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ISBN 978-0-309-46399-7 | DOI 10.17226/24861

CONTRIBUTORS

Glenn E. Schweitzer; Development, Security, and Cooperation; Policy and Global Affairs; National Academies of Sciences, Engineering, and Medicine

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U.S.- Iran Engagement in Science, Engineering, and Health (2010–2016)

A Resilient Program but an Uncertain Future

Glenn E. Schweitzer

Development, Security, and Cooperation

Policy and Global Affairs

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Washington, DC
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This activity was supported by Contract No. 10003040 with the Department of State, the Richard Lounsbery Foundation, the Thomas Lincoln Casey Fund, and the W. K. Kellogg Foundation Fund. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project.

Digital Object Identifier: https:// doi.org /10.17226/24861

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Printed in the United States of America

Suggested citation: National Academies of Sciences, Engineering, and Medicine. 2017. *U.S.-Iran Engagement in Science, Engineering, and Health (2010-2016): A Resilient Program but an Uncertain Future*. Washington, DC: The National Academies Press. doi: https:doi.org/10.17226/24861.

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The **National Academy of Sciences** was established in 1863 by an Act of Congress, signed by President Lincoln, as a private, nongovernmental institution to advise the nation on issues related to science and technology. Members are elected by their peers for outstanding contributions to research. Dr. Marcia McNutt is president.

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Preface and Acknowledgments

From 2010 to 2016, several hundred American and Iranian scientists, engineers, and health specialists participated in the cooperative activities sponsored by the National Academies of Sciences, Engineering, and Medicine and their partners in the United States and Iran that are discussed in this report. These specialists deserve many accolades for their joint efforts to contribute to and document numerous advances in science, technology, and health and to provide fresh perspectives for addressing important challenges in a variety of fields of global interest. Despite the political acrimony and constraints on international communication that have separated the United States and Iran in recent years, the interest in participating in joint efforts has been steady. At the same time, the interest in the National Academies' programs of the dozens of universities, research centers, and other organizations in the two countries that are the home institutions of the program participants has been essential for ensuring the success of activities carried out in the United States, Iran, and other countries.

In Washington, D.C., the Department of State (the department) has been an essential supporter of the National Academies' program. The department has been readily available to provide guidance concerning the uncertain political landscape and the ever-tightening legal constraints on cooperation. It has helped develop innovative steps that could be taken to ensure compliance with the increasing reach of economic sanctions. Also, the nongovernmental organization World Learning, a long-time partner of

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the department, has played an important role in facilitating scientist-to-scientist exchanges.

As has been the case since the inception of the program of cooperation involving Iranian and American colleagues in 2000, the leadership of the National Academies has provided strong support and consistent funding to ensure that the program would continue despite political and administrative barriers to implementation. At the same time, colleagues from the University of Arizona with decades of experience in promoting U.S.-Iranian collaboration, together with foreign policy experts in Washington, have contributed invaluable assistance to the National Academies' staff to improve awareness of the historical context and of up-to-date developments in Iran that have been important in developing and implementing appropriate programs.

For many years, the Richard Lounsbery Foundation has provided financial support for a variety of U.S.-Iran collaborative activities in the United States and abroad. During the time period under consideration, the Fondation des Treilles in Paris, France, generously opened the doors of its conference center in Tourtour in welcoming three groups of specialists from the United States, France, and Iran for week-long retreats. In the United States, the University of California at Irvine has offered hospitality for a number of workshops held at the National Academies' conference center on the edge of the university campus. All the while, a number of Iranian organizations have provided funding and made arrangements for a variety of collaborative activities in Tehran.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making each published report as sound as possible and to ensure that it meets the institutional standards for quality, objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We thank the following individuals for their review of this report: Peter Agre, Johns Hopkins University; Najmedin Meshkati, University of Southern California; Barbara Slavin, Atlantic Council; Soroosh Sorooshian, University of California, Irvine; and James Timbie, Stanford University.

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations of this report nor did they see the final draft before its release. The review of this report was overseen by Michael Clegg, University

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of California, Irvine. He was responsible for making certain that an independent examination of this report was carried out in accordance with the standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the authoring committee and the National Academies.

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Summary

In 2010, the National Research Council published the report *U.S-Iran Engagement in Science, Engineering, and Medicine (2000-2009)*. The review of the program described in detail the National Academies' science, technology, and health cooperation program carried out jointly with partners in Iran (hereinafter referred to as science-engagement).

The report in 2010 concluded that the science and technology benefits from science-engagement had been rewarding for both countries. According to the report, science-engagement can over time not only begin to contribute to improved economic and social conditions for the general public but also can offer a rallying point for bringing interested parties together nationally and internationally, with no need for major political compromises by any party. The review of the program emphasized that cooperation in science had been one of the few available options for bridging diverse interests of Iran and the United States and for establishing gateways to mutual understanding and to international security of global importance.

The purpose of this new report is to document the history and details of the National Academies' program of science-engagement from 2010 through 2016, while providing a perspective in considering future science-engagement. A variety of cooperative activities, and particularly workshops that dominated science-engagement during that period, are highlighted. Well-prepared gatherings of 20-30 experts in fields of priority interest to the National Academies and its U.S. and Iranian partners provided opportunities for in-depth discussions of research and field activities. Also,

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each workshop led to preparation of a proceedings, which addressed developments and challenges of national and international interest. The workshops were held primarily in the United States and Iran, and occasionally in other countries with participation of local experts.

As to other science-engagement activities sponsored by the National Academies in recent years, a few exchange visits to Iran, each involving one or two Americans, and visits by individual Iranians to the United States were important. Also occasional participation by American scientists in international conferences in Tehran and by Iranian scientists in conferences in the United States were significant. However, such limited endeavors seldom had substantial scientific impact without follow-on engagement.

More than 1,500 scientists, engineers, and medical professionals (hereinafter referred to as "scientists") from about 120 institutions in the two countries—primarily universities and other centers of research—participated in the program sponsored by the National Academies from 2000 to 2016. A comparable number of scientists in the two countries also were actively involved in arranging and hosting events for visitors from abroad. About one-half of the interested scientists participated in events from 2010 to 2016.

Another important activity was the frequent discussions between the National Academies and senior U.S. and Iranian government officials about the National Academies' objectives, activities, and findings. These discussions kept science-engagement on political screens as an important mechanism for promoting a common objective of the two governments, namely to support constructive science diplomacy. Also, the National Academies regularly shared its experience with other interested organizations in the United States and Iran concerning both the technical and administrative aspects of science-engagement, along with the results of joint efforts,

CONTEXT FOR SCIENCE-ENGAGEMENT FROM 2010 TO 2016

The original intent of the National Academies' cooperative program was to focus over the long-term on fields of science of mutual interest that were identified in 2000 by the leaderships of the academies of both countries. However, the administrative and financial aspects in developing and implementing cross-border activities were formidable. Therefore, the National Academies, in consultation with Iranian partners, quickly expanded the list of fields of interest; and the determination of priorities was based in large measure on the ease of arranging the travel details and the agendas for the events, while adhering to the overarching principle of mutual interest.

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This report begins with a review of some of the highlights during the initial years of science-engagement (2000-2009), with particular attention as to whether and how the early events set the stage for sustainable interactions. Among the activities that were most successful in leading to subsequent endeavors were workshops and individual exchange visits that addressed the following topics: (a) detecting and responding to outbreaks of food-borne diseases, (b) improving capabilities to prepare for, to record, and to respond to earthquakes and their aftershocks, (c) coping with drought conditions in arid lands, and (d) recognizing the importance of scientific cooperation as a catalyst for encouraging diplomacy.

Also of relevance from the early years of science-engagement have been the broad efforts of the Iranian government to develop a knowledge-based economy. Ambitions of the Iranian government call for the economy to be increasingly driven by emphasis on science and technology, with greater payoffs from investments in these areas. International cooperation is to guide the search for world-wide achievements of interest to Iran.

Five aspects of Iran's quest to become a technological leader in the Middle East that were increasingly evident in recent years of engagement are the following: (a) an expanded role of the Vice President for Science and Technology, who in recent years has had responsibility for shaping the science and technology policy of the country while administering an annual research budget of about $500 million; (b) increasing enrollment at Iranian universities, which by 2015 accommodated more than 4.5 million students; (c) sharpening the focus of government research centers on breakthrough fields of growing international interest, such as nanotechnology; (d) increasing the funding and other incentives for non-governmental technology-oriented small firms to become "engines of technological innovation;" and (e) expanding a small cadre of experts within and outside government who have been developing and monitoring the nation's science and technology policy that includes increased recognition of the importance of international cooperation.

Also, the report highlights the dramatic growth in publications of Iranian scientists in internationally recognized journals, including publications jointly authored with foreign colleagues.

PROGRAM ACTIVITIES

Participation in exchange activities devoted to the topics set forth below was the backbone of the National Academies' engagement activities from

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2010-2016. The National Academies had opportunities to invite excellent Iranian specialists to participate, including both fast-rising male and female investigators in the early stages of their careers. Many of the participants became important advocates of continued engagement upon their return to Iran. Some followed up this interest through direct contacts with American scientists that they had met and/or through participation in subsequent activities of the National Academies.

- Water Resource Management
- Earthquake Preparedness and Management
- Vehicle Transportation
- Solar Energy Research
- Wildlife Conservation and Habitat Management
- Mathematics Education
- Urban Air Pollution
- Resilient Cities
- Climate Change
- Conservation of Wetlands

With the election of President Hassan Rouhani in 2013, new opportunities for sustained engagement emerged. Workshops were organized in the United States, Iran, and France. At a workshop devoted to climate change, for example, the Iranian and American participants identified more than 25 cooperative activities that could be undertaken to improve regional or global understanding of the causes and impacts of global warming and steps to mitigate harmful effects. Also, as an example of near-term payoff from engagement, four Iranian water experts who participated in a workshop on the future of Lake Urmia were among the advisers appointed by President Rouhani on this topic immediately after he was installed as President of Iran in 2013.

Of special importance are lessons learned from past cooperative activities that should be of interest to many U.S. organizations involved in current and future cooperation with Iranian counterparts. They include, for example, the following approaches.

- Involve both highly respected leaders in the field of interest and early career professionals who can sustain joint efforts for years and even decades.

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- Ensure that specialists and organizations from both countries bring significant technical and managerial capabilities to the table and share equally in assuming responsibility for implementation of projects and in taking credit for successes.
- Encourage publicity for positive results of joint efforts, with solid scientific documentation available to support claims of progress,
- Give first priority to the scientific benefits from projects, and then the diplomatic successes will be easier to achieve.

CONSTRAINTS

At the top of the list of constraints in implementing the projects developed and/or supported by the National Academies have consistently been (a) concerns of American participants about their personal safety while participating in activities in Iran, (b) uncertainties as to the limitations on academic exchanges of specific regulations promulgated by the Office of Foreign Assets Control (OFAC) of the Department of Treasury, and (c) the paucity of funds available from the U.S. government or private sources to support science-engagement.

The National Academies have been very active with regard to OFAC-related issues. Since 2002, the National Academies have obtained 17 licenses to (a) ensure compliance with legal requirements, and (b) to convince American university administrators who approve international travel by faculty members and U.S. government officials who are involved in controlling visits to the United States that the U.S. government supports bilateral program activities endorsed by the National Academies. The National Academies has made limited progress in reducing OFAC constraints. In recent years, the National Academies has applied for three-year licenses rather than following the practice of some organizations in applying for a license for each individual event. Also, the National Academies' licenses have covered not only activities sponsored by the National Academies but also activities sponsored by the National Academies' U.S. partners. The National Academies ensure that their partners abide by the provisions of the licenses.

In addition, the National Academies have worked with the department in seeking general licenses to cover selected activities that do not involve the exchange of funds, equipment, or export-controlled information. As of 2016, two fields were covered by general licenses and did not require specific licenses issued to specific organizations, namely conservation of the environment and protection of wildlife. Other topics for general licenses

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that have been advocated by the National Academies, but not issued as of 2016, include (a) an expanded coverage of environmental "conservation" to include assessment, prevention, and abatement of pollution and preservation of the ecological landscape, and (b) medical research and protection of public health.

AN UNCERTAIN FUTURE

During recent years, the National Academies have modified the program from a fragmented approach addressing many scientific fields to sustained support of projects directed to a limited set of fields. The primary fields of interest changed over time; and in 2016 they were seismic science and engineering, conservation and effective use of water resources, promotion of resiliency of urban areas, reduction of air pollution, and conservation of wetlands.

The report also underscores the importance of more concerted cooperation with Iran by the international community, including the National Academies, in addressing the broad problems of environmental protection. In principle, Iran is committed to addressing a wide range of specific environmental challenges, including, for example, dust storms, droughts, decreased water runoff from mountainous areas, and near-elimination of important endangered species such as the Asiatic cheetah.

At the end of 2016, the outlook for continuation of the National Academies' science-engagement program was uncertain. Political relations between the governments of the United States and Iran were at a low ebb despite the success in 2015 in reaching agreement on the Joint Comprehensive Plan of Action (the nuclear deal), which was both praised and criticized in Washington and Tehran. Also, other aspects of the U.S.-Iran political relationship were often not only acrimonious but also threatening.

Thus, despite tangible benefits for science and diplomacy already achieved through the National Academies-initiated engagement activities, it will be difficult but even more important to justify commitment of financial resources of the U.S. government or foundations to support the National Academies' future efforts in the wake of political turmoil encompassing the overall U.S.-Iran relationship. Of equal importance is maintaining the steadfast support of the National Academies' program by the Department of State, which has played a critical role in visa issuance, support of applications for OFAC licenses, and assurances for the U.S. scientific community that the National Academies' program is in the national interest. While this

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report documents the science and technology benefits from cooperation, it should also contribute to a realistic understanding of the potential and the limitations of science-engagement as a significant approach in transcending the U.S.-Iran political stalemate.

