The Brookings Project on U.S. Relations with the Islamic World
2010 U.S. Islamic World Forum Papers

Scientific, Intellectual, and Governance Cooperation on Emerging Environmental Challenges in the Muslim World

Convener:
Amit Pandya

Authored by:
David Michel
Amit Pandya
Corey Sobel

Saban Center at Brookings
June 2010

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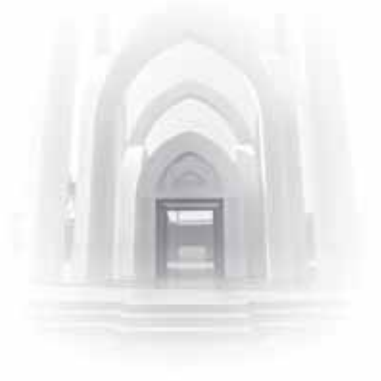

STEERING COMMITTEE

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For the past seven years in Doha, Qatar, the annual U.S.-Islamic World Forum has served as the premier convening forum for key leaders from government, civil society, academia, business, religious communities and the media from the across the global Muslim community and the United States. Over the course of three days, these dynamic leaders gather for thoughtful discussion and transformative dialogue on issues of mutual importance.

This past year we witnessed a significant shift in the conversation between the United States and global Muslim communities. A new American president has set forth a more positive tone for engagement, holding out the promise of a new relationship between the U.S. and Muslim communities, as set forth in his historic remarks in Cairo last June. Throughout the Forum, we explored whether this altered discourse has transformed the relationship and how it has translated into substantive policy recommendations and programs. We also explored and debated key issues of importance to global Muslim communities. The gathering was all the more notable for the presence and participation of Prime Minister Recep Tayyip Erdogan, Anwar Ibrahim, Saeb Erakat and Secretary of State Hillary Rodham Clinton, among many others.

This year also saw a change in the structure of the Forum, with the addition of five working groups who met for numerous hours throughout the course of the three-day Forum. Led by a convener, these working groups focused on specific thematic issues with the goal of provoking thoughtful discussion and, where applicable, developing concrete recommendations. Our five working groups this year included: "The Role of Religious Leaders and Religious Communities in Diplomacy," "Democracy and Islamist Parties: Opportunities and Challenges," Empowering Networks for Community Development and Social Change," Scientific, Intellectual and Governance Cooperation on Emerging Environmental Challenges," and "New Media to Further Global Engagement."

We are pleased to be able to share with you the following paper which is a product of the rich workshop discussion which took place at the forum. However, please note the opinions reflected in the paper and any recommendations contained herein are solely the views of the authors and do not necessarily represent the views of the participants of the working groups or The Brookings Institution.

We would like to take this opportunity to thank the State of Qatar for their partnership and vision in convening the Forum in partnership with us. In particular, we thank the Emir of Qatar, HRH Sheikh Hamad bin Khalifa Al-Thani, the Prime Minister and Foreign Minister of Qatar, HE Sheikh Hamad bin Jassim bin Jabr al-Thani, and the entire staff of the Permanent Committee for Organizing Conferences at the Ministry of Foreign Affairs for their support and dedication in organizing the Forum.

Sincerely,

Dr. Stephen R. Grand
Fellow and Director
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Scientific, Intellectual and Governance Cooperation on Emerging Environmental Challenges

CONVENER

Amit Pandya
Senior Associate and Director of the Regional Voices:
Transnational Challenges project at The Stimson Center

The working group will bring together scientists, engineers, educators, economists and entrepreneurs, technical subject experts, experts in science policy and governance, and observers and analysts of politics and of philosophical and intellectual trends. The group will identify the principal economic, social and natural challenges posed by environmental change, and their principal causes (demographic, economic, and social). It will consider the availability of scientific and other intellectual resources and institutions relevant to these, and will discuss existing and potential cooperation, among sectors and disciplines and at the regional, inter-regional and global levels. The workshop will identify, consolidate and expand existing networks, and foster creation of additional ones. We will emphasize integral multi-disciplinary approaches to economic, social and environmental trends.

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Table of Contents

Workshop

Scientific, Intellectual, and Governance Cooperation on Emerging Environmental Challenges in the Muslim World

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In his 4 June 2009 speech at Cairo University, President Barack Obama called for a new partnership on science and technology with Muslim-majority countries. Among other initiatives, the President announced the creation of a fund to support technological development in the Islamic world; proposed establishing centers of scientific excellence in Africa, the Middle East, and Southeast Asia; and declared his intention to name science envoys to collaborate on programs to develop new sources of energy, green jobs, clean water, and new crops.[1]

On 13-15 February 2010, The Stimson Center convened a Workshop on Scientific, Intellectual and Governance Cooperation on Emerging Environmental Challenges in the Muslim World as a component of the 2010 U.S.-Islamic World Forum held in Doha, Qatar. Participants included scientists, educators, policy analysts and practitioners from several Muslim nations and countries with important Muslim minorities (India, Philippines), as well as American analysts and U.S. government representatives. The Working Group identified the principal environmental problems facing the Islamic world, assessed the Muslim countries' existing and potential resources to address the emerging risks, and recommended priority strategies for advancing cooperation between the U.S. and the Islamic world to tackle these issues.

[1] Barack Obama, "Remarks by the President on a New Beginning," The White House, Office of the Press Secretary, Cairo, Egypt, 4 June 2009, available at <http://www.whitehouse.gov/the-press-office/remarks-president-cairo-university-6-04-09>.

This report provides a brief overview of the challenges posed by environmental change in several regions where significant Muslim populations are found: Southeast Asia, South and Central Asia, Southwest Asia/Persian Gulf, North Africa, and parts of Sub-Saharan Africa (the Sahel, coastal West Africa, and East Africa). It then discusses the major needs for improving scientific and technical research in these regions and reviews extant environmentally-focused scientific cooperation between the U.S. and the Muslim world. Finally, the paper presents some recommendations suggesting how scientific cooperation between the U.S. and the Muslim world could be expanded and deepened in the future.

Regional Overview

Stretching from Indonesia to Mauritania and from Mozambique to Kazakhstan, from the desert of the Sahel to the jungles of Suriname and from the shores of West Africa to the steppe of Central Asia, countries with large Muslim populations encompass an extraordinary historical, cultural, geographical, and ecological diversity. Yet despite their rich variety, the nations of the Islamic world, like all the nations of the earth, face unprecedented pressures from global environmental change. These pressures in turn place considerable strain on the continued economic growth and prosperity of Muslim societies. According to one recent analysis, the costs of environmental degradation across the Middle East and North Africa region already amount to 4.8% of GDP in Algeria, 5.4% of GDP in Egypt, 4.0% in Lebanon, 4.6% in Morocco, 4.7% in Syria, and 2.7% of GDP in Tunisia.[2] Similar calculations by the World Bank tallied the toll of environmental degradation in Bangladesh at more than 4% of GDP, over 5% of GDP in Indonesia, 6% of GDP in Pakistan, and 4.8-10% of GDP in Iran.[3]

Southeast Asia

In mainland countries as well as in insular Southeast Asian nations, deforestation remains a significant problem, particularly in Indonesia, Thailand, and the Philippines. Between 1990 and 2000 Indonesia saw 1.9 million hectares of forest disappear, and then lost that much again from 2000 to 2005, making it second only to Brazil in total area deforested but at an annual rate that was three times as fast.[4] The resulting release of CO_2 into the atmosphere secures Indonesia's place as one of the world's biggest carbon emitters. Smoke from fires set to clear forest land for agriculture frequently blankets the region, contributing to severe air pollution and public health risks. Major mining projects in Indonesia and the Philippines are leading to a suite of environmental issues, including deforestation, pollution, and the poisoning of major water supplies. The common practice of strip mining in Indonesia has led not only to massive deforestation but has also created tailing, waste rocks, and acid leaching

[2] Muawya Ahmed Hussein, "Costs of Environmental Degradation: An Analysis in the Middle East and North Africa Region," *Management of Environmental Quality: An International Journal* 19, No.3 (2008).
[3] World Bank, *Bangladesh: Country Environmental Analysis, Vol.1* (Washington, DC: The World Bank, 2009), p.ii; World Bank, *Investing in a More Sustainable Indonesia: Country Environmental Analysis* (Washington, DC: The World Bank, 2009), p.4; World Bank, *Pakistan: Strategic Country Environmental Assessment, Vol.1* (Washington, DC: The World Bank, 2006), p.6; World Bank, *Islamic Republic of Iran: Cost Assessment of Environmental Degradation* (Washington, DC: The World Bank, 2005), p.1.
[4] FAO, *State of the World's Forests 2009* (Rome: FAO, 2009), pp.109-115.

that has poisoned surface water and groundwater and disrupted local ecology.

