbai). Through such linkages and networks the COE initiative has the potential to foster strong relationships that can lead to the generation of long-term sustainable funding from a range of bilateral and multi-lateral donors.

SECTION I. INTRODUCTION

USAID has sought technical assistance to conduct a feasibility assessment of the capacity of selected universities in Pakistan to implement a USAID/Pakistan Centers of Excellence (COE) program. Pakistani universities, the Higher Education Commission (HEC) and USAID will use the results of the assessment to make final decisions in the design and implementation of a three-year project that will enhance the quality of education, research, and industrial-government linkages at the selected universities.

A more innovative and knowledge-driven economy must be reinforced by closer linkages and greater collaboration among research institutes, universities, and industry. The HEC has recognized the need to enhance university-industry-government linkages and has already taken steps to address the issue in the Medium Term Development Framework II (MTDF), involving university-industry technology support programs, career centers, collaborative programs, and research centers in priority areas for the socio-economic development of the country.

USAID will work with the HEC to design and develop Centers of Excellence in three priority areas: (1) Agriculture, (2) Energy, and (3) Water. It is envisioned that the COE's will provide important bridges across the academia-industry and academia-government divides and will deliver courses, conduct research, and perform other services that are valued by industry, the private sector, and government. When operational, it is expected that the COE's will be innovative and provide cutting-edge research, enhanced teaching and learning, entrepreneurship activities, and strengthened policy formulation for the Government of Pakistan. The JBS consulting team (hereafter 'the Team') investigated the following universities as potential Centers of Excellence:

Agriculture

- University of Agriculture (UAF), Faisalabad
- Sindh Agriculture University (SAU), Tando Jam

Energy

- University of Engineering and Technology (UET), Peshawar
- National University of Sciences and Technology (NUST), Islamabad

Water

- Mehran University of Engineering and Technology (MUET), Jamshoro
- Faculty of Geology, University of Peshawar (UPesh)

At the request of HEC and USAID, the investigation was broadened to include:

- Center of Excellence in Water Resources Engineering (CEWRE), University of Engineering & Technology (UET), Lahore

The Team included five Pakistani and four American specialists in higher education, agriculture, energy, and water, as well as a specialist to examine the private sector's intersection with higher education. During its one-month assignment, the Team, in the field from November 10 to December 8, 2011, visited the seven universities plus over a dozen public and private sector institutions, industries, and organizations. Team members conducted interviews with more than 200 faculty, staff, students, business leaders, farmers, and other key informants.

Methodology

The determination of a Center of Excellence drew on the COE criteria set forth by USAID and HEC: (1) curriculum, (2) faculty and students, (3) administration, (4) technically-advanced equipment and facilities,

and (5) faculty and student partnerships. These criteria were developed into the following six components that guided the investigation:

1. Quality of education issues
    - Faculty qualifications and preparation
    - Comprehensive and relevant curricula (include leadership, management, entrepreneurial or market awareness training, and research)
    - Programming: academic and activities
2. Research
    - Identification and distribution of research topics
    - Peer review and international publication
    - Dissemination
3. Infrastructure and technology
    - Libraries
    - Technology capacity
    - Facilities
    - Program resources
4. University partnerships
    - University to university
    - Community
    - Business and industry
    - Local and national/provincial government
    - International links to U.S., European, Asian universities and research institutions and multi-lateral institutions
5. Institutional organization and administration
    - Administrative qualifications and preparation
    - Accountability: financial management, transparency, checks and balances
    - Faculty and student recruitment and enrollment
    - Student services
    - Exchanges—with other national and international universities
6. Student profile
    - Access
    - Diversity: including gender considerations
    - Educational backgrounds

The Team investigated and reported on the current status of these components in the technical areas at each of the universities short-listed by USAID and HEC. The gap that exists between the current levels of functioning of each university against internationally recognized university performance benchmarks assisted teams to determine which university is better placed to host a COE. Final selection of possible Centers of Excellence, to be made by USAID and HEC, will be based on the different technical teams' strategic planning assessment using a Stakeholder Matrix, Delphi, and SOAR (Strengths, Opportunities, Aspirations, and Results) analyses to gauge the magnitude of the gap that each university faces to host a Center of Excellence.

The initial step of the assessment consisted of a review of a significant number of documents to provide the context for the current status of higher education in the country. Of particular interest were documents specifically relating to agriculture, energy, and water management and the possible junctions that exist between higher education and these technical areas that would effectively address current issues in these sectors.

The assessment methodology consisted primarily of qualitative data collection, supplemented by collection of programmatic information in-country. A wide variety of stakeholders who are both participants and end-users or potential end-users of higher education services were interviewed to ensure that all perspectives were taken into consideration. Individual assessment teams also made site visits to each of the selected universities (in Islamabad, Peshawar, Lahore, and Karachi/Hyderabad) to gain a perspective of infrastructure and staffing at each institution.

As the basis for analysis, all of the qualitative and quantitative data collected were compiled in a matrix to show the current status of each institute by technical sector. Thereafter, the two experts in each field (agriculture, energy, water, and higher education) systematically compared the data according to the six adapted criteria that define a Center of Excellence. After completing the first level of analysis, the team conducted Stakeholder Matrix, Delphi, and SOAR analyses by sector. SOAR, a strength-based approach, was used in questionnaires, interviews with stakeholders and team discussions to identify and tap into an organization's existing strengths and assets and guide stakeholders to envision potential opportunities for achieving future measureable results and impacts.

Using the current institutional capacity as a basis, the Team identified variables at each institution that offer opportunities for success and would lead to the strongest possibility to host a Center of Excellence. In this scenario, neither institution within a pair or triad was eliminated from the possibility of hosting a Center of Excellence; rather the decision was made that one is stronger than the other(s) at the present time. Using the SOAR knowledge as the basis for decision-making, the assessment team thereafter made recommendations regarding suggested inputs and action plans needed to fill critical gaps, including technology upgrades, a cost analysis, and types of assistance programs that can foster institutional capacity.

Constraints of the Study

Security issues in Pakistan played a major role in restricting the technical teams' travel around the country to the selected universities. While the teams were able to visit each of the universities for two to four days with security protection, such escorted travel, by necessity, required intense planning and coordination, eliminating spontaneity in meeting and speaking with relevant stakeholders, and shortening the actual observation time at each site. Contact with individuals out in communities, including students, community leaders, parents, and farmers, was severely limited; the lack of information from these important stakeholders is reflected in the frequent absence or inadequacy of certain data in this assessment.

The timing for the assessment was continually pushed back and condensed from the five weeks in the field initially planned, to just four weeks. Severely delayed approval caused the assessment schedule to undergo many changes and repeated delays in team mobilization. These delays meant that Team planning and preparation by JBS and Team members, as provided for in the proposal, was not possible; this limited the ability of the Team to conduct anticipated and/or adequate literature reviews or prepare and pretest database and questionnaire formats. These delays also were compounded by the pressures of 30-day visa limitations.

After the initial meeting in Pakistan with USAID and the HEC, the Team brought to USAID's attention a seventh university, the University of Engineering & Technology (UET), Lahore, because of its potential within the water sector. Additional USAID requests, including a revised list of key questions of special interest to the Mission and a request for an Issues Paper and Governance Assessment to review COE

implementation options, necessitated additional site visits, data analysis and reporting by JBS and technical team leaders. These requests were a complicating factor in the compilation and analysis of information collected.

Although the assessment team and the reason for the assessment were generally very well-received by all involved Pakistanis in Islamabad and the field, current political issues between the United States and Pakistan may have had some influence on the information received during interviews.

Structure of the Report

This report exploring the feasibility of Centers of Excellence at various universities is divided into seven sections:

- Section One: Introduction contains a description and methodology of the assessment and outlines the six components of the investigation.
- Section Two: Background contains an overview of Higher Education in Pakistan along with the defined mission of a Center of Excellence that was used as the lens for this investigation.
- Section Three: Sector Profile Summaries provide an overview of the current status of each technical sector.
- Section Four: Institutional Profile Summaries profile each of the selected universities, presenting information on the current status of faculty, student body, research capacity, infrastructure and technology, and current university partnerships.
- Section Five: Findings and Conclusions present the Team's conclusions for selection and development of Centers of Excellence, by technical sector (agriculture, energy, and water). Each sector review identifies current gaps that need to be addressed and makes recommendations for USAID programming that would lead to one university (of the two to three possible choices in each sector) becoming a Center of Excellence. A vision for work in the technical areas that would lead to a 'transformational change' in the country over the next 10 to 30 years (as per USAID request) together with specific technical recommendations to achieve that vision are also presented.
- Section Six: Summative Framework contains the Team's recommended approaches for USAID and HEC consideration, leading to the development of Centers of Excellence in Pakistani universities.
- Section Seven: Recommendations provides a summary statement of the report's major recommendations.

SECTION II. BACKGROUND

This important new Centers of Excellence initiative undertaken by Pakistan's Higher Education Commission and USAID builds on an often forgotten chapter in the history of international collaboration that unfolded over a half-century ago between Pakistan and the United States. It is the most recent chapter in a legacy that has involved over two generations of cooperation, progress, mutual respect and stability, a legacy of shared visions for the advancement of education, science, technology, agriculture and commerce with common human goals and aspirations. The original initiatives involved over 2,000 Pakistani students and colleagues, of whom approximately 200 received graduate training in the U.S. Working with these Pakistani professionals were over one hundred American partners including, professors, administrators, Peace Corps Volunteers, and technicians. Together with counterparts in India, these multinational teams helped create a remarkable 'Green Revolution' that turned South Asia from famine to food surplus. Together they laid the foundations for a national system of higher education in Pakistan that, with Pakistan's own substantial investments in higher education since 2002, now provides the base for a bold new initiative to create a network of Centers of Excellence in Agriculture, Energy, and Water Resources Management.

This feasibility assessment for Centers of Excellence follows on that legacy. Pakistan's need to enter the global economy in a stronger position requires highly trained personnel in a broad range of technical fields, as well as greater linkages among educators, government, and the private sector. Moreover, underpinning Pakistan's development is the critical need to improve basic services and goods to citizens in the form of better food security, enhanced quality and supply of drinking water and basic sanitation, and sustained electrical power.

Mission of Centers of Excellence

Drawing on the Team's Scope of Work and guidance from HEC and USAID, this assessment was guided by the following components that form the foundation of a Centers of Excellence:

- Promotion of innovation and public-private synergies leading to 'transformative growth' in the agriculture, energy, and water sectors over the next 10 to 30 years;
- Creation of related educational networks for Pakistan's advancement and well-being;
- Fostering of institutional capacity with identified roles for involvement of the U.S. higher education sector;
- Building of bridges among academia, industry and government to take advantage of provision of top quality education;
- Production of cutting-edge research, engaging in entrepreneurship activities;
- Provision of guidance in policy formulation to Pakistan Government;
- Attraction of the highest quality students and faculty.

USAID Pakistan requested that a specific roster of technical tasks be addressed during the investigation of the universities. During the Team's initial briefing in Islamabad, USAID requested that the Team focus on the following tasks from that roster:

1. Suggestions for the Centers' operation, expressed as a "summative framework for the establishment of successful Centers of Excellence."
2. Summary of activities by major component, including the specific inputs required to produce the desired outputs and how the outputs contribute to the results.
3. Identification of the factors that facilitate/constrain the effectiveness of such activities and programs.

4. Identification of the sub-disciplines within the agriculture, energy, and water sectors which are most likely to lead to the transformative growth of Pakistan's economy over the next 10 to 30 years.
5. Recommendations regarding the types of assistance programs the Team believes would be most effective in fostering the institutional capacity legacy and how the U.S. higher education sector can assist.
6. Identification of suitable U.S. institutions in the sector with the necessary institutional characteristics for successful collaborative partnership activities with Pakistani Centers of Excellence.

SECTION III. SECTOR PROFILES

Higher Education in Pakistan

Higher education has always been considered of paramount importance for providing leadership in all sectors of a society for social and economic development. Globalization has greatly heightened this reality and has brought higher education to the forefront for developing knowledge-based societies, considered to be the basis of survival in the fast growing competitive world.[6] Today's higher education should provide not only skillful human resource for industry, commerce, and other sectors, but also prepare individuals who have social commitment and responsibility for sustainable development of the society. This human resource must also be moral and humane.[7]

In Pakistan, emphasis on higher education has been fluctuating over the last thirty years. The budget on education has revolved around two percent of the GDP; however, the share of university education has continuously decreased from 18.7 percent in the First Plan period (1955-1960) to four percent in the 9th Plan Period 1998-2003.[8] West Pakistan, now Pakistan, inherited only one university. Other than offering degree programs in various disciplines, this university conducted external examinations for all academic programs from matriculation onwards for the whole country. The second university was chartered in 1951, four years after independence. By 2002, in a period of 55 years, the number of universities and degree-granting institutions had increased to 45 (including 18 in the private sector), providing access to about 2.6 percent of the relevant age group. The percentage of tertiary level students enrolled in the fields of science and technology was 0.1 percent and those in engineering constituted only 0.05 percent.[9] Interestingly enough, the National Education Policy 1998-2010 had targeted an increase of only five universities by 2010. At that time the university education was managed by the University Grants Commission and was funded by the Ministry of Education.

The HEC was established in 2002 through the Ordinance of Higher Education Commission, and higher education was placed directly under the control of the Commission, whose responsibilities included allocation of funds to the public sector institutions and quality control of all educational institutions in the public and private sectors. The mission of the Commission is to facilitate the institutions of higher education to serve as engines of growth for socio-economic development of Pakistan. The challenges before the HEC were identified as those relating to the degree of access, equity, and quality of education imparted, including relevance to the national needs and governance of higher education. From 2002 to 2007, the higher education sector received record funding, with peak funding of Rs.10 billion received in 2007, and witnessed huge expansion. The number of degree-awarding institutions has increased to 135 with 74 in the public sector. The relevant age group participation has increased to approximately 5.1percent.[10]

Along with expansion of access, the HEC has taken several measures to improve the quality of education such as faculty development by awarding scholarships to more than 4,500 faculty members for Ph.D. training abroad and nearly 4,000 scholarships for indigenous Ph.D. studies. More than 1,200 scholarship recipients have returned and are serving in the country; most of them will be in the mainstream of higher education within the next four years. For various reasons, it is anticipated that these individuals will stay in the country. While there will always be some out-migration, no major brain-drain is anticipated. Most public sector universities have appropriate ICT infrastructure, and provide digital access to more than 3,000 journals. Video conferencing facilities at the universities have linked the institutions at home and

[6] World Bank. (2002). *Constructing knowledge societies: New challenges for tertiary education*.
[7] Government of Pakistan. (1998). *National education policy 1998-2010.*
[8] Ibid.
[9] Higher Education Commission. (2003). *Annual report 2002-2003*.
[10] Higher Education Commission. (2009). *Annual report 2009*.

abroad. The quality dimension has been addressed by introduction of a two-tier quality assurance mechanism through establishment of four accreditation councils and coordination of the existing councils, establishment of financial aid development offices initially in eleven institutions for strengthened financial management and generation of funds through private sources, and capacity building of top university management in governance through foreign study tours.

Recently, seven pilot Offices of Research, Innovation and Commercialization (ORIC) have been established. As a result of quality inputs, research publications from public universities have increased at the rate of 25 percent annually. More than 70 local journals have been included in Institute of Scientific Information (ISI) Master List and seven journals are recognized as having an impact factor. Business Incubation Centers at some universities have been established to capitalize on the intellectual property and to promote university-industry linkages.

Challenges in Higher Education

In spite of the unprecedented, multidimensional progress, challenges in the sector remain. The National Education Policy 2009 has targeted an increased enrollment in higher education to10 percent by 2010 and 15 percent by 2020 with targets conditional on the availability of resources.[11] The Policy also plans to identify and strengthen National Centers in areas of economic importance to contribute and compete at the international level. All of these targets are supported with an umbrella plan to allocate seven percent of the GDP for education with a 20 percent share going to higher education. The targets and the plans are still awaiting necessary legislative and funding actions upon which implementation will depend.

HEC has identified other challenges faced by the sector including poor university-industry interaction, poor university-society relationship, low quality of education, low employability of higher education graduates, lack of high quality faculty for research, lack of facilities for continuous faculty and staff development, poor governance of universities, low fund generation by universities and low support of able, but needy students. Added to these is the lack of appropriate teaching-learning strategies and subject compartmentalization leading to the near absence of interdisciplinary study or research. High concentrations of core subjects are negligibly absent in the social sciences and do not represent on-campus best practice models for the society.

Centers of Excellence in Pakistan and the Way Forward

The Center of Excellence concept is well-established in Pakistan and, while different from the COE approach envisioned in this assessment, provides a useful foundation. Pakistan's COEs are independent entities established by the Federal Government under the Center of Excellence Act 1974 (XXIV) as amended in 1976 (Act NO.IX of 1976). These COEs have been established in a particular discipline as assigned by the Federal Government in consultation with the university in which the center is established. The Director of the Center is appointed by the Federal Government. The objectives of the center, among others, are to:

1. Engage in goal oriented high level research, and
2. Promote cooperation in interdisciplinary relationship with other teaching and research establishments.

The concept of the Center does not include establishing relationships with relevant sectors in society such as industry, agriculture, commerce or even with society at large.

[11] Higher Education Commission. (2011). *Higher Education Medium-term Development Framework II MTDF- HEII 2011-2015*.

The Federal Government has established twelve Centers of Excellence in various universities. Two of the centers are in Chemistry and one each in Molecular Biology, Marine Biology, Geology, Mineralogy, Water Resources, Solid State Physics Art and Design. Three centers are in the field of social sciences and arts. No Center of Excellence has been established in the fields of agriculture or energy.

According to an HEC assessment conducted in 2010, only 4 of the 12 centers fall into the top category ('W'). These include the National Centre of Excellence in Physical Chemistry, University of Peshawar; Centre of Excellence in Analytical Chemistry, University of Sindh, Jamshoro; Centre of Excellence in Molecular Biology, University of the Punjab, Lahore; and National Centre of Excellence in Geology, University of Peshawar. Six of the centers fall in Category 'X', one in Category 'Y' and one in the lowest category labeled as 'Z.'

One of the most probable reasons for the poor performance of existing centers is their high level of autonomy without clear accountability. The accountability locus is centered at the federal level and not at the university level. None of the subject areas of the centers fall within an external quality assurance or accreditation agency and no strong system of accountability exists within the structure of the centers.

Autonomy and Governance Issues

Huisman,[12] with reference to increasing autonomy of universities in Europe, cites Jamil Salmi's argument that autonomy is meaningful only to the extent that it actually empowers institutions in a responsible way. Similarly, Azam[13] proposes that with enhanced autonomy, the quality assurance mechanism should be strengthened at the institutional level. The Berlin Communique 2003[14] stressed that, consistent with the principle of institutional autonomy, the primary responsibility for quality assurance in higher education lies with each institution itself and that provides the basis for real accountability of the academic system within the national quality framework. However, they supported further development of quality assurance at institutional, national and European level by developing mutually shared criteria and methodologies on quality assurance.

Currently under the 18th Amendment in the Constitution, existing Centers have been transferred to the authority of the Provincial Governments which may have implications for several important functions including funding and governance. However, the adoption of amendments addressing these functions is pending until the formulation of provincial regulations.

Quality Assurance in Higher Education

With globalization, cross border education and accountability of publically-funded quality basic and higher education have become key items on the agendas of all nations of the world. Accreditation is one of the most effective mechanisms for quality assurance of academic programs. The process entails a peer-reviewed assessment based on formal judgments of an external agency, ascertaining that the quality of a program/course or an institution meets pre-set standards and that graduates of these institutions meet standards for entry to the profession. The process itself is an on-going review of quality whereby an institution or program assesses itself, is assessed by a third party, and shows commitment to an on-going effort to maintain quality enhancement.

Accreditation not only lends prestige to programs and institutions, justified by having quality standards and commitment to maintain these at a high level, but can also be instrumental in raising the status of the profession and graduates, be used as the basis for planning for program improvement, and is the

[12] Huisman, J. (2007). The anatomy of autonomy. *Higher Education Policy 20* 219-221. doi: 10.1057/palgrave.hep.8300162

[13] Azam, M.K. S. (2007). *Quality assurance in higher education: Initiatives in Pakistan.* [CD-ROM]

[14] Berlin Communiqué. (2003). *Realizing the European higher education area.*

foundation for development of trustworthiness at the national and international levels. Accreditation helps to raise the status of the profession by:

- Ensuring uniformity of standards across all teacher education programs in the country;
- Ensuring quality of professionals entering the profession against National Professional Standards;
- Providing data to the decision makers in particular, and public in general, that may be used for accountability of education providers; and
- Enhancing professionalism.

Feedback from the accreditation agency and self-evaluation reports help the institutions in:

- Identifying strengths and weaknesses of the program that need to be addressed for further improvement;
- Providing sound foundations for strategic long-term and short-term planning for a program's improvement (Self-improvement);
- Providing rational for making budgetary provisions and funding of improvement plans;
- Providing reliable information to the funding agencies about the required type of support; and
- Creating a strategic thinking environment.

Accreditation against the pre-set national standards develops trustworthiness by:

- Making comparison of higher education programs offered by different institutions;
- Facilitating students' mobility to other institutions of higher education in the country and abroad;
- Facilitating individuals in identifying quality programs/institutions;
- Providing information to foreign universities regarding the accreditation status of programs attended by Pakistani students seeking admission to their universities;
- Leading to international credibility of the programs in cross-border higher education and employment.[15]

Accreditation of Higher Education

In the United States

In the U.S., accreditation of higher education is available at two levels, institutional and program or specialized. The Council for Higher Education (CHEA) grants accreditation through approved accreditor associations or six regional councils which grant institutional accreditation. A number of approved bodies undertake program accreditation such as the Accreditation Board for Engineering and Technology (ABET) and National Council for Accreditation of Teacher Education (NCATE). Despite having a high value to institutions, accreditation is a voluntary process and is granted by a non-governmental agency.

In Pakistan

To address the challenge of quality education, the Higher Education Commission has introduced a two-tiered quality assurance system. The quality of institution is evaluated by the HEC and the quality of academic programs is evaluated by the accreditation councils for individual subjects. In most of the professional subjects, well-established accreditation councils exist, some dating back to 1964. These councils are autonomous professional bodies established by the federal government through legislation. Relevant to the subjects of the proposed Centers of Excellence are the Pakistan Engineering Council (PEC). This membership status brings international recognition to the degrees awarded by the Pakistani

[15] Mirza, S.M. (2011). *Accreditation for quality assurance in teacher education*. Pakistan: National Accreditation Council for Teacher Education.

institutions for all purposes from admission to advanced degree programs to employment. The subjects under Agricultural Engineering, Energy, and Water Management fall within the domain of the PEC. The Veterinary and Animal sciences are under the domain of Pakistan Veterinary Medical Council (PVMC). For quality assurance in other subjects, the HEC has recently established four accreditation councils (as per mandate Ordinance No. LIII, 2002) including the National Council for Agricultural Education Accreditation which will accredit all degree programs within the field of agricultural education. For the most part, only Bachelor degree programs are accredited.

In Pakistan, accreditation is mandatory for institutions and in the disciplines having accreditation councils. For internal quality assurance and self- assessment, the HEC established Quality Enhancement Cells (QEC) in 10 universities in the first phase which has expanded to 61 universities currently. The purpose is self-assessment, strategic planning for quality enhancement and preparing for external quality assessment by the HEC and the relevant accreditation councils. In addition to the accreditation councils and bodies, ISO certification is also used for quality control at the institutional level. Three Pakistani universities, NUST, NED, and MUET are ISO-certified universities. All of these are specialized engineering universities.