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1

Introduction

This report addresses the development and implementation of cooperation between American and Iranian scientists, engineers, and health specialists (hereinafter referred to as science-engagement) sponsored by the National Academies of Sciences, Engineering, and Medicine and their partners in the United States and Iran from 2010 through 2016. It extends the documentation of earlier science-engagement activities set forth in the related report titled *U.S.-Iran Engagement in Science, Technology, and Medicine (2000-2009): Opportunities, Constraints, and Impacts.* The National Academies Press published that report in 2010, and it is available at www.nap.edu.[1] In 2014, the University of Tehran published in Farsi the first report, without the supporting appendixes that contained additional details about the program; and the report in Farsi has been available from the University of Tehran.[2]

In late 2009, the National Academies temporarily halted the science-Engagement program. The National Academies and other U.S. non-governmental institutions, as well as their partner organizations in Iran, were uncertain as to the policies of the U.S. and Iranian governments

[1] Glenn E. Schweitzer: *U.S.-Iran Engagement in Science, Engineering, and Health (2000-2009): Opportunities, Constraints, and Impacts*, National Academies Press, 2010.

[2] Glenn E. Schweitzer: *U.S.-Iran Engagement in Science, Engineering, and Health (2000-2009): Opportunities, Constraints, and Impacts,* translated by H.R. Mahboodi (PhD) and Ajdolrahim Tandjalli, Tehran University Press, 2014 (in Farsi). Publication was proposed and arranged by the West Asia Council, Washington, D.C.

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concerning people-to-people programs following the election in 2009 of Iranian President Mahmoud Ahmadinejad for his second term. The National Academies considered the pause in engagement to be an appropriate time to review past efforts and to plan for the future when the policies of the two governments were more favorable for exchanges. The content and conclusions of that review are set forth in the report published in 2010. At about the same time that the review was completed, important government officials in both countries expressed their support for revival of cooperation sponsored by the National Academies. The program then continued, taking into account the findings during the review along with changes in the political landscapes in both countries that were relevant to exchanges.

Meanwhile, most U.S. nongovernmental organizations that had sponsored science-engagement with Iranian organizations and had temporarily discontinued their activities in 2009 decided to terminate their support of cooperation for the indefinite future. They were concerned primarily about (a) difficulties in obtaining funds for revival of earlier efforts or for initiation of new programs, (b) longer delays in both Tehran and Washington in approving issuance of visas, (c) increased interference with exchange programs by security authorities on both sides, and (d) compliance with U.S. licensing regulations as the requirements for carrying out exchanges became more complicated. These developments were also of considerable concern to the National Academies; but the early exchanges pursuant to the program had established sufficient credibility, support, and momentum in both countries for the program to continue.

In 2016, the engagement activities of the National Academies again stopped due to uncertainties concerning (a) policies affecting exchanges that would be adopted by the administration of President Donald Trump and the newly elected U.S. Congress, (b) Iranian policies that would be adopted following the presidential election in Tehran in May 2017, and (c) safety of Americans travelling to Iran as inter-governmental acrimony heightened. The leadership of the National Academies considered that the pause in activities was an appropriate time to conduct another assessment of its exchange activities and to begin planning for the future should the program again be revived. This report responds to the interest of the leadership. It reviews recent activities and the base of accumulated experience that can assist in developing future exchange activities of the National Academies, if science-engagement by the National Academies is to continue at a significant level.

Against this background, the purpose of this report is both to document the history and details of the National Academies' cooperation with Iranian

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organizations from 2010 to 2016 and to provide a perspective in considering future science-engagement. It describes a variety of activities, particularly workshops along with individual visits in both directions. Continuing consultations by the National Academies with U.S. and Iranian government officials are discussed. The report gives particular attention to sustainable relationships that have been developed; and it comments on the significance and impacts of past programs and projects, practical considerations in carrying out activities, and opportunities for future engagement. Also, it discusses trends in development of science and technology capabilities in Iran that provide an important context for exchanges.

The National Academies has not been involved in promoting student exchanges, which are of considerable interest to many universities in both countries. Thus, this report does not address the interests and activities of tens of thousands of Iranian students who have been enrolled in U.S. universities from 2010 to 2016.[3]

INTEREST IN BOTH COUNTRIES IN SCIENCE-ENGAGEMENT

From the outset of the National Academies' involvement in exchanges with Iran in 2000, important members and institutions of the U.S. science community have been interested in developing approaches whereby the global community of scientists can benefit more fully from achievements of Iran's research and development activities. A number of American scientists who traveled to Iran in recent years have been favorably impressed by the country's growing science and technology capabilities. Some of these travelers became important contributors in expanding the Naitonal Academies' relationship with Iranian institutions. At the same time, other American scientists who visited Iran did not find research or other activities at the institutions that they visited to be of sustained interest, taking into account the difficulties of arranging and carrying out cooperation. They had little

[3] Iranian students in higher education institutions in the United States reached a peak level of 55,000 in 1978, and the influence of some of these graduates on U.S.-Iranian scientific relations in recent years has been profound. During the academic year of September 2015 to June 2016, more than 12,000 Iranian students attended U.S. institutions, with most of these students enrolled in engineering programs at the graduate level. Department of State officials have informally estimated that the vast majority of these students will return to Iran when they complete their studies in the United States. The number of Iranian students in the United States has been growing at a rate of about ten percent per year during the past decade. Details are included in Institute of International Education, *Open Doors 2016,* November 2016.

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incentive for continuing or expanding the interactions that they experienced during their visits.

Many Iranian researchers who traveled to the United States or met with American colleagues in other venues within the framework of the National Academies engagement program have remained ready to continue contacts. However, few of these researchers have found pathways for meaningful interactions. Thus, visits to the United States by well-established Iranian scientists, beyond extended family gatherings, have only occasionally taken place, usually when an intermediary organization such as the National Academies has made the necessary travel arrangements and organized the programs. Some American and Iranian scientists with common interests have stayed in touch through electronic communication; and the number of jointly authored scientific papers, given political realities, is surprisingly high.

Still the importance of arranging exchanges that continue for many years has not been forgotten in Iran. For more than four decades, thousands of Iranian researchers who received their advanced education in the United States returned to Iran. In time, many obtained leadership positions in universities and in research centers where they promoted cross-ocean contacts with American colleagues. While these senior professors and researchers have now largely retired, they have left indelible impressions within their institutions and among their students that cooperation with American colleagues often paid off for science in general and for personal advancement.

In Tehran and other cities throughout Iran, many of these scientists continue to spread their admiration of important technological advances within the United States. Their views have often been magnified by television broadcasts showing technological achievements that drive the U.S. economy and affect many aspects of life in the United States. As governmental and personal efforts in Iran try to replicate technical advances abroad and as the number of scientific papers co-authored by American and Iranian researchers have increased, the National Academies and other organizations have realized that the scientific dividends to both countries from the revival of the often forgotten era of exchanges involving professionals in many fields of science and technology could be significant.

The political benefits from exchanges—such as building trust between important institutions and individuals in the two countries while contributing to institutional transparency—have frequently been cited by American observers as a strong justification for exchanges. However, the National Academies have considered *scientific* payoff as the most important outcome of its Iran program. Therefore, the National Academies have tried to avoid

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projects that could not be supported on the basis of scientific value, even if a proposed project seemed to offer high promise of advancing diplomatic objectives. To be considered successful, engagement activities needed to be professionally rewarding for the participants from both countries; and mutual enhancement of professional capabilities has been a guiding principle of the National Academies' efforts.

Occasionally the National Academies have sponsored "training" programs wherein American experts do not benefit immediately. However, these programs have been designed to enhance the technical capabilities of the participating Iranian scientists so that they are in positions to contribute to subsequent cooperative programs that benefit participants from both countries. An example is the training of early-career Iranian scientists to modernize data systems for storage and then for sharing of seismic measurements that are of broad international interest. When Iran has in place upgraded data storage, retrieval, and distribution systems, the global scientific community benefits from access to previously unavailable data.

The National Academies have been reluctant to engage in cooperative activities with sensitive security dimensions. The focus on "peaceful" activities has helped convince Iranian organizations that engagement activities are not targeted on obtaining information of importance to intelligence agencies. At the same time, this approach relieves anxieties of the U.S. government that the program might enhance Iran's military technology capabilities. Unfortunately, cautious avoidance of cooperative projects with potential dual-use implications has, in recent years, curtailed exchanges in basic research in physics, chemistry, and biology; and the curtailment has even extended to some aspects of basic mathematics.

An estimated 1,500 scientists from more than 120 institutions in the two countries have been active participants in the projects sponsored by the National Academies since 2000. About one-half of the participants were involved during the seven years covered by this report. Most participants have been faculty members from universities in the two countries, although a significant number of scientists from government, research institutions, and nongovernment organizations have also participated. In addition, a comparable number of scientists from the two countries have been involved as observers at meetings, hosts at sites of field visits, and participants in training programs organized by the National Academies and their Iranian partners.

Of special importance in considering impacts of exchange activities are the number and positions of government officials in both countries who have been aware of the overall program or of specific activities. They have

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included Foreign Ministers and Secretaries of State, who have been briefed by participants on program activities. According to Iranian organizers of exchanges, the Supreme Leader and two Presidents of Iran have at times expressed support of science exchanges; and President Mohammad Khatami participated in a collaborative workshop in Tehran following his retirement from government service. In Washington, close advisers to former U.S. presidents have also taken an active interest in the program.

Iranian ministers, U.S. senior officials, and/or their staffs have been aware of projects when they were being developed and carried out. At times, these officials have played crucial roles in obtaining governmental approvals (for visas or licenses, for example) or political endorsements of activities. Almost always, when informed of the details of exchanges, government officials in both countries have expressed interest in learning about the results of jointly sponsored events.

AUDIENCE FOR THIS REPORT

This report should be of interest to a variety of organizations, individual researchers, and program implementers, including, but beyond, the participants and organizations, which have been involved in organizing, sponsoring, funding, or approving activities. The 2010 report is one of the few readily available reports that chronicles a wide range of U.S.-Iran science-engagements activities in recent years and also provides pointers to more complete and available documentation concerning specific activities. This second report enlarges the shelf of readily available information and identifies new guide posts to additional sources of relevant information as of 2016.

Meanwhile, the popularity of the concept of science diplomacy is growing, not only among foreign affairs practitioners but also among academics and students in the United States, Iran, and other countries. The two reports published by the National Academies should serve as useful up-to-date resources in highlighting approaches to bridging the gap between academic hypotheses and on-the-ground realities. While each example of science diplomacy has unique characteristics, the threads of advancing science while improving diplomatic relations are usually common characteristics.

The Joint Comprehensive Plan of Action (the nuclear deal) has changed the nature of the U.S.-Iran relationship with commitments by both countries and by five other participating countries and the European Union to cooperate not only in observations of some of the most sensitive aspects of weapons research and development but also to consider cooperation in the conduct of civilian nuclear science. Thus, this report should provide useful

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information about the practical aspects of implementing different types of exchanges that might be carried out pursuant to the nuclear deal.

Finally, if other U.S. nongovernmental institutions are encouraged and able to revitalize and expand their interests in promoting exchanges in science and technology with Iranian institutions, the report will provide relevant information. It addresses the structure and activities of a variety of universities, research centers, and government agencies in Iran, which have long been interested in participating in international cooperation activities.

ORGANIZATION OF THE REPORT

The chapters of the report address the context, content, and outcomes of recent National Academies' activities and approaches. This experience can provide the starting point for considering whether and how to move forward again when political conditions for exchanges are favorable. To this end, the remainder of the report is organized into the following chapters.

Chapter 2 (the context) presents a brief overview of the first decade of the National Academies' program activities (2000-2009) that led to a well-tuned and widely respected framework for sustaining and expanding science-engagement as the political environment for cooperation slowly improved. It highlights Iranian efforts to elevate the status and impacts of science and technology as important keys to development of a knowledge-based economy and the associated implications for international cooperation. Special attention is given to the activities of universities and academies and to international publications of scientists. The expanded role of the Vice President for Science and Technology of Iran and the important science-related activities of several key ministries are discussed as the nation tries to strengthen its science and technology prowess to achieve laudable but overly optimistic economic and technological goals by 2025.

Chapter 3 (the program) describes bilateral science-engagement activities carried out since 2010, particularly workshops in the United States, Iran, and France, under the auspices of the National Academies and its partners. Impacts on research activities in Iran are noted. Involvement of highly qualified specialists from both countries in collaborative activities is reported, while emphasizing the considerable effort that has been devoted to (a) preparing and distributing documentation of exchange activities, and (b) informing officials in both countries of the short-term and long-term importance of joint activities, using recent exchanges as cases in point. Lessons learned during 15 years of cooperation are underscored.

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Chapter 4 (the constraints) discusses the many impediments complicating development and implementation of exchanges. Personal safety, sanctions, funding shortfalls, visas, and changing political winds have long been at the top of the list of difficulties in arranging mutually beneficial exchanges. At the same time, less obvious steps to sustainability, such as developing confidence concerning reliability of partners and willingness to invest time and resources into arrangements that may not come to fruition, deserve comparable recognition.

Chapter 5 (the future) highlights unfulfilled opportunities and uncertain political challenges in continuing cooperation in 2017 and beyond. The benefits to both countries in addressing some of the innumerable environmental challenges in Iran of regional and global importance are singled out for special attention. The spotlight is on the future program of the National Academies, which has played a central role in coordinating and focusing exchanges in directions wherein scientific payoffs can be achieved. At the same time, the Nuclear Deal is recognized as an overarching aspect of the U.S.-Iran relationship, with science and technology issues at the core of international concerns. Annex III of the Joint Comprehensive Plan of Action contains a list of areas wherein bilateral or multilateral civil nuclear cooperation could be developed. It is singled out in this report as a potential arena for significant science-engagement that could benefit from the National Academies' 16 years of experience in developing sustained relationships that have addressed important issues of common concerns.