In littoral Southeast Asian nations, overfishing and destructive methods of fishing have seriously compromised the productivity of the region's fisheries—with considerable economic and food security consequences, given that ASEAN (Association of Southeast Asian Nations) nations produce a quarter of the world's fish products every year. Coastal zones in Southeast Asia already face regular extreme weather events, and so the loss of large portions of the mangrove forests (which represent a natural buffer) renders these areas even more susceptible to storm-related damage. Climate change adds to the environmental risks confronting coastal areas, contributing to salinization of freshwater aquifers, coral bleaching, the spread of water-borne diseases, and an increased incidence of extreme weather. Sea levels around the region are projected to increase 40 cm or more by 2100. According to one estimate, Indonesia could lose 2,000 islands to the rising waters.[5]

Major environmental threats and challenges in mainland Southeast Asia center on the large river basins in the region, especially the Mekong, Menam Chao Phraya, and Irrawaddy. The cascade of dams being built by the Chinese on the upper Mekong is already disturbing key migratory fisheries and threatening to disrupt the livelihoods of millions. The prospective impacts of climate change are also significant in this regard, potentially altering the seasonality of the precipitation that nourishes the region's rivers. The Mekong, for instance, risks experiencing more flooding in the wet season and greater water shortages in the dry season as maximum monthly flows in the basin are projected to grow from 35 to 41%, while minimum flows will decrease by 17 to 24% over the coming decades.[6]

Additional causes of unsustainable exploitation of natural resources in the region include problems of poor governance, corruption, a lack of technical and scientific skills, urban bias, and the energy demands of a rapidly growing population.

South Asia and Central Asia

Continuing population growth and rapid industrialization in South and Central Asia are placing significant burdens on the region's key sources of freshwater. In the Indus and the Helmand systems, the volume of wastewater discharged into the rivers each year equals 19% and 16% of their available annual water resources, respectively. The Indus, Ganges, and Brahmaputra rivers are increasingly dammed and diverted for irrigation and hydropower, disrupting the annual flow of the rivers as well as decreasing water levels. In Bangladesh, India, and Pakistan growing exploitation of groundwater for agricultural purposes is rapidly depleting regional aquifers, leading to significant resource degradation. Annual per capita water availability in the Indus River basin is now only 1,330 m^3 per person (1,700 m^3 per capita is considered the threshold of water stress). In India as a whole, annual per capita water availability has fallen from 4,000 m^3 to 1,869 m^3 in the past two decades and could drop below levels of outright water scarcity (1,000 m^3 per head) by 2025.[7]

Global warming risks compounding these pressures. Because of their high population density, susceptibility to coastal flooding and saltwater intrusion from sea level rise, and exposure to storm surges, the Intergovernmental Panel on Climate

[5] Asian Development Bank, *The Economics of Climate Change in Southeast Asia: A Regional Review* (Manila: ADB, 2009), p.32.
[6] R. Cruz et al., "Asia," in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry et al. eds. (Cambridge: Cambridge University Press, 2007), p.483.
[7] Mukand S. Babel and Shahriar M. Wahid, *Freshwater Under Threat South Asia: Vulnerability Assessment of Freshwater Resources to Environmental Change* (Nairobi: UNEP/Asian Institute of Technology, 2008).

Change has specifically designated several of South Asia's coastal river deltas, including the Ganges-Brahmaputra and the Indus, as particular "hotspots" of climate change vulnerability.[8] Mounting sea levels are already leading to saltwater intrusion into coastal aquifers, especially in small island states such as the Maldives. Warming surface temperatures in the region appear to be contributing to melting the snow and ice pack in the Himalayas, where alpine glaciers are already receding more rapidly than anywhere in the world. The Himalayan glaciers, often called Asia's "water tower", nourish many of the continent's great rivers. Their retreat and disappearance would endanger the water supplies on which hundreds of millions of people in South and Central Asia depend. Shifts in river runoff could also substantially erode the power generation capacities and economies of countries like Tajikistan, the third largest hydropower producer in the world. Changes in temperature, precipitation, and water availability could also imperil regional food supplies. The World Bank projects that by 2080 climate impacts could cut agricultural output by 21.7% in Bangladesh, 38.1% in India, 30.4% in Pakistan, and 2.8% in Uzbekistan (although output could grow by 7.7% in Kazakhstan).[9]

Deforestation is another major environmental problem in the region. Afghanistan and Pakistan have two of the highest rates of deforestation in the world. Much of South Asia is already prone to flooding; the loss of forest cover exacerbates that susceptibility. Mangrove forests in India and Bangladesh are being destroyed to make way for shrimp ponds, rice paddies, and urban development—leading to a loss of crucial biodiversity as well as rendering those countries' coastal zones more vulnerable to tropical storms and cyclones. Lastly, the rapid growth of industry and population in the region has fed growing demand for sand and gravel, spurring an increase in destructive (and often illegal) mining of South Asian riverbeds.

Southwest Asia/Persian Gulf

Chronic air and water pollution constitute a major environmental challenge throughout Southwest Asia and the Persian Gulf. The sources of this pollution include open municipal waste dumps, the unregulated burning of municipal waste, an aging and poorly-maintained vehicle fleet, inefficient use of fossil fuels for power generation and in industry, and sulfur oxide emissions from industry. Such pollution harms the health of residents of urban and industrial centers and damages local ecosystems. The marine ecosystems of Southwest Asia and the Gulf particularly bear the brunt of rapidly expanding development and industry. While petroleum production has driven the region's phenomenal growth, ballast water released from oil tankers, dredging and filling operations, offshore oil and gas installations, tanker loading terminals, and the high volume and density of maritime traffic have proven especially destructive to the coastal environment of the Gulf countries.

Rapid economic development is also worsening the region's acute water scarcity. Groundwater is being overexploited for agricultural purposes—especially for "water-intensive" grains and crops—badly depleting an already finite source of freshwater. The most advanced Gulf states currently have some of the highest per capita water consumption rates in the world, driving them to turn to seawater to meet demand for potable water. Desalinization plants, however, are expensive, costly to maintain, and damaging to extant ecosystems. Desalinization and power plants generate 48% of the industrial effluent volume discharged into the Red Sea, for

[8] Robert J. Nicholls et al., "Coastal Systems and Low-lying Areas," in *Climate Change 2007: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry et al. eds. (Cambridge: Cambridge University Press, 2007), p.327.

[9] World Bank, *World Development Report 2010: Development and Climate Change* (Washington, DC: The World Bank, 2010), p.367.

example.[10] Elsewhere, the Turkish Ataturk Dam project is altering the quality and quantity of water flowing down the Euphrates, while the Iraqi wetlands and marshes—a key means of filtering water discharged into the Gulf—are drying up, impairing fisheries and freshwater supplies in the region. In 2003 every country in the Middle East except Iraq already registered annual per capita water availability below levels consistent with water stress. By 2025, all but Iraq are projected to confront grave water scarcity problems, with the Gulf nations facing annual per capita availability of less than 500 m^3.[11]

Global warming augurs further ills for the region's environmental balance. One meter of sea level rise could potentially reduce Qatar's land area by over 2% and submerge 13.95% of Bahrain.[12] Climate change will also expose the region to more frequent and severe extreme weather events, and aggravate desertification, biodiversity loss, air pollution, and the further pollution of marine and coastal areas.

North Africa and the Sahel

Water supplies represent a crucial environmental challenge in North Africa. There are persistent water shortages throughout the region, exacerbated by unsustainable uptake of surface water and draw down from water tables. More than three quarters of North Africa is desert, and ongoing desertification threatens another 16.5% of the region's land area.[13] Desertification will worsen as water sources continue to be depleted. Growing population density, combined with urbanization and industrialization are increasing the incidence of pollution throughout the region. As populations have grown, for example, so has production of industrial and household wastewater.