Engineering and Agricultural Education

Pakistan has 19 public and eight private engineering, science and technology universities and DAIs. All five agricultural universities and one university in animal and veterinary sciences are in the public sector. Due to focused attention on engineering and scientific disciplines, the number of doctoral dissertations in engineering has increased almost ten times. Agricultural sciences have received significant investment and saw a revival of research productivity. Two of the engineering universities, NUST and UET, Lahore, are among the top 500 universities of the world and two universities, NUST and MUET, are ISO-certified.

According to the HEMTDF-11, engineering, science and technology education will continue to be priorities and will on focus on application of knowledge to address local problems and promote university-industry linkages. Plans were made to identify and strengthen National Centers of Excellence in areas of economic importance such as Energy, Food Security, Water Resources and Biotechnology. Now, Pakistan is seeking USAID support to establish new centers of excellence in three areas: Agriculture, Energy, and Water Resource Management, and has envisioned that the centers will be innovative in provision of cutting edge research, enhanced teaching and learning, entrepreneurial activities and strengthened policy formulation for the government. The centers are meant to bridge gaps across academia-industry, academia-government and academia-society and will promote interdisciplinary and inter-institutional linkages of trust, support and scaffolding.

Women in Higher Education

The enrollment of female students has increased over the last few years and they now constitute more than one-third of the total student body of the universities. Disparities across disciplines and areas remain however. Urban and metropolitan universities may have close to a 50 percent share of women students while institutions in more rural areas still have smaller proportions. Similarly, women enter into disciplines that are viewed more favorably to females in the cultural context of Pakistan. For example, in engineering and agriculture, considered men's professions, the enrollment of women is particularly low. While gender-disaggregated data for higher education is not readily available, a few salient facts emerge that provide a picture of women's roles in higher education:

- Women constitute about 44 percent of the total enrolment of higher education institutions.
- In 1991-1992, about 28 percent of the student population in engineering and agriculture disciplines was women. By 2001, this had risen to 38 percent.
- In the engineering field, female enrollment is about 15 percent. UET Lahore, the oldest engineering university in Pakistan, has about16 percent women while MUET has about 14 percent women.

- In agriculture, women constitute about the same as the other sectors, with variations from 8 percent to 30 percent. UAF has the highest female enrollments because of specific disciplines such as Home Economics and other social sciences that appeal to women. In pure agriculture subjects, enrollment is not more than 20 percent.
- Women faculty in engineering represents about 14 percent. At UET Lahore, they are 19 percent of the total faculty.
- Very few women are in academic administration positions because of their recent entry to these levels (due to the limitations in advancement).
- Career Counseling or Placement Centers do not exist, are new, or are dysfunctional.
- Fewer than 50 percent of women graduates enter the job market.[16] The percentage of women entering the job market is higher among Masters and Ph.D. degree holders compared to Bachelor degree holders.
- Women prefer to work in universities or at research organizations. Very few choose to work in field jobs.[17]

Agriculture Sector Profile

Agriculture is central to Pakistan's economy, accounting for over 21 percent of GDP and absorbing 45 percent of the country's total labor force Pakistan.[18] It earns about 70 percent of the foreign exchange through export of raw, semi-processed and processed commodities. There are two principal crop seasons in Pakistan: the *Kharif,* or the sowing season which begins in April-June and harvesting during October-December, and the *Rabi,* which begins in October-December and ends in April-May. Rice, sugarcane, cotton, maize, mung bean (*mong*), black lentil (*mash)*, millets (*bajra* and *jowar*) are *Kharif* crops while wheat, gram, lentil, tobacco, rapeseed, barley and mustard are *Rabi* crops.

COE TEAM

Improved Red Sindh cattle breed at SAU

Total arable land is estimated at about 34.5 million hectares.[19] Of this, about 22 million are cultivated, 8.3 million are non-cultivated arable and about 4.2 million are forest. There is relatively little room for expansion in the area under cultivation and any production increase has to come, by and large, from productivity increases through the use of improved technology and management. Of the total cropped area, about 59 percent is allocated to food crops, 2 percent to cash crops, 5 percent to pulses, 11 percent to fodders, 2 percent to orchards, 2 percent to vegetables and 1 percent to other crops.

Land distribution is highly skewed. There are about 6.3 million farms of which the average size is 3.2 hectares. About 86 percent of farms are less than 5 hectares in size and account for 38.5 percent of farm area. Most small farms are jointly owned and time series data suggest that the number of small operators without ownership has been on the rise.

Ninety-one per cent of Pakistan's cropped area is irrigated (47.62M acres out of 52.31M acres). As a result of factors such as glacial melting, deforestation, and population growth, severe water shortages already

[16] Vice Chancellor, UET Lahore, personal communication December 20, 2011

[17] All information in this section came from personal communication with the Vice Chancellor of UET Lahore, December 20, 2011.

[18] Government of Pakistan (2010) *National Economic Survey: Agriculture.*

[19] All data in the next paragraphs are from the Government of Pakistan. (2000). *Pakistan 2000 agriculture census*. Agricultural Census Organization..

exist in the sector. Within the Indus Basin, about 105 million acre feet (MAF) out of 155 MAF of surface water is being diverted annually for irrigation while around 48 MAF is pumped from groundwater aquifers. However, due to inefficiencies, an estimated 50 percent of diverted water does not actually reach crops. Direct rainfall contributes less than15 percent of water utilized by crops.[20]

The use of modern farming inputs, such as fertilizer, pesticide, improved seed (including GM varieties) and farm credit is widespread. Total fertilizer intake during 2009-10 was estimated at 3.7 million tons, of which 78 percent was produced locally.[21] USD 1.97B (Rs166, 345 million) was disbursed as agricultural credit by public and private sector providers during the same year. There are more than 400,000 tractors in the country, most of which are produced locally. Most farmers use tractor-drawn tillage and planting equipment. Improved seeds of various crops, in particular cotton, maize, rice, sugarcane and vegetables, are in high demand and there is plenty of evidence in the existing literature to suggest that farmers are ready to pay higher prices for improved seed.[22]

A public-private mix of extension services serves Pakistani farmers. The public sector has a large network of agricultural universities, research institutes, crop research stations and the extension wings at the provincial Departments of Agriculture. When the multinational companies started selling their pesticides in Pakistan in the 1970s, they also provided advice to the farmers on a range of issues related to pest control. This was the beginning of the private sector extension services. Since then, the private sector has emerged as a major provider of extension services. All local and foreign companies maintain a cadre of extension workers who provide advice to farmers, particularly on the use of chemicals for crop protection.

The public sector extension system is under-staffed and over-stretched. On average, only one Agriculture Officer is available to advise about 9,000 farmers on the more than 50 crops cultivated in a given province. Davidson and Ahmad (2003) note that the extension services provided by the public and the private sectors in Pakistan are not effective in terms of the appropriateness of information, the timing of provision, and the extent of outreach. They note that the public sector has a bias for educated farmers and the private sector tends to support the large farms. Both approaches are exclusionary in a country where the literacy rate in the rural areas is estimated to be about 44 percent and where about 58 percent of farms are less than 5 acres in size.[23] There is virtually no direct link between university research and public/private sector extension. This emerges as a significant gap that agriculture universities can fill by expanding their farmer interface and delivering training programs for extension workers.

Key Issues

Key issues of agriculture in Pakistan as seen in the current literature[24] can be summarized as follows:

- Factor productivity and farm incomes are low. Crop and livestock yields are lower than the world average in almost all cases (tobacco is perhaps the only exception).
- Annual population growth, estimated to be 1.9 percent in 2007, has driven an increase in the number of farms from 3.7M in 1972 to 6.6M in 2000. Over the same time period, average farm size dropped from 5.3 ha to 3.1 ha. Agriculture universities remain focused on technology; no agriculture university visited by the team appeared to do training on land tenure or policy formulation.

[20] Pakistan Water and Power Development Authority. (2011).

[21] Government of Pakistan. (2010). *National Economic Survey: Agriculture*.

[22] See for example, Rana (2010) *Formalising the informal: The political economy of the commercialization of genetically modified cotton in Pakistan.* [Ph.D. Thesis]. Melbourne School of Land and Environment.

[23] Ministry of Finance. (2008). *Pakistan economic survey 2007-2008.* Government of Pakistan.

[24] See for example, ADB, 2005; Davidson & Ahmad, 2002; Davidson & Ahmad 2003; Akin, T., Mirza, F.B., Kuriakose, A., Husaini, S.A., & Hutcheson, T. 2009; Ali Shah, M.T., Khan, N., Israr, M., Ahmad, N., & Shafi, M.M., 2010

- Farm technologies and practices need improvement. Inadequate and inefficient use of key inputs, inefficient crop rotations or no rotations at all (e.g. in cotton where cotton-wheat cycle has been abandoned by several farmers in Southern Punjab) and low literacy levels lead to sub-optimal utilization of available resources.
- Existing infrastructure and support services are insufficient to meet growing needs of the farming community. Low level of public investment in farm-to-market roads, agricultural markets, inadequate access to and poor quality of support services, and a culture of rent-seeking has kept the Pakistani farmer from realizing the full potential of his labor.
- Natural resources are poorly managed. Land degradation, water logging, salinity, inefficient use of water leading to unsustainable extraction of ground water, and excessive dependence on chemicals are some of the more serious issues as noted in the literature.
- Research is mainly in the public sector and often fails to meet farmers' needs. Further, there is hardly any mechanism to translate academic research into actual changes in farming practices.[25]
- The overall framework in which the agriculture sector is governed inhibits private sector participation in research and policy-making.

Agricultural Research and Development

Six major universities conduct agricultural research in Pakistan, focusing on a range of problems centered on production and marketing. The universities are: the University of Agriculture, Faisalabad; the University of Arid Agriculture (Rawalpindi); the KPK Agriculture University (Peshawar); the Sindh Agriculture University (Tando Jam); the Lasbella University of Agriculture, Water and Marine Sciences (Lasbella); and the University of Veterinary and Animal Sciences (Lahore). They conduct research in, *inter alia,* plant breeding, plant physiology, agricultural biotechnology, agricultural engineering, animal husbandry and agricultural marketing. All these universities offer Bachelors, Masters, Masters of Philosophy, and Doctors of Philosophy programs for Pakistani and foreign students (though the number of foreign students is very small). At least three other universities offer programs and research opportunities in agriculture-related fields. These are: Baha Uddin Zakarai University (Multan), Islamia University (Bahawalpur) and Sargodha University (Sargodha). In addition, several institutes of the Ministry of Science and Technology, of the PAEC and of various research outfits are also actively engaged in agricultural research.

Agricultural research in Pakistan is plagued by low level of investment in agricultural research. The issue of poor infrastructure and low-quality human resources is persistent. The library, laboratory, classroom, workshop, conference and accommodation infrastructure in almost all institutions mentioned above fall far short of what is needed to carry out state-of-the-art research.

Energy Sector Profile

Pakistan is in the midst of an energy crisis. The electricity shortages in 2010 peaked at 5,000 MW and many rural areas have no electricity for up to 20 hours a day. Natural gas is rationed during winter months and reliance on imported fuels has increased, thereby increasing power generation costs and adding to the country's balance of payment problems. The shortfalls are compounded by the fact that the country's energy mix is greatly skewed towards imported fuel. The energy shortfalls have stunted the country's economic growth and the increasing reliance on imports has exacerbated the country's balance of payment problems because of long hours of load-shedding in both rural and urban regions. Meanwhile,

[25] Khan, M. A. (2000). *Identification of the factors affecting the working efficiency of agriculture (extension) department.* PhD thesis. Sindh Agriculture University.

security issues have obstructed the building of new hydroelectric projects in the KPK. On the positive side, energy efficiency programs have saved about 1,000 MW, although the potential for more improvements in the efficiency of energy use, distribution, transmission, and generation is tremendous. Electricity tariffs and oil prices have been allowed to increase and electricity transmission and distribution systems are being rehabilitated and upgraded with foreign assistance. In the past, the generation of electricity from low-carbon sources of energy played a significant role in Pakistan's economic growth, spearheaded an expansion of a "green jobs" base in the country, and has the potential to become an engine of sustainable development in Pakistan. However, these measures remain inadequate.

Table 1. Cost of Electricity in Pakistan by Source

Generation Sources	Hydro	Coal	HSD	RFO	Gas	Nuclear	Import from Iran
Annual Generation (GWh)	3,132	11	2	3,359	1,943	106	22
Percentage %	36.3	0.1	0	38.9	22.5	1.2	0.3
Cost- Rs. /KWh	0.37	4.7	15.74	11.29	7.11	0.51[26]	4.25

Hydroelectricity is based on more than a century of experience, starting with the Renala Hydroelectricity Project, which was developed in 1911. After completion of two mega hydroelectricity projects in the 60s and 70s, the Tarbela and Mangla Dams, economic growth in the country has been fostered by buying a supply of cheap and reliable electricity, highlighting the role of hydroelectricity and its nexus with sustainable development in Pakistan. Hydropower, which is a low-carbon resource, has set an excellent record in the generation of electricity, flood mitigation, and employment generation during the execution and operation phases of hydropower projects in Pakistan. The example often quoted is the success story of the Tarbela Multipurpose Project, which was completed in 1975 for a total cost of Rs. 16,380 million and boasted of hydroelectricity as a byproduct. As of the December 1, 2007, the national economy had benefited from a total of Rs.221, 902 million, 13.5 times more than the original cost of the dam. The Tarbela Multipurpose Project also provides substantial job opportunities for local labor. The cost to generate hydropower is the lowest of all the sources, as noted in Table 1.

Recently, the GOP announced a plan by which the Water and Power Development Authority (WADPA) will add 32,660 MW to the grid by 2030, while additions in coal, other renewable sources, oil and gas-based thermal is shown in Table 2. Although hydropower projects take a longer gestation time, they offer employment opportunities to specialists in diverse areas of expertise, including vast job opportunities for skilled and semi-skilled labor force during and after execution of project. The construction industry provides a platform for labor-intensive activities. However, in critical areas, especially in the design of hydropower projects, engineering institutions of Pakistan are lacking in the capacity to produce engineers.

Table 2. Types of Energy

	Nuclear	Hydro	Coal	Renewable	Oil	Gas	Total
Existing Capacity (2011)	400	6703	**160**	0	6845	**5672**	19540
Target for the year 2030	8800	32660	**19910**	9700	7760	**83760**	162590
Percentage (%)	5.41	20.10	**12.20**	5.97	4.77	**51.50**	

[26] Global and national reaction against nuclear energy is speedily growing especially after the Daiichi Nuclear Power Plant (7,456 MW) in Japan was crippled by the 11 March 2011 tsunami and an earthquake of 9.1 magnitude. Interestingly, compared with hydroelectricity, the cost of nuclear energy in Pakistan is much higher than the production from the hydro projects. Annual fuel cost and recurring expenditures are Rs 22 million per MW, a sum of 34 percent higher than hydro projects. Employment per MW is lower than hydro projects. Further, the political cost attached to nuclear projects, considering the inherent danger attached to them, is too high for a nation and the global environment. In Japan, Prime Minister Naoto Khan resigned on August 26, 2011 for not properly handling the Fukushima nuclear crisis and resulting outcomes.

Pakistan has 185 billion tons of lignite coal reserves, making Pakistan the 7th richest coal nation in the world. Just half of that is enough to generate 100,000 MW for 30 years. Yet coal accounts for just 0.1 percent of Pakistan's fuel mix. The government's Board of Investment has proposed a set of incentives and tax breaks for investors in coal-fired power plants and mining operations but no serious investment has resulted. If and when the coal resources are developed, foreign mining contractors will be needed because the country has no domestic expertise.

Pakistan has so far been unable to add wind-generated energy to the national grid in spite of having an economically viable potential of 13,000MW in Sindh alone as assessed by Pakistan's Metrological Department. On the other hand, in India, where the total wind energy potential is 65,000 MW, the country has made a remarkable achievement of harnessing about 11,807 MW, constituting about 19 percent of the entire wind potential. Moreover, in the last five years until March 2010, India has generated 8,213 MW of electricity from wind resources.

An official statement notes that one of the reasons for the delay in power generation from wind resources has been the rise in the cost of wind turbines, which comprise a major engineering, procurement and construction (EPC) cost of wind power projects. However, the capital cost of producing wind turbines has fallen steadily over the past 20 years. The manufacturing processes of wind turbines have been optimized, enabling mass production and automation and resulting in economies of scale. On this note, the Alternative Energy Development Board (AEDB) could have facilitated the independent power producers to avail themselves of the cheaper Indian wind turbines as their prices have always been lower than the global average due to lower labor and production costs. More than a dozen international companies now manufacture wind turbines in India.

COE TEAM

The first wind turbine at NUST

One of the reasons behind the failure to tap wind energy has been the absence of trained labor in this sector. The main obstruction in the promotion of wind energy is the cost of imported equipment that constitutes almost 82 percent of the EPC. This also makes the cost of operation quite expensive, raising the tariff on wind energy. Contrary to the facts, the assertion that wind energy is the only panacea for Pakistan's energy crisis is basically a myth fostered by those with a vested interest in wind propagation.

Besides the comparatively lower tariff, the primary advantage of wind power over fossil fuel based electricity generation is that it is environmentally friendly, an indigenous resource, has lower capital costs than rental power, and offers potential for economies of scale. The tariff for wind power forms an essential part of the EPC, subsequently arriving at Rs. 4.4429 after ten years of operation. One of the best options to electrify remote areas of the country would be to harness free wind energy in western, central and southern Sindh.

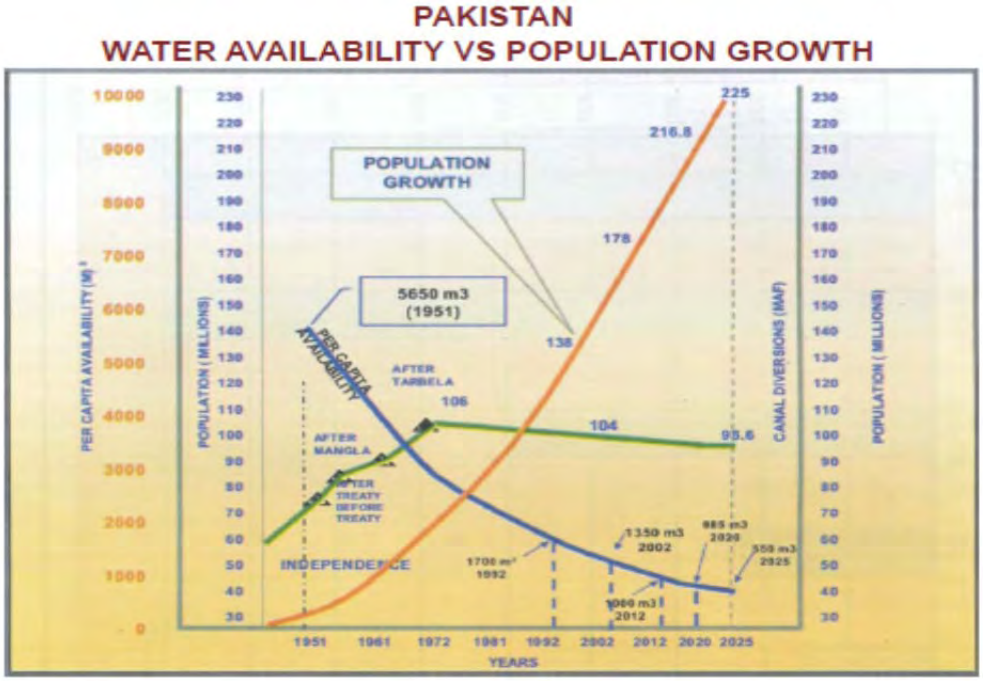
Similarly, biogas is the best and cheapest alternative to address the gas crisis in the country. The cattle population in Pakistan is enough to generate 1,147.75 million cubic feet per day**.** More than five million biogas plants can be installed to meet the cooking needs and electricity generation in rural areas of Pakistan and more than three million green jobs can be created in this sector.

Water Sector Profile

Pakistan is located in an arid to semiarid region with a low mean annual rainfall. Most of the surface waters come from snow and glacial melts and monsoon rains in July and August with some variability occasionally from June to September when most of the country receives water. The average annual water availability is 145 MAF and can vary from less than 90 MAF in dry years to more than 170 MAF in wet years. About 80 to 85 percent of water flows during the *Kharif* summer-crop season when water demand is 60 percent and 15 to 20 percent during the Rabi winter-crop season when water demand is at 40 percent. Pakistan's in-country glaciers cover an area of about 15,000 square kilometers or 8 percent of the Indus Basin, yet provides about 40 percent of the country's annual stream-flow from runoff.

The water availability per capita in 1961, when the population was 35 million, was more than 5,300 cubic meters (CM), declining to less than 1,100 CM per capita in 2011as an index for a population of 170 million. Pakistan is clearly becoming a water-deficient country, or a people-surplus country (Figure 1). Falkenmark,[27] who developed the Water Scarcity Index, notes that at 1,000 CM per capita, a country is water-stressed, causing adverse impacts on the population.

Figure 1. Water Availability Compared to Population Growth, Pakistan



Source: Tarar, R.N. (2011). 'Pakistan need for storages for different uses.' *Pakistan Engineering Congress, 71st Annual Session Proceedings (*Paper No. 680).

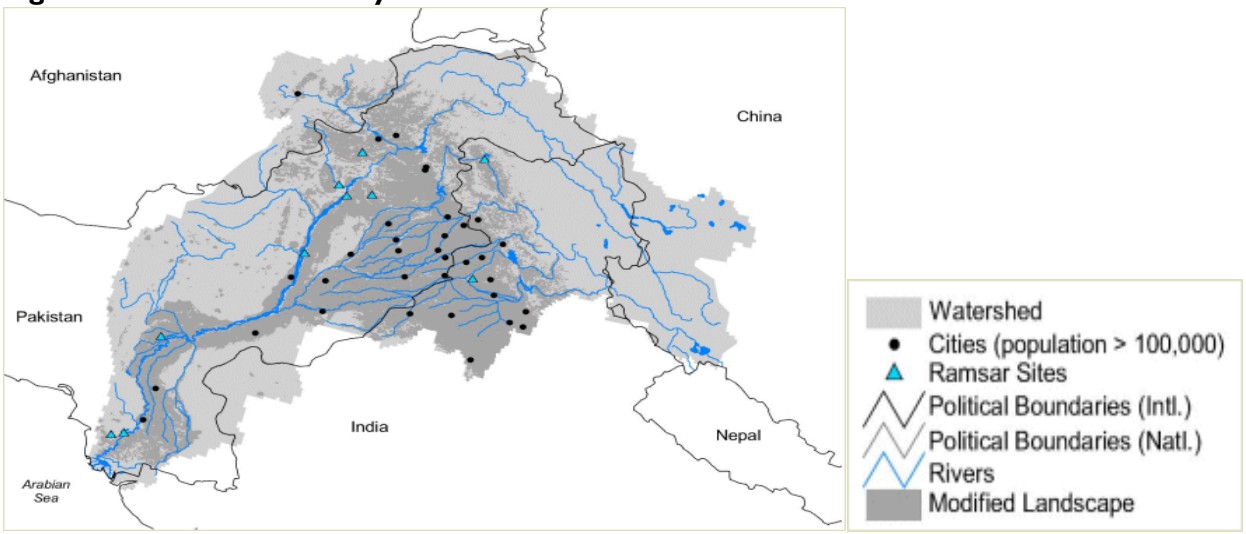
Pakistan had surface-water storage of only 13 percent of its average annual flows in 1975 after construction of Mangla and Tarbela Dams. The storage has now been reduced by 15 percent at Mangla and 29 percent at Tarbela reservoirs due to sedimentation and silt build up behind the dams, while storage has been reduced to less than 50 percent at Chashma Reservoir. World average storage is 40 percent of the average annual inflows. Pakistan stores water just sufficient for 30 days of use, compared to, for

[27] Falkenmark, M. (1989). 'The massive water shortage in Africa: why isn't it being addressed?' *Ambio. 18*(2):112-118.

example, the Colorado River in the U.S. which has storage for more than 560 days of use. The High Aswan Dam on the River Nile in Egypt can store water for nearly seven years of use. Pakistan's water-resources education providers need to pay closer attention to such glaring differences and looming threats in water availability.