A number of appendixes present information concerning the science and technology capabilities and interests of Iranian organizations. Many of these capabilities are not well known to the American scientific community, but they may offer the bases for exchanges. The appendixes provide information about the details of specific exchanges that should be helpful to other organizations interested in developing and carrying out activities in a number of fields. Appendix A provides a timeline for the most significant milestones in the National Academies' program from 1999 through 2016, and Appendix B identifies a large number of publications that document exchange activities. The remainder of the appendixes provide details that support discussions throughout the report.

In addition, footnotes are included that identify sources and additional information that relate to the discussions in the text. At times, it has been essential to identify sources of information in general terms in order to respect the concerns of the sources.

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2

Context for Science-Engagement Activities

"I was surprised by the advanced state of stem cell research in Iran"
– American neuroscientist, 2012.

Since the turn of the century, hundreds of Iranian and American scientists have worked together—in their laboratories, in the field, through electronic correspondence, and during international conferences and related events. The enactment in Washington of the Iran-Libya Sanctions Act of 1994, subsequent sanctions-oriented legislation, internal security precautions by both countries, and lack of financial support have continuously complicated cooperation. Nevertheless, determined scientists from the two countries have found ways to collaborate, at times during side-by-side meetings based on personal initiatives that have led to jointly authored scientific papers.

A primary objective of the National Academies of Sciences, Engineering, and Medicine (the National Academies) in embarking on a science-engagement program with Iranian organizations in 2000 was to help increase professional contacts, which would benefit American and Iranian participants, their institutions, and the international science community more broadly. Iran had developed significant science, engineering, technology, and medical capabilities in a number of fields of regional and global interest. However, in a variety of ways the Iranian scientific community had been isolated from the mainstream of international science; and many Iranian achievements were not well known beyond the borders of the country.[1]

[1] Glenn E. Schweitzer, *U.S.-Iran Engagement in Science Engineering, and Health (2000-2009)*, National Academies Press, Washington, D.C., 2010, p. 2.

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As the science-engagement program developed, many scientists and a number of government officials in the two countries became convinced that bilateral activities sponsored by the National Academies and by other U.S. organizations, in cooperation with Iranian counterparts, could lead to the evolution of important personal and institutional relationships. These connections would contribute to the development of a less adversarial relationship between the two governments. They argued that building and demonstrating trust between American and Iranian scientists could help soften negative attitudes of some government officials in both capitals about the dangers associated with cooperation on politically important issues. But such confidence-building usually requires a long and sustained process.

In 2010, the National Academies review of a decade of U.S.-Iran engagement in science, engineering, and medicine included the following observation on attitudes in Iran concerning science-engagement with American institutions.

> *Some forces in Iran would welcome a termination of engagement programs involving the United States, including engagement in science. At the same time, given Iran's long-standing commitment to excellence in science, it is difficult for even advocates of termination who live in Iran or elsewhere to ignore the wellspring of technology in the United States. Nor have powerful isolation-oriented voices succeeded in suppressing the views of others who believe that scientific cooperation is essential if Iran is to graduate from being viewed as a developing country and join the ranks of the industrialized countries in the foreseeable future.*[2]

In the United States, much of the early enthusiasm for science-engagement had declined by 2010, in view of the uncertainties and difficulties in carrying out rewarding exchanges within the downward spiral of the bilateral political relationship between the two governments. However, as noted in Chapter 1, the National Academies decided to revive their program after a temporary pause in carrying out cooperative activities. Even though it became increasingly difficult to bring important specialists from the two countries together, both the Department of State (the department) and the National Academies considered continuation of the program to be important.[3]

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[2] Ibid, p. 68.
[3] Meeting with Deputy Secretary of State, Nov. 15, 2009.

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By 2010, a small cadre of influential enthusiasts interested in the program of the National Academies was in place in each country. Some proponents of exchanges at various universities and research centers in the two countries were pleased with the results that had been achieved and wanted to continue activities on the same tracks. Others were planning to expand activities, while also focusing on the topics that they previously had explored. A few scientists in the two countries urged consideration of fresh topics and new modalities in moving forward.

This chapter now turns to a brief overview of the National Academies-supported program activities from 2000 to 2009. Then a summary of the continuing evolution of Iran's science and technology infrastructure that provided the framework for engagement is presented. Intimately linked to the interests of the Iranian government in international engagement in science has been the evolution of the government's policy in striving for a knowledge-based economy, which is highlighted. The continued expansion of educational opportunities and research activities in selected fields and the effort to expand the number of technology-oriented companies despite economic constraints are discussed since they reflect important Iranian commitments that should be taken into account in designing the National Academies' strategy for engaging Iran in ways that are mutually beneficial. Finally, the ingenuity and experience of Iran in coping with economic difficulties, including sanctions over many decades, are added to the array of topics of relevance to the future of science-engagement.

THE NATIONAL ACADEMIES' INITIAL PROGRAM ACTIVITIES (2000 TO 2009)[4]

During the first decade of science-engagement, the National Academies, in cooperation with partner organizations in the United States and Iran, organized seventeen workshops, with each workshop usually involving 25-30 specialists from the two countries. Almost all workshop participants were active in the specific fields of science, engineering, or health being considered. From the beginning of engagement, workshops have been the primary mechanism for initiating and at times continuing cooperation.

With few exceptions, each participant in the workshops made a presentation on an important aspect of the topic of interest; and each presentation was then considered for publication in a Proceedings of the workshop pre-

[4] Schweitzer, *op. cit.*, p. 15.

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pared by the National Academies, an American partner organization selected by the National Academies, or an Iranian organization. This requirement underscored that only qualified scientists could participate in the activity and ensured that the Iranian and American participants would have written records of the scientific achievements that were considered sufficiently important to be included on the workshop agenda. These Proceedings have been important documents in highlighting serious research efforts in Iran and the United States. In some cases, the proceedings are the only readily available records of significant Iranian research achievements.

The topics of workshops through 2009 can be clustered as indicated below.

- Food-Borne Diseases (2)
- Effective Use of Water Resources (3)
- Earthquake Science and Engineering (2)
- Science, Ethics, and Appropriate Use of Technology (2)
- Science and Society (2)
- Preventing and Responding to Crises (2)
- Ecology and Energy (2)
- Higher Education and Research Challenges (2)

Additional engagement activities through 2009 included the following:

- Individual exchanges in both directions involving a total of 25 travelers.
- Six joint planning meetings in Iran, the United States, and third countries.
- Visits to Iran by four American Nobel Laureates.
- A group visit to Iran by seven U.S. university presidents.
- A four-year pilot project in Iran on food-borne disease surveillance and response.

Engagement activities have always been complicated to arrange. Workshops held abroad usually have taken 12-18 months to organize, despite pressures to show near-term results. During the early years of engagement, more than a dozen planned events were cancelled; and many more were postponed. Occasionally, unexpected political concerns arose; but administrative issues were more frequently the reason for delays or cancellations.

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Representatives of the two governments usually continued to express support for delayed programs. Obtaining visas on time, processing license applications in accordance with U.S. requirements, and arranging for the presence at events of both key scientific leaders and early-career researchers were sometimes difficult. Additionally, financial support for engagement activities was often uncertain; and almost all activities depended to an extent on a number of scientists contributing considerable personal time and even personal financial resources to ensure success.

The original plan of the National Academies called for individual exchanges to become a major component of the program. However, few Americans were interested in visiting Iran alone; and usually they travelled in groups of two or more. In general, American scientists were interested in not only participating in a workshop on a scientific topic in Iran but also adding side visits to their workshop program. This pattern quickly developed as the most common approach.

Also, the American travelers quickly learned that there were few sources of funds available for follow-on activities. This reality dampened enthusiasm for developing partnerships that depended on personal initiatives to raise financial resources for sustaining relationships.

Meanwhile, many Iranian scientists seemed more comfortable travelling alone to the United States, particularly if they had opportunities to visit relatives or friends in addition to exploring new scientific challenges. They frequently combined the two purposes of their travel. This approach was usually successful.

As the engagement program developed, interest of the leaders of the academies and of prominent politicians in the two countries increased. During the early period of the National Academies' program, three Presidents of the National Academies visited Iran at the invitation of the Iranian Academy of Sciences and of a leading medical university. The President of the Academy of Sciences of Iran visited the United States on three occasions. During one of his visits he presented a medal to the President of the National Academy of Engineering in recognition of his American colleague's support of cooperation between the two countries. Also, former President of Iran, Mohammed Khatami, visited the National Academies following completion of his term in office; and he led a lively dinner discussion concerning the intersection of engagement with political concerns. Shortly after his visit to the National Academies, he was the keynote speaker at an inter-academy workshop in Tehran titled *Science as a Gateway to Understanding.*

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In 2009, the National Academies' staff recorded the following observations as to accomplishments and impressions during a decade of science-engagement.

> *Personal testimonials about the importance of science exchanges are common. A well-known American water expert considered that his visit to Iran was the highlight of his long professional career. An e-mail from a brilliant young Iranian microbiologist stated that her just-completed visit to the United States was helping her focus her research interests. An American science-policy analyst cannot wait to return to Iran for his third visit where he will obtain further information about the difficulties of shaping policies in a scientifically advancing and rapidly changing country.*
>
> *But the number of U.S.-Iran exchanges is now very small—three to four significant events each year in addition to the occasional individual visitors driven by professional interests and not simply by family ties. There should be opportunities for dozens of exchanges sponsored by a number of U.S. universities and nongovernmental organizations as was the case in earlier years. Obtaining U.S. visas is a major impediment for Iranians hoping to travel to the United States—for study, for conferences, or simply for the cultural experience. Also, it is not surprising that Americans are apprehensive about traveling to Iran, which is portrayed by the U.S. media as a dangerous country.*
>
> *Politics is on the agendas of a large segment of the Iranian population. Relatively few Americans spend much time thinking about developments in Iran and that nation's policies. Meanwhile, many Iranian leaders of all stripes within and outside the government spend a considerable amount of their time discussing U.S. policies.*

During the initial period of cooperation, the National Academies did not attempt to adhere to a master list of priorities in terms of topics, methods of cooperation, or types of projects, although priority interests were a frequent topic of discussion between the scientific leaders and their supporting staffs of the two countries. The activities were difficult to arrange, and ease of implementation was an important criterion in moving forward with a proposal of mutual interest when selecting projects to be supported. Nevertheless, each project that was undertaken addressed issues of professional scientific

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interest to participants from both countries, with a reasonable chance of full implementation and sustainability.

Unfortunately, as previously noted, a number of promising proposals developed by the National Academies were not included in cooperative activities for a variety of reasons. The difficulties included shortage of funds available for implementation (a primary constraint), lack of support by one or both governments, and highly publicized political concerns that arose at critical stages of the planning process, which discouraged proponents in the United States and in Iran from moving forward.

From the outset of the program, the National Academies frequently consulted with the U.S. government on the status of similar activities since governmental endorsement was essential to obtain visas for visitors and important to ensure compliance with government requirements. Of particular concern was uncertainty as to the need for licenses from the Office of Foreign Assets Control (OFAC) of the Department of the Treasury. These consultations were also an important mechanism in staying abreast of related activities of other organizations and in ensuring that the National Academies' activities and program results would be brought to the attention of both key policy officials in the U.S. government and leaders of other organizations with related interests.

In addition, the National Academies played an important role in serving as an unofficial interlocutor between the department and other interested nongovernmental scientific organizations in the United States. Among the issues of broad concern were the changing political constraints in Washington and Tehran on exchanges, developments concerning personal safety of American travelers, and occasionally new funding opportunities to support exchanges. While the National Academies' science-exchange program was small, it was larger than other science-exchange programs being carried out at the time. Therefore, consultations of the National Academies with the department were of interest to other institutions, which had fewer opportunities for such discussions.

The National Academies' programs almost always involved American specialists from a number of U.S. universities, research centers, and other organizations. Thus, the National Academies became an important mechanism for informing many organizations interested in exchanges about developments in Washington.

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THE *VISION* AND SUBSEQUENT ACTIONS TOWARD A KNOWLEDGE-BASED ECONOMY IN IRAN

A significant aspect of designing and implementing exchange programs that has been and should continue to be of interest to American scientists is a general understanding of the organization, policies, and programs of the many elements of the Iranian science and technology enterprise. To this end, a brief discussion of the evolving policy and institutional framework for carrying out research, higher educational, and high-tech innovation activities in Iran is presented below. Also, pointers to additional information in this area are set forth, while recognizing that considerable information is available on the many English-language websites established and regularly updated by hundreds of relevant Iranian organizations, and particularly public sector organizations.

By the early 2000s, government leaders of Iran had become impatient with the rate of progress in attaining international recognition for Iran's science and technology (S&T) wherewithal, particularly in raising the low global rankings of its universities. In 2005, the government released a 20-year *Vision* for development of Iran's economy and the associated S&T capabilities that would strengthen the technical prowess and reputation of the country at home and abroad. At about the same time, a new economic development plan that reflected many of the policies set forth in the *Vision* was released. The government's declarations called for Iran to attain first

BOX 2-1
Underpinnings for Economic Growth[a]

1. Development of a diversified knowledge-based economy, with adequate human resources and advanced technologies.
2. Encouragement of logical, scientific, and analytical thinking throughout society.
3. Adoption of unambiguous concepts that embrace the objectivity of science and technology, in concert with international approaches.
4. Increased emphasis on excellence in higher education.
5. Recognition of the importance of universities and research centers in bringing about international understanding.

[a] *Proclamation of the Vision, Iran,* 1404/2025, released by Iranian Government, 2005.

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place in the region with regard to economic, scientific, and technological capabilities based on the five principles set forth in Box 2-1.

The *Vision* challenged the concept prevalent in some areas of the Moslem world that science is subordinate to theology. Rather, the document suggested that rationality should be based on scientific evidence.