Climate change will significantly impact North Africa, decreasing water availability and intensifying destructive sand and dust storms in places such as Egypt and Sudan. The populous Mediterranean coast of Egypt is especially vulnerable to climate change, given high population growth, land subsidence, excessive erosion rates, salt water intrusion, soil salinization, and a lack of appropriate institutional management systems. A one meter sea level rise, for example, would submerge 4,500 km^2 of croplands in the Nile Delta and inundate 6.1 million people, displacing three quarters of the population in the city of Alexandria alone.[14]

The Sahel of North and West Africa is already home to some of the most fragile ecosystems in the world. Droughts strike the region every two to five years, making food security and agricultural productivity highly uncertain. According to the United Nations Environment Program (UNEP), soils in the region are intrinsically fragile, low in carbon and poor in plant nutrients. Nutrient-rich topsoil is often destroyed by water and wind erosion, rendering sustainable farming difficult. Deforestation, continuous cropping, and overgrazing by pastoralist populations in the Sahel further compromise its ecosystems. High-intensity and increasingly unpredictable storms are projected to worsen with climate change and desertification threatens to further undermine food and human security.[15]

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[10] Mahmoud Khamis El Sayyed, "Marine Environment," in *Arab Environment: Future Challenges*, Mostafa K. Tolba and Najib W. Saab eds. (Beirut: Arab Forum for Environment and Development, 2008), p.85.

[11] Musa N. Nimah, "Water Resources," in *Arab Environment: Future Challenges*, Mostafa K. Tolba and Najib W. Saab eds. (Beirut: Arab Forum for Environment and Development, 2008), pp.64-65.

[12] Mohamed El Raey, "Coastal Areas," in *Arab Environment: Climate Change – Impact of Climate Change on Arab Countries*, Mostafa K. Tolba and Najib W. Saab eds. (Beirut: Arab Forum for Environment and Development, 2009), pp. 52, 57.

[13] UNDP, *Arab Human Development Report 2009: Challenges to Human Security in the Arab Countries* (New York: UNDP, 2009), p.40.

[14] Mohamed El Raey, "Impacts and Implications of Climate Change for the Coastal Zones of Egypt," in *Coastal Zones and Climate Change*, David Michel and Amit Pandya eds. (Washington, DC: The Henry L. Stimson Center, 2010), pp. 36, 45.

[15] Serigne Tacko Kandji, Louis Verchot, and Jens Mackensen, *Climate Change and Variability in the Sahel Region: Impacts and Adaptation Strategies in the Agricultural Sector* (Nairobi: UNEP/World Agroforestry Centre, 2006), p. 11.

Coastal West Africa

According to the World Conservation Union, West Africa has seen a significant drop in rainfall and hydrometric series for 40 years. This has led to a decrease in the surface area of natural wetlands. . "[P] articularly due to the reduced flow velocity in watercourses, [there is] temperature change as well as the deterioration of water quality," and important regional water sources have suffered a proliferation of so-called floating weeds. "These weeds hinder fishing, navigation, the functioning of irrigation schemes, [and] hydroelectric developments." [16]

The replenishment of West Africa's aquifers has noticeably decreased, while flooding has worsened in many of the region's major water basins and rivers. Shifting water supplies may in turn impact public health and sanitation, including a rise in the incidence of water-borne diseases. Climate change is expected to worsen desertification in the north as well as lead to sea level rise in littoral areas, causing the salinization of water sources and an increase in extreme weather storm surges.

East Africa

In East Africa the land base is constantly degraded by cyclical droughts, overgrazing, and harmful agricultural practices that have severely compromise agricultural productivity, food security, and health. This pressure on land is also contributing to accelerated desertification. Given the region's susceptibility to El Niño and other major precipitation events, flooding is also a persistent problem. Deforestation is severely damaging important regional water catchments, causing increased water scarcity. Global warming threatens to worsen these existing problems as the dry and rainy seasons become harder to predict for farmers and governments, as well as increasing the incidence of extreme weather events.

Littoral and island states—as well as countries that border on major freshwater lakes—face their own particular set of environmental problems. Edward Kimani and his colleagues estimate that, in the Western Indian Ocean, "75 percent of fisheries are currently being exploited at their maximum biological productivity, while the other 25 percent are overexploited and require better management."[17] In addition to exhausting coastal ecosystems, fishers frequently employ environmentally harmful fishing techniques.

There are several sources of pollution on the coast, including oil from tankers, chemical runoff from agriculture and growing industry, and contamination from inadequate sewage treatment. Climate change is an especially salient threat to these littoral countries, as flooding in coastal areas is set to increase with sea level rise and important coral systems along the coast are being bleached by increased ocean temperatures. Finally, small island states face grave threats from climate change and are already grappling with rising sea levels, increased saltwater incursion into fresh water resources, and an increased incidence of extreme weather events.

[16] Madiodio Niasse et al., *Reducing West Africa's Vulnerability to Climate Impacts on Water Resources, Wetlands, and Desertification* (Gland, Switzerland: IUCN – The World Conversation Union, 2004), p. xi.

[17] Edward N. Kimani et al., "Fisheries in the Southwest Indian Ocean: Trends and Governance Challenges" in *The Indian Ocean: Resource and Governance Challenges*, Ellen Laipson and Amit Pandya eds. (Washington, DC: The Henry L. Stimson Center, 2009), p. 8.

Issues of Need and Capacity for Science and Technology

The Muslim world has historically been a global center of intellectual innovation and exchange (inventing algebra and the magnetic compass, preserving and promulgating the achievements of Classical Antiquity). Muslim countries now need to reinvigorate this tradition, to capitalize on their existing areas of scientific strength and also create new initiatives to bolster their capacity for innovation and adaptation to address environmental change.

Scientific Output in the Muslim World

For centuries before the European Enlightenment, intellectual innovation and scientific discovery flourished in the Islamic world. In more recent decades, though, Muslim nations have been under-represented in the creation of new knowledge. From 1963 through 2009, the 57 countries of the Organization of the Islamic Conference (OIC) together obtained 2696 U.S.patents. This is fewer than half the number of patents awarded to Norway alone—a country of 4 million people—and constitutes less than 0.06% of the more than 4.5 million patents for invention granted worldwide over the same period. Further, just four countries accounted for more than two thirds of the OIC total, while fourteen member states registered no patents at all.[18]

The Muslim countries also lag in contributing to the scientific literature. In 2007, the seven most productive Muslim countries combined produced fewer scientific papers than did India by itself. According to the U.S. National Science Foundation, in 2003 46 Muslim countries generated 1.17% of the world's scientific literature, less than the 1.48% accounted for by the single country of Spain. The global average for the production of scientific articles was 137 per million inhabitants, but no OIC country contributed more than 107 per million, and the OIC average was only 13.[19]

Even so, against this generally discouraging picture, some more positive indicators are emerging. Publication rates have surged since the 1990s in a few Muslim countries, notably Turkey and Iran (although concerns about the quality of these contributions remain.) Output is also rising in the Arab states, and there has been a marked jump in joint publications between Arab researchers and their European and American colleagues. Notably,

[18] U.S. Patent and Trademark Office, "Patents by Country, State, and Year – Utility Patents," December 2009, available at <http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_utl.htm>.

[19] Declan Butler, "The Data Gap," *Nature* 444, Nos.26-27 (2006); Pervez Amirali Hoodbhoy, "Science and the Islamic World: The Quest for Rapprochement," *Physics Today*, August 2007.

work on "Energy Sciences" and "Environment and Agriculture" now predominates in the Arab nations' scientific literature, representing 47% and 24% respectively of all scientific articles published in these countries from 1998 to 2007.[20]

National Spending on Research and Development

The Islamic nations understand the importance of science and technology in a globalizing world. As early as 1981, the OIC established a Standing Committee on Scientific and Technological Cooperation (COMSTECH) to build indigenous scientific capacity and promote cooperation among member states. In 2002, the landmark first Arab Human Development Report identified knowledge production and acquisition as one of the key challenges facing the Arab states, while the follow-on 2003 Report was entirely devoted to "Building a Knowledge Society".[21]

Despite this rhetorical recognition, however, funding for scientific research and development in the Islamic nations considerably trails the global average. This is true across the board, from the poorer countries of Sub-Saharan Africa to the oil-rich nations of the Persian Gulf. Among the OIC countries for which data are available, Tunisia leads the Muslim world, devoting 1% of GDP to science and technology R&D, followed by Turkey at 0.7% of GDP and Iran, Malaysia, and Morocco at about 0.6%. By comparison, Japan allots some 3.4% of GDP to R&D, the U.S.2.7%, and Germany 2.6%. Research and development expenditures in Brazil, Russia, India, and China (the so-called BRICs) range from 0.8% of GDP in India to 1.5% in China, while the world average is 1.4%. With an R&D intensity of just 0.3% of GDP among the Arab states in Africa and only 0.1% among the Arab states in Asia, all the Arab countries combined accounted for under one half of one percent of global R&D spending in 2007.[22] (See Annex)

Here too, however, some positive trends have surfaced. Several Muslim countries, including Malaysia, Morocco, Pakistan, and Tunisia have more than doubled the share of GDP they consecrate to R&D. Going forward, the 2007 Arab Summit called upon the Arab states to lift their spending on scientific research to 2.5% of GDP within ten years.