The country suffers from frequent years of drought and floods. For example, during the year 2010, floods caused billions of dollars of damages in addition to more than 200 deaths. On the average, about 32 MAF of fresh water goes down to the sea while the country suffers from shortages of water. In the year 2010, 55 MAF of fresh water was lost to the sea and more than 25 MAF flooded and stood in Pakistan's low-lying areas of Sindh and Baluchistan Provinces until it evaporated or infiltrated. In addition, water losses occur from stagnant flood water in the affected areas. Some reports suggest more than 77 MAF of fresh water river flows either end up in the sea or cause destruction and diseases in the flood-affected areas. A small amount of flow, approximately 5,000 cubic feet per second, to the Indus delta below Kotri Barrage is necessary for fisheries as well as downstream agriculture and human consumption. Figure 2 illustrates the extent of influence of the Indus River system.

Figure 2. The Indus River System



Source: Shafique. (2008). *Water management: Shifting sands of original assumptions, emerging issues and options; and strategic brainstorming – Potential for water wars*

In addition, approximately 40 MAF of groundwater is being abstracted annually. In some cases, over-mining of the aquifers has resulted in up-coning of saline groundwater. This amount is a blessing as well as curse for Pakistan in general and Punjab in particular as almost 89 percent of irrigation tube-wells are located in Punjab, the region of Pakistan which contains 80 percent of the country's irrigated area and 70 to 80 percent of total crop production. Sodicity of groundwater is risking the very sustainability of irrigated agriculture in Pakistan. Review of literature suggests that 70 to 80 percent of the groundwater is sodic and unfit for irrigation. In Punjab, almost 7 million hectares are irrigated with groundwater where the threat of secondary sodification is a serious challenge. This threat becomes even more extreme when considering salt-affected soils, as 89 percent of these soils are either sodic or saline-sodic in nature. These water-related issues adversely impact agricultural productivity and food security.

On one hand, agricultural yield is low due to water scarcity and inefficient management of production resources; on the other hand, water logging and salinity, and sodicity are rendering otherwise productive agricultural land barren, in part due to mismanagement of water resources. The updated Left Bank Outfall Drain was built on the left bank of the Indus in Sindh Province to drain the water-logged areas into the sea, while on the right bank of the Indus, the updated Right Bank Outfall Drain is under construction. Both

drains will discharge directly into the sea and not into the Indus River. Pakistan has still 20 million acres of virgin land which could be brought under plow if water was made available. Therefore, Pakistan must conserve its water resource and provide more storage.

Pakistan has the largest and oldest contiguous river water distribution system on land, using an equitable principle of water distribution within each province. Once water is diverted from barrages of each province, as agreed by the Indus River System Authority (IRSA), that water must be turned to fields whether required or not. Since there is no capacity to withhold water whether or not a demand exists because of rainfall or crop water requirements, irrigation water is often not available when needed. About 45 million acres of land are irrigated in the Indus Basin. Of 145 MAF water entering Pakistan per annum at the rim gauging stations, on the average 105 MAF is diverted into the canal heads for irrigation systems. This is mainly because Pakistan does not have capacity across rivers to normalize sharply-skewed water availability or canals to carry or store beyond barrages to hold back water until demand for water is felt. The water available at the farm gate is less than 50 percent of this amount; the rest of the water is lost during conveyance, evaporation, and seepage. Pakistan uses a century-old flood irrigation system, frequently laid out on unleveled land. Therefore, there is a dire need for saving and a more judicious use of water. More efficient drip and sprinkler systems, for use on farms, have not generally been adopted by farmers.

Although Pakistan has a water rights law, it has limited legal support and poor regulation and enforcement. Corruption is rampant in water-sector administration. The country has poor urban and rural drinking water systems and no operating municipal wastewater treatment plants. The country's surface water and groundwater are extensively polluted from agricultural, industrial, commercial, and human wastes. Some of Pakistan's natural ground waters contain high levels of arsenic and other metals which exceed recognized human health standards. The sector has limited technical outreach and management programs for adoption of new technology and commercialization of high value crops to replace subsistent crops. Pakistan is an ideal land for growing vegetables, fruits and flowers along with fiber crops but the missing links of value addition and marketing ties with neighboring countries and across the Middle East are holding the country back.

Much of Pakistan's population has limited access to dependable and safe potable water, and the country suffers from extensive deforestation, soil erosion, desertification, and rapid uncontrolled urbanization which adversely impact water resources. In addition, as in most of South Asia, lack of transparency, significant corruption with cronyism and nepotism, and a lack of trust in the government and its agencies, are common place and unfortunately well-established in management of the water sector. Having too much administrative power and discretion without scrutiny, transparency and accountability often leads to poor water management policies and decisions which is the basis for the current push by international agencies towards decentralization, local controls, and water-user association water management policies.

Much of the country's distributed water is unaccounted for by administrative losses (unauthorized usage, disallowed takings, theft) and by technical losses (reservoir evaporation and seepage, canal seepage, urban pipeline leakage). Water usage is distributed at approximately 2 percent, 2 percent and 96 percent for domestic, industrial and agricultural use, respectively. The contribution from the agricultural sector is only about 21 percent of Pakistan's GDP compared to over 25 percent from industry and 53 percent from services;[28] a unit of water produces less economic benefit from agriculture than it does from industry or services.

Although WAPDA and the IRSA have some water system data, there is no national water database. WAPDA has a Surface Water Hydrology Directorate which has recorded and maintained stream-flow

[28] CIA Factbook. (2011). *Pakistan*.

data of selected rivers since 1923; groundwater data is also being recorded by WAPDA's Water and Soils Investigations Division (WASID) in salinity and water-logged areas, now renamed National Drainage Program (NDP). The lack of a national database or hydrologic information system for water resources within the country and the trans-boundary watershed, poor water sector administration, and management practices lead to water use inefficiencies; the high and rising cost of and often unavailable energy resources impedes sound water management practices and lowers economic water sector productivity and contribution to GDP.

Pakistan has no comprehensive water Center of Excellence. Departments of public health, environmental sciences, and related fields address health and water quality issues, while civil engineering and water resources engineering address water supply. Lahore has a limited COE in water resources that could be expanded; its strength is in irrigation and drainage. There is a national demand for more comprehensive expertise, such as dam engineering, hydropower engineers, sediment management, conjunctive water use, water conservation and its judicious use, groundwater balance, water quality, wastewater engineering, safe domestic water supply, etc. Reportedly, nowhere in Pakistan is education about the Indus Water Treaty and the Water Apportionment Accord provided although provincial debates take place on water distribution and hydro-politics. These subjects are not taught anywhere at the higher level in Pakistan. Public Health programs provide some expertise in public health issues related to water.

Table 3. Selected Key Pakistan Water Facts

Number of major reservoirs	3
Number of barrages	20
Number of headworks	2
Number of inter-link canals	12
Number of canal systems	54
Number of water courses	107,000
Total length of canals in kilometers	60,000
Total length of water courses, kilometers	1,600,000
Average canal water diversions, MAF	105
Groundwater extraction, MAF	40
Number of tubewells	>600,000
Irrigated area, million acres	40
Average surface water escaping to the sea, MAF	33

Private Sector Profile[29]

The private sector in Pakistan is substantial with respect to the national economy, contributing over 84 per cent of total GDP. This figure would be greater if the contribution of the informal sector was added. The contribution of private sector in the total gross fixed investment is about 73 percent. An overall increase in private investment has been evident in recent years even in infrastructure and social sectors. Total foreign investment has been fluctuating between USD 5.2 billion in 2008 and USD 8.4 billion in 2007, rising from USD 559 million in 2003.

The private sector, Pakistan's engine for growth and development, represents a hitherto un-tapped resource for higher education improvement. Critical partnerships between universities and private sector actors, mutually-beneficial to both sides, would add resources and increase supply and demand in a complimentary cycle of growth. The higher education sector would benefit from private industry's innovation, drive, and ground-level perspective of national needs, while private sector players would benefit from human resource development and research to improve production in all technical sectors.

[29] This section draws directly from the Asian Development Bank's 2008 report *Private Sector Assessment Pakistan*.

Agriculture[30]

Agriculture, almost totally in the private sector, is the largest contributor in terms of total employment to the country's economy. The sector also contributes directly to over 60 percent of all merchandise exports, supplying the majority of raw materials for the export industry, particularly for textiles. Agriculture land is virtually all in private hands and produces the paramount value-added output. Public sector involvement in the agriculture sector is largely limited to providing and maintaining irrigation systems and waterways for farming. While private extension services are a feature of agro-business, the public sector provides the majority of agriculture extension services and is the main financial contributor to agriculture research. From a private sector perspective, the most important issues related to agriculture include an inefficient agriculture marketing system, distorted agricultural input and output pricing, and a continued inability to price and manage water.

Energy[31]

The total installed electricity generation capacity in the country is about 21,036 MW, of which 30 percent is generated by the private sector. After the restructuring of the Water and Power Development Authority (WAPDA), four generation companies (GENCOs) started functioning as public limited companies. Today in Pakistan, 16 Independent Power Producers (IPPs) exist and together produce 8,295 MW of electricity on a 'build, own and operate' ("BOO") basis, under the private power policy announced by the Government in 1994. Of these, the Hub Power Project is the largest, with a total generation capacity of 1292 MW. The ADB reports that:

- **Hydro Power Plants** Pakistan's water sector strategy has identified potential private sector hydropower projects. These projects have not elicited much interest from the private sector.

- **Alternative Energy Plants** The Alternative Energy Development Board (AEDB) has been established, which has issued letters of interest (LOIs) to eighty-two national and international companies for proposals to generate 700 MW of power.

- **Gas Fired Power Plant:** There is considerable potential for the development of gas-based thermal projects in the private sector.

- **CNG Gas:** The current low price of compressed natural gas (CNG) has triggered the conversion of vehicles from petrol to gas. In one year alone there has been a 35 percent increase in the number of vehicles running on CNG. There are many private companies involved in gas exploration and production activities.

Water

Water supply systems are owned, managed, and operated by public sector agencies and suffer from deteriorating institutional capacities, inadequate operation and maintenance funding, and poor cost recovery. Efficiency could be improved by introducing private operators and measures to provide an adequate revenue stream.

Private Sector Universities

The number of private sector universities has grown from 25 in 2001to 53 in 2010. Private sector enrollment in higher education institutions has increased from 43,873 in 2001to 115,369 in 2009, although the expansion in the institutional capacity of private educational sector may not have guaranteed

[30] Ibid
[31] Ibid

employability. Private sector universities need to improve access to education; promote excellence in learning and research; develop faculty; and establish industrial linkages. The focus of autonomous private sector universities has largely been demand-led and quality of research in pure/basic disciplines has been ignored to some extent.

SECTION IV. INSTITUTIONAL PROFILE SUMMARIES

Agriculture

University of Agriculture, Faisalabad

Institutional Organization and Administration

The University of Agriculture, Faisalabad (UAF) was established in 1961 by upgrading the former Punjab Agricultural College and Research Institute, Lyallpur. The University is organized into six faculties, six institutes and 37 departments. The faculties are: 1) Faculty of Agriculture; 2) Faculty of Agricultural Economics and Rural Sociology; 3) Faculty of Agricultural Engineering and Technology; 4) Faculty of Animal Husbandry; 5) Faculty of Sciences; and 6) Faculty of Veterinary Sciences. UAF has three sub-campuses at DG Khan, Toba Tek Singh and Debalpur. The Faculty of Agriculture is the largest faculty and has already trained over 11,000 undergraduates and 6,000 graduates in the various fields of agriculture.

Infrastructure and Technology

UAF is spread over an area of 1,950 acres and contains academic buildings, libraries, research laboratories and research farms. It has well-furnished classrooms with reasonably good teaching facilities for students. Not all lecture theaters have multimedia facilities, but these can be organized easily upon request to departmental authorities. Classrooms and lecture theatres provide segregated seating for men and women. Each Department has its own laboratories for analytical and research work which is carried out by students in the various programs. Moreover, a Central Hi-Tech Laboratory was also established in 1997, housing many high technology instruments and qualified research officers. University students and researchers can use these facilities at nominal rates. The Hi-Tech laboratory also provides analytical services to outside clients on a fee basis. While these laboratories provide basic scientific facilities to students and faculty, they will require a massive upgrade to become state-of-the-art facilities that are the hallmark of modern education in developed societies.

The UAF library, established in 1961, spreads over 45,000 square feet and has seating capacity for about 1,500 people. The current collection of books and periodicals is 255,473. Many of these books are from previous decades (some are from the 1960s) and can be replaced with later editions or newer books. The library holds in hard copy 22,925 theses (897 are Ph.D. theses). In collaboration with the HEC, the University is in the process of digitizing all the Ph.D. theses, but the process may take a couple of years to complete. The library subscribes to 35 journals/ magazines and 15 Pakistani newspapers. In addition, 85 foreign journals are also received regularly. The library is linked to a digital library developed by the HEC where over 15,000 full text journals and 25,000 abstracted journals are available free of charge. The number of journals and the databases subscribed to are two areas that need significant investment.

There are separate computer rooms with internet access for male and female students. The number of computers available is inadequate and a far larger number of work stations should be available to students and staff than is presently the case.

The University agro-livestock farms are spread over 1,519 acres. These farms are located at various places where students have an opportunity to get practical training in the disciplines of agriculture, livestock, poultry and fisheries. These farms provide the basic infrastructure for field research and also serve as demonstration places for students. Sometimes, farmer visits to these farms are also organized as a means of enabling two-way communication between the university and farmers. These farms are also a source of income for the university; however, they earn far less than their potential, which is estimated at about USD1.78M (Rs150 million) per annum.

The University provides reasonably good housing facilities for faculty and support staff comprising 172 houses for faculty and 470 units for technical and support staff. There are eighteen residential halls at the University, providing accommodation for more than 4,200 students. Of these, three hostels are reserved for female students.

Student Profiles

Since its founding, the UAF has conferred 24,488 bachelor's degrees, 24,985 Master's degrees, and 916 Ph.D.s. Current enrolment stands at 11,797 students. These students come from very diverse backgrounds. UAF uses a district quota system for admissions to undergraduate studies from every district of Punjab. It caps girls' enrolment in bachelor's programs at 20 per cent. Presently, 74 students come from other provinces/areas. The University awards fellowships, financial assistance, and merit scholarships to assist needy students to receive a higher education. Financial aid comes from University resources with assistance from various individual and institutional philanthropists. In 2009-2010, 2,108 (18%) students were receiving some scholarship. The financial assistance, not including the indigenous Ph.D. program from HEC, totalled USD 316,694 (Rs27.73 million) or an average of USD150 per assisted student.

Quality of Education Issues

The Higher Education Commission currently scores UAF as the top-ranked agriculture university in Pakistan and the third highest-ranking university in the country for the publication of research papers in the natural sciences in peer-reviewed journals (see Tables 4 and 5 below). Clearly, the university has already met a very significant challenge with considerable success.

Table 4. Pakistan's Agriculture Universities by HEC Ranking

Rank	University	Score (out of 100)
1	University of Agriculture, Faisalabad	66.4
2	KPK University of Agriculture, Peshawar	64.1
3	University of Arid Agriculture, Rawalpindi	43.6
4	Sindh Agriculture University, Tando Jam	39.3

Source: Higher Education Commission

Table 5. Research Articles in 2010 in Natural Sciences including Agriculture by University

Rank	University	Research Papers
1	Quaid-i-Azam University, Islamabad	556
2	University of Karachi, Karachi	348
3	**University of Agriculture, Faisalabad**	**278**
4	University of the Punjab, Lahore	238
5	Government College University, Lahore	204
6	COMSATS Institute of Information Technology, Islamabad	180
10	**KPK Agriculture University, Peshawar**	**139**
12	**PMAS University of Arid Agriculture, Rawalpindi**	**73**
39	**Sindh Agriculture University, Tando Jam**	**8**

Source: Higher Education Commission, Pakistan
Note: **Agriculture universities in bold type**

Faculty Qualifications

Current faculty strength is 593, of which 288 (49%) hold a Ph.D. and 23 (8%) are women. The faculty comprises 90 professors, 48 Associate Professors, 188 Assistant Professors, 239 Lecturers and 28

Research Officers. Female faculty members comprise about 19 percent of the total faculty. The scope of faculty trainings and participation in conferences, symposia, and workshops is international. Of 40 UAF faculty receiving scholarships in 2009-2010, two were pursuing Master's degrees in Australia, two were pursuing Ph.D. programs in Pakistan, thirty were in Ph.D. programs overseas, four were participating in Post-doctorates in the U.S. or Australia, and two were unspecified. In 2009-2010, 227 UAF faculty members reportedly participated in local training courses, seminars, conferences, workshops, symposia, or exhibitions, whereas 160 UAF faculty members participated in foreign trainings, workshops or conferences.

Research

In addition to on-going research related to key crops, the university also conducts research on livestock, agricultural machinery, agricultural economics, and other subject areas. Over the years, the number of research projects undertaken by the University and funding for these projects have increased exponentially. As with most research universities, outside funding for research plays a large role in shaping the topics and subject areas that faculty conduct research on.

In addition to publication of research findings in national and international journals as well as monographs, dissemination is implicit in the knowledge that graduates take with them when they leave the University for employment in private or public sectors. Additionally, some 19 technology-transfer projects were funded in 2009-2010. Faculty also participated in three agricultural fairs and eight demonstration projects including the establishment of a demonstration orchard and the assessment of water-saving cultivation systems in fine grain rice.

University Partnerships

In 2009-2010, UAF faculty submitted 588 project proposals valued at USD176.7M (Rs14,908 M). The largest source of funding applied was to the 'Pak-U.S. S&T' and 'Pak-U.S. S&T Crop Program' each application being at USD 32.7M (Rs2763.439M). Total value of these two groups of proposals would be equivalent to USD 65.5M in funding if all proposals were approved. By contrast, three local companies reported to have funded UAF research in 2009-2010, involved USD 279,158. In other words, private sector funding of research at UAF in 2009-2010 was less than 0.2 per cent of all funding applied for that year.

On-farm research at UAF appears to be a concept that is largely limited to rural sociologists and agriculture economists. Student internship opportunities are limited and tend to be with local banks or other businesses rather than involved in villages or on farms. The exception to this lacuna is a core of veterinary faculty who are involved in research and demonstrations on farms and the social science faculty who do village-level survey work.

Sindh Agriculture University, Tando Jam (SAU)

Institutional Organization and Administration

SAU is in a remote location and remains severely constrained by a limited budget and organizational and staffing structures that need radical reform. An aging male faculty dominates decision-making and resource allocation.

SAU is over-compartmentalized, consisting of five faculties containing 35 departments with 254 faculty teaching 6,099 students in 2010-2011. There is also an Institute of Food Sciences and Technology and an affiliate college in Larkana District. The 12 faculty holding the rank of Professor in the Faculties of Crop Production, Crop Protection and Social Sciences have been teaching on average for 24 years. Added to the current issue of the inability of younger, more qualified staff to advance is that many SAU faculty members

have achieved only a SAU master's degree as their highest degree. Staff recruitment needs must emphasize searching outside of the SAU campus.

On the positive side, the University has strong linkages with farmers and has an admirable problem-oriented approach to research that is often focused on local problems. In the absence of a strong provincial extension service, SAU provides advisory services to neighbouring farmers for better farm management and crop productivity.

Infrastructure and Technology

The University campus spreads over an area of 417 acres. In addition, it has two farms covering 769 acres including an orchard of 200 acres. There is also a livestock experimentation station, veterinary hospital, poultry research and hatchery unit and milk & meat processing unit, student farm, 50-acre horticultural garden and agricultural engineering workshop.

Some departments collaborate with foreign universities and the laboratory facilities in these departments are visibly better. The foremost example is a Molecular Parasitology laboratory that partners with the University of Rhode Island on a study of tick-transmission of disease from livestock to humans in Pakistan.

The SAU library system has 87,557 books, of which 30,991 are kept in faculty/departmental libraries. Most are on technical subjects with only six percent devoted to social sciences. The Information Technology Centre (ITC) was established in March 2002 and currently has an academic staff of 18. The center has more than 600 students enrolled in the Bachelor of Science Honors in Information Technology College.

SAU is primarily a residential campus with accommodation for over 2,500 students in twelve hostels including one girls' hostel and one hostel for research fellows. Hostels do not have a Wi-Fi internet. A hostel for visiting faculty has just been built, but has not yet opened.

Student Profiles

Eighty per cent of SAU student admittances are from rural areas, meeting quotas for each district. Of the 6,699 students enrolled at SAU in 2010-2011, 5,138 were undergraduates, 647 were in Master's programs, and 314 were in Ph.D. programs, with a teacher/student ratio of 1/25. Only 417(8%) were women. Female undergraduate enrollment was highest in the Institute of Food Science (16%) and lowest in the Faculty of Agriculture Engineering (1.8%). Of 31 Ph.D. students, 6, or 19 percent, were women, whereas only 6.5 percent of M.Sc. candidates were female. A total of 189 USAID Merit and Needs Based Scholarships and 64 Japanese Need Based Scholarships were available to students in 2010-2011.

Quality of Education Issues

The University employs 254 faculty members; 40 have foreign Ph.D.s and 15 have Ph.D.s from Pakistani Universities. Women hold 40 of 254 of faculty positions (16%). Of 53 faculty members currently pursuing their Ph.D.s abroad, 29 are studying in China and seven each in Malaysia and Germany. SAU has conferred only 16 Ph.D.s during the period 2005-mid 2011. 2011 is the first year in the past 38 for which the number of men and women faculty hired was equal (one of each gender). Presently, there are no women among the 191 faculty members who were hired 24-38 years ago, but there are 22 male faculty hired during that period. Five years ago only six out of 25 new hires were women. Women remain under-represented at every degree level at SAU, but are approaching parity for the few hires at the Bachelor's degree level.

The quality of SAU's faculty undoubtedly suffers from a problem of institutional involution, where the institution prefers to hire its own graduates. One hundred twenty five out of 191 faculty, or 65 percent of the faculty for whom data were provided, had obtained their highest degree at SAU. Of the 83 faculty in the Faculties of Crop Production, Crop Protection and Social Sciences, 59 staff, or 71 percent, had a SAU Masters as their highest degree.

An internal Quality Enhancement Cell and The National Agricultural Education Accreditation Council (NAEAC) carry out assessment reports to meet national and international standards of accreditation. Leveraging these existing evaluation resources could provide a basis for establishment of future U.S. accreditation of COE-mentored research programs. However, a more robust initiative would involve establishing a 'dual degree' program with a U.S. land grant university in a COE-mentored subject area (e.g. the dual degree program in food science offered by Cornell University and Tamil Nadu Agricultural University (TNAU) in India).

Budget

HEC is by far the largest source of funding for Sindh Agriculture University, providing between 80 and 90 percent of annual budget over the period 2006-2007 to 2011-2012. Although the Government of Sindh did provide the equivalent of about USD 304,000 or about three percent of the annual budget in 2010-2011, the university treasurer does not expect follow-on funding from the province for 2011-2012. The university's anticipated budget for 2011-2012 is worrisome in that the university's income from its own resources is expected to be below USD one million for the first time in the six-year period for which data were provided. Funding from the Province appears to have been discontinued and funding from the HEC has dropped by USD1.65 million or 19 percent.