The economic importance of an improved approach to research as advocated in the *Vision* was quite significant due to adverse trends in Iran at the time, including the following:

1. Loss of Iranian expertise to countries with better developed infrastructures for research and innovation.
2. Unemployment that resulted in university graduates driving taxis in order to support their families.
3. Inadequate and dwindling water supplies with serious adverse impacts in (a) expanding modern agriculture practices, and (b) providing clean drinking water for both urban and rural populations.
4. Excessive dependence on oil exports to generate income needed for imports of consumer and capital goods.
5. Population growth and city/rural inequities, with wealthy residents increasingly separated economically from the general population.
6. Inadequate investments in future development of energy and mineral resources while depletion of non-renewable resources continued.
7. Introverted and inflexible economic structures that stifled innovation.
8. Inadequate regional and global integration that lead to wastes of resources in competition with other countries.
9. Inadequate participation of women in the work force.[5]

The 20-year *Vision* focused on policies and concerns at the highest level of government. At the same time, many organizations in Iran had their own policies and budgets. In a number of ways, their activities collectively determined the S&T policy of the nation, which was constrained by economic realities and competing priorities that limited the mandates of the *Vision*. When President Mahmoud Ahmadinejad took the reins, for example, he was to chair a national council that would address the most important S&T issues facing the country. After several meetings—directed in large measure

[5] Reza Mansouri, former Deputy Minister of Science, Research, and Technology, "Presentation," Washington, D.C., September 13, 2006.

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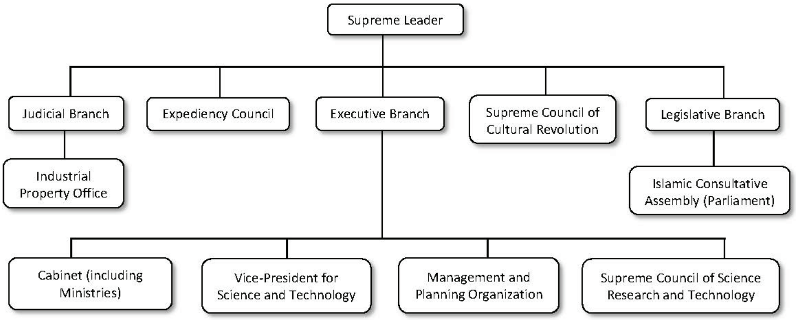

FIGURE 2-1 Adapted from Institutional Map of Science and Technology Law and Policy Making Bodies. Abdol S. Soofi and Mehdi Goodzari, editors, *The Development of Science and Technology in Iran*, Palgrave Macmillan, New York, 2017, p. 16. For a more detailed schematic diagram of the many organizations involved in formulating science, technology, and innovation policy, see United Nations Conference on Trade and Development, "Science, Technology, and Innovation Policy Review, Iran," New York and Geneva, 2016, page 36.

to the responsibilities of universities, which were soon to be guided by newly appointed rectors—he focused on economic and other issues; and the council played a largely passive role in promoting development and implementation of a rational S&T policy for the nation. The ministries continued to establish their own policies—at times in consultation with many stakeholders at the highest level of government and at other times largely on their own.[6]

As of 2016, the formal organizational structure for formulating science and technology policy within Iran is set forth in Figure 2-1. However, as discussed below, this structure does not adequately reflect the importance of the ministries and companies in influencing policy and in determining both the courses of development and the implementation of activities that are within their purview.

In many respects, the importance of the ministries in determining the policies of the country have long been linked to their access to funds for supporting their special interests. At the top of the list of the best-endowed organizations that support research have traditionally been the Ministry of

[6] Information provided by group of policy-oriented Iranian scientists during a National Academies planning visit to Iran, Tehran, January 2007.

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Defense, Ministry of Oil, and Ministry of Energy. Of course, the Ministry of Science, Research, and Technology (Ministry of Science) and the Ministry of Health and Medical Education (Ministry of Health) have long played key roles in guiding the universities, but their funds available to the universities have been limited. These two ministries and other government bodies also allocate limited funds to their research centers that should provide leadership for the country in selected areas.

By 2007, the Iranian government had appointed a Vice President for Science and Technology. That official's influence was to be wielded primarily through a relatively small research fund that the Vice President's office controlled. However, the fund did not grow to reach its financial goals; and much of the limited funding was allocated for short-term projects of immediate interest to the country's political leadership.

Shortly thereafter, a reorganization placed 15 offices, institutes, and agencies interested in technological advancement within the framework of the Office of the Vice President. By 2014, this cluster of organizations had significantly expanded the reach and influence of the Vice President. An estimate of the annual budget resources of this office at that time was $400 million available to support research.[7]

In 2012, the Office of the Vice President published a list of seven priority areas for technological development, which is set forth below. These priorities have been refined on an annual basis. Meanwhile, individual ministries and other governmental bodies have supported their own priorities, which often overlapped with the national priorities financed by the Office of the Vice President.

1. Biotechnology: Pharmaceuticals: interferon, growth hormones, and recombinant hepatitis B vaccine. Biomedicine: medical genetics for early detection, Schwann cell therapy, and bone marrow transplants. Bio-agriculture: foot and mouth vaccines, bio-fertilizers, bio-pesticides and bio-herbicides. Bioengineering: desludging of crude oil, control of corrosion, and media cell cultures.
2. Nanotechnology: Use of scanning tunnel microscope and deep reactive ion-etching. Industrial electrolysis. Ion mobility spectroscopy. Chemical vapor deposition.

[7] Comments by Vice President for Science and Technology of Iran, during his visit to the United Nations in New York, September 25, 2014.

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3. Advanced materials and composites technology: Resins. Glass fibers. Fajr-3 full composite aircraft. Composite folded structures. Reinforcement of gas and oil tanks and pipelines
4. Information and communication technology: E-government. Analog TV transmitters and FM transmitters. Combiners and filters. Satellite translators and antennas. Persian voice dictation. Searching large-scale biometric databases.
5. Energy: Captanization of petroleum fractions; Hydro-conversion. Light naphtha isomerization. Renewable energy including hydro, wind, solar, geothermal, and biogas; Hydrogen fuel cells
6. Aerospace. Omid satellite for research data processing. Rasad 1 satellite for environmental monitoring. Data collection in thin atmospheres
7. Marine: Shipbuilding. Fisheries. Offshore seabed exploration. Offshore rig repair services.[8]

Examples of new technological interests that were subsequently adopted by the office are (a) water and waste water treatment with an emphasis on desalination, disinfection and purification, emergency water treatment, and expanded use of ground penetrating radar in the assessment of underground aquifers; and (b) high performance concrete and thermal insulation of composite systems to support urban development.[9]

Turning to the role of technology-oriented companies, until 2010 their potential contributions had not received much attention by the government, which focused on strengthening the scientific capabilities of government universities and research institutes as the primary route to a knowledge-based economy. When funds from exports of oil and raw materials were plentiful, necessary technologies were readily imported; and limited attention was given to developing the advanced engineering potential of even state-controlled enterprises. But as import opportunities declined due to sanctions and the increasing economic crisis, the government significantly increased its efforts to strengthen the technological contributions of knowledge-based companies—both in the public and private sector.

[8] Center for Innovation and Technology Cooperation, *A Summary of Selected Technological Achievements in the Islamic Republic of Iran*, Tehran, 2012.

[9] Technologies Studies Institute, *A Brief Representation of Technological Achievements in the Islamic Republic of Iran,* Tehran, August 2014.

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By the end of 2015, more than 1,800 companies had been certified as knowledge-based enterprises, reflecting the expanded government support of such companies. Many of these companies did not achieve their lofty goals, despite financial incentives. These incentives included tax and tariff breaks for 15 years, long-term and short term loans at low interest rates, priorities in techno-parks and special economic zones, and financed guaranties on quality products from production through distribution and use. While the survival and success of many of the firms have yet to be determined, the focus on private companies—including both partially owned government enterprises and completely private firms—has certainly captured the attention of high-tech aspirants throughout the country.[10]

Representatives of these companies began playing increasingly active roles in science-engagement activities with western counterparts, particularly in exchanges supported by European organizations. In an unusual instance, one of the National Academies' key partners in Iran proposed sending representatives of 15 small companies who were interested in the topic of entrepreneurship to the United States on a visit to be financed through the IVLP and programed by the National Academies. In consultation with the department, the National Academies considered this proposal to be a good step forward in encouraging development of newly organized private firms, which were seeking greater independence from the government. However, when the entrepreneurs applied for visas, other U.S. government agencies objected due to concerns over access to U.S. technologies even though the program was to focus on management, financing, and marketing and not on specific technological developments. On several other occasions, a few aspiring entrepreneurs were included in the National Academies' other engagement activities that were limited to environmental, solar energy, and other "non-sensitive" issues.

SCIENCE AND TECHNOLOGY GOALS

Given the foregoing developments, the key targets as of 2013 for growing the importance of S&T in Iran were the following:

- Raise investments in research and development (R&D) to four percent of Gross Domestic Product (GDP) by 2025.

[10] Soofi, *op. cit.,* 2017, Chapter 3.

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- Raise investments by companies in R&D to 50 percent of national investments by 2025.
- Raise the share of researchers employed in the business sector to 40 percent of the country's researchers by 2025.
- Increase the number of full-time university professors per million of the population to 2,000 by 2025.
- Privatize 80 percent of state-owned firms by 2014.
- Raise foreign direct investment to three percent of GDP by 2015.
- Increase by four times the publication of scientific articles in international journals by 2025.[11]

These goals were clearly aspirational goals, and it soon seemed clear that few if any of the goals would be met. Nevertheless, they indicated the ambitions of important components of the government in moving toward a knowledge-based economy. These and other goals, along with implementation and financial details, are set forth in Appendix C. Appendix D highlights relevant policies and plans of the government.

GOVERNMENT RESEARCH CENTERS

In the early 2000s, the Ministry of Science reported the number of government research centers, with many affiliated with state universities, as follows: Research Centers of Ministry of Science (29); Research Centers of Ministry of Health (99); Research Centers of other Ministries (69).[12]

In recent years the number of research centers increased dramatically. Then some centers became of reduced importance as the economy tumbled from 2010 to 2015, despite the commitment of the government to press hard in developing a knowledge-based economy as discussed above. Plans on paper were a long distance from activities in the research laboratories. A few centers are stand-alone centers, while others are subordinate to universities or other parent institutions. Twelve of the centers have long been considered by the Iranian government as "major" centers and have with some difficulty withstood the economic slump of recent years. They are set forth in Box 2-2. All of these centers have international connections, and they presumably are well aware of many relevant research efforts in the United States.

[11] Kioomars Ashtarian, "Iran," *UNESCO Science Report 2015*, Paris, 2015, p. 389.

[12] "Report," Ministry of Science, Research, and Technology, Tehran, June 2009.

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BOX 2-2
Leading Government Research Centers[a]

- Institute for Research in Fundamental Science (previously named Institute for Studies of Theoretical Physics and Mathematics and currently referred to as IPM)
- National Center of Genetic Engineering and Biotechnology
- International Institute for Earthquake Engineering and Seismology
- Institute of Materials and Energy
- Iranian Research Organization for Science and Technology
- Research Center of Chemistry and Chemical Engineering
- Iranian Polymer and Petrochemical Institute
- Iranian National Center of Oceanography
- Research Institute of Petroleum
- Iranian Telecommunications Research Center
- Razi Institute of Sera and Vaccines
- Pasteur Institute of Iran

[a] Institute for Education Research, Tehran, Oct., 2014; Also see longer list of leading institutes set forth in Abdol S. Soofi and Sepehr Ghazinoory, editors, *Science and Technology Innovations in Iran,* Palgrave Macmillan, New York, 2013, p.71.

Early in the 2000s, the government selected nanotechnology as an emerging technology that deserved strong government research support—focused particularly on the biotechnology sector—which in the near term could lead to economic payoff. Research increased, with the Center of Genetic Engineering and Biotechnology, the Razi Institute, and the Pasteur Institute playing leading roles. By 2014, more than 140 companies of various sizes and capabilities were engaged in research and in attempting to take biotech achievements into the market place. Spurred by these and other developments, Iranian researchers claimed seventh place in the number of international publications on nanotechnology among the countries engaged in relevant research. However, concerns mounted in Tehran that quantity and not quality had become the primary metric of success.[13]

While government and university centers dominate the research scene, several quasi-independent institutions are also important. For example, the

[13] Ashtarian, *op. cit.*, p. 401.

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Royan Research Center for Reproductive Medicine, Cell Biology, and Technology has a strong reputation in stem cell research. It works collaboratively on developing leading edge approaches with several other Iranian centers such as the Institute of Biochemistry and Biophysics and the Bone Marrow Transplantation Center.

THE ACADEMIES

Iran has four academies: Academy of Sciences (reactivated in 1988), Academy of Persian Language and Literature (1990), Academy of Medical Sciences (1991), and Academy of the Arts (1998). A single Board of Trustees under the Office of the President of Iran, with the First Deputy of the President presiding, oversees the activities of the four academies. The President of Iran appoints the presidents of the academies after he receives recommendations developed during electoral processes within the academies.

The Academy of Sciences and Academy of Medical Sciences have been significant participants in international science-engagement activities during the past fifteen years. Each academy elects its members, many of whom have been active internationally. Neither has research facilities. The two academies have various scientific sections, and they can mobilize scientists from a variety of institutions to assist in facilitating international contacts.[14]

While both academies seem far from the mainstream of national policy formulation, many of their members hold important positions in universities and other institutions. At times, their memberships in the academies add weight to the significance of activities that they undertake in their full-time positions.

Academy of Sciences

As of 2014, the Iran Academy of Sciences had 50 Fellows, 100 Associates, and five honorary members selected by the incumbent Fellows at General Assemblies of the entire membership.