Even so, the total resources directed to science and technology by the Muslim world remain constrained by their dependence on government funding and institutions. Only in Malaysia and Turkey does the private sector play a predominant role in financing and performing research. In the Arab nations, governments supply 95% of research spending, compared to developed countries such as Germany, Japan, and the US, where the private sector is responsible for two thirds of R&D expenditures. Similarly, in Indonesia, Iran, Pakistan, and many Islamic countries in Africa and Central Asia government agencies carry out 50 to 90% of scientific research, compared to the OECD countries where government institutions typically perform 10 to 20% of R&D activities. While not inherently detrimental to scientific development, such extensive government involvement can in practice limit both the funding resources available for scientific investigation and the avenues for dissemination of research results in Muslim societies.[23]

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[20] Mohammed bin Rashid Al Maktoum Foundation/UNDP, Arab Knowledge Report 2009: Towards Productive Intercommunication for Knowledge (Dubai: Mohammed bin Rashid Al Maktoum Foundation/UNDP, 2009), p.198.

[21] UNDP, *Arab Human Development Report 2002: Creating Opportunities for Future Generations* (New York: UNDP, 2002); UNDP, *Arab Human Development Report 2003: Building a Knowledge Society* (New York: UNDP, 2003).

[22] UNESCO Institute for Statistics, "A Global Perspective on Research and Development," UIS Fact Sheet No.2, October 2009; UNESCO Institute for Statistics, Data Center: Science and Technology, "Gross Domestic Expenditure on R&D (GERD) as a percentage of GDP and GERD per capita," available at <http://stats.uis.unesco.org/unesco/TableViewer/tableView.aspx?ReportId=1782>.

[23] Mohammed bin Rashid Al Maktoum Foundation/UNDP (2009); UNESCO Institute for Statistics, "A Global Perspective on Research and Development," UIS Fact Sheet No.2, October 2009.

Scientific Education and Research Institutions

While science budgets fall below the global average throughout the Islamic world, national expenditures on education vary more widely. Several Muslim countries count among those with the greatest relative spending. Measured both as a percentage of GDP and as a share of total government outlays, education expenditures in a number of OIC members surpass spending by most OECD states.

TABLE 1. Public Expenditure on Education in 2005

	As % of GDP	As % of Total Government Expenditures
Djibouti	8.4	22.4
Malaysia	6.2	25.2
Morocco	6.8	27.2
Saudi Arabia	6.8	27.6
Senegal	5.4	18.9
Tunisia	7.3	20.8
United States	5.3	13.7
Germany	4.6	9.8
Japan	3.5	9.2
Brazil (in 2000)	4.0	12.0
Russia	3.9	12.9
India	3.2	10.7
China (in 2000)	1.9	13.0

SOURCE: UNESCO Institute for Statistics, Data Center: Education, "Time Series Data – Table 3: Total Enrolment, Life Expectancy, and Expenditure on Education," available at <http://stats.uis.unesco.org/unesco/tableviewer/document.aspx?FileId=201>.

But though several Islamic states stand out in their budgetary commitment to education, for the most part they have yet to obtain world class results. Sixteen OIC members participated in the *2007 Trends in International Mathematics and Science Study* (TIMSS), testing the academic performance of eighth-grade students from 48 developed and developing countries around the world. Malaysia scored highest among Muslim countries on the math test, coming in 20th place with an average student score of 474, compared to a global average score of 500. Despite their educational spending, Tunisia came in 32nd and Saudi Arabia 46th. OIC countries occupied fourteen of the bottom twenty places internationally. On the science test, Jordan performed best among Muslim countries, also coming in 20th place with an average score of 482 against a global average of 500. Malaysia occupied 21st place, Tunisia 34th, and Saudi Arabia 44th. OIC countries filled thirteen of the bottom twenty places internationally. Compared to the prior 2003 TIMSS, in which OIC members made up 11 of 45 participating countries, the best performing Muslim states actually slipped down the rankings. In 2003 Malaysia scored 10th on the math test, with an average score of 508, well above the global average of 466. Malaysia also placed 20th on the science test, scoring 510, easily topping the global average of 473. Jordan, in 25th place with a score of 475 also surpassed the global average. By the 2007 test, however, of the ten OIC countries that took part in both TIMSSs, all ten lost ground relative to the global average math score from 2003, and eight dropped further behind the global average science score.[24]

The Muslim countries also show poorly in international evaluations of higher level academics. Of the approximately 1800 universities in the OIC states, only one figured in the 2009 *Times Higher Education Supplement* list of the top-200 schools worldwide, a Malaysian institution in 180th place. Similarly, only three OIC country institutions

[24] Patrick Gonzales et al., *Highlights from TIMSS 2007: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context* (Washington, DC: National Center for Education Statistics/U.S. Department of Education, 2009), pp.7, 32; Patrick Gonzales et al., *Highlights from the Trends in International Mathematics and Science Study (TIMSS) 2003* (Washington, DC: National Center for Education Statistics/U.S. Department of Education, 2004), pp.5, 15.

broke into the 2009 top-500 "Academic Ranking of World Universities" compiled by Shanghai Jiao Tong University, one each in Turkey, Saudi Arabia, and Iran, none ranked among the top 400 schools. By way of comparison, the Shanghai Jiao Tong University list also included three universities in South Africa, six in Brazil, two each in Russia and India, and eighteen in China.[25]

In addition to academic institutions, research centers operating through various government ministries play significant roles in many countries. Egypt, for example, has fourteen specialized government research centers and 219 centers functioning under the aegis of different ministries, in addition to 114 centers located in universities. Compared to their lack of success in the university rankings, some Muslim countries fare moderately well in international assessments of research institutions. In a survey carried out by the World Economic Forum for the 2009-2010 *Global Competitiveness Report*, Malaysia's scientific research institutions ranked 28th, Qatar's 32nd, and Saudi Arabia's 37th, of 133 countries evaluated, with Azerbaijan, Indonesia, and Tunisia also in the top 50.[26]

A number of Muslim nations have also begun to establish technology parks, attempting to bring together businesses with similar interests and coordinate with research institutions and academia to commercialize scientific R&D. To date, the United Nations Industrial Development Organization has participated in the development of more than forty technology parks in eighteen OIC countries devoted to various industrial sectors including advanced engineering, agro-food, energy, and the environment, among others.[27]

Education and Research in the Environment Sector

Many Muslim world governments provide substantial support for environmental research. The Egyptian Ministry of Scientific Research, affiliated with the National Research Center, represents a large base of research and development focusing on materials sciences and engineering, environment, and agriculture among other fields, as well as coordinating research with partners throughout the Muslim and developed world. The Qatar Foundation for Education, Science and Community Development, established by the Emir of Qatar in 1995, coordinates with several American universities as well as other established centers of scientific research. The Middle East Science Fund (MESF) has used seed funding from Jordan's King Abdullah to sponsor international conferences, promote research on water and agriculture, and to help link Middle Eastern members of academia and civil society with their American counterparts. And as recently as April 2010, Saudi Arabia announced the creation of the King Abdullah City for Atomic and Renewable Energy as a center for renewables research and to coordinate national and international energy policy.[28]

Several strong environment-focused educational initiatives reside in some of the least wealthy Muslim countries. Pakistan boasts many well-established universities that house programs in major environmental fields such as marine biology (Karachi University) and forestry (the University of Peshwar's Pakistan Forest Research Institute.) Senegal's Université Cheikh Anta Diop de Dakar hosts several significant West African research centers and participates in various regional and international

[25] The *Times Higher Education Supplement* rankings are available at <http://www.thes.co.uk>. The Shanghai Jiao Tong University rankings can be found at <http://www.awru.org/AWRU_5.jsp>.
[26] World Economic Forum, *The Global Competitiveness Report 2009-2010* (Geneva: World Economic Forum, 2009), p.467.
[27] A listing of many of the projects can be found through the UNIDO website at <http://www.unido.org/index.php?id=o27387>.
[28] James Dacey, "Saudi Arabia to Create Renewable Energy 'City'," Environmental Research Web, 12 May 2010, at <http://environmentalresearchweb.org/cws/article/news/42584>.

research partnerships. And the Islamic University of Technology in Dhaka, a subsidiary organ of the OIC, houses an Energy and Environment Centre. But in these countries, and indeed in all of the poorest Muslim countries—Indonesia, Bangladesh, Afghanistan, Yemen, and all of Sub-Saharan Africa—there is a need for more programs dedicated to improving basic math and science education. Strengthening primary and secondary school education would help establish a wider and deeper knowledge base on which to further build more advanced programs.