Research

The Higher Education Commission ranked SAU 39th among 48 universities for publication of articles in peer-reviewed journals in the Natural Sciences in 2010, due to only eight articles being published in 2010. In one listing of 15 research projects funded at SAU in 2010-11, representing an investment of USD 420,000, six were funded by the Agriculture Department of the Government of Sindh with budgets totalling USD 202,800, or slightly less than half of the overall value of the 15 projects. Other sources of funding were the Higher Education Commission (USD163,000), Pakistan Science Foundation (USD 40,900), and ASLP (USD 13,400).

Of 320 Master's theses completed at SAU during the period, 2006-2010, 60, or 19 percent, were done within the Faculty of Agricultural Social Science on topics such as the role of agriculture in poverty alleviation in selected villages, impediments to adoption of improved agricultural practices, farmer perceptions regarding social organizers involved in agricultural extension, and perceptions of NGO workers on farm-level constraints on the adoption of sustainable agriculture practices. As at UAF, no instance of research on the land tenure system was encountered.

In view of existing issues and existing capacities, subject areas that would possibly most benefit from COE investment would include climate change, bio-saline agriculture, agriculture extension, and molecular biology. Whereas UAF publishes quarterly journals in both veterinary science and agricultural sciences, SAU publishes one biannual journal, *The Pakistan Journal of Agriculture, Agricultural Engineering, and Veterinary Sciences* (PJAAEVS). The Second issue in 2010 lists a 13-person advisory board of which 8 persons were faculty at foreign universities. However, the quality of the underlying research for various articles in this issue suggests a lack of a rigorous peer-review process.

University Partnerships

The university has made the following partnerships:

- The SAU-University of Rhode Island joint research project on tick-borne diseases as described above has just exhausted its original HEC-USAID budget.
- The Australia-Pakistan Agriculture Sector Linkages Program Phase 2 (ASLP-2) is reportedly providing less than USD12,000 for a Mango Production Project and a Social Research Project.
- Starting in 2010, SAU constituted a Coordination Committee for Seed Production and Development Center (SPDC). Other stakeholders besides SAU faculty include the Agricultural

Research Institute Tando Jam, the Nuclear Institute of Agriculture Tando Jam, the Sindh Seed Corporation, Foundation Seed Cell ARS Tando Jam, Wheat Research Institute Sakrand, Cotton Research Institute Sakrand, Federal Seed Certification and Registration Department, Hyderabad, Private Sector Seed Corporations, the Sindh Chamber of Agriculture, and Sindh Abadgar Board.

Table 6. Agriculture Team Gap Assessment

Gaps	Findings	Recommendations
Education Quality • Faculty qualifications • Preparation • Curricula	• 22%-53% of faculty holding Ph.D.s; Lack of faculty training opportunities • Only 8%-19% faculty are women • Few inter-disciplinary courses	• Provide greater opportunities for doctoral and post-doctoral studies • Place a premium on recent foreign qualification/experience • Mainstream social sciences into curriculum taught in various faculties
Research • Research topics	• Research tends not to be interdisciplinary, applied, or industry-financed research is uncommon	• Promote interdisciplinary research • Mainstream social sciences into ongoing research in various faculties
Infrastructure • Libraries & IT • Technology capacity	• Books mostly ancient and little used; limited full-text academic journals • Laboratories provide basic facilities • IT infrastructure has improved	• Invest in laboratories, libraries and IT infrastructure • Equip more classrooms with multimedia
University partnerships	• Only USD 280,000 in industry funding of UAF research in 2009-10; none at SAU • Limited on-farm research • Weak linkages with provincial extension system • Current engagement with agric. universities in India	• Improve collaboration with local industry and farmers • Offer training programs for private sector extension Establish linkages with provincial extension system • Encourage and support continuation and expansion of international and U.S. university links
Governance	• Too many faculties and departments; inhibits interdisciplinary research and teaching • Limited stakeholder participation in governance No women in senior administrative and managerial positions	• Launch a Faculty Renewal Program that mandates strict male/female ratios for filling of new positions & some mandatory early retirement • Reorganize and reduce no. of faculties to integrate curriculum coverage & reduce administration costs • Provide flexibility to Deans & Institutional Heads to attract best available talent

Energy

National University of Sciences and Technology (NUST), Islamabad

Institutional Organization and Administration

After just 17 years in existence, NUST is already considered one of the leading universities in Pakistan; the engineering program is currently ranked second by HEC among engineering universities in Pakistan. NUST is a multi-campus university, with a central and newly-built technology-smart campus located in Islamabad.

Since 1996, NUST has enrolled over 8,200 students at the undergraduate level and over 1,200 pursuing graduate degrees, including 177 pursuing doctoral degrees. NUST has more than a dozen constituent colleges, schools, and research centers, with research and development one of the stated primary

functions of the university. It currently has MOUs with higher education institutions in 14 countries and is actively seeking linkages with others.

Student Profile

NUST is highly selective in admissions. Of the 50,000 undergraduate applications received each year, the university admits just 2,000. The medical school admits just 40 students out of the 40,000 applications received each year. Graduate students must score at least 1,200 on the GRE. Still, the university is proud that most of NUST students come not from elite families but from the middle and working classes.

Currently, eight Ph.D. and four M.S. candidates are focused on energy-related topics and NUST students have internships with the Oil & Gas Development Corporation, Pakistan State Oil Company, WAPDA, a private wind power company, and private hydropower developers.

Quality of Education

As with admissions, NUST is highly selective in faculty recruitment. Assistant, associate, and full professors must have Ph.D.s from universities in one of the twelve top-tier countries as determined by the HEC. The three levels of professorship also have strict requirements on work experience, teaching experience, and authorship of articles in international, peer-reviewed journals. Lecturers must have at least an M.S. from a university in one of the 12 countries.

The university reports that it currently has 21 energy-related courses and 20 energy-related laboratories. Some are located at the main campus in Islamabad and some are at satellite campuses around the country. The following is a list of the schools and their energy-related focus.

- CES (CTL / Biofuels)
- SMME (Solar thermal /EC)
- CEME (Solar/Geothermal)
- SCME (Thin films/ Nano)
- IESE (Biogas / water)
- SEECS (Power engineering)
- SCEE (Hydro power)
- PNEC (Wind rotors)
- RCMS (Modeling)
- CAE (Solar PV/Wind)

Research

NUST places a major emphasis on conducting research and publishing research results. Although quantity is not an indication of quality, NUST is the leading Pakistani university in terms of producing research papers in a comparison of 25 Pakistan universities.

In the energy field, NUST has a number of ongoing research projects. Research priorities for the new Center for Energy Systems are thin films for solar cells, biofuels, fuel cells, and clean coal. In the area of solar thin films, NUST has some ongoing research by a Master's student working with Professor Bilal Khan, head of the Center for Energy Systems and a specialist in thin films. In the area of biofuels, research has resulted in the recent development of a catalyst (and a U.S. patent) that lowers the required temperature and shortens the time for producing biodiesel fuel produced from the *Jatropha* plant.

Also, student research resulted in the design of a unit for converting campus kitchen waste into biogas. The biogas units are being distributed in rural areas of KPK in conjunction with a Pakistani NGO (PCRET) and the University of Calgary, whose involvement is sponsored by a grant from the Gates Foundation.

NUST plans to demonstrate the technology using chicken waste and plans to bring the main PCRET staff member onto NUST's staff.

In the area of fuel cells, NUST offers a 3-unit course (elective) on the subject within the School of Mechanical and Manufacturing Engineering. The course is taught be two faculty members, one from Germany and one from the Asian Institute of Technology in Bangkok. NUST is not presently conducting any research on fuel cells, but is planning to in the future.

In the area of clean coal, NUST has been analyzing coal samples from different areas of Pakistan for sulfur content and wants to build an experimental coal gasifier on campus to conduct research on how to reduce sulfur content in gasified coal.

Partnerships

Partnerships within Pakistan
NUST has five joint research projects with Punjab University in the area of chemical engineering and more than five joint research projects with COMSATS in applied physics. Altogether, the institute has 20 joint research projects with Pakistani universities. Most of the joint projects have been initiated informally as a result of discussions at conferences or personal contacts.

International partnerships
NUST has a few formal partnerships with foreign universities. It has research cooperation with Oregon State University and the University of Calgary, and potential research cooperation on biofuels with M.I.T., which has also offered to conduct some biofuel instruction via teleconference.

Table 7. NUST Partnerships with Foreign Universities

Institution	Energy Focus	Type of Collaboration
Oregon State University	Micro-hydro	Assistance with research & lab upgrade
University of Calgary	Solar thin film & biogas	Joint research & visiting professorship
M.I.T.	Biofuels	Offer from M.I.T. for teaching via teleconference; possible cooperation on biofuel research

Source: NUST

The OSU collaboration is the result of a chance meeting between NUST and OSU professors at an international conference. There is now a joint NSF grant to the two universities, which could expand into a larger 3-year grant. Both universities have thermo-fluid labs, and OSU has offered to help upgrade NUST's lab. OSU is also helping analyze Pakistani hydrological gauge-stream data and is looking to host NUST students. NUST is seeking research partnerships with Arizona State University and Ohio State University on solar energy and advanced renewable energy technologies, respectively.

NUST encourages its faculty to engage in international exchanges with foreign universities. It also participates in three programs that bring faculty from overseas universities: the HEC Visiting Scholar Program; the Ministry of Labor and Manpower's Talent Pool Program; and the Fulbright Short-Term Program supported by USAID.

University of Engineering and Technology -Peshawar (UET-Peshawar)

Institutional Organization and Administration

The University of Engineering and Technology, generally known as UET-Peshawar, is a public, coeducational, university located in Peshawar, the capital of the Khyber Pakhtunkhwa (KPK) province formerly known as the North-West Frontier Province (NWFP). UET-Peshawar is recognized across Pakistan for engineering education. Initially set up as a 'constituent' Engineering College of Peshawar University in 1952, the engineering collage was upgraded in 1980 to the University of Engineering & Technology, Peshawar, an independent degree awarding institution.

UET-Peshawar has strong capacity for project planning based on experience gained during the last 10 years through establishment of research institutions such as National Institute of Urban Infrastructure Planning, Earthquake Centre, Institute of Mechatronics Engineering, and the Gems & Jewellery Development Centre. The six-billion rupees Jallozai Campus project continues today. In the recent past, the university has also established three new campuses: a Technology Incubation Centre, a Public Policy Research Cell, Video Conferencing facility, and Continuing Engineering Education Centre.

Infrastructure and Technology

Information Services Center
The Information Services Center (ISC) was established in 2004 on Peshawar Campus and provides widespread internet and intranet facility to UET. The ISC is equipped with the best available hardware and data resources, has a dedicated 4mb fiber optic-line from the NTC, and a separate 1MB dedicated downlink to serve the data needs of all the campuses. All the three remote campuses have a separate 1mb downlink.

Technology Incubation Center
The Technology Incubation Center offers support services for new entrepreneurs, to start up and run their technology related business. The Center also facilitates faculty and students to obtain intellectual property rights and commercialization of their technology.

Continuing Engineering Education Center
The Center was developed at NWFP UET as an initiative of Higher Education Commission. The CEEC has been functioning since December 1, 2008 and has trained almost 300 professional engineers.

Quality of Education

The university has ten different engineering disciplines for students to choose from. These are supported by laboratories, departmental research, a central library, sports facilities and dormitory accommodation to house students. The degrees awarded by each engineering disciplines are listed below.

Table 8. Degrees Awarded in Engineering Departments

Department	Bachelor of Engineering;	Masters	Ph.D.
Agricultural Engineering:	√	√	√
Basic Sciences & Islamiyat	**Additional Subjects for all degree courses**	×	×
Computer Sciences & IT	√	√	×
Computer System Engineering:	√	×	×
Chemical Engineering:	√	√	×
Civil Engineering:	√	√	√
Electrical Engineering:	√	√	√
Industrial Engineering:	√	√	×
Mechanical Engineering:	√	√	√

Mechatronics Engineering:	√	×	×
Mining Engineering:	√	√	√

UET-Peshawar has three additional campuses, one in Abbottabad and others in Bannu and Mardan. All administrative and operative activities however, are located at the main campus in Peshawar. The Abbottabad campus is the pioneer campus of the university as it was the first to introduce electronic engineering in UET history. At this campus, two degree programs are offered in the fields of engineering: Architecture, City and Regional Planning; and Electronic Engineering. The Bannu campus offers degree programs in Electrical and Civil engineering and the Mardan campus offers degree courses for Telecommunication and Software engineering.

Research

The faculty of Electrical and Mechanical Engineering have undertaken multiple research projects since the early 1970s. Two scholars of UET-Peshawar, Dr. M. Abdullah and Dr. I. H. Shah, have received many awards, including a Pride of Performance, for their work in engineering. Some of the achievements that are a result of UET-Peshawar research and work are:

- The design, building, and installation of micro-hydropower plants in the northern areas of KPK in collaboration with the Pakistan Council of Appropriate Technology (now called Pakistan Council of Renewable Energy).
- The development and dissemination of bio-gas plants and efficient cooking stoves.
- The development of solar thermal technology for space and water heating as well as cooking.

Currently students of departments of mechanical, electrical and chemical engineering are active in energy-related research only at the basic level, with the support of civil, mining, agriculture, and computer sciences. University management is very optimistic that the level of research will strengthen as more and more scholars return from abroad with Ph.D. degrees in all the modern areas of engineering research, including energy systems. The university also has experience in the planning and execution of large projects, such as the Jallozai Campus and the Earthquake Engineering Center. It has collaborated with many universities from developed countries as well as with industry and government departments in such efforts.

Partnerships

UET-Peshawar collaborates with national and international educational institutes for research, student and faculty training, and exchange programs. Universities with whom it has collaborated include:

1. Asian Institute of Technology (Thailand),
2. University of Strathclyde (UK),
3. McGill University (Canada),
4. George Washington University (USA), Universiti Teknologi Petronas (Malaysia),
5. University of Liverpool (UK), and
6. University of Maryland, College Park (USA).

Table 9. Energy Team Gap Assessment

Gaps	Findings	Recommendations
Education Quality: Curricula	• Both universities have solid engineering curriculum • Distinguishing the degree of integration between the various engineering departments is difficult. • Energy courses which are provided within the mechanical engineering, civil engineering, and electrical engineering departments, but are not integrated into an overall energy course of study diminishes the focus of the energy curriculum. • This leads to a bigger problem, that students are not learning what the energy industry needs.	• The energy curriculum should be consolidated and better integrated with energy resource economics and energy policy & management at the NUST Business School. • Undergraduate and graduate degree programs should be established in energy resource economics, policy, and management. • The energy major should be expanded to include instruction on renewable energy, energy management and efficiency, and smart grid. • The curriculum needs input from industry to ensure its relevancy to the country's energy needs.
University partnerships/ links: Industry	• The university has few links with Pakistan's energy industry despite having the NUST VC and EUT rector sitting on the boards of electric utility companies and despite the establishment of university-industry boards. Links that do exist include: o Students internships o Industry reps sit on thesis committees • UET has a research link with the local PEPCO utility regarding the smart grid. • Neither university is advising the energy industry on policy, governance, economics, or engineering solutions.	• Substantial and extensive linkages between the universities and the energy industry should be forged. • The energy industry should be involved in energy-related curriculum, research agendas, community projects, and business incubation. • Both universities should increase collaboration with industry in the identification and carrying out of energy-related research. • Research should be applied and should support the near- and medium-term energy needs of Pakistan.
Community	• Neither university has an energy-related link to a Pakistani community. • IUET had a mini-hydel program in KPK in recent past. • NUST had a solar pumping project in the tribal areas and Baluchistan, but both projects ended without any independent measurement or evaluation of results.	• These two programs are precisely the kind of programs universities should be doing more of. • Programs should continue beyond a semester or academic year. • Programs should be periodically evaluated by independent parties.
Links with domestic and international universities	• Study-abroad programs provide some international links. • Some minimal research linkages exist with other Pakistani universities. • However, neither university has strong linkages to the U.S. and other foreign universities.	• University-to-university linkages should be greatly expanded in terms of joint research and jointly sponsored colloquia, conferences, and forums. • An energy scholarship program should be established for Pakistani students to study energy-related technical or economics/policy topics at U.S. universities.
Student Profiles: Gender	• Women are minimally represented at both NUST and UET-Peshawar. • Of the 12 Ph.D. engineering students at UET-Peshawar, none are female. • The NUST Business School has better female representation.	• Both universities need to engage in major efforts to recruit more females and to encourage pre-university schools to encourage their female students to apply to engineering universities. • Both universities should encourage their female undergraduate students to continue with M.Sc. and Ph.D. programs and provide financial assistance to them if needed.

Water

Center of Excellence in Water Resources Engineering, University of Engineering and Technology, Lahore

The Center of Excellence in Water Resources Engineering at the University of Engineering and Technology Lahore was founded in 1976 by the Government of Pakistan. The Center has awarded 10 Ph.D.s and over 100 Masters' degrees and has a reputation for strength in irrigation and drainage and hydrology.

CEWRE currently awards Masters of Science, Masters of Philosophy, and Doctor of Philosophy degrees in four water-related disciplines:

- Water Resources Management
- Engineering Hydrology
- Water Resources Engineering
- Hydropower Engineering

Current sources of funding include HEC for salaries and development, various sponsors for research, and donors and foreign linkage programs for international events. The water sector in the country is directly (through line departments) or indirectly (through consultants, contractors, NGO's, private organizations) controlled by the federal/state funding and development programs; therefore the effectiveness of higher education in the water sector is dependent on the interaction of faculty with professionals, opportunities for research funding, and job opportunities for the graduates.

Infrastructure and technology

CEWRE includes a Hydraulics Engineering Lab, Hydrology Lab, Irrigation & Drainage Lab, Electric Analogue Lab, and a Remote Sensing Lab. Soil and Water Testing, a Model Tray Hall, a Computer Lab, and Video-Conferencing are also available. CEWRE also maintains a library with 6,986 books; 8 maps; 510 reports, 198 publications, 26 subscriptions to international journals, and 27 subscriptions to local journals.

Research

CEWRE has over 100 publications. They have organized several national and international water-related conferences. The Institute is currently conducting the following projects and studies:

- Spatial and temporal water quality modeling;
- Stochastic flood risk mapping (zoning);
- Hydraulic and sediment simulation of Chasham Right Bank Canal;
- Integrated water resources management for sustainable development;
- Capacity building for research – education – training;
- Regional scale sediment yield modeling using GIS and RS;
- Hydraulic modeling of canal irrigation systems;
- Performance characterization of irrigation systems with GIS and RS;
- Effectiveness of tertiary canal lining and its impacts; and
- Development of operational and management strategies for gravity flow subsurface controlled drainage system.

Partnerships

CEWRE has links with several international universities, including Colorado State University, University of Arizona, University of Illinois, University of South Carolina, Utah State University and links with national

organizations, especially the Pakistan Agricultural Research Council, Pakistan Water Resources Center, Water and Power Development Authority, Irrigation and Power Department of the Province of Punjab, and Water and Sewerage Board of Lahore.

Center of Excellence in Geology, University of Peshawar, Peshawar

Established in 1950, the University of Peshawar provides academic programs in humanities and basic science subjects at the graduate and postgraduate levels. Although it is contiguous to the University of Engineering and University of Agriculture of Peshawar, it is an independent and separate entity.

The University has 6 academic faculties, 43 departments and/or institutes, and 5 five federal centers. It also has numerous affiliated public and private sector colleges, two constituent colleges, a College of Home Economics, and two constituent professional colleges. The University is home to seven research centers:

- The National Center of Excellence in Geology (NCEG),
- The National Center of Excellence in Physical Chemistry (NCEPC),
- The Area Study Center (ASC),
- The Pakistan Study Center (PSC),
- The Sheikh Zayed Islamic Center(SZIC),
- The Center for Disaster Preparedness & Management, and
- The Center of Biodiversity.

The Department of Geology, in association with the Center of Excellence in Geology and Center of Excellence in Chemistry, is a candidate for a COE in Water. The COE/Geology and the old Geology Department are conducting graduate and postgraduates studies in geology and hydrogeology. Being a non-engineering university, they do not have faculty in water resources engineering or dam/hydropower engineering. They supply geologists to carry out geological studies for dam engineering, a strong point in their program. In addition, the University of Peshawar has programs in geology, geotechnical engineering, environmental sciences, and land-use planning and development.

Quality of Education

The University employs 530 teaching faculty. Under the University's Faculty Development Program, currently 26 scholars have been, or are in the process of being sent abroad for doctoral studies.

Working with other departments, the COE Geology has over 15 faculty members specializing in environmental economy, GIS/RS, hydrology, chemistry, watershed management, seismology and earthquake engineering, potable water, river basin hydrology, dam foundation geology and mapping, feasibility studies, climate change, and related areas.

The COE Geology employs two Professors in Mineralogy/Petrology/Geotechnical and Structural Geology/Tectonics. The Center's four Associate and Assistant Professors focus on Carbonate Sedimentology/ Depositional Systems/Clastic Systems/Geotechnical/ Petroleum Geology; Geochemistry; Structural Geology; and Geo-tectonics. The Center's seven lecturers teach Micropaleontology/ Biostratigraphy/ Sequence Stratigraphy; Economic Geology; Stratigraphy / Sequence Stratigraphy; Environmental Geology; Mineralogy/Petrology/ Geotechnical; Geophysics/ Petroleum Geology; and Sedimentology/Paleontology. An additional seven faculty (retired and lecturers) serve on a part-time basis. The COE has identified the need for 10 additional faculty members (one professor, two associate professors, three assistant professors, and four lecturers) to ensure the Center's continued growth.

Infrastructure and Technology

The University has 273 faculty houses and a total of 13 hostels which house 6,000 male and female students. The Central Library contains over 150,000 books in hard copy, and 40,000 e-books. It has access to 23,000 full-text electronic journals. The University also has 43 seminar libraries and provides reference services, internet, and CD-burning.

The COE Geology currently has eight faculty offices, six temporary offices in labs, and two rooms for office staff. The COE Geology has seven existing labs:

- Petrographic Lab with Assembly Research Microscope;
- Sedimentology Lab;
- Computer Lab;
- Chemistry Lab;
- Thin-Section Lab;
- Structural Lab; and
- Paleontology Lab.

It also has four classrooms and a geology museum. The COE employs office assistants, lab assistants and technicians, and a librarian to support these facilities. Additional laboratories and support staff have been identified as necessary for growth.

Research

The University has numerous research publications, with 45 percent of them published internationally. The University publishes the following journals:

- *The Geological Bulletin*
- *PUTAJ*
- *The Journal of Law and Society*
- *The Journal of Economics*
- *The Journal of Science and Technology*
- *The Journal of Faculty of Islamic Studies and Arabic*
- *The Research Journal of SZIC (Urdu/English)*
- *Al-Idah (Arabic)*
- *PASHTO*
- *The Journal of Humanities and Social Sciences*
- *Ancient Pakistan*
- *Central Asia Khayaban*

The COE Geology has over 100 publications, with three recent papers published in international journals (*the American Mineralogist, Journal of Metamorphic Geology*, and *Geohazards*). The Institute provides a field program that includes faculty-supervised field studies in Salt Ranges, Hazara Hill Ranges, Khair-e-Murat Range, Margalla Hill Ranges, and North Pakistan (SWAT, Kohistan and Northern Areas); these programs require that students spend between 7-15 days in the field, depending on their current academic level, with students in their final year spending 5-10 days in the field collecting data as part of a thesis requirement.

Partnerships

COE Geology has links with several international universities, including the Texas Christian University and the Utah State University and links with national organizations, oil and gas companies, mineral departments

and exploration companies. These links provide professional services and technical advice, feasibility studies, and evaluations; however, little outreach and service to the community is conducted. Other linkages include those to NGOs and public sector organizations related to Geology, Hydrogeology, Environment, and Geotechnical Engineering.