Significant responsibilities of the Academy set forth in 2008 include:

[14] See ias.ac.ir, accessed February 15, 2010. Also, *Academy of Medical Science of Islamic Republic of Iran,* Tehran, 2010.

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1. Analyses of the status of science, technology, education, and research within Iran and provision of suggestions to the government to improve conditions.
2. Scientific assessments requested by the government and academic centers.
3. Studies of experiences of other countries on development of science and technology and their applications.
4. Awarding of leave and scholarships for international contacts.
5. Organization of seminars and conferences.
6. Publication of journals, with the best developed journal being devoted to engineering education.
7. Representation of Iran in international organizations and societies with comparable aims and responsibilities.[15]

The departments of the Academy are as follows: Agricultural Sciences, Basic Sciences, Engineering Sciences, Human Sciences, Islamic Sciences, and Veterinary Sciences, Also, there is an Office for Foresight Studies.

In recent years, the Academy has become more active than in earlier times in providing advice to the government on policies governing research and related activities. This development is consistent with global trends for such academies to stretch beyond traditional interests in the history of science to the applications and the policy implications of research at the national, regional, and global levels.

Of importance in establishing a policy role for the Academy of Sciences was a message from the Academy to the newly elected President of Iran in 2013 that covered the following topics:

1. Authority of the Ministry of Science, Research, and Technology.
2. Recognition of the independence of universities.
3. Role of professors in selection of executives of universities.
4. Improving relations between universities and society.
5. Rethinking university regulations and codes.
6. Decentralizing admission of Ph.D. students.
7. International cooperation with prestigious universities and institutions.[16]

[15] *The Academy of Science, Islamic Republic of Iran*, Tehran, 2007-2008.

[16] "A Message to the New President of Iran," Academy of Sciences of the Islamic Republic of Iran, 2013.

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The Iran Academy of Sciences has been an important partner of the National Academies in organizing bilateral workshops, meetings, and other cooperative activities. The National Academies has agreements for cooperation with many foreign academies. However, according to its staff, during the early 2000s the Iranian Academy of Sciences' cooperative activities with the National Academies were by far its most active bilateral engagement efforts.

Of particular interest in considering science-engagement has been the capability of the Iranian Academy of Sciences to attract leading scientists from many institutions to participate in bilateral events. Typically, five to ten Iranian universities, government agencies, and other organizations have been represented in scientific workshops in the United States jointly organized by the academies of the two countries. For events in Iran or other countries, the Iranian Academy has reached well beyond the best-known institutions in Tehran, Shiraz, and Esfahan.

At the same time, the Academy is careful to ensure that the activities it sponsors, and particularly international activities, are appropriately coordinated throughout the Iranian government. Such coordination for a single international workshop may require up to six months. Indeed, government agencies in Tehran have not always given the green light for proposed international workshops; but the Academy has been helpful in reshaping approaches to ensure that the proposals are politically acceptable.

The projects of the Academy are limited in number and scope. However, the importance of the Academy cannot be measured simply by examining the limited impacts of its own projects. The membership of the Academy includes leaders of science from many institutions; and at times they collectively try to influence the policies that constitute a portion of Iran's national science policy. Even though most members are based at academic institutions, a number of these professors rotate in and out of government positions; and most have some type of personal linkages to national and regional political leaders. Thus, influence is reflected in informal, as well as in formal, interactions.

Academy of Medical Sciences[17]

The goal of the Academy of Medical Sciences is "to achieve scientific and cultural independence in the field of medical sciences and promote the art of

[17] Much of the information in this section is supplemented by discussions on the academy's website. Also, members of the academy are quite outspoken concerning the responsibilities and work of the academy.

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medical research. Also, it is to support medical innovations in the country, including the support of projects involving young researchers." In 2015, the Academy had 32 members and 30 affiliate members. It had departments for Clinical Sciences, Basic Medical Sciences, Nursing, Pharmacy, Dentistry, Public Health and Food, Traditional and Islamic Medical Sciences, and Women Specialists and Consultants.

One group of American visitors to the Academy was very impressed by the attention given to the successes of Iranian surgeons in performing transplantation of important organs. These operations have included not only routine kidney transplants but also difficult liver transplants, for example. In cooperation with the Tehran University of Medical Science and other leading research centers, the Academy carries out a program of careful tracking of both donors and recipients following operations and has accumulated extensive records that provide guidance on maintaining healthy lifestyles following such major surgeries.[18]

Also of importance to the Academy are its many publications in Farsi and in English that report on the achievements of the medical science community. Walking through the Academy, visitors can observe writers and editors busy at work preparing articles for publication and dissemination. It is difficult to depart from the Academy without an armful of scientific publications reflecting research-oriented activities of the members. Iranian scientific leaders claim that the country produces more than two times the number of scientific journal articles than the number produced by all Arab countries combined, and it seems that medical publications are one of the reasons for this impressive record.[19]

As an example of issues that have been of interest, in 2015 the Academy was actively pursuing (a) tobacco dependence and smuggling, (b) health impacts of pesticide residues in food, including leukemia, (c) air quality and clean air standards, (d) outbreak of malaria, (e) regulation of bottled water, and (f) new health-care facilities. Such interests are a welcome expansion of the traditional and important focus of the academy on publications reporting on results of medical research by individuals and by groups of laboratory investigators.

As to international interests, over the years the Academy has given importance to cooperation with the Chinese Academy of Sciences, the University of Sao Paulo, the University of Michigan, and the French National Center

[18] Visit to Academy of Medical Science, June 27, 2007.
[19] Ibid.

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for Scientific Research. Other universities of interest to the Academy include the University of Washington, Stanford University, University of California in Los Angeles, and University of California in San Diego.

UNIVERSITIES AND OTHER INSTITUTIONS OF HIGHER EDUCATION

The Iranian ministries, the Parliament, the Organization for Management and Planning, and the Supreme Council for Cultural Relations play important roles in influencing the policies and planning activities that shape the higher education system of the country. The executive power of the government for overseeing the universities is vested primarily within the Ministry of Science and the Ministry of Health. As previously noted, other ministries—such as the Ministry of Oil, the Ministry of Energy, and the Ministry of Defense—also have significant roles in determining the course of research and higher education.

According to Iranian colleagues, the research funds available from the Ministries of Oil, Energy, and Defense dwarf the research funds available from the ministries that are directly responsible for science and for health. For example, the Iranian press reported in 2007 that one important university had 150 contracts with the Ministry of Defense. This approach seems to parallel the approach of the defense agencies in the United States and other western countries in tapping the broad academic community for ideas and technologies that are relevant to national security interests.[20]

At the university level, policy-making and planning are responsibilities of the university leaderships. The government universities operate under the direction of rectors, who are appointed by the ministries, or by boards of trustees, university councils, and departmental councils. The private universities have their own approaches to governance.

As of 2016, according to available information, 220 government universities were active, with 154 operating under the auspices of the Ministry of Science, 58 operating under the auspices of the Ministry of Health, and a few others reporting to other ministries.

Relevant statistics concerning the universities as of 2015 are set forth in Box 2-3.

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[20] *Tehran Times*, "Headlines," March 15, 2007, stating that 450 Iranian universities have defense contracts. Also, "University Handling 150 defense Projects," *Iran Daily*, October 11, 2003, p. 1.

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BOX 2-3
Higher Education Institutions in Iran[a]

- Government State Universities (non-medical): 154 universities, having 200 campuses with 1.2 million students.
- Government State Medical Universities: 58 universities, presumably with a larger number of campuses with 150,000 students.
- Payam-e-Noor University (a government distance education university): 531 centers reporting to 32 regional centers with 810,000 students who are primarily part-time students.
- University of Science Applications (a government science university emphasizing vocational training and granting Associate degrees): 1100 campuses with 390,000 students.
- University of Science and Technology (a government science institution offering continuing education, primarily for students already in the work force): 170 campuses with 63,000 students.
- Islamic Azad University (private): 567 campuses, including at least one medical campus, with 1.7 million students.
- Other Private Faculties (primarily involved in business, humanities, and social-oriented courses): 354 centers (under supervision of 200 registered institutions) having 2,300 branches with 260,000 students.

[a] This information is based on the following sources: op. cit, Soofi, 2013, Chapter 3. United Nations Conference on Trade and Development, "STI Policy Review of Iran," 2016. Nader Habibi, "Iran's Over-Education Crisis: Causes and Ramifications," Brandeis University, February 2013: www,brandeis.edu/crown/publications/meb/MEB889.pdf; Institute for Planning in Higher Education, *National Report on Higher Education, Research, and Technology*, 2011-2112, Iran Ministry of Science, Research, and Technology, 2013. Statistics which are different and may not be as authoritative are set forth in Technology Studies Institute, *A Brief Representation of Technological Achievements of the Islamic Republic of Iran*, Office of the Vice President for Science, Tehran, August 2014, p. 14; *op. cit.* Soofi, 2017, Chapter 2.

A particularly important responsibility of the medical universities is their management of a significant portion of the country's public health system. Most medical universities have responsibility for providing primary care health services for designated geographic areas that blanket the country, in addition to their educational and research responsibilities. The National Academies' most ambitious joint project focused on improving services in

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addressing food-borne diseases, and the collaborators in this project were the Oregon State Health Department and Shaheeb Beheshti Medical University. The support of the Iranian government for the university's outreach activities, which involved hundreds of volunteer health workers in rural areas who were trained by the university, was very impressive.

Techno-parks and business incubators have significantly expanded, both in number and activities, during the past decade, with many located at or near universities. According to the Ministry of Science, in 2015 there were 36 techno-parks (including 160 business incubators) that were hosting 3,400 companies, and employing 22,000 scientists. Several hundred patents had been awarded to residents of techno-parks. Accelerator organizations were also established to provide funding for start-up companies in exchange for equity in the companies.[21]

In May 2014, the Minister of Labor and Social Security reported that about 4.5 million university graduates would enter the labor market in the next few years. Meanwhile, 2.5-3 million working-age adult Iranians were already unemployed and looking for work. The unemployment rate among university graduates was 20 percent with a large number of holders of master's and PhD degrees seeking employment. When university graduates with bachelor's degrees cannot find suitable jobs that match their skills, they have several options including acceptance of a low-skill job, waiting until a suitable job is found, or going back to the university to obtain a graduate degree. For male students, the decision is sometimes inter-woven with compulsory military service.[22]

In short, many Iranians are highly focused on university education; and families go to great lengths to send their children to a university. They view a university degree as both a ticket to economic success and a source of social status. Their pre-occupation with a university degree has been reinforced by policies of the government that require a degree for employment in most public sector jobs. Also candidates for many elected positions, such as members of city councils, must hold university degrees.[23]

Can expanded cooperation with U.S. universities help resolve the employment crisis? Certainly not in the near-term. But perhaps in the long-term, exposure of Iranian educators to approaches in the United States, and probably more important in economically progressive middle-income

[21] Ashtarian, *op. cit.* p. 403.
[22] Haribi, *op. cit.* supplemented with observations of the author.
[23] Ibid.

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countries such as South Korea (a model country often cited by Iranian economists), could encourage new innovative efforts, which generate income.

JOINT PUBLICATIONS[24]

An increasing number of Iranian scientists, including a large number who have occupied important government positions, have long been aware of the importance of internationally accepted scientific publications. They know the requirements for publishing in journals that are covered in the Web of Science Citation Index, which is maintained by the International Science Information (ISI) organization. At the same time they seek the prestige and the development of new international contacts associated with publication in international journals. However, many Iranian scientists have not yet ventured into this unfamiliar area, confining their publications to Iranian journals, and particularly Farsi-language journals, which may not meet international standards.

During the late 1990s, a dramatic upsurge in the number of papers being published by Iranian scientists in international English-language journals began. Starting near the bottom of the list of middle income countries ranked according to their scientific publications, Iran rapidly climbed to a leadership position in the Middle East. Within a decade the country ranked side-by-side with Turkey and Egypt as the scientific achievers of the region. There were several reasons for this sharp upward trend.

1. The Iran-Iraq war had come to an end, and university students developed new interests in becoming members of the global scientific community.
2. A number of Iranian universities established Ph.D. programs that led to increased faculty and student interest in addressing scientific problems that they were studying in depth.
3. A new era of international scientific collaboration began as many scientists leaving the country stayed in contact with their mentors, colleagues, and students still in Iran. Jointly authored publications provided convenient avenues for staying in touch.

[24] See Malise Nikzad, “Foreigners’ Point of View toward Collaboration with Iranian Authors,” Webology, Volume 9, No.2, Dec. 2012. He surveyed 320 Iranian authors with 55% response. Major findings were (a) main reason for cooperation is new knowledge, and (b) major factor in stimulating cooperation is previous study abroad.

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4. The Iranian government, individual Iranian organizations, and even international organizations financed sabbatical leaves abroad for Iranian university professors who then had new opportunities to address developments on the cutting edge of their fields of interest.
5. Soon, Iranian scientists began to have more confidence in the integrity of their own research; and they became less hesitant in trying to have their works accepted by international journals.
6. Finally, international data bases were coming on line; and Iranian researchers could obtain copies of publications of others as they weighed the opportunities for publishing the results of their investigations.[25]

Against this background, within the ten-year period of 1995-2005, the number of Iranian-authored papers in the natural sciences and engineering published in ISI journals went from 1,500 to 5,500. By 2013, the number had reached 24,000.[26] In the field of medical research, citations of articles published by Iranian scientists has been particularly impressive. Beginning at nearly zero in 1986, by 2006 the number had risen to 8,000, surpassing citations of articles prepared at Turkish institutions, for example.[27] Appendix E sets forth the results of a search by the National Academies of Iranian scientific publications.