More significant tertiary-level environmental education opportunities exist in wealthier and more developed countries of the Muslim world. A 2008 report by the Arab Forum on Environment and Development found 40 research centers on environmental studies, 37 undergraduate degree programs, and 24 graduate programs across the Arab world. The author concluded that all Arab countries need to provide larger and more robust environmental science-related higher degree programs. "Most of the degrees pertaining to environmental studies offered by universities in the Arab world are at the bachelor's level, with fewer at the Master's level and even fewer offering a Ph.D."[29] There remains an overall need to enlarge and refine the tertiary-level opportunities, to both boost enrollment in and expand the scope of university-level environment programs. Expanding these programs will in turn help to encourage more specialized forms of environmental studies that are currently lacking, including programs on environmental legislation and management. Several countries have already taken steps to increase such opportunities including the University of Sfax in Tunisia, the Masdar Institute of Science and Technology in Abu Dhabi, and the King Abdullah University of Science and Technology (KAUST) in Saudi Arabia.

[29] Riyad Y. Hamzah, "Environmental Education'" in *Arab Environment: Future Challenges*, Mostafa K. Tolba and Najib W. Saab eds. (Beirut: Arab Forum for Environment and Development, 2008), p.206.

Current U.S. Cooperation With the Muslim World

Most scientific collaboration between the U.S. and the Muslim world takes place through U.S. government agencies or private sector and academic actors. Despite its widespread and often substantive engagement with many Muslim countries, however, the U.S. government does not have an explicit policy or strategy of cooperating with the Muslim world. Instead, many of the major departments of the government engage in their own collaborative initiatives. Below are brief descriptions of some of the more notable science and environment-related projects.[30]

Department of Commerce

Within the Department of Commerce, the National Institute of Standards and Technology (NIST) has entered into scores of cooperation agreements with Muslim countries, including bilateral memoranda of understanding for the U.S. to host Muslim-world researchers. The National Oceanic and Atmospheric Administration (NOAA) Office of Global Programs has sponsored efforts to study climate-related issues in Ethiopia, Mauritania, Djibouti, Bangladesh, and the Sudan-Sahel region, as well as research, education, and technology transfer in Southeast Asia.

Department of Energy

DOE laboratories have split their collaborative efforts in the Muslim world into two parts: security-focused projects and energy-focused projects. The Lawrence Livermore National Laboratory engages with issues of security and seismic, hydrological, and environmental science and technology. The Sandia National Laboratory helps to collaboratively monitor air, water, meteorological, and seismic issues in much of the Muslim world. Environment-related technology transfer, as well as confidence-building measures, are regularly performed via DOE channels such as the South Asia Water Analysis Network. In the year following President Obama's Cairo speech, DOE also concluded MOUs with the UAE's Masdar City and Saudi Arabia's King Abulaziz City for Science and Technology to facilitate clean energy cooperation and energy partnerships.

Department of State

Following the President's Cairo speech, Secretary of State Clinton named three prominent scientists as special envoys to foster scientific partnerships with the Muslim world. The Department of State

[30] The following section draws substantially on and updates Michael A. Levi and Michael B. D'Arcy, *Untapped Potential: U.S. Science and Technology Cooperation with the Islamic World* (Washington, DC: The Brookings Institution, 2005). Recent activities and developments can be followed in periodic reports from the Environment, Science, Technology, and Health officers stationed at U.S. embassies in the region and made available through the White House Office of Science and Technology Policy at <http://www.whitehouse.gov/administration/eop/ostp/sciencediplomacy>.

creates umbrella agreements to facilitate science and technology cooperation and on intellectual property rights, legal liability, and export controls. In the past year, it has launched six new Middle East Regional Cooperation projects to fund research and cooperation with institutions in Israel, Jordan, the West Bank/Gaza, and Tunisia on agricultural, environmental, and health issues.

The National Science Foundation

The NSF's US-based collaboration with the Muslim world includes: travel grants, workshops, and joint research projects. In addition, the program called PIRE "Partnership for International Research and Education" provides large grants, of several million dollars each, to allow one or more US universities to engage in joint research with scientists in one or more foreign countries in a topic of mutual interest, and these have the potential to engage Muslim-majority countries in significant collaboration with US universities. The NSF also participates in various regional networks and outreach efforts to study and act on environmental change. For example, it sponsors the Asia-Pacific Network for Global Change Research and the SysTem for Analysis, Research, and Training (START). NSF also is supporting the expansion of the International Network for Research and Education (INRE) to countries in the Middle East and South Asia.

USAID

USAID seeks to promote and strengthen local and regional science and technology capacity in five priority areas: health, energy and information technology, agriculture, natural resources management, and environmental policy. Technology transfer and capacity-building by USAID often focus on improving science in agriculture and better addressing challenges in the areas of environment and energy. For example, for over thirty years USAID has supported the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS), a center of excellence in West Africa that carries out important research on food security and also works to ameliorate the consequences of drought and desertification in the Sahel. USAID has an established presence throughout the Middle East, as well, and has helped fund the Middle East Water and Livelihoods Initiative. The initiative helps to address various challenges involved with water management in the region.

Academic Collaboration with the U.S.

Cooperation with the scientific and educational communities of developed countries can bolster national efforts to strengthen educational opportunities and training for environmentally-focused scientists. Such collaboration already exists in a wide variety of forms, from Muslim-country authors co-writing studies with Western scientists to the joint construction and administration of environmental research institutions in Muslim nations. In this way, Muslim countries can draw on their existing areas of expertise and match them up with resources from the developed world.

Thus the Qatar Foundation for Education, Science and Community Development has partnered with six U.S. universities, including Carnegie Mellon, Cornell, Georgetown, Northwestern, Texas A&M, and Virginia Commonwealth University to open branches in the so-called Education City outside of Doha. Stanford, the University of California at Berkeley, and the University of Texas at Austin have entered into agreement with the newly launched KAUST in Saudi Arabia to assist in designing the curriculum and hire faculty. Similarly, the Massachusetts Institute of Technology has collaborated with partner institutions in Malaysia and Abu Dhabi to build graduate-level programs on the MIT model, so helping to create the Malaysia University of Science and Technology and the Masdar Institute of Science and Technology. KAUST has designated energy and the environment among its initial areas of focus, while Masdar, which opened its doors in September 2009, is intended to be the Middle East's first graduate institution devoted to researching alternative energy and sustainable environmental technologies.

Science and Technology Policy Challenges and Opportunities[31]

As Islamic countries strive to enhance their scientific and technological capacities to respond to the environmental stresses and seize the development opportunities of the 21st century they confront several critical policy challenges. These challenges could be characterized as strengthening Three "I"s: Individuals, Institutions, and International Collaboration.

- Individuals – training and retaining the qualified researchers and technicians necessary to prosper in the global economy.

- Institutions – forging the institutional environments necessary to support these researchers and advance their endeavors.

- International Collaboration – constructing and sustaining the international intellectual and innovation networks necessary to help scientists and technicians thrive in an increasingly interconnected world.

Individuals

First among these challenges is the need to educate and cultivate the new generation of scientists and researchers in the Muslim world. This entails improving schooling in science and technology at all levels. According to a study by the International Islamic University of Malaysia, OIC countries have 8.5 scientists, engineers, and technicians per 1,000 people on average, while the global average is 40.7 and the average in OECD countries is 139.3.[32] Despite the recent flagship initiatives of a few countries, Muslim nations generally enroll fewer university students in scientific, engineering, and technical subjects than do a number of other emerging economies. So although some 40% of Malaysian students, 31% of Libyan and Tunisian students, and 30% of Jordanian students are training in these fields, fewer than 20% of students in Algeria, Egypt, Indonesia, Morocco, Oman, Qatar, Saudi Arabia, and the West Bank and Gaza are. Meanwhile, 46.8% of Chinese university students, 41.1% of South Korean, 32% of Chilean and Mexican, and 20.1% of Brazilian students are enrolled in scientific, engineering, and technical disciplines.[33]

At the same time, there is reason to worry that, especially among many poorer Muslim nations governments are failing to devote more than minimal resources to technical and vocational education.

[31] This section reflects the discussions of participants in the Working Group on Scientific, Intellectual, and Governance Cooperation on Emerging Environmental Challenges in the Muslim World at the 2010 U.S.-Islamic World Forum.
[32] Hoodbhoy (2007), p.50.
[33] World Bank, *The Road Not Traveled: Education Reform in the Middle East and North Africa* (Washington, DC: The World Bank, 2008), p.21.