Mehran University of Engineering and Technology (MUET), Jamshoro

Mehran University provides academic programs for undergraduates and graduate studies in 17 disciplines of engineering, science and technology. MUET houses five water related Centers: the Institute of Water Resources of Engineering Management; the Civil Engineering Department; the Institute of Chemical Engineering; the Institute of Environmental Engineering; and Mehran University of Science, Technology and Development in addition to a start-up program in Water Policy and a Land Use Planning and Development Program. The Institute of Water Resources of Engineering Management is described below.

The Institute's main activities include teaching, research, and trainings in the field of water sector. Research areas include hydraulics, hydrology, computational hydraulics, agriculture drainage engineering, irrigation water management, wastewater treatment and recycling, groundwater, water quality and water policy and legislation. The core objectives of the Institute are to:

- Continually improve in imparting advanced knowledge through courses and research to the engineers in the fields of water resources, hydraulics, irrigation and drainage engineering leading to award of postgraduate diplomas and degrees.
- Conduct research pertaining to water resources engineering problems and disseminate pertinent results through research journals

Activities and programs are supported by:

- The Mehran University of Engineering & Technology (MUET), Jamshoro
- The Higher Education Commission (HEC)
- DFID, British Council
- National Drainage Program (NDP), WAPDA
- USAID
- The Food and Agriculture Organization (FAO)
- United Nations Environment Program (UNEP)
- UNDP
- WWF-Pakistan
- The Government of Sindh

Quality of Education

The Institute currently has one Professor/Director with a B.E. (SAU), M.E. (MUET), and Ph.D. (Poland), with Post-Doctorate work in the U.S. and Australia. Additional teaching staffs include one individual with a B.E. (China), M.E. (MUET), and a Ph.D. (Japan), one with a B.E., M.E., Ph.D. (MUET), and a Professor Emeritus with a B.E. (NED) and Ph.D. (UK). One associate professor with a B.E. and M.E. (MUET) is on staff.

Mehran University of Engineering & Technology has been certified under the ISO 9001 Quality Management System (QMS) Standard since 2003.

Infrastructure

Available facilities include a number of laboratories, a central library, seminar libraries, an auditorium, seminar halls, and hostel accommodations for foreign and visiting faculty and postgraduate students.

Laboratories
The Institute has three laboratories in hydraulics, soil-water, and river engineering. It also has a field laboratory located near the University Nursery on which sprinkler and trickle irrigation systems and agro-meteorological stations have been installed. The following is a list of the laboratories and a compilation of their current capabilities related to water engineering:

- *Hydraulics Laboratory.* Long Glass Flumes, Long Mobile Bed Flume, Permeability Tank, Basic Hydrology System, Pipe Surge and Water Hammer Apparatus, Sprinkler Test Rig
- *Soil-Water Laboratory.* EC/pH Meter, Tensio-meters and Soil Moisture Meters, Water Level Indicator, Soil Core Samplers, Water Discharge Measurements, Spectrophotometer, Flame Photometer, Electric Oven, Horizontal Sieving Machine
- *River Engineering Laboratory.* Indus River Model, Rainfall Hydrographs, Lysimeter, Infiltration Apparatus
- *Field Laboratory.* Head Control Unit and Pump, Filters and Flowmeters, Main Pipes and Laterals for Sprinkler and Trickle Irrigation Systems on one-hectare area
- *Computing Laboratory.* Computers, software, scanners, printers, Internet facilities
- *Seminar Hall and Library.* Appropriate facilities in seminars, conferences and library materials

Research

The Institute of Water Resources of Engineering and Management, in association with other Mehran University water-related institutes, has produced more than 100 publications. The institutes have organized several national and international water-related conferences.

Research is currently being funded by MUET, USAID, HEC, FAO, DFID, the National Drainage Program (NDP), WAPDA, UNEP, and WWF-Pakistan. The research work is considered indigenous and basic, and sometimes is selected in association with the field requirements of the Irrigation and Drainage Department of the Government of Sindh.

MUET publishes a quarterly, peer-reviewed, journal, the *Mehran University Research Journal of Engineering and Technology*. The journal is indexed by INSPEC, the American Concrete Institute (ACI), the British Library, the Library of Congress, and the Transportation Research Board (TRB).

Faculty members have also participated in a number of international conferences, including:

- International Conferences on Irrigation and Drainage by the U.S. Society for Irrigation and Drainage Professionals (USCID);
- The International Water Technology Conference, Egypt;
- The International Conference on Integrated Water Resources Management, China;
- The International Training on Groundwater Governance in Asia organized by IWMI in India;
- The International Training and Conference on IWRM and Interdisciplinary Water Resources organized by SaciWATERs in Nepal;
- The Knowledge-Sharing International Workshop on Mainstreaming of Spate Irrigation, organized by UNESCO-IHE, Delft, the Netherlands;

- The Knowledge Sharing for Food and Water Security in Asia, organized by International Center of water for Food Security (IC WATER), Charles Stuart University Australia;
- The International Conference on Chemical Engineering & Application, Singapore;
- The International Conference on Chemical Engineering (ICCE 2007), Berlin, Germany;
- The Fourth Asian Pacific Landfill Symposium Sapporo, Japan;
- The 10th International Conference on Environmental Science and Technology CEST Greece; and
- The International Conference on Environment and Circular Economy in Tianjin, China.

Partnerships

MUET is collaborating with the CEWRE at UET Lahore to conduct courses and training in Irrigation and Drainage. Both centers have video conference facilities which enable them to jointly present these programs. The Institute of Water Resources of Engineering and Management have some research collaboration with the four water departments within MUET.

The Institute of Water Resources of Engineering and Management has linkages with the following entities: Colorado State University; Charles Strut University NSW, Australia; Massachusetts Institute of Technology; University of Arizona; Exeter University, UK; Water Center, Hohai University, China; UNESCO-IHE Delft; Global Water Partnership; and International Water Management Institute (IWMI).

Other established partnerships include:

- UN Food and Agriculture Organization (FAO) and SaciWATERs;
- Pakistan Council of Research in Water Resources (PCRWR), Islamabad;
- Pakistan Agricultural Research Council (PARC), Islamabad; Water and Power Development Authority (WAPDA);
- Centre of Excellence in Water Resources Engineering, UET Lahore;
- Sindh Agriculture University, Tando Jam;
- Agriculture University, Faisalabad;
- University of Sindh, Jamshoro;
- QUEST, Nawabshah;
- Sindh Irrigation and Drainage Authority (SIDA);
- Irrigation and Power Department, Govt. of Sindh;
- Agriculture department, World Wide Fund (WWF), Pakistan;
- International Union for Conservation of Nature (IUCN);
- Oxfam GB; NGOs: and
- ActionAid-Pakistan, SAFWCO, SRSP, RDF and Lead Pakistan.

The following tables show how the three universities compare across critical areas (Table 10) and the gaps and recommendations for developing the capacity of the universities to host a Center of Excellence (Table 11).

Table 10. Comparison of the Three Potential Water Universities for a Center of Excellence

Components	MUET IWREM	UPesh Department of Geology	CEWRE/UET/Lahore
Quality of education	Improvement necessary.	Water Resources Engineering is absent in the Department of Geology + COE	Acceptable in Water Resources.
• Faculty qualifications and preparation	Institute of water Resources Engineering Management five Ph.D.s, very little preparation, four centers in water.	Geology + COE of Chemistry, Ph.D.s & M.Sc. levels.	COE in water resources since 1976. 5 Ph.D. Professors + Assistant Professor + Lecturers. Competent in irrigation and drainage. Started M.Sc. in Hydropower Engineering 2000 with visiting faculty. Needs increased numbers of faculty in Hydropower.
• Comprehensive and relevant curricula	Not comprehensive enough with presentations only in Irrigation and Drainage and Hydrology. No coursework on dams. Hydropower Engineering, and water conservation water policy	Not comprehensive enough. Programs only in Geology and not in water-resource engineering.	Curricula are comprehensive.
• Programming	No programming.	No programming except in Geology.	Very little in dam. Engineering and only in Irrigation & Drainage.
Research	Very basic.	Surface Geology mapping for GOP.	Research in Irrigation and Drainage, Ground water in consultation with Irrigation Department and WAPDA.
• Identification of topics	Faculty and students select topics in consultation with the Irrigation Department Sindh.	In consultation with Petroleum and Mineral Industry, OGDC GOP.	
• Dissemination	To some extent through seminars, conferences, training courses.	To some extent through seminars.	To some extent through seminars, conferences, and training courses.
Infrastructure and technology	Building available IWREM + 4 water department labs.	Building, COE Geology + COE. Chemistry labs, needs labs for water resource engineering.	Buildings, Labs, Auditorium, Video conference Centre, computer labs.
• Libraries	State of the art Central Library.	Good library.	Good Library.
• Technology capacity	Labs for graduate level	Have labs for Geology. Water Engineering Lab required.	Technology is acceptable.
• Facilities	Hostels, Hospital, Busses.	Hostel, Hospital, and Residence.	Hostel, Hospital, and Residence.
• Resources	Share with MUET	Share with University of Peshawar.	Share with UET Lahore.

University partnerships • Intra/inter-university • Community • Business • Government • International	To some extent. Weak. Yes. Yes but limited.	Weak. Weak. Yes. Limited.	To some extent. Weak. Yes. Limited.
Institutional org. and admin. • Administration: qualifications and preparation • Accountability: financial management, transparency, checks and balances • Faculty and student recruitment • Student services • Exchanges	A professor is Director Vice Chancellor is Administrator but has no Autonomy. Administration needs preparation training & relevant education. University, Government Audit University and HEC. Students graduate from Civil Engineering Department MUET and Agriculture university, Tando Jam. Faculty mostly from Sindh province. Health, sports, transport, union. Share with MUET. Rare.	A professor is Director Vice Chancellor is Administrator but has no Autonomy. Administration needs preparation training & relevant education. M.Sc. and Ph.D. University, Government Audit. University and HEC Student from Peshawar university. Mostly from KPK Province. Health, sports, transport, union. Share with U Pesh Rare.	A professor is Director Vice Chancellor is Administrator and has autonomy, Board of Directors. Administration needs preparation training & relevant education. M.Sc., M. Phil. and Ph.D University, Government Audit University and HEC. Graduates from all over Pakistan majority from UET, Lahore. Faculty mostly from Punjab. Share with UET Lahore. Rare.
Student profile • Access • Diversity, incl. gender • Educational backgrounds	Competition admissions. Minimal number of female students. Graduates in Civil Engineering and Agriculture	Competition for admission. A few female students. Graduates.	Competition for admission, test, interview. A few female students. Graduates in Civil Engineering and Agriculture

Table 11. Water Team Gap Assessment

Gaps	Findings	Recommendations
Security	Universities have serious security issues.	Strengthen and maintain monitoring of security measures and intelligence gathering.
Admissions Procedures	Admission is based largely on demographics and not on academic or social achievement or potential, resulting in a large number of unqualified students pursuing advance degrees.	Emphasize academic and social achievement over discriminatory demographic quotas and equity.
Teacher Training	Teachers have poor instructional techniques and depend largely on boring assignments, lectures, and rote memorization and regurgitation.	Provide and monitor teacher training in instructional skills and practical teaching so that graduates can independently identify, solve and implement water-resources challenges for their employers.
Research	Research is generally irrelevant to Pakistani conditions and funded by arbitrary, poorly thought out donor grants.	Encourage and monitor research proposals and progress to assure they apply to Pakistan conditions.
Outreach	Outreach to stakeholders and beneficiaries is generally inadequate or completely lacking.	Promote and monitor significant outreach programs to share the knowledge and expertise with stakeholders and beneficiaries
Inter-Departmental, Inter-University and International Linkages	Linkages are generally very limited, inadequate, or completely lacking.	Promote and monitor to improve linkages within and across university departments, within and across Pakistani universities, and internationally with US and other foreign universities; improve administration to coordinate with other departments and universities; improve inter-faculty research and curricula to encourage students in cross-disciplinary fields
Faculty Selection	Faculty are generally academicians and are hired based on degrees, publications and years of experience; they typically have little or no teaching experience, practical knowledge in engineering problem identification and solving, relevant research and significant outreach activities.	Reform the process to identify, solicit, hire and retain faculty who have good teaching skills and practical, relevant knowledge and abilities rather than simply available with degrees, publications and experience years
Faculty Gender, Minority and Disability Mix	Few women, minority and faculties with disabilities are found in the engineering programs.	Improve efforts and monitor progress to encourage qualified women, minority and faculties with disabilities to enter and succeed in engineering programs. Improve accessibility of environment and infrastructure.
Student Gender, Minority and Disability Mix	Few women, minority and disabled are found in the engineering programs.	Improve efforts and monitor progress to encourage qualified women, minority and students with disabilities to enter and succeed in engineering programs. Improve accessibility of environment and infrastructure.
Facilities for Women and Minorities and Disabled	Facilities for women, minorities and the physically-challenged are limited, inadequate and in some cases not available.	Improve facilities for women, minorities and disabled, including private, social, prayer and toilet facilities which are lacking.
Faculty Publications	Faculty publications are generally academic or irrelevant to Pakistan.	Encourage and monitor faculty publications which are relevant to Pakistan.

Gaps	Findings	Recommendations
Faculty Participation in International Conferences	Faculty participation in international conference which often appear irrelevant to Pakistan.	Encourage and monitor participation in proposals for faculty international conferences to assure they are relevant to Pakistan.
Faculty Advancement	Faculties generally are quite old and past retirement age; no processes are in place to advance younger faculty.	Encourage and monitor younger faculty advancement if they are good teachers with practical skills and relevant research.
Libraries and Computer Centers	Libraries typically consist of publications, indexes and computer listings of publications; computers typically have old and antiquated software.	Improve library and information technology capacity with online databases (not just listings of library holdings) and modern computers and software, including numerical modeling, USEPA EPANET, and other engineering software.
Laboratories	Laboratories are generally antiquated and conduct irrelevant or impractical research.	Improve laboratories including forensic and environmental capabilities, and practical and relevant laboratory research.
Field Stations	Field stations are generally antiquated and conduct irrelevant or impractical research.	Encourage field stations to modernize and conduct relevant research and demonstration projects, not the current project interruptus which depends solely on donor initiatives often irrelevant to Pakistan
Policy, Governmental Affairs and Hydropolitics	Water-resources policy, governmental affairs and hydropolitics are not taught or researched.	Encourage policy and governmental affairs training in several areas, including hydropolitics, perhaps with linkages to better-prepared private universities like IBA and LUMS in Lahore.
Community Linkages	Few community linkages are apparent.	Improve Pakistani university linkages, industrial and community linkages, taking advantage other universities, industry and community participation.
Funding	Funding is nearly exclusively from government, nominal fees and donors.	Enhance endowments and fund-raising, and private sector incubators and spin offs to raise funds and improve facilities and scholarships. Seek ways for the universities to become sustainable through innovation and participation rather than current isolation.
Portfolio-based Certification	Portfolio assessment of prior learning without additional professional development does not increase teacher quality; rather it has become a welfare program to raise teacher salaries.	Introduce on-going professional development post-certification (i.e., induction) for beginning teachers.
Creativity	Professors generally are poor role models in imparting creative, imaginative, innovative teaching methodologies that would prepare potential teachers to transfer knowledge and skills to the classroom.	Establish and support a *Center for Effective Schools* in each university to lead teacher education program improvements and guidance.
Facilities	University facilities for teaching practice are inadequate and outdated.	Improve the teacher education facilities institutions, particularly their facilities, libraries, laboratories, and classrooms.
Capacity	Professors confirmed that training is needed in a range of innovative teaching methodologies, new technologies, and classroom observation techniques.	Create a professional development program for professors based on the new performance standards.

SECTION V. FINDINGS AND CONCLUSIONS[32]
Selection and Development of Centers of Excellence

Agriculture

Despite impressive achievements and academic progress in agriculture universities, the need is there for a true paradigm shift in agriculture education and research that focuses directly on the needs of small and medium farmers, including pursuit of innovation in credit/market linkages, intermediate and appropriate technology, sustainable farming systems, and value-added interventions that link fully with water and energy concerns. Further attention must also be given to adaptive research related to existing farming systems, including development of mangroves, *jatropha,* and other agroforesty and forestry systems that are well-adapted for Pakistan's vast high salinity areas. UAF and SAU are keen to develop new and expand existing partnerships with leading U.S. universities, to secure long-term research funding from the Punjab and Sindh Governments and to assist the COE to develop productive linkages with institutions in other countries across the Indus Valley region and around the world that have similar interests and mandates.

Findings

Using a gap assessment, the Agriculture Team scored both candidate universities on a matrix. UAF scored 60 percent out of 100 percent and SAU scored 37.6 percent out of 100 percent.

The detailed assessment of UAF and SAU shows that, on balance, UAF outperforms SAU in several key areas outlined here:

- Faculty qualifications: UAF has a larger faculty (593 as compared with SAU's 254). Some 288 (48%) of the faculty members hold Ph.D.s from local/foreign universities, compared with 55 at SAU (22%).
- Faculty research and publications: The HEC currently scores UAF as the top-ranked agriculture university in Pakistan and the third highest-ranking university in the country based on the number of research papers in the natural sciences in peer-reviewed journals (66.4% out of 100 as compared with 39.3% for SAU on HEC ranking of universities) published.
- Faculty national and international linkages: UAF has established partnerships with several U.S. universities and is also the lead university in a recently signed MOU with Monsanto for development of new biotech crop varieties suited to needs of Pakistani farmers.
- Campus infrastructure and IT connectivity: UAF provides better research and teaching infrastructure than is the case in SAU. The lecture theatres, laboratories, equipment, IT facilities, libraries, research farms, green houses and hostels are all better, partly due to UAF being a more-established university and partly due to the location in the heart of Faisalabad, a large industrial town of Punjab.
- Vibrancy: Much activity is taking place in UAF in celebration of the 50th anniversary of the institution in 2011. The university has already organized more than 100 national and international. There is a widespread feeling of dynamism and vibrancy in the air. During the evaluation team's three day visit,

[32] This section includes a vision for sectoral work in the technical areas that would lead to a 'transformational change' in the country over the next 10 to 30 years together with specific technical recommendations to achieve that vision. The major recommendations of the Team are summarized in the concluding Recommendations section.

UAF was hosting an international conference on Food Science and received delegations including the Punjab Chief Minister, US Ambassador, and Vice-Chancellors of two other universities.

SAU, on the other hand, is a more down-to-earth institution with a local perspective, more committed to providing farmers with reliable seed supplies and, for areas underlain by salt water, new crops and crop varieties that are adapted to saline conditions.

Conclusions

Identified Center of Excellence

The Team recommends that the University of Agriculture, Faisalabad be chosen to host the Core Agriculture COE, to receive 75 percent of COE funding. The Sindh Agriculture University, Tando Jam, is recommended to host the affiliate COE, to receive 25 percent of COE funding.

Table 12. Funding Scenario for Agriculture Center of Excellence

Line Item	USD	Core UAF	SAU Affil.
Staff and administration with Director @ $40,000/yr	500,000	375,000	125,000
Lab equipment and machinery under a COE-Univ MOU	500,000	375,000	125,000
Lab supplies and inputs for research farms	50,000	37,500	12,500
Procurement of germ-plasm, technology traits, etc.	200,000	150,000	50,000
Faculty and staff capacity building and training	1,100,000	825,000	275,000
Graduate student scholarships, fellowships, assistantships	1,000,000	750,000	250,000
Workshops, seminars, and conferences	500,000	375,000	125,000
Upgrading of library under a COE-Univ MOU	600,000	450,000	150,000
Upgrading of IT facilities under a COE-Univ MOU	200,000	150,000	50,000
On-farm agro-ecosystem research trials	200,000	150,000	50,000
Field surveys and social research studies	500,000	375,000	125,000
Outreach, advertising, community services, field trips	1,200,000	900,000	300,000
Performance-based incentives for COE faculty and staff	100,000	75,000	25,000
Miscellaneous	350,000	262,500	87,500
Total	**7,000,000**	**5,250,000**	**1,750,000**

Recommendations

Proposed Focus Areas for Core and Affiliate COE

The following course/program/subject areas are proposed for the Core COE in UAF:

- Adaptation of Crop and Livestock Systems to Climate Change.
- Precision Agriculture.
- Agricultural Extension, Land Tenure and Population, Credit, and On-Farm Research.

The following subject areas are proposed for the affiliate COE:

- Development and Extension of Appropriate Technology, including adapted seeds
- Center for Biosaline Agriculture
- Molecular biology, as applied to the diagnosis of animal and zoonotic diseases

This mix of subject areas plays on strengths of both universities but also pushes the universities toward new frontiers and fills the gaps in existing programs. UAF already has one course on climate change and

water resources as well as several courses on watershed and water resources management. A climate change focus at UAF is likely to include both watershed modeling and the development of crops that are better adapted to changes in the environment. SAU has one HEC-funded molecular biology lab that has begun work on Crimean-Congo Hemorrhagic Fever, but funding has ended. The lab has the potential to develop an effective vaccine within the next decade and to become a national diagnostic laboratory for tick-borne diseases, leading to cost recovery potential and increased national and international prestige. SAU also has an incipient Center for Biosaline Agriculture, but remains woefully underfunded to adequately address the issue of cropping systems adapted for the estimated 35 percent of Sindh soils affected by salinity.

Practical Outreach Activities

- Work with private firms such as Syngenta that have their own farmer-targeted extension teams to a) provide training of extension agents on best practices related to the use of agri-chemicals in different agro-ecosystems, and b) teach extension agents to guide farmers to employ precision agriculture methods and integrated pest management strategies, leading to improved farm income and optimal use of purchased inputs.
- Relying on faculty, student researchers, and farmers implementing on-farm trials, identify water-efficient crop varieties and more efficient uses of irrigation water for various soil and crop conditions. Thereafter, use on-farm demonstrations, videos, radio and other means to promote findings to the farming community.
- Create editorial teams that will translate relevant journal articles into appropriate English and Urdu that can be readily understood by a wide array of farmers. In many cases, authors of journals articles may first need to revise their articles to include farm-relevant recommendations when possible.
- Encourage outreach staff at affiliated universities to develop appropriate technology packages adapted to the various crops, soils, and water conditions within each district of each province. For example, staff might acquire, for resale to farmers in saline areas, a low-cost portable electrical conductivity meter for assessing soil and water salinity levels and seeds or other plant stocks for saline and drought tolerant crops such as *Jatropha.*
- Develop a range of university-based extension services that farmers would be willing to purchase, such as vaccinations for livestock, with the idea of spinning off student trainees into their own service businesses whenever possible.
- Develop a range of value-adding tools and technologies that can either be accessed at university research farms or marketed to farmers, such as extrusion of *Jatropha* and cottonseed oils.
- Work with local newspapers, radio, and television to develop regular media releases on farm-related issues.

Suitable U.S. Institutions for Establishing Partnerships with the COE

The following U.S. universities already have ties with the UAF: 1) Cornell University (Norman Uphoff: SRI Rice); 2) Oregon State University 3) Purdue University; 4) Texas A&M University (Ed Price and Norman Borlaug: Inst. for Int'l Agriculture); 5) UC Riverside; 6) University of Idaho; 7) University of Nebraska, Lincoln; and 8) Washington State University. SAU has ties with the University of Rhode Island (Thomas Mather, Vector-Borne Diseases).

The following organizations also have prior or present experience in Pakistan: IFPRI (Pakistan-IFPRI Advisory Council @Pakistan Agricultural Research Council); Southern Illinois University (TIPAN Project); University of Illinois Champagne-Urbana (TIPAN project); and the World Wildlife Fund (WWF-Pakistan already has ties with NUST).

In addition to the U.S. universities/organizations listed above, the following additional universities and institutes are proposed for developing partnerships with Core and Affiliate COEs: 1) Harvard Kennedy School of Government; 2) Iowa State University, Ames; 3) Rodale Institute; 4) University of California-Davis; 5) University of Wisconsin (including the Land Tenure Center and Center for Integrated Agricultural Systems); 6) the U.S. Department of Agriculture (USDA); and 7) World Resources Institute.