Turning to co-authorship of scientific papers in ISI journals, more than 22 percent of Iranian publications had co-authorship during the period 2008-2014. American collaborators were the most prevalent, followed by co-authors from Canada, the United Kingdom, and Germany.[28]

THE OVERHANG OF SANCTIONS

This chapter concludes with optimistic pronouncements from two of Iran's experts on science, technology, and innovation policies of the country. One contends that sanctions have forced Iran to strengthen its internal scientific capabilities rather than to look abroad for scientific achievements that lead to economic success. The sanctions of concern were as follows: during the hostage crisis (1979-1981), during the Iran-Iraq war (1981-1988),

[25] Ashtarian, *op. cit.* supplemented by Soofi, 2017, Chapter 5.
[26] *National Report on Higher Education, Iran (2011-2012)*, Institute of Planning in Higher Education, Tehran, 2013, p. 2.
[27] Ministry of Science, Research, and Technology, January 2013.
[28] Ashtarian, *op. cit.* p. 390.

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during post-war reconstruction (1989-92), during the Clinton administration (1993-2001), after the 9/11 attacks (2001-2006), and during the Ahmadinejad administration (2004-2012).[29] According to the other expert, "More than any other factor, the growing importance of science, technology, and innovation policy in Iran is a consequence of the tougher international sanctions. Science can grow under an embargo. This realization offers a hope for a brighter future in Iran."[30] Others argue that there may well be short-term benefits from sanctions; but the long-term negative impacts of sanctions that reduce available funds for supporting education and research limit access to international technologies and inhibit international scientific cooperation.

That said, long-term sanctions will probably have a corrosive effect on efforts of Iran to develop a stable and modern infrastructure for supporting a knowledge-based economy. Of particular relevance for this report, the overhang of sanctions will continue to complicate effective U.S.-Iran science-engagement as discussed in Chapter 4.

[29] Soofi, 2017, p. 251.
[30] Ashtarian, *op. cit,* p. 403.

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3

Program Activities from 2010 to 2016

The National Academies were conducting exchanges when no one else was and in so doing, we as a nation are prepared to seize on a historic opportunity with projects that reinforce a fragile diplomatic process.
– Senior Department of State official. 2015.

As discussed in Chapter 2, following a brief pause during the second half of 2009, the National Academies of Sciences, Engineering, and Medicine revived the program of science-engagement with Iranian institutions. The decision to resume the program gave considerable weight to (a) endorsement of continuation by the Department of State (the department), (b) revival of interest in exchanges by a few U.S. research and higher education institutions that had been partners of the National Academies, and (c) enthusiasm for further exchanges within many scientific organizations in Tehran and other cities of Iran. Despite the steady deterioration of the political relationship between the two governments, the promoters of science-engagement in the two countries were confident that they could continue the program. Most of the National Academies' partners in the United States and Iran were interested primarily in continuing activities that had already been initiated, while some organizations hoped to spread efforts into other areas of science, engineering, and health.

Several U.S. organizations beside the National Academies and their partners were also interested in reviving their dormant activities. But most U.S. organizations that had carried out science exchanges with Iran decided to focus their international efforts on cooperation with other countries, which was less complicated. Then, following the election in 2013 of Iranian President Hassan Rouhani who advocated international cooperation, interest at a number of U.S. universities and other science-oriented institutions increased.

PREPUBLICATION COPY—UNCORRECTED PROOFS

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Until 2013, the National Academies followed the programming approach for exchange activities that had been developed in earlier years. The emphasis was on bilateral and trilateral workshops held in the United States, Iran, and other countries, usually with visits to relevant institutions before or after the workshops. Also of importance was the National Academies' financial support or simply encouragement of participation of American scientists in individual exchange visits to Iran or in presentations of their research findings at international conferences in Tehran. Participation in such conferences could usually be coupled with visits to research organizations.

During the first decade (2000-2009) of the National Academies' program, the topics of workshops and visits were numerous, with only limited efforts by the National Academies to consolidate efforts under a small number of themes. The workshops and visits usually involved different scientists for each event. The National Academies often gave priority to the ease of organizing programs in order to establish groups of interested partners in both countries without extensive delays. At the same time, as noted in the previous chapter, U.S. security concerns ruled out most programs devoted to research in chemistry, biology, or physics that might touch security sensitivities concerning the possibility of access to dual-use technologies.

In 2013, the National Academies began to modify their overall approach and concentrate on science-engagement within a limited set of topics. This change was due in part to the support of Iranian government officials concerning the importance of each event and their interest in continuing the program with the same topics. Thus, interest in sustaining relationships between scientists in the two countries through follow-on activities to workshops rather than supporting one-off workshops increased. Later in this chapter, the topics that were pursued during workshops are highlighted. As will be evident, the projects of interest soon became broadly defined science-intensive activities, which in time could lead to near-term societal and environmental benefits.

At the same time, an upsurge continued in the number of Iranian students at U.S. universities, reaching a level of more than 12,500 in 2015/2016. Most were enrolled in engineering programs at the graduate level.[1] The Iranian government supported a number of these students. Many of the remainder were supported with private funds of Iranian relatives of the students or with research grants available to their American mentors.

[1] Institute of International Education, *Open Doors, 2016: Fact Sheet Iran,* New York 2016.

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The department estimated that by 2015, most of the Iranian students were returning to Iran after completion of their studies, whereas in earlier years the percentage remaining in the United States was larger. The Iranian government's policy in providing support at times required family collateral, including real estate in Iran to be forfeited, should the students not return to Iran; and this policy affected the return-home rate.[2]

With the ascendancy of President Hassan Rouhani in 2013, institutions in a number of other countries gradually increased their science-oriented cooperation with Iran (beyond acceptance of Iranian students)—particularly institutions in Canada, Europe, and Asia. Many Iranian organizations soon became interested in taking advantage of opportunities to place their scientists for short periods at foreign research centers. But the disenchantment in Tehran with arrangements with new partners that called for social as well as scientific acumen was at times serious. "It was simply too difficult to master the language," commented some Iranians who worked at research facilities in Beijing, Tokyo, and other distant cities to the east. "We were lost in an unfamiliar culture despite the efforts of our hosts to welcome us in their cities," was another refrain from scientists returning home from abroad.[3]

As the possibility of participation in U.S.-Iran science-engagement activities received more attention in Iran, some Iranian organizations hesitated in implementing existing agreements that called for further involvement with other countries, for example China. U.S. institutions were often considered preferred partners. At the same time, the sustained involvement of well-educated and experienced Iranian scientists in exchanges that had been carried out by the National Academies over many years provided a rallying point for some scientists at major Iranian institutions to consider travelling abroad for the first time, having heard positive reports of hospitality of American colleagues in the United States.[4] However, for the longer term visits, research positions in the United States were in high demand; and rising Iranian stars increasingly accepted the European or Canadian alternatives as both practical and good choices, given the intense competition in the United States and also the stagnation of U.S.-Iran political relations that hindered opportunities to make needed contacts.[5]

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[2] Estimates of Department of State officials who followed student exchanges, November 2016.

[3] Reports of American visitors to Iran, 2010-2012.

[4] Reports of Iranian organizers of delegations scheduled to visit the United States, pursuant to the IVLP, October 2012.

[5] Senior professor representing Iranian Academy of Sciences familiar with dozens of Iranian post-doctoral scientists conducting research in Europe, 2013.

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In 2013, when officials in Tehran, Washington, and several other capitals publicly discussed inter-governmental negotiations that would begin to resolve the long-standing nuclear standoff, a number of optimistic scientists in the United States and Iran focused on new opportunities for bilateral science-engagement. The science communities of the two countries were hopeful as to a positive outcome from the slow progress in Lausanne and Vienna in reaching a nuclear deal. They knew that engagement in research linked to development of nuclear weapons would be discussed in great detail, but they were uncertain as to whether civilian science cooperation would be on the agenda. Nevertheless, they began giving serious attention to expansion of activities in non-nuclear fields as well; but they still recognized that progress in any field depended to some extent on the closing of a nuclear deal.[6]

With new government leaders in place in Iran in 2013, the National Academies soon received accolades from government officials in both Tehran and Washington about the importance of science engagement programs during previous years. Significant voices in Tehran commended the National Academies both for advancing science and for bridge-building across a turbulent political crevasse. These votes of confidence tempered the impatience of non-nuclear scientists to move forward as the nuclear negotiations slowly advanced toward an end. A priority task of the National Academies was to continue supporting the few non-nuclear scientist-to-scientist activities in the pipeline, while searching for more ambitious ways to scale up and sustain engagement activities in the months and years ahead.[7]

The outlook of a few leading Iranian scientists who were in touch with the National Academies slowly improved. Engagement with colleagues from the United States, they underscored, could encompass many disciplines. Among the areas for cooperation of interest in Tehran was construction of an optical telescope in Iran. A modern observatory could then be linked to the global network of similar astronomy research centers throughout the world, supporters emphasized. On another front, Iranian physicists reported progress in construction of a modern synchrotron, soon to be available to all interested researchers, with Iranian government funds in hand to ensure the opening of a circular particle accelerator by 2020. Far

[6] Conversations with visitors to Iran and with U.S. officials who followed activities in Iran, 2015-2016.

[7] Based on strong encouragement to expand exchange program from Department of State officials.

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distant from cooperation in physics, entomologist in both countries urged joint studies in Iran of finger-size biological phenomes that could walk on water. Promises of prompt steps by the government of Iran to prevent the killing of the estimated 70 remaining Asiatic cheetahs in Iran also garnered support by wildlife conservationists in the United States and elsewhere. Many other examples of American interest in scientific capabilities of Iran soon emerged.

In summary, during the period addressed in this chapter, science-engagement programs of other U.S. organizations declined to a small handful of activities; and the National Academies' programs, although also small, included more than one-half of the participants in all U.S.-Iran institution-based science-engagement activities. In addition, interested individual researchers in each country stayed in touch, and the number of scientific publications with both U.S. and Iranian authors continued to increase as discussed in Chapter 2.

CONTINUATION OF THE PROGRAM OF WORKSHOPS SPONSORED BY THE NATIONAL ACADEMIES

As the National Academies program of engagement slowly expanded from 2010 to 2016, and particularly in the aftermath of the election of President Rouhani, the Iranian interest in engagement increased dramatically. Highlighted below are the workshops that the National Academies and their partners in the United States and Iran organized, beginning in 2010.

1. ***Transportation***: During 2011, 12 Iranian transportation scientists and engineers visited the United States at the invitation of the National Academies and the department, with Sharif University of Technology assisting in organizing the visit. During a workshop at the National Academies, the visitors made presentations on the following topics:

- Four decades of urban transportation in Tehran.
- Comprehensive transportation planning studies in Iran.
- State of pavement engineering in Iran.
- Median U-turns and the increased occurrence of night-driving accidents.

A discussion of activities of the National Academies' Transportation Research Board then set the stage for participation of the Iranian visitors

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in the 90th Annual Meeting of the Transportation Research Board. They attended sessions on energy, hydraulics and hydrology, planning and forecasting, transportation safety, bridges and tunnels, traffic management, concrete materials, rural transportation, and transportation technology. Following their attendance at the meeting, they visited the International Road Federation, the American Public Transportation Association, and the University of Maryland's Department of Civil and Environmental Engineering.

In Atlanta, Georgia, the Iranian specialists discussed the following themes with appropriate counterparts:

- Transportation research at the university level.
- Role of state agencies in transportation planning.
- Regional cooperation.
- Public transportation systems.
- Support of the business community for transportation projects.

In Tampa, Florida, the visitors considered the following topics:

- Future planning for various modes of transportation.
- Citizen involvement in improving transportation.
- Relevant university initiatives.
- Business solutions of transportation issues.
- Engineering services in the transportation industry.[8]

The National Academies received several messages from Tehran concerning continuation of contacts between the visitors and hosts. Also, follow-up correspondence was carried out between the visitors and Iranian-American faculty members at U.S. universities, who had immigrated into the United States. However, exchanges in other fields began to take priority; and interest in both countries in further exchanges in the field of transportation waned.

2. ***Solar Energy***: In August 2011, 12 Iranian specialists in solar energy spent three weeks in the United States, visiting Washington, Colorado, and Arizona, before completing their tour with participation in a workshop with

[8] U.S. National Academies, "Global Perspectives on Transportation," Compendium of material on a Visit to the United States by Iranian Scientists. The National Academies Press, Washington, DC 2011.

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American colleagues in Irvine, California. At the workshop, the following sessions were held:

- Solar-thermal power innovations.
- Solar energy market analysis and policy.
- Photovoltaic and photo-electrochemical solar energy conversion.
- Design of solar energy systems.

American scientists became aware of the scope of solar energy research in Iran and also had an opportunity to learn about the operating experience of the country's first pilot solar-thermal power plant near Shiraz. Relentless sunshine and vast flat areas of land characterize much of Iran where there are numerous potential locations of future plants. Suggestions as to how to move forward based on the experiences at Shiraz and elsewhere included the following:

- Prepare an authoritative solar map for Iran that is based on satellite data.
- Carry out feasibility studies for site-selection of future solar plants.
- Improve designs of glass mirrors and absorber tubes.
- Exchange information on long-term thermal and optical performances of power plants.
- Promote exchanges of solar-energy research scientists.

During the workshop an Iranian expert set forth the following concerns about the approaches that were to be adopted in the past and were being carefully examined once again.

- Rural electrification is complicated, and life-cycle costs should be calculated over 20 years.
- Overall stability of legal and financial frameworks for power plants are very important.
- Electrification projects should involve local communities and local companies.
- For each project, strengthening both operations and maintenance practices is essential.

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- Energy efficiency should be a guiding principle from the very beginning of each project.[9]

Unfortunately, due to financial constraints the National Academies were not able to accept an invitation from a senior government research leader in Iran to organize a follow-on visit of American specialists to Iran. Of particular interest, according to the official, were (a) establishment of many efficient and inexpensive village grids, and (b) development of large-scale solar farms covering vast territories of land, well-suited to transform solar radiation into energy that could be stored and distributed as electricity to lightly populated areas.