According to (unfortunately dated) figures compiled in a recent UNESCO study, of ten Sahelian and Sub-Saharan African OIC countries surveyed, only Gabon allotted more than 10% of total education spending to technical and vocational education, while Benin, Chad, Ivory Coast, Mauritania, Senegal, and Togo, all accorded less than 5% of spending to such programs.[34]

Finally, even as the Muslim world moves to increase education and training in science and technology, "brain drain" remains a common concern for many states as researchers frequently leave their home countries in search of often better-funded opportunities elsewhere. Loss of educated professionals has long been a problem in Sub-Saharan Africa and is also a serious issue in the Arab world. Indeed, the Gulf Center for Strategic Studies estimates that "Arab countries lose half of their newly-qualified medical doctors, 23% of engineers and 15% of scientists each year, with three quarters of these moving to the United Kingdom, United States and Canada. This is estimated to equate to annual losses to Arab states of more than U.S.$2 billion."[35] Meanwhile, 45% of Arab students who study abroad do not return to their home country after receiving their degree.[36]

In some cases, though, countries may be able to draw upon this reservoir of expatriate expertise to their advantage. For example, since 1977, the UN Transfer of Knowledge Through Expatriate Nationals (TOKTEN) program has provided for over 4,000 professionals from developing nations to return to their home country for short periods as volunteer consultants to share their skills. TOKTEN has brought scientists and technical advisors to several Muslim countries including Afghanistan, Egypt, Lebanon, Mali, Pakistan, the Palestinian Territories, Senegal, Sudan, Syria, and Turkey.[37]

Institutions

A second set of closely related questions concern how the Islamic countries can create the enabling institutional environments required to build a strong corps of scientific professionals and to catalyze and improve their capacity for scientific and technological innovation. Muslims nations must foster the institutional supports necessary to both produce more qualified scientists and to enhance scientists' productivity and the quality of their work.

Recent studies of the Arab states illuminate the ongoing challenges. Egypt, Jordan, and Lebanon, for instance, have undertaken curricular reforms and other initiatives to improve science training and promote the use of information and communication technology in the classroom. Several countries have considerably expanded their university systems. Nevertheless, academic establishments across the Arab world continue to turn out too many graduates mismatched to the needs of their societies. Numerous Arab nations suffer shortages of science and technology specialists. Oil exporting states are importing engineers from abroad, while international corporations in the region are resorting to establishing their own in-house training programs to meet their work force requirements.[38] Yet at the same time, unemployment rates in many of these countries are disproportionately elevated among

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[34] UNESCO Institute for Statistics, *Participation in Formal Technical and Vocational Education and Training Programmes Worldwide* (Bonn: UNESCO-UNEVOC, 2009), p.36.

[35] Wagdy Sawahel, "Brain Drain Threatens Future of Arab Science," *SciDev.Net*, 3 June 2004.

[36] Mohammed bin Rashid Al Maktoum Foundation/UNDP (2009), p.207.

[37] Mohammed bin Rashid Al Maktoum Foundation/UNDP (2009), p.208; UN Volunteers, "TOKTEN," Fact Sheet, 1 December 2008, at <http://www.unv.org/fileadmin/docdb/pdf/2008/TOKTEN_factsheet_01.12.2008.pdf>; International Labor Organization, "The TOKTEN (Transfer of Knowledge Through Expatriate Nationals) Programme," at <http://www.ilo.org/dyn/migpractice/migmain.showPractice?p_lang=en&p_practice_id=26>.

[38] Kristin M. Lord, *A New Millennium of Knowledge? The Arab Human Development Report on Building a Knowledge Society, Five Years On* (Washington, DC: The Brookings Institution, 2008), p.35; Mohammed bin Rashid Al Maktoum Foundation/UNDP (2009), p.115.

the more highly educated. In Algeria those with a post-secondary qualification represent 20% of the labor force but 37.8% of the unemployed. In Bahrain they constitute 25.9% of the labor force but 59% of the unemployed. In Egypt the numbers are 42% and 80%, in Morocco 16.4% and 29.6%, in Oman 15.4% and 39.7%.[39] Such statistics suggest that the educational institutions in many countries are insufficiently responsive to the requirements of businesses and the market, ill-serving their students and their societies.

In addition to producing more researchers, the Muslim world must also improve the supporting institutional environment to allow its researchers to be more productive. By one calculation, the Arab world counts some 210,000 research and development professionals, but the total publications rate of all the Arab nations combined is equivalent to just 24 scientific papers per 1,000 university professors and full-time researchers. Evaluated on another measure, Finland spends about 1.75 times as much as the Arab region on scientific research but registers more than 22 times as many patents as all the Arab countries put together.[40]

Multiple factors contribute to the Arab states' meager yield for their investment. Research institutions around the Arab world—and in the Muslim nations as a whole—are all too often underfunded. So too, in many countries they are generally inadequately attuned to industry and the private sector, either as sources of funding or as partners and pathways for translating research findings into practical applications of benefit to society. Underlying these elements, however, runs a more systemic institutional deficit. Most Muslim countries possess insufficiently robust enabling frameworks of legal, regulatory, and administrative structures—what the authors of the *Arab Knowledge Report 2009* term the "institutionalism" of knowledge society—necessary to protect and promote the innovation, evaluation, and dissemination, of knowledge into society.[41] This institutional fabric supporting knowledge production and management will be more challenging to realize in the Muslim countries as, unlike individual researchers or technologies, it cannot be imported but must be cultivated indigenously.[42]

International Scientific Networks

Strong international scientific networks can help facilitate better information-sharing within the Muslim world. Such institutions can provide primary research and discussion forums for scientists from developing countries and less well-funded scientific communities, helping to harness region-wide capabilities and allowing countries to pool capacities in order to overcome the scientific limitations of individual states.

Despite its lack of resources in many important areas, Sub-Saharan Africa hosts some of the strongest scientific networks in the developing world, including The New Partnership for Africa's Development (NEPAD), the University Science, Humanities, and Engineering Partnerships in Africa (USHEPiA), and the Association of African Universities. In the Middle East, the Arab League Educational, Cultural, and Scientific Organization seeks to promote educational and scientific cooperation throughout the Arab world. On a broader level, the OIC has set up several "Inter-Islamic Networks" in a number of areas:

- Genetic Engineering and Biotechnology (INOGEB) based in Egypt

[39] World Bank (2008), p.214.
[40] Mohammed bin Rashid Al Maktoum Foundation/UNDP (2009), p.201.
[41] Mohammed bin Rashid Al Maktoum Foundation/UNDP (2009), p.84.
[42] For the view that rising religious fundamentalism in the Islamic countries is impeding this development, see Hoodbhoy (2007); Ismail Serageldin, "Science in Muslim Countries," *Science* 321, No.5890 (2008).

- Renewable Energy Sources (INRES) in Pakistan
- Oceanography (INOC) in Turkey
- Space Sciences and Technology (ISNET) in Pakistan
- Tropical Medicine (INTROM) in Malaysia
- Water Resources Development and Management (INWRDAM) in Jordan
- Biosaline Agriculture (INBA) in Dubai
- Information Technology (INIT) in Pakistan
- Veterinary Science and Research (INVSR) in Sudan
- Environment (INE) in Sudan

In addition to these topic-oriented networks, the OIC has established the Islamic Foundation for Education, Science, and Culture in Morocco to coordinate the specialized agencies of the OIC in these fields. It has also created a Network of the Academies of Sciences in the Countries of the OIC (NASIC) gathering the National Academies of the member countries, and the Islamic World Academy of Sciences comprising eminent individual scientists. Most recently, in April 2009, the OIC announced the creation of a Technology Exchange Forum to furnish scientists and research institutions with assistance in transferring home grown technologies in fields such as agriculture, engineering, and energy between member countries.[43]

The OIC experience, however, also points up the challenges facing such initiatives. International networks are much easier to announce than to animate. These bodies have been chronically underfunded and underutilized, with years often lapsing between their announcement and their activation. As an emblematic example, a proposed OIC Islamic Center for Science Policy for Techno-Economic Studies, approved in 1984 to help member states develop coherent strategic science policy, for years lay dormant for lack of funds, never functioning before ultimately being replaced in 2008 by an International Science Technology Innovation Centre for South-South Cooperation housed within the OIC's COMSTECH.[44]

Research networks are often held up as a partial solution that can help offset the relative lack of resources afflicting some countries and institutions through connectedness, sharing learning and pooling capacities. But connectedness itself requires resources. According to Ismail Serageldin, Director of the Library of Alexandria, "One of the largest obstacles to conducting scientific research is the high cost of broadband access. At the Bibliotecha Alexandrina, we spend ten times what we would spend at a comparable research institution in the United States."[45]

If not managed correctly, network connectedness can also carry hidden costs. Some observers worry that in some cases, the requirements of assembling cooperative projects capable of securing international participation and funding may distance scientists from research more closely related to national needs and priorities, and that this problem may disproportionately affect the most qualified researchers since they are most likely to attract foreign support.[46] Regional and international networks clearly can offer advantages that make them more than the sum of their parts, but they must be assembled and managed as partnerships for mutual (institutional and national) benefit.