Energy

Crucial findings in this sector are that issues around energy are much less technical than policy- and management-related. Specifically, energy policy is not being addressed in Pakistani universities where crucial social sciences are largely absent or neglected. Major disconnects exist between universities and the energy industry and between universities and communities. Thus a COE for energy must serve the nation as an Energy Policy Think Tank with strong connections to industry and U.S. universities and organizations in energy research and policy, especially in the areas of power sector governance, mini-hydel, bioenergy, solar, wind, energy efficiency, and fossil fuel plant performance. The sector should also have linkages with the Agriculture COE in the area of biofuels, in particular *jatropha* cultivation and biodiesel production.

Findings

Despite being centers of knowledge and expertise in engineering and business management, Pakistani universities have not played a strong role in the solution of the country's energy problems. Establishment of an energy Center of Excellence could play an important role in production of engineers with practical skills relevant to Pakistan's energy sector. It can also engage in policy and regulatory analysis and development that pinpoint policy and governance constraint, thereby enabling the provision of appropriate recommendations to overcome them.

With both the technical and policy imperatives in mind, the Team appraised two universities, the National University of Sciences and Technology (NUST) and the University of Engineering and Technology (UET) Peshawar, to determine the appropriate candidate for the site of an energy Center Of Excellence. Both universities have a base of energy-related engineering curricula, laboratories, and research on which to build a Center of Excellence.

Strengths:

- Both NUST and UET-Peshawar have solid engineering curriculum. NUST's engineering instruction is highly regarded and is highly rated by HEC. The NUST Business School is likewise highly regarded.
- NUST is doing some relevant and useful research on bioenergy and solar thin films.
- UET-Peshawar is doing some relevant and useful research on mini-hydel and energy efficiency.

Challenges:

- A disconnect exists between universities and the energy industry. Many graduates do not have the requisite engineering skills on leave-taking.
- A disconnect exists between universities and the country's energy policies and institutional management. Focused energy policy work does not exist at any Pakistani university.
- A disconnect exists between Pakistani universities and the world outside their gates. The universities are insular and do not form partnerships with each other or with local communities.
- Neither NUST nor UET-Peshawar offer any degree programs or courses in energy policy, governance, or management.

Conclusions

- Policy is as important (if not more important) than the engineering aspect in the sector; an energy policy think tank is needed.
- Connections between universities and industry are needed beyond internships and thesis review committee representation. Industry needs to be involved in the Center of Excellence in curriculum development and energy-related research.
- Currently, NUST rests on a stronger engineering, laboratory, and policy base than the UET-Peshawar.

Identified Center of Excellence

The Team recommends that the National University of Sciences and Technology (NUST) be designated as the Center Of Excellence, further recommending a name change to the Center for Energy Policy and Technology Development (the 'Energy Center'). The Team found NUST to have strong energy-related curricula and a strong energy research base, although both areas could be strengthened. An additional on-campus faculty, the NUST Business School, could serve as the seat for establishment of an Energy Policy Project. The Team further supports the designation of the UET-Peshawar as an affiliate of the NUST Energy Center to receive a portion of USAID funding and support. UET has a similarly strong engineering curriculum and some relevant research initiatives that are worth expanding in coordination with NUST.

Secondly, the Team recommends that the joint NUST-UET Energy Center focus on four components, listed here in the order of importance:

1. Energy policy analysis and development.
2. Energy curriculum development.
3. Faculty and student exchanges, scholarships and forums.
4. Energy research.

Energy policy analysis and development, which includes issues of governance and management, is ranked at the top of the list because most of the individuals interviewed agreed that Pakistan's energy problems have less to do with engineering knowledge and capacity than they do with governance, management, and energy policy and regulation issues in the sector.

Activities to Foster Institutional Capacity Legacy

The Energy Center should support applied research designed to directly benefit Pakistan in the near- and medium-term. Research conducted by faculty and graduate students should be the highest priority, followed by research by Ph.D. and M.Sc. candidates while the funding of basic undergraduate research should not be a priority. Potential COE research areas are shown in the figure below. Research linkages between NUST and UET-Peshawar are essential; joint bioenergy research is almost self-evident, but there may be other linkages as well.

Recommendations

Based on the comparative ranking summarized in the chart below, NUST scored higher and should therefore be designated as the energy Center of Excellence while UET-Peshawar should be designated as an affiliate.

Table 13. Comparison between NUST and UET-Peshawar.

	Curriculum	Faculty	Research	Laboratories	Policy Program	Management Training	Campus Energy Projects	US Univ Linkage	Pak Univ Linkage	Industry Linkage	Community Linkage	TOTAL
NUST (0-5)	3	5	3	4	2	4	1	2	1	2	2	**29**
UET (0-5)	3	5	2	2	1	1	1	1	1	1	2	**20**
Weighting (1-3)	3	3	3	2	3	3	1	1	2	3	2	
NUST weighted	9	15	9	8	6	12	1	2	2	6	4	**65**
UET weighted	9	15	6	4	3	3	1	1	2	3	4	**51**

COE Recommendations

- The Center of Excellence should have a stronger focus on policy, curriculum and partnerships and relatively less on R&D.
- The COE organization and structure should involve all relevant departments at both NUST and UET-Peshawar (See summative framework below).
- A COE Board of Governors should be established with strong representation from industry as well as from the government and the local communities.
- An Energy Policy Project should be created at the NUST Business School
- Energy-related curriculum, especially in energy economics, policy and management, but also in technical areas of direct relevance to Pakistan's energy industry, should be improved and expanded.
- Energy fora, debates, and colloquia should be held, partnerships with U.S. universities, institutions, and companies established, and energy-related scholarships provided.
- The process of becoming a COE should move the NUST and UET-Peshawar campuses themselves towards more sustainable energy, water, and environmental practices.
- The financial resources allocated for a COE should be used initially for policy-oriented curriculum development (with new faculty), linkages to industry, and U.S. scholarships
- The HEC should institute periodic independent reviews of the performance of the COE.
- Research should focus on Pakistan's current and future energy needs.

The COE should support research that is not limited to the laboratory, but also uses the community as a research setting; both UET-Peshawar and NUST already have some experience with this. NUST installed solar systems on the rooftops of KPK households, while UET-Peshawar installed micro-hydel systems in KPK. Unfortunately, an opportunity to do field research for this assessment was not possible; therefore no data was collected on the performance of these systems, whether their operability declined and, if so, why. These are the kind of research projects that should be encouraged and supported by the energy COE.

Potential U.S. universities for Energy Partnerships

The Team offers the following universities and programs for consideration as potential partnerships in energy.

1. Stanford University, Palo Alto, California
   a. Program on Energy & Sustainable Development

   b. Precourt Energy Efficiency Center
   c. Steyer-Taylor Center for Energy Policy and Finance
   d. TomKat Center for Sustainable Energy & Energy Solutions
2. University of Delaware, Newark
   a. Center for Energy & Environmental Policy
   b. University of Delaware Energy Institute
   c. University of Delaware Institute of Energy Conversion
3. Energy Resources Group, University of California, Berkeley
4. Energy Systems Analysis Group, Princeton University, Princeton, New Jersey
5. Joint Global Change Research Institute, University of Maryland, College Park
6. The Center for Energy and Environmental Studies, Boston University, Massachusetts
7. Energy Policy Institute, University of Chicago, Illinois
8. Virginia Tech Advanced Research Institute, Blacksburg, Virginia (smart grid)
9. Iowa State University, Ames (wind simulation & testing)

One way to connect with these universities would be to first connect with expatriate groups in the U.S. such as the Pakistan Caucus at the Harvard Kennedy School, to seek contacts and introductions at the universities.

Other U.S. institutions that may be considered for potential energy COE partnerships:

1. Electric Power Research Institute, Palo Alto, California
2. Lawrence-Berkeley National Laboratory, Berkeley, California
3. National Renewable Energy Laboratory, Golden, Colorado
4. National Association of Regulatory Utility Commissioners, Washington D.C.
5. The Tellus Institute/Stockholm Environment Institute, Boston, Massachusetts
6. Joint Institute for Energy & Environment, Knoxville, Tennessee
7. Biomass Energy Resource Center, Montpelier, Vermont
8. The U.S. Green Building Council, Washington D.C.

Additional Recommended Linkages: Private Sector

The Association of Energy Engineers (AEE), Atlanta, GA

Although not a university, the AEE offers training and certification for professionals practicing in the fields of energy management, renewable energy and green buildings. The 'Certified Energy Manager' designation is well known in the U.S. and indicates that the individual is capable of performing energy audits of buildings and facilities. One of the first steps the energy COE could take is to become the Pakistan chapter of the Association of Energy Engineers. A number of international chapters have already been formed, but not in Pakistan.

Potential linkages with industry

Pakistani industry

The energy COE should have strong links to the Pakistan energy industry, with industry representatives on the Board of Governors of the COE and involvement in the design and delivery of the energy curriculum. Short course instructors or guest lecturers from WAPDA, PSO, NTDC, the Pakistani distribution companies, the independent power producers, the renewable energy industry, and power project engineering firms will enhance the COE energy curriculum and ground it in the reality of the Pakistani energy sector.

Through USAID, the COE should seek to connect with the U.S. Trade & Development Agency, which sponsors reverse trade missions for representatives of foreign industries to visit U.S. industries. These

trade missions can be beneficial because they include private sector specialists but also can include university faculty. Although the purpose of the USTDA missions is to promote the export of U.S. products and technologies, they also foster interactions between the faculty and the industrialist participants on the tour. Few opportunities currently exist for these kinds of interactions between Pakistani academics and industrialists; being on a trade mission together has the potential to carry over into working relationships and mutual support well after the trade mission is over.

U.S. Industry

The Energy Center should seek to create links to U.S. industries for the purpose of receiving research assistance, briefings/lectures on emerging technologies, presentations at COE-sponsored conferences, teleconferences, and internship and job placement. The topic of smart grid technologies and applications provides one example of a link with U.S. industry. The following is a sampling of U.S. companies that could be engaged for the above purposes.

Engineering companies:

1. Burns & McDonnell, Vienna, Virginia
2. AECOM, Los Angeles, California
3. POWER Engineers Inc., Hailey, Idaho
4. Parsons Brinckerhoff, Inc., New York
5. TRC Companies Inc., Windsor, Connecticut
6. Tetra Tech Inc., Pasadena, California
7. Black & Veatch, Overland Park, Kansas
8. URS Corp., San Francisco, California
9. HDR Inc., Omaha, Nebraska
10. Stanley Consultants, Muscatine, Iowa

Controls and Smart Grid components:

1. General Electric, Fairfield, Connecticut
2. Utility Integration Solutions, Lafayette, California
3. Telvent, Fort Collins, Colorado
4. Trilliant, Redwood City, California
5. ABB (U.S.), Cary, North Carolina
6. Open Access Technology International, Minneapolis
7. IBM, Armonk, New York
8. Tendril, Boulder, Colorado
9. Astaro Corporation (U.S.), Wilmington, Massachusetts
10. ESCO Technologies, St. Louis, Missouri
11. Emeter, San Mateo, California
12. Cisco Systems, San Jose, California

Funding Scenarios

A very preliminary funding scenario, based on cost estimates and submissions from NUST and UET-Peshawar, comes to USD 16,716,000. The estimate is dominated by the energy research agendas of the two universities. The figure also shows three funding levels assuming USAID annual contributions are the only source of resources. The scenario does not show in-kind contributions from NUST or UET-Peshawar in the form of teaching staff, facilities, etc., although the 20 percent addition for administration and overhead would cover some of those costs. Given the research emphasis, there is proportionately less funding for teaching, scholarships, or holding conferences and workshops. An alternative to this approach would be to eliminate research as a function of the COE and have research find its own funding. Although

the COE will be headquartered at NUST, USAID should consider using funds to support UET-Peshawar as an affiliate. This preliminary break-down does not attempt to define how much would go to each university; that recommendation would need to be made after a more thorough appraisal.

Table 14. Funding Scenario for Energy Center of Excellence

			Annual USAID Contribution		
	Budget Item	**Full Program**	**$7,000,000**	**$5,000,000**	**$3,000,000**
1	Faculty & honoraria	100,000	100,000	80,000	80,000
2	Fundraising	20,000	20,000	20,000	20,000
3	Conferences, workshops, study tours	750,000	500,000	300,000	290,000
4	Scholarships & fellowships	2,000,000	2,000,000	1,000,000	500,000
5	Research & Lab equipment	11,000,000	3,150,000	2,705,000	1,555,000
6	Outreach to media, industry, community	50,000	50,000	50,000	50,000
7	Office equipment & supplies	10,000	10,000	10,000	5,000
8	Admin & overhead @ 20percent	2,736,000	1,166,000	833,000	500,000
	TOTAL	16,716,000	6,996,000	4,998,000	3,000,000

Water

The most important finding of the Water Team is that a water crisis is at hand in Pakistan, with the population growing exponentially while available water per capita is dropping dramatically. As with Agriculture and Energy, policy issues frequently trump technological constraints, evident in both the floods and droughts of recent years. Old but ingenious irrigation systems have shown remarkable resilience, but have been overwhelmed by larger issues of water management that are the result as much from man-made as from natural disasters. Key recommendations for COE priorities point to a focus on the following:

1. *Addressing Policy Constraints* to avert an emerging water/population crisis
2. *Practical* education and training in water resources
3. *Research* relevant to country needs
4. *Effective* outreach to promote dissemination of knowledge and results of research
5. *Links* to U.S. water-resources universities
6. *Forums* to promote cooperation for regional and transnational management of water, energy and agricultural resources

Findings

Pakistan will need to develop, refine, and implement modern water resources management principles including integrated water resources management, scientific agriculture and efficient off- and on-farm water management, watershed management and best management practices. These will need to include, among other issues, water sequencing, flood and drought early warning and monitoring and response, water pollution prevention and water safety management and response, and wastewater collection and treatment. Pakistan needs a strong and robust water-resources information collection and management database supported by highly trained and incentivized administrators, managers, engineers, scientists,

technicians and support staff and equipment. Such human resource capacity emanates only from premier higher education colleges, universities and training centers that currently are not generally available in the country. Higher education receives a very small federal budget and most of Pakistan's highly trained technical people are consequently educated and trained abroad with many choosing to not return to Pakistan.

Building on the existing Pakistan Higher Education Commission facilities, identifying and nurturing premier or COEs is one of several possible remedies for the water sector in Pakistan. Organizing such Centers as focal points with satellite extensions where practical would provide better equity and parity and take advantage of the dispersed though limited expertise in this highly diverse country. Moreover, the water sector is quite diverse in itself, including, for example administration, management, engineering, laboratory sciences, health and environment, agricultural and industrial issues, information technology, economics, soil and water science, law, and so on. This suggests that a diverse set of satellite supporting centers would be more appropriate than a centralized and limited focal point that could not otherwise meet all the multiple requirements and demands of a modern water resources management system. Involving the private and public sector and linking them to outstanding international universities and organizations, which may ultimately employ higher education graduates in the water field, could contribute to potential innovation, impulse, and sustainability of such initiatives.

Currently no comprehensive water Center of Excellence exists in Pakistan. However, Lahore has a limited COE in water resources that could be expanded; its strength is in irrigation and drainage. There is a national demand for more comprehensive expertise, such as dam engineering, hydropower engineers, sediment management, conjunctive water use, water conservation and judicious use, groundwater balance, water quality, wastewater engineering, safe domestic water supply, etc. Reportedly, nowhere in Pakistan is instruction on the Indus Water Treaty and the Water Apportionment Accord being offered, although provincial debates on water distribution and hydro-politics are going on. These subjects are not taught anywhere at the higher level in Pakistan. Public Health programs provide some expertise in public health issues related to water; hence the requirement of a comprehensive COE in water resources.

Conclusions

The Water Team's major conclusion is that a water crisis threatens the environment, economy and society of Pakistan. As reported by both the Agriculture and Energy Teams, policy issues around water trump technological constraints, evident in both the floods and droughts of recent years as well as in stagnating incomes and environmental degradation.

Several existing Pakistani institutions appear interested and capable of contributing to a Center of Water Excellence with satellite supporting centers, including those located in Islamabad (NUST, PIEAS), Peshawar (UPesh), Jamshoro (MUET), and Lahore (UET); others may also be potential candidates. These institutions already have water resources curricula, although they are typically underfunded and have restricted access and opportunity. They struggle to find and retain the bright faculties and students needed to advance the understanding of water research and break away from the traditional, pedagogical approaches. However, given the ongoing and long-term security and instability issues in the country, it would be prudent to be extremely cautious in selection and implementation of COEs to avoid unnecessary risks. In addition, none of the mentioned universities have ongoing formal programs to train or teach their students or faculty in communication skills, teaching or presentations.

Table 15. Water-related Courses Across Three Universities

	Geology, Geotechnical Engineering	Chemical Engineering	Civil Engineering	Environmental Engineering or Sciences	Hydropower	Irrigation and Drainage Engineering	Land Use Planning/ Development	Water Policy
Geology COE, UPesh – Peshawar, Peshawar Province*	YES			YES			YES	
COEWR/ UET – Lahore, Punjab Province**					YES	YES		
MUET UET – Jamshoro, Sindh Province***		YES	YES	YES		YES	YES	YES

*UPesh also has a Center of Excellence in Chemistry. **UET, Lahore has strong departments in Civil Engineering, Chemical Engineering, Geology and Geotechnical Engineering, and Land Use Planning/ Development.
***MUET UET, Jamshoro is just starting up a Water Policy program. This information is based on a review of the literature, interviews, and site visits.

Pakistan's level of competitiveness is in the bottom third of countries ranked in the 2007-2008 Global Competitiveness Index.[33] The economy has not improved and competitiveness has stagnated. Human resources are particularly weak, and business competitiveness is getting weaker.

The following table presents a comparison across three Universities (MUET, IWREM & U PESH Department of Geology) in each technical area.

[33] World Economic Forum. (2008). *Competitiveness Support Fund, State of Competitiveness in Pakistan Report 2008: Creating Sustainable Economic Growth*.

Table 16. Comparison of Three Water COE/Universities

Components	MUET IWREM	U PESH Department of Geology	CEWRE/UET/Lahore
Quality of education • Faculty qualifications and preparation	Mediocre. Institute of Water Resources Engineering Management: 5 Ph.D.s, very little preparation, 4 centers in water.	No Water Resources Engineering Department of Geology, COE Geology , COE of Chemistry and no Ph.D. & M.Sc. levels.	Acceptable in Water Resources. COE in water resources since 1976. 5 Ph.D. Professors + Assistant Professor + Lecturers. Competent in irrigation and drainage. Started M.Sc. in Hydropower Engineering 2000 with visiting faculty. No faculty in Hydropower.
• Comprehensive and relevant curricula	Not comprehensive. Has curricula only in Irrigation and Drainage and Hydrology. No dams, Hydropower Engineering, water conservation, or water policy	Not comprehensive. Only in Geology. Not in water-resource engineering.	Curricula comprehensive.
• Programming	No programming	No programming except in Geology	Very little in dam engineering. Only in Irrigation & Drainage.
Research • Identification of topics	Very basic. Faculty and students select topics in consultation with Irrigation Department Sindh.	Surface Geology mapping for GOP. In consultation with Petroleum and Mineral Industry, OGDC GOP.	Research in Irrigation and Drainage, Ground water in consultation with Irrigation Department and WAPDA.
• Dissemination	To some extent via Seminars, conferences, training courses.	To some extent via Seminars.	To some extent via Seminars, conferences, training courses.
Infrastructure and Technology	Building available at IWREM + 4 water department labs.	Building, COE Geology + COE Chemistry labs. No labs for water resource engineering.	Buildings, Labs, Auditorium, Video conference Centre, computer labs.
• Libraries	State of the art Central Library.	Good library.	Good Library.
• Technology capacity	Labs for graduate level.	Labs acceptable for Geology. No Water Engineering Lab.	Technology acceptable.
• Facilities	Hostels, Hospital, Busses.	Hostel, Hospital, and Residence.	Hostel, Hospital, and Residence.
• Resources	Share with MUET.	Share with University of Peshawar.	Share with UET, Lahore.

University partnerships • Intra/inter-university • Community • Business • Government • International	To some extent. Weak. Yes. Yes limited.	Weak. Weak. Yes. Limited.	To some extent. Weak. Yes. Limited.
Institutional org. and admin. • Administration: qualifications and preparation • Accountability: financial management, transparency, checks and balances • Faculty and student recruitment • Student services • Exchanges	A professor is Director Vice Chancellor is Administrator. No Autonomy. Administration needs preparation, training & relevant education. University, Government Audit University and HEC Students graduate from Civil Engineering Department MUET and Agriculture university, Tando Jam. Faculty mostly from Sindh province. Health, sports, transport, union. Share with MUET. Rare.	A professor is Director Vice Chancellor is Administrator. No Autonomy. Administration needs preparation training & relevant education. M.Sc. and Ph.D. University, Government Audit University and HEC. Student from Peshawar university. Mostly from KPK Province. Health, sports, transport, union. Share with U Pesh. Rare.	A professor is Director Vice Chancellor is Administrator. Autonomy, Board of Directors. Administration needs preparation training & relevant education. M.Sc., M. Phil and Ph.D. University, Government Audit University and HEC. Graduates from all over Pakistan majority from UET, Lahore. Faculty mostly from Punjab. Share with UET Lahore. Rare.
Student profile • Access • Diversity, incl. gender • Educational backgrounds	Competition for admission A few girl students Graduates in Civil Engineering and Agriculture	Competition for admission A few girl students Graduates	Competition for admission, test, interview. A few girl students Graduates in Civil Engineering and Agriculture

Recommendations

Practical Outreach Activities

- Promote regional and transnational water resources policies and management processes to encourage peace and security with neighbors and other countries, e.g., Afghanistan, Bangladesh, China, Iran, Nepal, and Tajikistan.[34]

[34] Along the lines of *The Blue Peace: Rethinking Middle East Water* from the Swedish International Development Cooperation Agency, 2011.

- Promote highly visible, high impact programs with good success stories.
- Add value; be effective and visible in Pakistan's core water issues to improve the country's economy and competitiveness.
- Take advantage of distance learning and video conferencing capacities to provide greater access, link distant institutions, and overcome security constraints.
- Sponsor connecting conferences with broad and interesting themes such as 'The Road to Peace' through Regional Water Management, Increasing Pakistan's Competitiveness and Economic Growth through Water Management, Improving Pakistan's Water Resources and Use Knowledge Base from Glaciers to the Sea, etc.
- Carefully review and implement feasible and practical recommendations made by water-resource experts who have been studying these issues in Pakistan for months and even decades, for example, the FODP, John Priest, Mirza Asif Baig, Muhammad Siddique Shafique, Ramchand Oad, Ross Hagan and others.
- Promote water-user to user workshops and exchanges.

Potential U.S. Partner Institutions

The Water Team contacted approximately 40 U.S. universities which had water-resource areas of specializations, based on: 1) recommendations made by CEWRE-Lahore, MUET-Jamshoro, UPesh-Peshawar, HEC, and USAID; 2) JBS-provided lists of U.S. universities with experience working with USAID in education programs involving water in South Asia and the Middle East; 3) review of Pakistan water-related publications; and 4) professional contact. The following U.S. universities responded with interest to participate as partners in future roles:

U.S. Water-Oriented Universities that expressed interest in linking/ partnering with Pakistan a COE/Water:

- Colorado School of Mines, Golden. Colorado.
- Colorado State University, Fort Collins, Colorado.
- Emory-Georgia Tech-CARE at Carter Center Consortium, Atlanta, Georgia.
- Massachusetts Institute of Technology, Cambridge, Massachusetts.
- New York University/ Polytechnic, Brooklyn, New York.
- Oregon State University, Corvallis, Oregon.
- Texas Agricultural & Mechanical, College Station, Texas.
- Tufts, Boston, Massachusetts.
- University of California at Berkeley, California.
- University of California at Davis, California.
- University of Michigan, Ann Arbor, Michigan.
- University of Nevada at Las Vegas, Nevada.
- University of North Carolina, Chapel Hill, North Carolina.
- University of South Carolina, Columbia, South Carolina.
- Utah State University, Logan, Utah.
- Washington State University, Pullman, Washington.