3. ***Wildlife Conservation and Habitat Management***: In 2012, 13 Iranian wildlife specialists visited the United States. After consultations with several organizations in the Washington area, including a visit to the Smithsonian research center near Front Royal, Virginia, the visitors traveled to New Mexico and southern California, including the Salton Sea. They concluded their stay with a workshop in Irvine, California, and then visits to nearby mountain habitats for wildlife (the Irvine Ranch Conservancy) and to a well-managed coastal ecosystem south of Irvine.

According to workshop participants, a number of the wildlife challenges in Iran are similar to challenges in the southwestern United States. Both have a diverse selection of flora and fauna. One speaker reported that the fauna in Iran consists of 194 species of mammals, 534 species of birds, 216 species of reptiles 20 species of amphibians, and 180 species of fresh water fish, for a total of 1,144 species. Seventy-eight of the species are considered threatened, including 17 species of mammals, 20 species of birds, nine species of reptiles, four species of amphibians, and 28 species of fish.

Iran's Department of Environment has responsibility for 27 national parks, 42 wildlife refuges, 150 protected areas, and 35 national monuments. Together they comprise over 10 percent of the country's land area, and managing this dispersed area is a difficult challenge. At the time of the workshop, the Iranian department had three major projects involving international experts: conservation of the Asiatic cheetah, conservation of bird-life in wetlands, using the Siberian crane as the flagship species, and protection of sea turtles, using the Hawksbill Sea Turtle as the flagship species. Given this

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[9] Lori Greene, editor, *Challenges in the Development of Solar Energy. A Joint Iranian U.S. Workshop, Proceedings*, University of California, Irvine, August 2011.

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background, the visitors were intensely interested in protection of wildlife species and habitat management practices in the United States.[10]

While wildlife enthusiasts in both countries were interested in a reciprocal visit to Iran, the lack of financial resources limited contacts to correspondence and planning for activities that have not yet been carried out.

4. ***Mathematics Education***: Given political hesitation in Washington over sharing advances in science that might in time support the Iranian defense community, the National Academies were stymied in their efforts to promote cooperation in some areas of basic science—in physics, chemistry, and biology in particular. In order not to totally neglect basic science, the National Academies decided to support a visit to the United States by Iranian professors of mathematics. Mathematics has long been a perennial strength at a number of Iranian universities, and the topic seemed somewhat distant from dual-use concerns. However, in order to be cautious concerning such security concerns, the focus was on mathematics education, primarily at the university level, while highlighting the overlaps between research and education at universities. In 2014, the University of California at Irvine hosted a workshop on mathematics education attended by 14 Iranian scientists and a comparable number of Americans, who were active in the field.

A portion of the three-week program coincided with the large annual mathematics conference for 2014, held in Baltimore. Traditionally, a number of U.S. mathematics associations and societies sponsor the conference; and without hesitation they welcomed the Iranian attendees. This venue afforded the visitors an opportunity to gain broad overviews of many research activities that were sufficiently distant from security concerns so as not to raise objections concerning application of advanced mathematics to intelligence activities. After additional stops by the Iranian visitors at mathematics departments of universities in Chicago and Texas, the workshop in Irvine attracted additional American mathematicians to meet with the Iranian researchers/educators.[11]

While the American host organizations provided outstanding support for the visit, neither the Iranian nor American participants promoted follow-on activities. It was possible that had there been greater interest, the

[10] Tyler Cutforth, editor, *Wildlife Conservation and Habitat Management*, University of California, Irvine, April 2012.

[11] Donald Saari, editor, *Challenges of Mathematical Education, An American and Iranian Discussion, University of California, Irvine, January 27-29, 2014*, The Mathematical Association of America, 2014.

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National Academies could have considered supporting short visits by several American mathematicians to Iran.

Two years later an Iranian mathematician, who had immigrated to the United States and became a faculty member at Stanford University, was the first female scientist to win the Fields Prize—the highest world-wide distinction for a mathematician.

5. ***Seismic Science and Engineering***: The earthquake tragedy that killed an estimated 30,000 people in Bam, Iran, in 2003, had been a loud wakeup call for expanded international collaboration between seismologists, civil engineers, and other highly skilled specialists who address tectonic rumblings in countries throughout the world. By 2012, the National Academies have accumulated a decade of experience in bringing together experts from the United States and Iran with common interests in many aspects of seismic science and engineering related to detection of the first underground tremors signaling eruption of an earthquake and then the after-shocks, to locating and rescuing victims of the eruptions, to using modern methods for cleaning up debris, and finally to rebuilding facilities after widespread destruction.

By 2012, the National Academies were well into the process of passing the torch of responsibility for the U.S. side of bilateral cooperation in this field to the Pacific Earthquake Engineering Research Center (PEER) at the University of California in Berkeley. The center carried out regular electronic communications between Berkeley and Tehran as it assembled teams of interested colleagues from a number of U.S. and Iranian research centers. Recognizing the prevalence and similarity of earthquakes confronting Iran's northern neighbors, PEER also reached out to counterpart institutions in Turkey and Armenia in encouraging regional approaches for understanding the threat and consequences of violent seismic tremors that were common throughout the region.

A workshop in Tehran in 2012, the fourth bilateral event sponsored by PEER and the National Academies, exceeded expectations. Five seismic specialists from five U.S. institutions travelled to Iran. There, dozens of faculty members and graduate students from Sharif University of Technology, the host for the workshop, and from ten other Iranian universities and research centers enthusiastically greeted them. An estimated 15 percent of the 230 Iranian attendees at the workshop and the one-day training program that immediately followed the workshop were female graduate students and female early-career scientists. This amazingly diverse participant list was noticed by all, after decades of relegation of women scientists to observer

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status during similar events. In 2014, a U.S.-Iran-Turkey workshop in Istanbul was also successful in contributing to the global storehouse of important seismic experience about one of the most volatile regions of the world. A U.S.-Iran-Armenia workshop was then held in Yerevan, Armenia, which is a close neighbor of Iran situated in the geographically linked earthquake-prone region, where the participants again contributed to a growing base of up-to-date regional data.

Issues of primary concern to the PEER team and its Iranian partners soon included (a) reinforcement of the structures of 17,000 vulnerable school buildings that had been lightly constructed in earthquake-prone areas of Iran, and (b) practical and affordable technical approaches in strengthening the resilience of tall buildings in Tehran and other cities of the country to survive seismic shocks. These two tasks—to be carried out by Iranian construction firms—were daunting but important imperatives. Also, a new initiative of PEER called for Iranian colleagues to make available to the public extensive seismic data that they had collected in Iran over many years. PEER, in turn, sorted and presented well-organized data to the international community via the internet. Information about the behavior characteristics of a variety of types of eruptions in diverse underground settings that had been lying dormant in Iranian file cabinets was becoming widely available.[12]

6. ***Deterioration of the Lake Urmia Basin***: In 2013, the National Academies responded to a personal request for bilateral cooperation from the then Iranian Foreign Minister Ali Akbar Salehi. He subsequently returned to an earlier position as director of the Atomic Energy Organization in Tehran. In that position he had the added responsibility of serving as the key Iranian nuclear science expert during the negotiations that led to the nuclear deal.

In his request, Minister Salehi suggested that American and Iranian scientists jointly focus on the conditions in a large saline lake—Lake Urmia—that provided water for a well-populated water basin. The availability of water was steadily receding due to evaporation and inadequate measures for limiting overuse of the limited resource, which was being devoted primarily to the agriculture sector. Water-use quickly outpaced

[12] Earthquake Engineering Research Center, *Urban Earthquake Engineering, Proceedings of the U.S-Iran Seismic Workshop, December 18-20, 2012*, Tehran, University of California, Berkeley, 2013; Earthquake Engineering Research Center, *Seismic Risk Management in Urban Areas, Proceedings of a U.S.-Iran-Turkey Seismic Workshop, December 14-16, 2010*, Berkeley, California, 2011.

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adequate replenishment, and salt particles were increasingly exposed along previously submerged shores on a massive scale. The wind promptly carried salt-laden soil particles to nearby fields under cultivation where the salt had devastating effects.[13]

While the wind was relentlessly turning down-wind areas into contaminated surfaces unfit for agriculture, the National Academies organized a workshop in France that involved American and Iranian scientists along with several European experts. They offered practical suggestions to help address the problem. More extensive recycling of water, erection of physical structures to reduce and then guide runoff into productive uses, and provision of coverings for exposed salt-infested lake beds and shores were among the themes of the workshop. These experts cast serious doubts on the merits of proposals by Russian specialists for seeding clouds to stimulate rainfall and suggestions by other international groups to build a canal for transferring water from the Caspian Sea to the shrinking lake.[14]

After this round of discussions between water specialists from the two countries, the National Academies asked the University of California in Irvine to lead the U.S. component of follow-on activities in carrying out more serious engagement efforts. In 2014, American experts from Irvine and other research centers in the United States then played prominent roles in several relevant conferences in Iran and the United States. Utah State University also became active and effective in sharing the experience of its faculty members in studying the history and conditions of the Great Salt Lake.

The National Academies-initiated program was of considerable political as well as technical significance. In President Hassan Rouhani's first public edict after he took office in 2013, he called for prompt steps to address the rapid evaporation of Lake Urmia. Shortly after the National Academies' joint workshop in France, the Iranian government assembled a number of Iranian experts as advisors, including four Iranian scientists who had participated in the workshop and had then continued their interactions with American counterparts. Careful selection of the American and Iranian participants in the workshop in France and in other collaborative activities paid off in a variety of ways.

[13] Discussion with Foreign Minister Ali Akbar Salehi, New York City, September 20, 2013.

[14] U.S. National Academies, *A Compendium: U.S., Iranian, and European Experience in Assessing and Managing Water Resources: An Emphasis on Lake Urmia, Les Treilles, Tourtour, France, March 4-8, 2013*, Washington, D.C. 2013.

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7. ***Urban Air Pollution***: The lingering brown clouds of particles and health-threatening gasses has long been of serious concern to residents of Tehran and many other Iranian cities. Some cities have been coping with high levels of not only the traditional air pollutants from an ever-expanding fleet of cars, trucks, and motorcycles, but also from the increasing fury of dust storms. A gray blanket frequently covers cities in southern Iran due to pollutants from refineries and petroleum production facilities in the paths of frequent dust storms.

In 2013, the University of Southern California (USC), in collaboration with the American Association for the Advancement of Science (AAAS), organized a U.S.-Iran workshop on megacities. Fifteen Iranian scientists and a comparable number of American colleagues made presentations at the workshop. In addition, USC arranged a day-long site visit of participants to the South Coast Air Quality Management District and organized a roundtable devoted to environmental engineering, air pollution, and health research involving graduate students and faculty members. These activities were held under the auspices of the National Academies.[15]

The workshop and related visits by the Iranian scientists to several U.S. cities where rampant air pollution was declining led to a reciprocal event in early 2015 in Tehran. There the call for action to curtail the ever-growing level of air pollution resonated through the halls of government, academic laboratories, and residences. Then the municipality of Tehran and the University of Tehran joined in inviting experts from several countries to bring specific examples of successful experiences elsewhere to the table, experiences that would be helpful in combating a problem with huge health and welfare implications for millions of Iranians.

The National Academies responded to the request of the conference organizers to send two appropriate keynote speakers. The positive reactions in Tehran to their participation were impressive. The American experts suggested practical and inexpensive steps to improve estimates of urban air pollution at specific locations that could guide monitoring strategies. They emphasized more effective use of available monitoring equipment and the importance of improved location of monitoring stations in Tehran. In short order, newly sited and better located monitoring sites could help identify the locations of the most important contributing sources to pollution. Pollution control could then focus on the most significant sources, whether they be

[15] American Association for the Advancement of Science, *The U.S.-Iran Symposium on Air Pollution in Megacities, Proceedings, September 3-5, 2013*, Washington, DC, 2014.

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production facilities, uncovered waste sites, transportation centers, or other emitters of pollutants.[16]

8. ***Resilient Cities***: As large segments of the populations of many countries continue their influx into urban areas, the topic of resilience has risen to a high place in the research portfolios of many U.S. universities and centers. Also, the topic has gained a prominent position on the agendas of city officials in a number of countries. Thus, the topic was a popular focal point for promoting cooperative ventures with Iran that addressed cities where urban growth is expanding.

The initial National Academies event was a bilateral workshop in the United States. This activity helped set the stage for a sustained cooperative effort involving a number of U.S. and Iranian organizations. Some American Iran-watchers have described this workshop as the most successful U.S.-Iran event held in the United States in recent years. Specialists from a number of disciplines broadened their perspectives of the complexity of improving life in bulging metropolitan areas while limiting the damage from natural disasters. They also became optimists that U.S.-Iran science engagement has the potential to demonstrate technical solutions for reducing vexing urban problems encountered around the globe.[17]

The success of the initial efforts pioneered by the University of Arizona and Sharif University of Technology far exceeded expectations. The two universities agreed to focus future collaborative efforts at a new Center for Resiliency on a campus of Sharif University of Technology. By the end of 2015, the center had recruited an initial cadre of talented Iranian scientists with a wide range of specialties. They had begun working with municipality leaders of Tehran, launching studies of the resiliency weaknesses of selected areas of the city. They focused initiatives on reducing earthquake vulnerability, conserving water, curtailing vehicular emissions, and highlighting the importance of preserving critical elements of the environmental landscape as the population spreads into areas on the edge of the city.

9. ***Climate Change***: During the past decade, a number of U.S.-Iran bilateral interactions, along with discussions at international meetings, have

[16] Discussion with American air pollution experts who participated in conference in Tehran, June 2014.

[17] University of Arizona, *Proceedings of U.S.-Iran Symposium of Resilient Cities, June 16-18, 2014*, Irvine, California, 2015.