[43] Wagdy Sawahel, "Islamic Countries Establish Tech-Sharing Forum," *SciDev.Net*, 23 April 2009.
[44] COMSTECH, "Working Paper," Twenty-Fifth Meeting of the COMSTECH Executive Committee, 7-8 January 2007, Muscat, Sultanate of Oman.
[45] Quoted in Lord (2008), p.42.
[46] Mohammed bin Rashid Al Maktoum Foundation/UNDP (2009), p.195.

Recommendations for U.S. Cooperative Initiatives

Given the sheer breadth of current U.S. government science and technology initiatives in the Muslim world, it is critical to establish a coherent and explicit U.S.agenda in order to address the gaps in scientific capability noted in the previous section.[47]

Programmatic Recommendations

In order to create a more-unified U.S.agenda, several steps need to be taken to establish proper governmental infrastructure. These include:

- Building an internal clearinghouse for U.S.government-funded activities;
- Conducting institution surveys in critical regions;
- Expanding the scope and consistency of training and exchange fellowships, while reviewing visa practices; and
- Creating a travel fund for workshops and conferences

Strategy Recommendations

Once the programmatic details of a U.S.strategy have been established, policymakers and scientists can formulate a strategy that can 1) Create more efficacious means of technology and scientific transfer in the Muslim world and 2) Expand the reach of U.S.efforts to help countries in these regions adjust to environmental challenges. This strategy should:

- Focus first on science and technology, not research and development, since most Islamic countries will derive more benefit from learning and adapting foreign technology than from creating new technology. This is the first step toward enabling these countries to produce their own cutting-edge research;

- Use science and technology cooperation as a tool to achieve policy changes carefully and sparingly, since science and technology cooperation is unlikely to induce breakthroughs by itself;

- Take advantage of bilateral cooperation, since regional networks and cooperation can often be politically fraught and, consequently, inefficient. This is especially true in the Middle East, due to the competitive nature of country-to-country relationships in the region;

- Regional approaches and networks can be powerful tools for regions where political

[47] The following recommendations draw from Levi and D'Arcy (2005).

barriers to cooperation are less onerous. An example of this is Africa, where many small, poor states lack the resources to develop their scientific and technical capacities absent international cooperation;

- Involve the Islamic world diasporas—this will take advantage of immigrant communities' willingness to retain and deepen their involvement in assisting with their countries of origin;

- Coordinate science and technology cooperation with ICT improvements in order to facilitate more efficient lines of communication and information exchange;

- Promote cooperation that improves export capabilities; and

- Develop a coordinated public diplomacy strategy for science and technology cooperation.

Recommendations of Priority Strategies and Issues for U.S.-Islamic World Cooperation

Priority Strategies

- **Adaptation**: With important exceptions, most Islamic countries contribute comparatively little to most drivers of global environmental change (e.g., greenhouse gas emissions, deforestation, over-fishing) while being disproportionately vulnerable to the impacts. Cooperation should privilege technologies and practices that increase the Muslim countries' resilience and capacity to adapt to environmental stresses when they cannot avoid them.

- **Information**: For many environmental issues, adequate, accurate data is unavailable or inaccessible to policymakers (e.g., regional scale climate models, time-series records of meteorological variables, river runoff, water pollution levels, fish stocks, etc.). Cooperation should prioritize technologies and practices that increase the Muslim countries' ability to monitor, record, evaluate and disseminate data on key environmental variables at local, national, and regional scales.

- **Duplication - Don't Reinvent the Wheel**: Muslim countries already possess not only many capable researchers and research centers but also some international research networks. Cooperation should take advantage of the collaborative infrastructure these networks can provide. In many cases they have failed to live up to their potential for lack of resources, not lack of connections.

- **Facilitation – South/South Cooperation**: Despite their diversity, many Muslim countries confront similar environmental risks while also sharing similar technical and institutional capacities. Experience in one country will often provide a more appropriate technology or applicable policy model than developed country practice. The U.S. should strive to facilitate and fortify cooperation among the Islamic countries as well as between the U.S. and the Muslim world.

- **Transition**: Strategies to build capacity in the Muslim world should explicitly plan for the transition to greater target country autonomy in funding / managing cooperative projects and networks. The past record of such efforts suggests that many such programs languish or fold in the longer term when funding streams or other assistance ends.

Priority Areas of Work

- **Climate Change**: Scaling of Global Circulation Models to Regional-scale Resolution; Modeling and Monitoring Himalayan Snow and Ice Cover; Integrated Research on Climate, Biodiversity, Desertification, and Water; Impacts of Sea Level Rise

- **Water Resources**: Impacts of Environmental Change on Transboundary River Basins; Shared Aquifers; Environmental Flow Assessments

- **Food Security**: Agricultural Adaptation; Saline water agriculture, Dryland agriculture and Drought-resistant agriculture; Fisheries; Biotechnology; Extension services

- **Energy Security**: Research and Capacity Building for Renewable Energy, especially Solar; Low Cost Technology Applications; Energy Management

- **Biodiversity**: Monitoring of Impacts of Climate Change and other Anthropogenic Factors on Wetland, Dryland, and Mountain environments

- **Environmental Health**: Air Pollution Impacts; Changing Disease Vectors

- **Science Policy and Environmental Governance**: Setting National Priorities; Integrating Science & Technology with Development Policy

Annex

Gross Expenditures on Research and Development as a % of GDP

YEAR	2000	2001	2002	2003	2004	2005	2006	2007
Germany	2.454255	2.460864	2.489935	2.523178	2.490345	2.487238	2.549578	2.554633
Japan	3.042685	3.1228	3.1653	3.198775	3.167131	3.325189	3.399967	3.445418
United States	2.745791	2.761431	2.659595	2.656179	2.5807	2.61216	2.648592	2.670289
Brazil	0.938709	0.963033	0.907552	0.884927	0.830184	0.968866	1.023205	...
China	0.902752	0.950691	1.070031	1.133556	1.229894	1.332461	1.417071	1.486891
India	0.770521	0.747631	0.733335	0.716142	0.687099	0.80374	0.794577	0.801543
Russian Federation	1.04984	1.176942	1.246526	1.282636	1.149923	1.067194	1.074431	1.124914
Algeria	...	0.238461	0.364516	0.19578	0.164168	0.066596	...	...
Azerbaijan	0.335995	0.340011	0.301552	0.324959	0.29831	0.219942	0.171647	0.179861
Brunei Darussalam	...	...	0.015925	0.018419	0.037014	...	...	...
Burkina Faso	...	0.190567	0.330009	0.26708	0.22916	0.171683	...	0.110692
Egypt	0.192473	...	...	...	0.269936	0.248839	0.259025	0.229759
Indonesia	0.067693	0.047563	...	...	...	0.049054	...	...
Iran	...	0.55195	0.547542	0.67451	0.587419	0.73454	0.668143	...
Jordan	...	...	0.336816	...	...	...	...	...
Kazakhstan	0.181041	0.220085	0.255091	0.252462	0.248373	0.283606	0.24281	0.210872
Kuwait	0.125428	0.17882	0.180015	0.143602	0.130096	0.097173	0.084341	0.087849
Kyrgyzstan	0.15637	0.171893	0.198098	0.222721	0.199257	0.198614	0.23141	0.250786
Malaysia	0.487012	...	0.691492	...	0.599897	...	0.636917	...
Morocco	...	0.634035	0.548791	0.659137	...	...	0.637974	...
Mozambique	...	...	0.504208	...	...	...	...	...
Pakistan	0.128277	0.166701	0.219767	...	...	0.436892	...	0.671211
Saudi Arabia	...	...	...	0.062687	0.054931	0.044028	0.044863	0.049269
Senegal	...	...	...	...	...	0.089253	...	...
Sudan	0.468615	0.440866	0.390543	0.337273	0.292767	0.289055	...	...
Tajikistan	...	0.089527	0.070684	0.068845	0.067077	0.095295	0.104997	0.064354
Tunisia	0.457771	0.532039	0.628262	0.726652	0.999001	1.022057	...	...
Turkey	0.479088	0.537785	0.525939	0.48311	0.518309	0.591039	0.58016	0.711265
Uganda	...	...	0.389134	0.270755	0.303478	0.227468	0.315568	0.412033

SOURCE: UNESCO Institute for Statistics, Data Center: Science and Technology, "Table 12: Gross Domestic Expenditure on R&D (GERD) as a percentage of GDP and GERD per capita," available at <http://stats.uis.unesco.org/unesco/TableViewer/tableView.aspx?ReportId=1782>.