Funding Scenarios

Table 17. Funding Scenario for Water Center of Excellence

			USAID Annual Contribution		
	Funded Activity	**Percent of total**	**USD 3,000,000**	**USD 5,000,000**	**USD 7,000,000**
1	Administration/ coordination	20	600,000	1,000,000	1,400,000
2	Additional or improved classrooms	10	300,000	500,000	700,000
3	Additional or improved laboratories, computer software, computer hardware and peripherals	10	300,000	500,000	700,000
4	Workshops, seminars, conferences, information exchanges	10	300,000	500,000	700,000
5	Pakistan water-sector relevant research	10	300,000	500,000	700,000
6	Graduate student scholarships, fellowships, assistantships	15	450,000	750,000	1,050,000
7	Additional faculty or faculty incentives, honorariums, etc.	10	300,000	500,000	700,000
8	Outreach, advertising, promotions, community services, field trips, water-user to water-user exchanges	15	450,000	750,000	1,050,000
	Total	100	3,000,000	5,000,000	7,000,000

Cross Cutting Recommendations

Fulbright Scholarships as the Bedrock for COEs

The Pakistan Fulbright program, the largest in the world, has had a major impact on higher education in Pakistan and provided support and sustainability to early Pakistan/U.S. partnerships in higher education for development during the decades when donor and national funding was limited. Furthermore, contrary to the conventional wisdom regarding the issue of 'brain-drain' or the best and the brightest leaving the country after receiving a quality overseas education, the Fulbright program has demonstrated an extremely high rate of return and retention over the decades since it began in the 1950s. Among 542 Fulbright Masters and Ph.D. alumni for whom data is available, over 90 percent have returned to work in Pakistan.

According to the U.S Educational Foundation/Fulbright office (USEF), the private sector employs the largest proportion of alumni: 137 are working in local or multinational organizations), including banking, engineering, telecommunications, publishing, media advertising and service industries. Of these, 20 have chosen to strike out on their own by setting up freelance consultancies in various fields, such as animation, law, journalism and photography. Of 126 alumni in the education sector, 51 are teaching in public sector universities throughout the country and 75 are teaching at various private institutions. The Government of Pakistan absorbs 76 alumni as judges of the civil courts, in various ministries (such as Finance, Foreign Affairs and Education), in the State Bank of Pakistan, as police officers, and among various other departments including the Federal Board of Revenue. The development sector accounts for 59 alumni, 26 of whom are working with international organizations including the World Bank and the United Nations, while the remaining 33 alumni are working with NGOs. Four alumni, having completed their two-year terms in Pakistan, are currently employed or undergoing further education abroad. Among recent alumni, 72 are unemployed; among these individuals, many are still weighing options and offers after recently returning to Pakistan. USEF has been unable to contact 45 alumni, who have returned to Pakistan but are currently unreachable. Nine alumni are still in the U.S. after completion of their grants. Another nine

grantees abandoned their programs without completion of their degrees. Four grantees have withdrawn and one grantee passed away during the program.[35]

The assessment team identified a shortage of human resources as a critical issue within each of the three areas under discussion, Water Resource Management, Energy and Agriculture. The establishment of the Centers will take some time, but initiatives to train the required type of professionals can begin immediately under the Fulbright Scholarship Scheme. It is encouraging to note that USEFP has already announced that the Fulbright scholarship selection process for the year 2012 will focus on the priority areas of Agriculture, Energy, and Water.[36]

It is recommended that the Fulbright Selection Committee in Pakistan be kept in the communication loop during the process of awarding scholarships so that individuals in the appropriate sub disciplines identified by the assessment team within each area are targeted. Preference may be given to the candidates from the provinces of the proposed locations of the COEs and the Affiliate Institutions, which will facilitate their placement at the most suitable places after return. This well trained and appropriately placed network of specialists will form the bedrock for the organic growth and sustainability of the COEs and the whole network.

Private Sector

The private sector, Pakistan's engine for growth and development, represents a largely untapped resource for the improvement of higher education. Critical partnerships between universities and private sector actors, mutually beneficial for both parties, will ensure that the training and specialization supported by the COEs responds to the needs of the growing private sector. The higher education sector will benefit from private industry's innovation, drive, and ground-level perspective of national needs, while private sector players will take advantage of the significant human resource development and research to improve production in all technical sectors.

A survey of the private sector identified the following strengths of the higher education system that the private sector is currently able to benefit from:

- The intellectual level at professional staff at the selected universities is adequate in terms of the numbers of Ph.D.s.
- Collaborations with some foreign universities have been initiated.
- The practice of placement of interns in industry for training opportunities is also growing.
- Some consultancies and contracted research are occurring in the private sector environment.

However, the same survey identified the following gaps at universities which diminish the ability of the private sector to work closely with academia and constrains further partnership opportunities between the two sectors:

- Faculties have more theoretical knowledge than practical ability; therefore they are limited in their ability to respond to ground-level needs.
- Continuous up-dating of technology is not being done.

[35] US Educational Foundation Fulbright Program data courtesy of Rita Akhtar, Director, personal communication, December 13, 2011

[36] Funds For NGOs. (2011). *2012 Fulbright advanced degree scholarships available for Pakistani graduates*.

- Curricula, training, and research programs are not oriented to the specific needs of the technical sectors.

Operation of COEs to Facilitate University-Private Sector Partnerships

To create an environment for enhanced partnership opportunities between the proposed Centers of Excellence and private sector actors, players on both sides of the partnership need to be actively involved. Both will also need to alter certain current patterns of behavior that do not encourage mutually beneficial interactions.

The Centers should have autonomy to operate in a participatory process with well-qualified international universities and local industries, sharing technology and joint funding through public-private investment mechanisms. In conjunction with identified private industry bodies, the Centers will need to identify the areas that are most crucial to the development of the national economy and meet citizens' most urgent service needs. Issues identified in this report provide specific recommendations of the most vital national needs in each of the three technical sectors. The following action plan is suggested:

a. Address issues of national economy through targeted smart curricula, research programs, and executive development programs that respond to the principal national priorities in the three broad technical areas.

b. Procure relevant technology from foreign universities and upgrade the faculty of the COEs.

c. Produce appropriately-trained graduates and develop research programs that meet the specific needs of industry.

To support strengthened partnerships between higher education institutions and the private sector, the following recommendations are made:

- Build capacity of university staffs at proposed COEs: Upgrading and applying knowledge on the part of the academic and research staffs at COEs is a priority for the development needs of the country. As the private sector is the main provider in the agriculture sector and is a growing partner in the energy and water sectors, any efforts to improve the supply and quality of human resources and research to increase production in the technical sectors should quickly yield benefits. Collaborative arrangements with U.S. universities can supply the advanced and targeted knowledge and technology needed to upgrade the sectors.

- Prepare the private sector for the targeted participation of universities through an advocacy or public relations campaign: Targeting the private sector will make them aware and encourage openness to engage with the higher education sector. Such efforts to encourage more private sector involvement with higher education institutions need to be seen in terms of fulfilling private sector interests: increased returns to investments, material gains, and meeting of business objectives.

- Provision of modern technology in each sector: To complement upgrades in training, it is necessary that the most current equipment, tools, and instruments in each technical area be provided. Where equipment is present but not effectively used, specific training should be undertaken to ensure that students know how to use the equipment. The joint provision of equipment by university and private sector actors is encouraged to increase ownership (and therefore usage) to directly benefit identified needs in the community.

For the initial focus of efforts, the assessment team makes the following recommendations for priority areas and technical sectors for attention. These should be, however, 'ground-truthed' based on a more intensive local investigation of needs and interests of beneficiaries.

- Agriculture: yield enhancement, harvest and post-harvest technologies, and supply chains.
- Energy: hydropower generation, alternative energy, independent generation, co-generation, and transmission and distribution.
- Water: resource prospecting, dams and infrastructure building technologies, water quality, and environmental engineering.

SECTION VI. SUMMATIVE FRAMEWORK
Overall Program Approach

Implementation Options for COEs

The Pakistan Higher Education Commission and USAID/Pakistan plan to establish Centers of Excellence in the three areas of Agriculture, Energy, and Water Resource Management. Based on the assessment of seven shortlisted universities, the JBS Assessment Team, at a joint meeting with HEC and the USAID Mission on December 2, 2011, proposed the following three options for establishment of Centers of Excellence at selected host universities:

1. Three stand-alone COEs, one each in Agriculture, Energy, and Water Resource Management.
2. Three sector-specific COEs, with three or more affiliate COEs.
3. A multi-sectoral COE as the lead university campus with multiple affiliates.

The team received some tentative indication from HEC-USAID that Option 2 might have particular merit. Members of HEC and the USAID Mission emphasized that it was critical that the new COE capacity be set up with a governance structure that will enable Directors of new COEs to perform in line with HEC and Mission targets. The Executive Director of HEC repeated this message in a wrap-up meeting on December 7, 2011, suggesting that it be preferable for recruitment of Directors who have significant private sector management experience and that the COEs be subject to private sector standards of accountability and results-oriented performance.

Three alternative approaches to COE governance are outlined below, keeping in mind that:

a) Performance of the existing 12 COEs in Pakistan has on the whole been less than stellar, and

b) Specific legal structures and details are within the purview of a design mission, not the current assessment.

Regardless of which of the three options selected by HEC and USAID, COE governance should be designed to support the following principles:

- Build on the existing strengths of the selected universities/ institutions.
- Promote interdisciplinary approaches in teaching and research.
- Ensure efficient resource utilization through sharing and pooling of resources.
- Emphasize relevance to the present and future needs of the society as envisioned collectively by the stakeholders, particularly of the relevant sector/s.
- Provide an opportunity for participation of all partners and stakeholders in decision-making.
- Extend boundaries to the society at large through open dialogue, action and outreach.
- Promote a climate within higher education that enables the establishment of creative policy Think Tanks with strong social science components that promote high-level strategic dialogue on higher education policy.
- Support policy and institutional development to enhance gender equity, quality, transparency and accountability within the Agriculture, Energy, and Water sectors.

- Ensure quality, transparency and accountability to the same levels across the board.
- Enhance trust between institutions of higher education, the government, and society.
- Ensure participation of young qualified professionals.
- Promote and enforce gender and disability equity.
- Develop a scheme for the sustainability of the COEs after the project period.
- Design the COEs in terms of a compatible legal framework.

The Team also poses three alternative legal approaches for consideration for structuring new COE capacity. These are compared in Table 17 below:

A) Autonomous entities, based on the Not-for-Profit Federal Law, Section 42.

B) University-owned institutes.

C) Autonomous entities, based on existing Centers of Excellence Law (as in the 12 existing COEs).

Table 18. Three Alternative Governance Structures for Center of Excellence Capacity

	Pros	Cons
A Center for Advanced Studies and Research (CASR) as an autonomous institute created by the host university under its own statutes.	• Participation of all stakeholders with the Director recruited from outside the host university. • Minimum university representation, only 2/16. • Academic, financial, administrative autonomy. • A dynamic board and director to provide leadership in all areas. • Can hire the Director, faculty and staff on own prescribed terms and conditions. • Some administration issues, joint appointments, etc. can be handled by the university. • Critical issues, sustainability etc. can be handled by university.	• Extent of autonomy and freedom to research and promote outside the box thinking may be less than that of a not-for-profit entity whose legal underpinning does not derive from the university. • Conflict resolution between host university and the autonomous institution may be biased in favor of the university. • As in the not-for-profit, a CASR relying on co-appointments of host university faculty to fill its staffing roster may lack the institutional foundation of a 'bricks and mortar' institution as with a Classic COE that has its own full-time faculty and independent degree-awarding capacity. • To the extent that this type of CASR relies on host university budget lines, a less entrepreneurial ethic may prevail.
Center for Advanced Studies and Research (CASR) as a Not-for-Profit formed Under Section 42	• Operates as a Not-for-Profit autonomous entity with its own board. • Board selects its own Director. • Autonomy enables more freedom to formulate policy. • Better situated to engage and respond to a range of stakeholders outside the university. • Fewer conflicts of interest. • Board likely to be younger, better-trained, more entrepreneurial, and innovative and therefore able to thrive.	• Must do own funding raising, therefore, has a greater risk of failure than if entitled to budget from the host university. • Generous 'launch' funding from a single donor may make the CASR less entrepreneurial and less likely to develop alternative donors or revenue during and after the launch years. • If conflict arises with the host university or the government, impartial mediation may be difficult to implement. • If member faculty are employees of the host university, autonomy may not be robust and commitments part-time.

Center of Excellence (COE) formed Under Centre of Excellence Act 1974/1976	• COE operates as an autonomous entity capable of taking actions independent of the host university. • Ability to hire own staff may confer more cohesion and staying power than might be found in a not-for-profit CASR that relies on joint-appointments with few full-time staff. • Ability to confer and qualify own degrees.	• Much higher overheads than a not-for-profit CASR, so less efficient use of funds. • More insular over time without the imperative to continually network and show results to donors and other clients. • The Center of Excellence Act mandates a conservative board which is unlikely to use outside-the-box thinking. • Devolution to province law creates risk and uncertainty and compounds accountability issues.

Option A: CASR organized as a Not-for-Profit (NfP) Entity on the host university campus

With respect to funding and longer-term sustainability, unlike the existing Centers of Excellence set up as COEs under Federal Law, it is suggested that the more flexible NfP approach will succeed by virtue of its director being recruited from a private sector/management background. This type of COE entity will be called a Center of Advanced Study and Research (CASR). A CASR would be set up on property leased from the host university at no cost. The CASR would have very low administrative costs. Host university faculty would compete for membership. Those chosen for co-appointments would earn no additional salary from the CASR but would likely have better access to research funding and to research forums.

This sort of CASR will collaborate with the host university and other universities/CASRs, institutes, and existing COEs and other stakeholders to ensure that a multidisciplinary, multi-sectoral approach is embedded in research design and grant applications. The CASR, acting on the advice of co-appointed faculty members and other stakeholders, functions more as a mentoring and funding pass-through entity rather than as 'research shop' in its own right.

On the other hand, CASRs, once in the business of funding policy research on host campuses, will convene Policy Think Tanks on their own premises to ensure that a modicum of independence is maintained for policy formulation activities. Legal and organizational details are described in the full report, as is a 24-person board that would be drawn from a diversity of stakeholders. In some cases, the board will use selection criteria to ensure that at least one-third of board membership will be women, and as much as half the board will be drawn from researchers who have earned an advanced degree or served with a Post Doctorate in the past eight years.

Option B. Center for Advanced Studies and Research (CASR) as a University Institute

Under this option, COE capacity would be established at selected host universities with the understanding that the COE would be organized as an on-campus institute that belongs to the university and functions as such. All staff would be university employees, although a director with entrepreneurial skills could in theory still be hired from the private sector. Faculty could still apply for co-appointments and selection criteria could be employed to bring in younger and female faculties who have earned an advanced degree within the past eight years. However, as a university institute subject to the usual protocol relating to seniority, this CASR would be less likely to have women and younger researcher on the board and staff than would an Option A CASR.

On one hand, a university institute would, from an institutional perspective, be more sustainable, as the university would likely be more obligated to provide salary and other support once it was set up. On the other hand, in this time of uncertain support from the Federal Government, government universities need additional sources of funding, not additional overhead. The principal question then is which of the three options would be the most entrepreneurial and the most likely to actively search for outside funding. Seen from this perspective, the university institute is likely to be the least entrepreneurial and this may be

reinforced if the board is older and less recently educated. This sort of CASR would likely have a Board of Advisors rather than a Board of Governors.

Option C. Center of Excellence (COE) Under Centre of Excellence Act 1974/1976

If set up under the Centre of Excellence Act of 1974/1976, the resulting COEs would be autonomous entities existing on host university campuses. However, the law states that the director will be appointed by the Federal Government in consultation with the Vice Chancellor of the host university and the Commission. The Law also lays out a fairly rigid formula for Board of Governors membership, stipulating that the Vice Chancellor of the host university will not only be on the COE BOG but will also be the Chairman. This provision suggests that it would be difficult for the COE to function at arms-length from the university. The eleven other BOG members stipulated by the Act are also unlikely to consist of young, recently trained faculty. The law may allow additional members of a BOG to be added to those required by the Act; however, the requirement that the Vice-Chancellor chair the BOG and have a say in the appointment of the director augurs poorly for allowing COE faculty to engage in 'out-of-the-box' thinking. The goal of departure of highly innovative thinking from the university's standard operating procedures may be diminished. On the other hand, as the BOG may meet only twice a year, a strong-minded director with dedicated staff could be more independent than the director of a relatively independent NfP CASR BOG who, in turn, must rely on a CASR-membership still paid by the university.

Agriculture Summative Framework

As part of the Team's overall assessment of implementation options, the Agriculture Team looked for innovative ways that an Agriculture-Water-Hydropower network of COEs could become more self-sustaining through dynamic linkages to existing research networks in the larger region. These are reflected in the overall Summative Framework options explored above. Specific to consideration of an Agriculture COE, the Team noted that the Indus River Basin, which annually provides 105 million acre feet of irrigation water to the world's largest irrigation system, seemed to be the most obvious integration point for both Pakistan's agroecosystems and those portions of the Indus Basin in the three other riparian countries, Afghanistan, China, and India.

The Team understands that Pakistan's agriculture is intimately interwoven with Indus River Basin water resources and these resources are very much subject to climate change. Thus, rather than identify one Pakistani university to host an agriculture COE or alternatively one lead COE and an affiliate, the team concluded that any new agriculture COE/COE-affiliate investments needed to be underlain and integrated from the very start by a commitment to the concept of Integrated River Basin Management (IRBM).

UAF's Vice Chancellor listed climate change as one of three focal areas for a UAF-based COE. At SAU, the team was informed of catastrophic flooding for the past two wet seasons as well as the salinization of about 35 percent of Sindh Province's cropped land. With a focus on integration of the Indus River Basin for the agriculture, water and hydropower COE-network, the team reasoned that IRBM was a gap in knowledge and expertise at both UAF and SAU that could be 'mentored' by a COE linkage to the Center of Excellence in Water Resources Engineering, University of Engineering and Technology, Lahore, as well as to the International Centre for Integrated Mountain Development (ICIMOD) in Nepal.

Two Ways Forward for USAID

In this context, the Agriculture Team explored two options, included in the overall framework above, to be considered as ways forward for HEC and USAID:

Option A: Work closely with UAF and possible affiliates to establish a core agriculture COE at UAF with affiliates at other universities or research institutes. This will eventually span the entire Indus Basin, leveraging, for example, existing agriculture market linkages between Eastern Afghanistan and Pakistan and

a common interest among all countries in the region to conserve and sustainably manage water resources within the Basin.

Option B: Work closely with UAF and MUET (and possibly NUST) to create an Agriculture and Water (and possibly Energy) COE network that leverages existing capacity at lead universities but which is also quick to address inter-sectoral dependencies. This option includes the need to link the COE investment to existing capacity in policy formulation as well as to affiliate universities or institutes to achieve both adequate geographic coverage and the accompanying stakeholder ownership and linkages. This approach is more complex but should yield significant inter-sectoral synergies, more institutional sustainability and a greater likelihood of eventual impacts on national and regional policy.

Agriculture Center of Excellence activities

The overall program or activity approach would involve the following proposed foci**:**

1) Focus on needs of small-medium farmers:
    - Credit/market linkages
    - Appropriate technology and dissemination of existing research findings in Urdu
    - Sustainable farming systems
2) Climate change
    - Indus Basin time series Remote Sensing: glaciers, forests, crops, water
    - Adaptation: genomics, plant breeding
3) Modeling and policy formulation
    - Linkages: population growth-water-land-energy
    - Genetically modified/adapted crops
    - Land tenure
4) Possible affiliate COE at Sindh Agriculture University with a focus on Biosaline Agriculture and Agroforestry or, alternatively, at KPK Agricultural University, which may have greater institutional capacity than SAU but which has a smaller client agricultural area unless training of Afghan students is considered.

COE Design and Management

Each COE/COE affiliate should be set up on the participating university campus as an independent, not-for-profit institute. The director should be drawn from a business or administrative background so that self-sustainability is attained, and the COE is designed to operate as any competitive commercial organization is. The COEs and their affiliates should survive the end of initial USAID funding by adopting an entrepreneurial business model that involves a mix of professional grantsmanship and, when realistic, the marketing of professional services, such as research studies and monitoring and evaluation services.

The relocation of the Mehboob-ul-Haq Institute from Islamabad to the LUMS campus is an example of how an independent not-for-profit institute can be situated on a university campus in a manner that promotes mutually beneficial synergies.

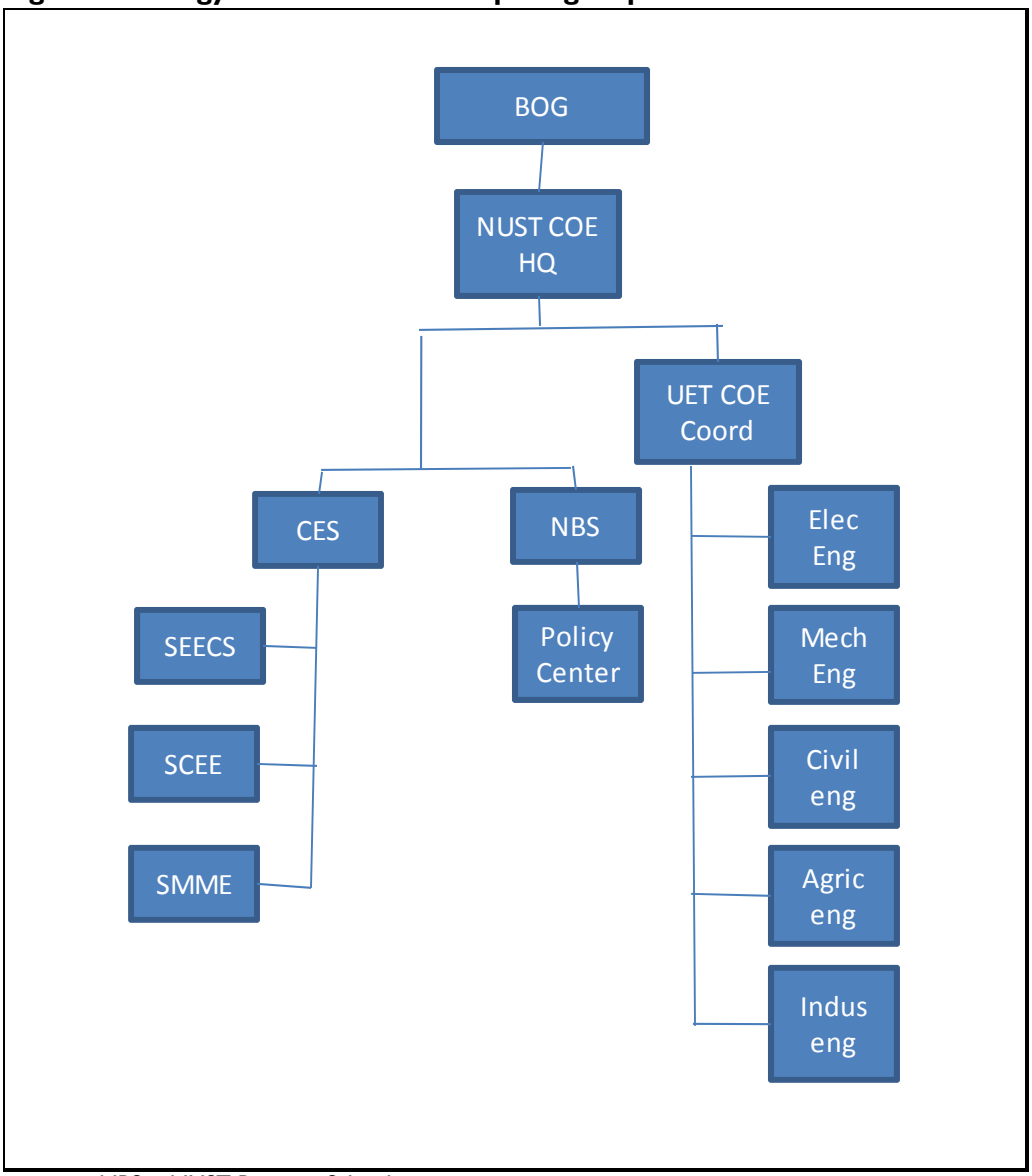
In either plan A or Plan B above, the design of the COEs will require a locus of coordination and management that is relatively independent of university politics and agenda, to support the need to harness existing capacity at the universities to conduct excellent technical research into a broader, more multidisciplinary research network.