Gross Expenditures on Research and Development per capita (in PPP$)

	2000	2001	2002	2003	2004	2005	2006	2007
Germany	637.0227	662.819	688.9894	722.5989	745.2148	757.7881	809.7343	846.1954
Japan	779.5566	819.5627	851.0494	882.2254	922.3677	1009.773	1088.909	1158.478
United States	931.4861	956.1626	942.3731	975.7801	1003.398	1069.738	1140.536	1194.785
Brazil	66.06979	69.34272	67.2874	66.95759	67.42738	82.43315	92.13794	...
China	21.33411	24.72797	30.67276	36.25233	44.23646	54.15363	65.89534	78.92721
India	11.43185	11.75162	11.97018	12.72954	13.38553	17.35152	19.12572	21.28045
Russian Federation	80.01811	96.95978	109.9749	124.7002	123.8112	126.5664	141.8477	165.4949
Algeria	...	12.77142	21.39052	12.35782	11.04405	4.778873	...	...
Azerbaijan	7.677554	8.677435	8.608144	10.45413	10.76606	10.22391	10.9463	13.87577
Brunei Darussalam	...	...	7.150506	8.514277	17.33022	...	...	...
Burkina Faso	...	1.632033	2.915808	2.519846	2.250012	1.7856	...	1.249316
Egypt	6.761972	...	...	...	11.042	10.747	12.10618	11.5902
Indonesia	1.643361	1.209184	...	...	...	1.584038	...	...
Iran	...	37.6282	40.37766	53.82784	50.11219	66.79566	65.62822	...
Jordan	...	...	11.83726	...	...	...	...	...
Kazakhstan	8.637419	12.24417	15.83528	17.41359	19.18699	24.59502	23.88897	22.94371
Kuwait	38.95684	54.58964	55.21887	50.51326	50.28736	41.24378	...	...
Kyrgyzstan	2.065541	2.419746	2.807381	3.41732	3.332451	3.380398	4.125098	4.870353
Malaysia	44.90181	...	66.61391	...	65.9951	...	79.90267	...
Morocco	...	17.91702	16.1185	20.74922	...	...	24.68892	...
Mozambique	...	...	2.713809	...	...	...	...	...
Pakistan	2.048187	2.714796	3.673999	...	...	8.965229	...	15.88997
Saudi Arabia	...	...	...	11.61271	10.74654	9.147272	9.699542	11.06435
Senegal	...	...	...	...	...	1.440579	...	...
Sudan	5.508187	5.515282	5.133216	4.752983	4.370081	4.627703	...	...
Tajikistan	...	0.888153	0.77007	0.835042	0.914767	1.41062	1.692314	1.130773
Tunisia	22.3649	27.67451	33.50686	41.42489	61.56815	66.87373	...	...
Turkey	42.42897	44.76109	43.99043	41.00688	50.85699	62.06343	67.74618	89.84753
Uganda	...	...	2.873289	2.070132	2.435157	1.941778	2.826876	3.905469

SOURCE: UNESCO Institute for Statistics, Data Center: Science and Technology, "Table 12: Gross Domestic Expenditure on R&D (GERD) as a percentage of GDP and GERD per capita," available at <http://stats.uis.unesco.org/unesco/TableViewer/tableView.aspx?ReportId=1782>.

About the Brookings Project on U.S. Relations with the Islamic World

The Project on U.S. Relations with the Islamic World is a major research program housed within the Saban Center for Middle East Policy at the Brookings Institution. The project conducts high-quality public policy research, and convenes policy makers and opinion leaders on the major issues surrounding the relationship between the United States and the Muslim world. The Project seeks to engage and inform policymakers, practitioners, and the broader public on developments in Muslim countries and communities, and the nature of their relationship with the United States. Together with the affiliated Brookings Doha Center in Qatar, it sponsors a range of events, initiatives, research projects, and publications designed to educate, encourage frank dialogue, and build positive partnerships between the United States and the Muslim world. The Project has several interlocking components:

- The U.S.-Islamic World Forum, which brings together key leaders in the fields of politics, business, media, academia, and civil society from across the Muslim world and the United States, for much needed discussion and dialogue;

- A Visiting Fellows program, for scholars and journalists from the Muslim world to spend time researching and writing at Brookings in order to inform U.S. policy makers on key issues facing Muslim states and communities;

- A series of Brookings Analysis Papers and Monographs that provide needed analysis of the vital issues of joint concern between the U.S. and the Muslim world;

- An Arts and Culture Initiative, which seeks to develop a better understanding of how arts and cultural leaders and organizations can increase understanding between the United States and the global Muslim community;

- A Science and Technology Initiative, which examines the role cooperative science and technology programs involving the U.S. and Muslim world can play in responding to regional development and education needs, as well as fostering positive relations;

- A Faith Leaders Initiative which brings together representatives of the major Abrahamic faiths from the United States and the Muslim world to discuss actionable programs for bridging the religious divide;

- A Brookings Institution Press Book Series, which aims to synthesize the project's findings for public dissemination.

The underlying goal of the Project is to continue the Brookings Institution's original mandate to serve as a bridge between scholarship and public policy. It seeks to bring new knowledge to the attention of decision-makers and opinion-leaders, as well as afford scholars, analysts, and the public a better insight into policy issues. The Project is supported through the generosity of a range of sponsors including the Government of the State of Qatar, The Ford Foundation, The Doris Duke Charitable Foundation, and the Carnegie Corporation.

The Project Conveners are Martin Indyk, Vice President and Director of Foreign Policy Studies; Kenneth Pollack, Senior Fellow and Director, Saban Center; Bruce Riedel, Senior Fellow in the Saban Center; Stephen R. Grand, Fellow and Director of the Project on U.S. Relations with the Islamic World; Shibley Telhami, Nonresident Senior Fellow and Anwar Sadat Chair for Peace and Development at the University of Maryland; and Hady Amr, Director of the Brookings Doha Center.

About the Saban Center for Middle East Policy at Brookings

THE SABAN CENTER FOR MIDDLE EAST POLICY was established on May 13, 2002 with an inaugural address by His Majesty King Abdullah II of Jordan. The creation of the Saban Center reflects the Brookings Institution's commitment to expand dramatically its research and analysis of Middle East policy issues at a time when the region has come to dominate the U.S. foreign policy agenda.

The Saban Center provides Washington policymakers with balanced, objective, in-depth and timely research and policy analysis from experienced and knowledgeable scholars who can bring fresh perspectives to bear on the critical problems of the Middle East. The center upholds the Brookings tradition of being open to a broad range of views. The Saban Center's central objective is to advance understanding of developments in the Middle East through policy-relevant scholarship and debate.

The center's foundation was made possible by a generous grant from Haim and Cheryl Saban of Los Angeles. Ambassador Martin S. Indyk, Vice President of Foreign Policy at Brookings was the founding Director of the Saban Center. Kenneth M. Pollack is the center's Director. Within the Saban Center is a core group of Middle East experts who conduct original research and develop innovative programs to promote a better understanding of the policy choices facing American decision makers. They include Bruce Riedel, a specialist on counterterrorism, who served as a senior advisor to four presidents on the Middle East and South Asia at the National Security Council and during a twenty-nine year career in the CIA; Suzanne Maloney, a former senior State Department official who focuses on Iran and economic development; Stephen R. Grand, Fellow and Director of the Project on U.S. Relations with the Islamic World; Hady Amr, Fellow and Director of the Brookings Doha Center; Shibley Telhami, who holds the Sadat Chair at the University of Maryland; and Daniel Byman, a Middle East terrorism expert from Georgetown University. The center is located in the Foreign Policy Studies Program at Brookings.

The Saban Center is undertaking path breaking research in five areas: the implications of regime change in Iraq, including post-war nation-building and Gulf security; the dynamics of Iranian domestic politics and the threat of nuclear proliferation; mechanisms and requirements for a two-state solution to the Israeli- Palestinian conflict; policy for the war against terrorism, including the continuing challenge of state sponsorship of terrorism; and political and economic change in the Arab world, and the methods required to promote democratization.

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