Energy Summative Framework

NUST recently established a Center for Energy Systems (CES) by drawing together the engineering schools. The CES should represent the technical component of the center of excellence, while the NUST Center of Policy Research in the business school should represent the policy component.

The organizational chart below in Figure 3 shows the major departments in each university that would participate through faculty and curriculum in the energy COE. Each department would appoint a faculty member to serve as a liaison to the COE to assist coordination of curriculum development, research, and outreach activities.

Figure 3. Energy COE - Main Participating Departments



NBS = NUST Business School
SCEE = School of Civil and Environmental Engineering
SEECS = School of Electrical Engineering and Computer Sciences
SMME =- School of Mechanical and Manufacturing Engineering
CES = Center for Energy Systems
BOG = Board of Governors

As with the agriculture and water COEs, the Energy COE will have an executive director and a small staff (See budget section below), and will be overseen by a board of governors (BOG). Since the COE will operate under the rules of NUST and UET-Peshawar, and since those universities will be contributing faculty, facilities, and their good names, they will have budgetary authority over the affairs of the Energy COE, in collaboration with USAID and other major funders. The BOG will serve in an advisory, oversight, promotional, and fundraising role. It will help set priorities, directions, and next steps which the funders and university administrations should take seriously.

Members of the BOG will include administrators from both universities, the COE executive director, and representatives of industry, government, and the community. The Team believes the industry connection is so important that they recommend that the BOG consist of four members, including the BOG chairman from private industry with one of the other members representing the renewable energy sector. The government representatives should include the chairmen of WAPDA and the HEC. The BOG should thus be composed of:

- Chairman of the BOG (from private energy industry),
- COE Executive Director,
- One representative appointed by NUST (vice chancellor or dean or faculty member),
- One representative appointed by UET-Peshawar (vice chancellor or dean or faculty member),
- One representative appointed by HEC,
- One representative appointed by WAPDA,
- Three representatives of private industry (e.g., energy project developers, suppliers, contractors, IPPs),
- One representative appointed by the Ministry of Water and Power,
- One representative of civil society or an NGO from Punjab, and
- One representative of civil society or an NGO from KPK.

Total: 12 members

The BOG should have four committees reflecting the mission of the COE, policy analysis, research, curriculum, and partnerships/scholarships/events, plus a fundraising committee. Membership on a committee should not require membership on the BOG.

An important task of the BOG will be to ensure that all COE activities are linked to industry, local communities, provincial and national governments, and other Pakistani universities. A possible model can be found in the Iowa Alliance for Wind Innovation and Novel Development (IAWIND), a consortium of universities and colleges engaged in policy, training, research and testing, linked with major stakeholders (see Figure 4).

Figure 4. The Iowa Alliance for Wind Innovation & Novel Development

Source: Iowa Alliance for Wind Innovation and Novel Development (2011).

Given the mixed record of centers of excellence in Pakistan, the HEC should hire an independent organization or consulting firm to periodically appraise the performance of the COE. The HEC should also establish performance indicators against which the COE's performance, including the Board of Governors' performance and the working relationship between NUST and UET-Peshawar, can be evaluated.

Energy Center of Excellence Activities

The Team further recommends that the joint NUST-UET center of excellence be called the **Center for Energy Policy and Technology Development** ('The Energy Center') and focus on four components in the following order of importance:

1. Energy policy analysis and development.
2. Energy curricula development.
3. Faculty and student exchanges, forums & partnerships.
4. Energy research.

Policy is listed first because if the energy COE is to play a major role in the solution of Pakistan's energy problems, then tackling policy and regulatory issues are primary. Pakistan's energy problems do not require engineering solutions so much as improvements in policy and performance.

The policy issues should also be reflected in university curricula, which are listed second. The curricula fostered by the energy COE should also address basic best technical practices in electric power supply, modern natural gas development and supply approaches, contemporary wind turbine design, and so forth.

Third are faculty and student exchanges, which involve exposing the academic community to the latest thinking on energy matters and bringing energy-related professors, industrialists, analysts, and researchers from the U.S. to give lectures, run workshops, and teach short courses on contemporary energy topics. This category would also encompass more cross-fertilization among Pakistani universities on energy matters through conferences, seminars, etc.

Research is listed as a fourth priority because it is expensive and could easily consume all the funds allocated for the energy COE. Building laboratories and buying equipment is important, but would need additional funding in any case. Nevertheless, the energy COE should support some highly specialized applied research which should build on the existing research strengths at both universities that are most relevant to Pakistan's energy needs.

The COE should orient all components, policy, curriculum, partnerships and research, towards contribution to Pakistan's energy and economic development, while also limiting environmental and social damage. Thus, within the energy field, priorities should be:

- Energy sector governance and management;
- Energy efficiency in the generation, transmission, distribution, and end-use of energy;
- Hydropower development, including small and mini-hydro;
- Smart grid, including electricity theft detection and reduction, transmission automation, demand response, energy storage, advanced metering, and integration of renewable energy into the grid;
- Bioenergy development, including biogas from municipal waste and biofuels from energy crops;
- Large-scale wind power development; and
- Solar energy development, including both hot water heating and photovoltaic (PV) power generation.

Policy analysis & development

An Energy Policy Project (EPP), housed at the NUST Business School (NBS), would be an interdisciplinary center for policy research, analysis and development focusing on Pakistan energy policy/regulation and comparative energy policies/regulation in other countries. The purpose of the EPP would be to assist to identify ways to meet Pakistan's energy needs and foster economic growth while limiting negative environmental and social impacts.

The EPP would involve participation and inputs from faculty in economics, business, physical sciences and engineering schools to conduct research, analysis, debate, and public discussion on relevant energy topics. It would issue policy reports that are coordinated with, and peer reviewed by, industry, government, and civil society and that contain recommendations for improving government policies and actions in energy. A media effort needs to accompany these efforts to inform the public and spotlight initiatives in Pakistan energy policies, assisting them to move in a positive direction.

Curriculum

The energy COE will need to review the curricula at both universities and develop an energy engineering track and an energy policy and management track that can lead to undergraduate and graduate degrees. An energy engineering curriculum can be established that provides instruction on various energy sources, conversion technologies, and improvements in efficiency, while an energy policy curriculum can focus on comparative energy law, energy resource economics, and issues of governance and management in the Pakistani energy sector.

Faculty & student exchanges and events

The Energy COE would sponsor, promote, and catalyze a range of activities to enhance the knowledge and skills of faculty and skills alike. The exchanges would consist of hosting energy experts from the U.S. to teach seminars and short courses on select energy topics. Exchanges in the other direction are important as well, although both NUST and UET-Peshawar already send students to U.S. universities for semesters or years abroad. The energy COE would help open doors to Pakistani Masters and Ph.D. students at some of the U.S. universities that have energy programs, such as those listed as the end of this paper. Finally, the energy COE would be involved in sponsorship of a series of colloquia and conferences for students and

faculty across Pakistan on both technical and policy topics in order to foster cross-pollination and collaboration among Pakistani universities.

Research

A research program fostered by the energy COE would build on the existing research strengths of NUST and UET-Peshawar and focus on applied research relevant to Pakistan. The Energy Team's assessment documented the research strengths of the two universities and a link where the two should collaborate on joint research.

Both universities are involved in energy research beyond the subjects identified. In particular, both universities conduct research and outreach on hydropower but the energy COE will not be able to provide monetary support for those. Even these five areas may be too many given the total limited level of funding anticipated.

Water Summative Framework

The summative framework was developed for the establishment of successful a Centers of Excellence for the Government of Pakistan on behalf of the HEC. This framework provides four options: 1) a stand-alone COE/ Water, 2) a core COE/ Water with affiliates; 3) one master COE /COE to administer funds and provide national direction; and 4) simply fund existing scholarship, fellowship, training and exchange programs in water.

In choosing a Center, the factors that facilitate the effectiveness of such activities and programs include availability of infrastructure, faculty, competent/ effective leadership, standards, sustainability, linkages, and stakeholder satisfaction. Factors that would constrain the effectiveness of COEs include low motivation of university leadership and instructors, poor security, a bureaucratic hierarchy, poor instruction, irrelevant or mundane research, no teacher training, no outreach, and a poor reputation with employment entities that prefer to hire foreign-trained engineers.

This framework requires that the COEs minimize administration and bureaucracy costs. They must also break down the departmental and inter-university barriers within the universities. The COE needs to involve the private sector and employers through commitments and needs to emphasize practical teaching/ learning, Pakistan-relevant research, and outreach/ exchange programs. Finally, the COE needs to teach the art of teaching, communication, and outreach to overcome the poor quality of Pakistani current practices.

The overall program or activity approach must maximize contact and exchanges with U.S. universities for the best, long-term and sustainable results and impacts. A potential activity which could span several years and decades would be to promote a regional peace initiative based on transnational water and other resource management which impacts a large area either regionally or geographically such as the Indus Basin. Such an initiative, similar to existing programs in progress in the Eastern Mediterranean, have been successful in attracting multi-donor and NGO funds and engaging universities, government ministries, and other academics, scholars and politicians.

The framework would have MUET-Jamshoro as the COE/Water with COE/Geology UPesh and CEWRE/UET Lahore as affiliates. The college of Lahore University Management Sciences (LUMS), Institute of Business Administration (IBA-Lahore) would be included for policy support and university departments of public health for sanitation support. Additionally COES would:

- Aim for *practical* teaching, Pakistan-*relevant* research and *community and stakeholder* outreach. Most of the USAID contribution to funding should be allocated to instruction (especially U.S. university scholarships), research, and outreach.

- Provide scholarships, fellowships, training programs, and faculty/ student exchanges with U.S. universities; link the COE/ Water with outstanding U.S. universities and existing fellowship programs (Fulbright, Holbrook, Humphrey, etc.).
- Engage private and public Pakistan and U.S. sponsorship programs such as from Friends of Democratic Pakistan (FODP), Pakistan National Research Council (PARC), Pakistan Water Power and Development (WAPDA), National Engineering Services of Pakistan (NESPAK), Pakistan Frontier Works Organization (FWO), Pakistan Science Foundation (PSF), Pakistan Forestry Institute (PFI), USACE, USBR, USEPA, USGS, U.S. Higher Education for Development (HED), Ford Foundation, and GEF.
- Leverage other USG programs, for example the Middle East and North Africa (MENA) COEs, USAID/EGAT Collaborative Research Program (CRSP), USDA/Foreign Agricultural Service (FAS), USDA Endowment Grants, and National Science Linkage Program (NSLP) PL480.

In general, the out dated and irrelevant subject matter covered in the curricula should be reformed with modernity, practicality, relevance and application in mind. The focus should be on improving the quality of teaching and learning through teacher professional development and linkage to U.S. universities through memoranda of understanding (MOU) and other mechanisms for scholarships, fellowships and student and faculty exchanges. This would further support the need for US-Pakistan university linkages and US institutional linkages such as the U.S. HED, Fulbright, Holbrook, Humphrey and other scholarship programs.

The often antiquated faculty using traditional command-and-control instructional methods at universities and departments need to be reformed through COEs with a dedicated faculty that is subject to more rapid turnover than is currently present in the universities. COEs staff need to be mentally dynamic not ossified. This could be structured such that a professor, selected by the COE governing board, can only spend a defined period of time in the COE, but any given professor could receive more than one appointment if remaining productive. Teaching, presentation and communication skills should be taught, monitored, evaluated and acted upon.

The COE should have a governing board comprised of representatives from university faculty, private sector businesses, the government sector, international research organizations such as IWMI (Pakistan Branch), non-profits/ NGOs (such as farmer associations and IUCN), minorities, women, and students to provide broad representation, accountability, monitoring, intelligence and responsiveness.

The COE should build an **online freely-accessible** database-library of Pakistan water information and publications and free, on-demand online courses; computers are generally available throughout Pakistan and within the major university libraries and department. This would allow students at all universities to do reference searches for research on Pakistan water resources, donors could access information needed to plan/design assistance projects [donors could submit their technical reports to the library], and field practitioners would have more information and refresher courses available for decision-making. This is not expensive to do; the largest hurdle will be making it free.

The COE should add an outreach or social marketing component to promote water awareness, conservation, reuse, irrigation efficiencies, as well as public health and safety and sanitation, targeted to specific audiences and enhanced by public workshops, seminars, meetings and media, especially involving stakeholders such as irrigators, householders, businesses and industries. Such campaigns have been fruitful in much of the Middle East and Asia, including Bangladesh, China, India, Iran, and Jordan; some have been sponsored by USAID, university and water-user associations, and industrial groups such as soft-drink bottlers.

The COE should promote online and face-to-face conferences and workshops with broad and appealing themes to connect practitioners, such as like Road to Peace through Regional Water Management, Increasing Pakistan's Competitiveness and Economic Growth through Water Management, Improving Pakistan's Water Resources and Use Knowledge Base from Glaciers to the Sea, etc.

The COE should look for and leverage potential private-to-public sector partnerships to support teaching and research that is focused and appropriate for Pakistan water sector entities.

Overall, Pakistan should improve basic education in the sciences and mathematics, and link educational opportunities to existing and upcoming Pakistani Vocational Institutes and Community Colleges for technical training thereby laying a stronger foundation for higher education.

Governance Issues in Higher Education in COE/Water

The Water Team believes that the governance process *must assure that not only academic but practical education is emphasized, relevant research is promoted, and outreach is encouraged and effective.* Research should not necessarily be funded just because money is available, but rather because it would be useful and applicable to appropriate skill development and/or the needs of the complex water sector in Pakistan. *There must be some transparency and accountability for practical education and relevant research to benefit Pakistan*. Screening of water resources curricula and research proposals might be appropriate. In addition to teaching and research, outreach or social marketing to promote good water-resources practices must be part of the three-part stool: teaching, research and outreach. Skills teaching, communications, public relations, and outreach skills must be promoted. Perhaps the COEs should be required to prepare action plans for approval by USAID, HEC or a governing executive board or entity.

While structure, organization, and models for COE/Water governance are necessary, they are not sufficient. What is *more* important is that champions or visionaries are found, empowered and encouraged to lead these issues in an otherwise mostly stagnant if not moribund higher education culture in Pakistan water.

Water Center of Excellence Activities

The table below is a summary of COE/ Water inputs and potential outputs. To be most effective and potentially sustainable, the Government of Pakistan and HEC should be a major contributor along with USAID funding to assure GoP and HEC commitment to the program. Moreover, USAID programming is typically short-term and without GoP and HEC commitment and funding, the COE/ Water would collapse unless another fund source is found. In the best case scenario, the GoP and HEC would fund nearly all hardware, construction, equipment, salaries, and routine GoP and HEC activities while USAID would fund educational functions (scholarships, relevant research, outreach) to the extent feasible.

Table 19. Summary of COE/Water Inputs and Potential Outputs

	Input	Output
1	Administration/ coordination	Program management, funding allocation, advocacy, a necessary evil and costs should be minimized.
2	Additional or improved classrooms	Improved access and teaching/ research facilities.
3	Additional or improved laboratories, computer software, computer hardware and peripherals.	Improved teaching/ research facilities and increased student learning.
4	Workshops, seminars, conferences, information exchanges	Improved information and outreach exchanges to directly benefit teaching, research and outreach and increase knowledge.
5	Pakistan water-sector relevant research	Improved value to the Pakistani economy and employers.
6	Graduate student scholarships, fellowships, assistantships	Cadre of practical educated engineers for Pakistani economy and employer; potentially the only long-term or sustainable output.
7	Additional faculty or faculty incentives, honorariums, etc.	Improved faculty performance in teaching, research and outreach.
8	Outreach, advertising, promotions, community services, field trips, water-user to water-user exchanges	Improved information and outreach exchanges to benefit Pakistani people, government and employers.

Practical outreach activities that would promote access and assimilation of research findings within the identified client community for Water Sector could include these following activities:

- Promote regional and transnational water resources policies and management to encourage peace and security with neighbors and other countries, for example, Afghanistan, Bangladesh, China, Iran, Nepal, and Tajikistan.
- Promote highly visible, high impact programs with good success stories in, for example, extending the irrigation season, enriching hydropower, improving water conservation and reuse, expanding wastewater collection and treatment, managing water demand through pricing and outreach.
- Add value, be effective and visible in Pakistan's core water issues to improve its economy and competitiveness through, for example, efficient and low-cost water allocation and use, reduced health problems from water-borne diseases by improved sanitation, adding value to irrigated crops through scientific farming methods, sustained hydropower from improved stream flow and dam management
- Advantage distance learning and video conferencing to provide greater access, link distant institutions and overcome security constraints.
- Sponsor connecting conferences with broad and interesting themes like Road to Peace through Regional Water and Other Resource Management, Increasing Pakistan's Competitiveness and Economic Growth through Water and Other Resource Management, Improving Pakistan's Water Resources and Use Knowledge Base from Glaciers to the Sea.

- Carefully review and implement feasible and practical recommendations made by water-resources experts who have been studying these issues in Pakistan for months and even decades and have developed model curricula for water-resources higher education.
- Promote water user- to -user workshops and exchanges such as, for example, water conservation workshops, farmer-to-farmer and water-user-to-water-user association exchanges, power generator-to-power-user exchanges.

SECTION VII. MAJOR RECOMMENDATIONS

This Centers of Excellence feasibility assessment builds on a half-century of collaboration between Pakistan and the United States for the advancement of higher education for development. The study examines seven Pakistani institutions of higher education to determine their potential to host COEs in the fields of agriculture, energy, and water resources management.

Seeking solutions that were neither 'winner-take-all' nor 'designed to fail,' the assessment concluded that the strongest institutes for viable and sustainable Centers of Excellence in Agriculture, Energy, and Water were the University of Agriculture, Faisalabad (UAF); the National University of Sciences and Technology, Islamabad; and Mehran University of Engineering and Technology, Jamshoro. The Team also recommended affiliated COEs in selected areas be supported at Sindh Agriculture University in biosaline agriculture, agroforestry and climate change; the University of Engineering and Technology, Peshawar, in Energy Efficiency, and Mini-hydel; the University of Peshawar in Geology; and in hydropower at the Center of Excellence in Water Resources Engineering at the University of Engineering and Technology, Lahore.

The Team outlined three options for implementing these COEs and affiliates to build excellence in Energy, Water and Agriculture; develop collaboration among COEs and affiliated universities; and foster networks and collaboration in the Indus Valley Watershed among COEs, affiliated universities, regional universities, and international organization. The options proposed included:

1. Three stand-alone COEs, one each in agriculture, energy, and water
2. Three sector-specific COEs with three or more affiliate COEs
3. A multi-sectoral COE on one lead university campus with multiple affiliates

Consensus discussions among the Team, HEC and USAID suggest that the governance structure for the COEs, whichever implementation option is chosen, will be the most critical issue contributing to the success of the initiative. Thus it will be very important that HEC facilitate a participatory stakeholder dialogue at the earliest opportunity to consider the implementations options proposed, together with organizational and management governance options, in order to determine the most viable, practical, and sustainable model for the implementation and governance of the COE initiative at the national and university level.

Despite impressive achievements and academic progress in agriculture, the Team concluded that a true paradigm shift in agriculture education and research is crucial, one that focuses directly on the needs of small - medium farmers, including pursuing innovation in credit/market linkages, intermediate and appropriate technology, sustainable farming systems, and value-added interventions. Further attention must also be given to adaptive research related to existing farming systems, and to the development of mangrove, *Jatropha,* and other agroforesty and forestry systems that are well-adapted for Pakistan's vast high salinity areas.

The Team's conclusions regarding energy highlight the crucial fact that the issues around energy are much less technical than policy- and management-related. Specifically, energy policy is not being addressed in Pakistani universities. There are major failures of communication and agreement between universities and ongoing efforts to solve Pakistan's energy problems, between universities and the energy industry, and between universities and communities. In short, the energy COE must serve the nation as a Policy Think Tank. Connections with industry must be more profound than the current use of internships and industry representation on thesis review committees. On the technological side, the Team's key recommendations are to form a biofuel linkage between the Energy COE and the Agriculture COE, especially with regard to *jatropha* cultivation and biodiesel production; and to strengthen ties with U.S. universities and organizations

in energy research and policy – especially in mini-hydel, efficiency, bioenergy, solar, wind, and energy efficiency.

The Water Team's most important conclusion is that a water crisis is at hand in Pakistan. Pakistan's population is growing exponentially while available water per capita is dropping dramatically. Clearly, as with agriculture and energy, policy issues frequently trump technological constraints, as is clearly evident in both the floods and droughts of recent years. Aged and ingenious irrigation systems showed remarkable resilience but were overwhelmed by larger issues of water management that were as much man-made as natural disasters. COE priorities should focus on addressing policy constraints to avert an emerging water/population crisis, practical education and training in water resources, relevant research to address country needs and effective outreach to promote dissemination of knowledge and results of research.

The private sector is Pakistan's engine for both growth and innovation. Enhanced, vital partnerships with industry will be critical to the success of each of the COEs in Energy, Water and Agriculture. Important gaps to be filled include recognition that faculty strengths are often theoretical rather than practical and need-oriented**.** Curricula, training, and research are not yet oriented towards the needs of farming communities, value chains, and industry or the major socioeconomic and environmental issues facing the country. More "ground-truthing" and more rapid technological updating are needed.

Overall, the Team recommends that three sector-specific COEs with four affiliated universities be the backbone of a broader vision of an Indus Basin Program Knowledge Platform to evolve over the next 10 to 30 years.

Funding will be required at the maximum USD 7 million level per COE per year. Higher Education and this COE model in particular provide an attractive investment opportunity for the US Government that lends itself to accountability, transparency, and long-term sustainability through the development of enduring partnerships with U.S. universities. It is further recommended that:

- Major proportions of allocated funding should go to human resource development as well as outreach to and partnerships with farmers and the private sector
- Support at the maximum level provides a strong framework for attracting:
    - Complementary funding from other USAID and Embassy programs
    - Matching/supplementary funding from HEC and national and regional governments for further faculty training, research, and infrastructure and facility development
    - Focused Fulbright funding for Energy, Water and Agriculture

These investments in creating Centers of Excellence will help lay a foundation for a network that has the potential to involve regional universities across the Indus watershed and other regional and international institutions such as the World Bank, Asian Development Bank, Global Environmental Facility, International Center for Integrated Mountain Development, International Maize and Wheat Improvement Center (CIMMYT), International Center for Agricultural Research in the Dry Areas, International Food Policy Research Institute, International Water Management Institute and Tata Institute of Social Sciences (Mumbai). Through such linkages and networks the COE initiative can foster strong relationships that can lead to the generation of long-term sustainable funding from a range of bilateral and multi-lateral donors.