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led to assessments of the many drivers and significant impacts of climate change. But it wasn't until 2015 that the National Academies organized a U.S.-Iran workshop, again in California, with the University of Arizona having organizational responsibility, which was devoted to climate change in arid and semi-arid regions of the United States and Iran. Iranian specialists reported on the increased demand for manufactured goods and expanded transportation with climate change implications despite the economic slump in the country. They shared many reports of harmful environmental effects attributed to high temperatures, low rainfall, lengthy droughts, and poor allocation of resources.

The National Academies promptly scheduled a follow-on workshop for 2015. This workshop was held in France and attracted both well-known and early-career scientists. Several Iranian participants at the workshop in California also traveled to France. Presentations by experts from the three countries on the causes and effects of climate change provided a good foundation for continuing the pursuit of this topic in the years ahead, with important outputs for global discussions as well. Appendix F includes a range of cooperative follow-on activities that were suggested by the participants of the workshop. Some addressed the need for regional approaches along the borders of Iran. Others focused on the importance of Iran strengthening its policies and programs for addressing climate change. Already in early 2016, Iranian participants at the workshop in France reported progress in transforming some of the suggestions into action.[18]

10. ***Conservation of Wetlands***: The international community recognizes 24 wetlands in Iran, covering 1.5 million hectares, as being of global importance. They are set forth within the framework of the Ramsar Convention, which has been adopted by more than 150 countries, including the United States.

Several of these wetlands, such as the area surrounding Lake Urmia, which is discussed above, are of considerable interest to the U.S. government. Nine are along the coastal areas of the Caspian Sea, with the conditions of the wetlands impacting the quality of the water of the Sea that in turn affects the coastlines of neighboring countries. The Howizeh marshes straddle the Iran-Iraq border and have influence on the quality of the increasingly contaminated atmospheric currents that flow from Iraq over Iran. The survival

[18] University of Arizona, *Proceedings of U.S.-Iran Symposium on Climate Change: Impacts and Mitigation, March 3-April 1, 2015*, Irvine, California, 2016.

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of Hamoon Lake in eastern Iran depends on diminishing water flows from the Helmand River that has headwaters in Afghanistan. There upstream growers of poppies continually expand their fields, using the limited water to increase supplies of heroin.

Wetlands are frequently linked to both economic and ecological conditions of large areas. Some sustain agricultural and fishery activities. Others are preserves of unique ecological resources. Still others serve as clean sanctuaries that contribute to the health conditions of nearby populations. Many have or could have ecotourism potential. Others are currently challenged by the slow rise in global temperatures and the associated effect on water resources and by growing populations that seek space in habitable areas that are shrinking.

Thus, in 2016, the National Academies arranged for 13 senior and early-career scientists from Iran to spend three weeks becoming familiar with U.S. efforts to conserve wetlands. The shores of the Chesapeake Bay, the areas surrounding the Great Salt Lake, and California coastal areas provided good examples of approaches that have been adopted to increase the economic contributions of wetlands while constraining activities that degrade the ecology of the areas. Perhaps the most surprising discovery for the Iranians was an area of wetlands in Indiana, distant from large water bodies. There they visited a wetlands that had been largely destroyed as it became a dumping ground for urban waste. Then local authorities rehabilitated the land into productive agricultural use. The visitors could relate to this experience as destruction of wetlands becomes increasingly common in too many regions of the world.[19]

The capstone event was the traditional workshop, with the University of Arizona again having organizational responsibilities. A proceedings was prepared and provided an important guide for many research activities of interest in the United States and Iran while setting a high standard for the quality of proceedings.

The Iranian team members shared their findings with colleagues at home. Within two months Iranian participants reacted by inviting the National Academies to participate in a workshop to be held in Ramsar in the near future, the site of the signing of the international convention devoted to conservation of wetlands three decades ago. The importance of continued cooperation in this field seems clear. In addition to expanding

[19] University of Arizona, *Proceedings of U.S.-Iran Symposium on Wetlands*, April 4-6, Irvine, California, 2016.

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interest in global approaches to conservation of wetlands as set forth in the international convention, additional steps are required to ensure compliance with other international agreements that touch on issues encountered in wetlands.

Other U.S. organizations also hosted groups of visiting scientists from Iran during the past several years. They arranged appropriate meetings and visits in fields of considerable interest. Several examples of such hosts are as follows:

- Georgetown University: Neuroscience
- Yale University: Substance Abuse and Management
- U.S. Department of Agriculture: (a) Food Supply in an era of climate change, and (b) Water and Soil Management
- Retina Group of the Carolinas: Ophthalmology Research and Treatment

LESSONS LEARNED

The 2010 review of the National Academies' programs identified the following five lessons-learned, an observation that was reinforced during implementation of the program from 2010 through 2016:

- Committed and influential U.S. and Iranian leaders of projects are essential both to bring important specialists to the table and to navigate successfully through the governmental policies and procedures that determine whether and how each project can be implemented.
- The project leaders should be strongly encouraged to invite young professionals to be among the participants.
- When an opportunity for an activity of interest to both sides arises, immediate steps should be taken to carry out the activity even if it is not at the top of the priority list of activities-in-waiting.
- Documentation of results of projects that is publicly available can significantly magnify the impact of projects.
- An important criterion in selection of project participants should be the likelihood that they would have the interest and time to sustain the contacts made during the project.

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Additional lessons that have become apparent in more recent years include the following.

- In considering impacts of projects, a forward look of three-to-five years is appropriate; and significant impacts of one-off events are difficult to achieve.
- Coordination among the various U.S. institutions interested in promoting engagement in overlapping fields of science and technology deserves priority.
- Appropriate publicity for progress and results of joint efforts, with solid scientific documentation available to support claims of accomplishments is important.
- Specialists and organizations from both countries should bring comparable capabilities of mutual interest to the table and share equally in assuming responsibility for implementation of the project and in taking credit for success.
- Participants in projects should focus on "science," and then diplomatic successes will be easier to achieve.
- The importance of careful selection of highly qualified Iranian-Americans to help initiate and sustain institutional contacts cannot be exaggerated.
- The importance of establishing and maintaining relationships with prominent, capable, and enthusiastic advocates of science-engagement in Iran is essential.

As to specific projects carried out in the field of water and land management, the World Bank has published an excellent assessment of the lessons learned from a pilot effort in Mazandaran Province of Iran. The assessment underscores that the lessons learned in this effort have wide applicability in other areas of the country, as well as addressing pressing science, engineering, and management issues of broad concern throughout Iran. In future programs supported by the National Academies or other organizations with strong international experience, there should be opportunities to promote the concepts highlighted by the World Bank. (See Appendix G).

INITIATIVES BY OTHER ORGANIZATIONS

Other U.S. organizations also have sponsored a number of science-oriented exchange activities in recent years. A few examples are set forth below.

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1. *I-Bridges: Emergence of High-Tech Entrepreneurs* In August 2014, Silicon Valley IT leaders, and particularly entrepreneurs from the Iranian-American diaspora, gathered in San Francisco. The event named iBridges attracted 700 IT enthusiasts interested in exploring opportunities for and challenges of high-tech entrepreneurship in Iran. In June 2015, the second iBridges event was held in Berlin where it attracted 1,100 participants from 50 countries, with the American contingent from Silicon Valley featured on center stage. At the time, engaging Iranians in high-tech ventures seemed complicated since the outcome of the nuclear negotiations in Lausanne and then in Vienna remained far from certainty. But the turn-out of interested persons from the United States and Europe was impressive. A third iBridges event in December 2016 in Barcelona, Spain, attracted 200 participants from Europe, 120 from the United States, and 200 from Iran.

Were real investors with interests and clout at home and abroad in attendance at the iBridges events? Yes. For example, in Berlin Saeed Amidi, the founder and CEO of the IT investment power-house Plug and Play in California, was one of the inspirational speakers. At his investment center in California (often described as Silicon Valley in a box), more than 300 companies and universities from around the globe have desks staffed by knowledgeable representatives ready to innovate, invest, or provide expertise. Every day a number of his colleagues who had been trained in Iran are successfully matching investments with innovation in the United States and in many other countries.

Examples of Iranian companies that were represented in Berlin promoting their achievements included (a) Mamanpaz.ir, an online food delivery service with 200 customers a day, which offered dishes cooked by actual mums to customers who preferred home cooking to canteen or takeout food, (b) Maijo.com, a crowd-funding site to help Iranian entrepreneurs interested in art, music, and films of children, (c) Takhfiafan.com, a deal-of-the day website similar to Groupon, selling theater and concert tickets, and (d) Aparat.com, a video-sharing site showing music clips and films similar in concept to You Tube. While these were very modest initial efforts, their market orientation was impressive. Then in Barcelona, impressive Iranian applications in biotech, mart cities, and big data were on display. An Amazon-type enterprise had already entered the scene in Iran. Iranian government and nongovernmental leaders praised these and other new

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ventures—often with exaggerated expectations about their futures.[20] Since the 2015 event, many additional IT-based business ventures have been launched in Iran.

2. *Biomedical Research*: The National Institutes of Health (NIH) have been one of the most consistent U.S. organizations in supporting activities involving Iranian researchers, although their Iran-oriented activities began to decline after 2010. A high-profile activity of interest to American scientists has been Iranian investigations of the long-term health impacts on Iranian military veterans during their exposure to chemical agents in the Iran-Iraq war more than three decades ago. According to NIH-supported American investigators, an estimated 30,000 Iranian victims of the Iraqi chemical attacks (particularly mustard and sarin) were still alive in 2010. At the time, they reportedly were housed in Sasan Hospital and other facilities near Tehran. Unfortunately, little is known about more recent medical findings of Iranian researchers that focus on this topic.[21]

3. *HIV-AIDS*: For several years, scientists at the Dana-Farber Cancer Institute and Harvard Medical School have promoted collaborative activities in this field. They have successfully organized international meetings in Iran directed to youth and women in order to advance understanding of reproductive health issues. Also of interest has been the reduction in the infection rate along with reduction of the stigma of having contracted HIV-AIDS in Iran. In addition to bringing together Iranian and American investigators at conferences in Tehran, the organizers of this program have encouraged the spinning off of special-interest working parties.[22]

4. *Bioethics*: In the early 2000s, Iranian investigators, with strong encouragement by the National Academies, launched an investigation of the views of Iranian scholars, doctors, and theologians concerning a variety of ethical

[20] See www.theguardian.com/technology/2015/may/amazon-ir, accessed July 14, 2015. See also, www.ibridges.org/i-bridges-barcelona-2016-report/.

[21] Information provided by National Institutes of Health, February 15, 2012. See also, Robin Wright, "Iran Still Haunted and Influenced by Chemical Weapons Attacks," *Time*, January 20, 2014.

[22] Navid Madani, "Dialogue and Collaboration Open Up Opportunities that Are Vast and Truly Rewarding," *Cultures*, Volume 1, Issue 2, 2014, p. 38.

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issues.[23] The focus was on bioethical considerations of human cloning and stem cell research, genetic screening, human material patents, and genetic research confidentiality. Their report, based on questionnaires and interviews in Iran, was well received by the World Health Organization, which had supported the research; but in time key members of the research team went on to other types of endeavors.

In more recent years, faculty members at Georgetown University have pioneered important cooperative approaches in related areas of bioethics, involving Iran and other countries. These scientists have met with scientific and religious leaders and visited a number of academic and research centers in Iran. Iranian bioethicists, researchers, and clinicians have in-turn visited and lectured at Georgetown and other U.S. institutions. Plans have been prepared for joint publications and for visiting scholar arrangements.[24]

5. *Telecasts of Orthopedic Surgery*: In 2014, the Department of Orthopedic Surgery at the University of California in Los Angeles considered a series of telecasts involving orthopedic surgeons from the United States, Iran, and several other countries. The concept began with discussions of shared medical interests. Subsequent sessions were then to feature live broadcasts of surgical procedures being carried out at designated locations, with transmission of the surgeries to other participating medical centers in distant countries. During the surgeries, there were to be open lines between the team supporting the surgery and collaborators abroad which permit immediate commentary by on-site observers and the international collaborators concerning surgical approaches, successful procedures, and problems that are encountered. The initial discussions attracted attention of surgeons at Tehran University of Medical Sciences. Initial plans called for eventual coverage of spine surgery, total knee arthroplasty, shoulder surgery, limb lengthening, radiology, anesthesiology, and road traffic trauma. This program is still in the stage of discussion.[25]

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[23] Mohammed Reza Zali, Mansoureh Saniee, *Attitudes of Iranian Scholars and Theologians towards Bioethical Considerations of Cloning, Genetic Screening, Patents, and Confidentiality*, Research Center for Gastroenterology and Liver Diseases, Shaheed Beheshti University of Medical Sciences, May 29, 2005.

[24] Irene Anne Jillson, "The United States and Iran, Gaining and Sharing Scientific Knowledge through Collaboration," *Science and Diplomacy*, March 2013.

[25] Information provided by Edward Johnsen, UCLA, March 10, 2016.

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6. *Massive Open On-line Courses (MOOCs)*: International interest in MOOCs grew rapidly in 2013-2015. There were concerns in Washington over unfettered access by Iranians to these courses. Of particular interest have been access by Iranian students, along with others, to advanced courses being offered by the Massachusetts Institute of Technology. At the same time, comparable courses offered by the University of California university system have also been under consideration.

In 2014, the U.S. government authorized access by interested Iranian students to MOOCs that were devoted to technical subjects traditionally associated with undergraduate-level classes. As to graduate-level classes, Iranian students were not permitted to participate in courses in science, technology, engineering, or mathematics (STEM). The U.S. government decided that such access would not be in the national interest, and therefore denied a request for an OFAC license for opening these courses to Iranian students.[26]

In time, it may be that any course that is put on line will be accessible throughout the world; and the only restriction will be focused on the recognition that is given by the universities for satisfactory completion of courses. Some universities may decide to grant degrees based on MOOCs, with the final examination for each course conducted in person on campus. Others may decide simply to issue certificates and not degrees for participation in MOOCs.

Beyond the foregoing areas of interest to a variety of organizations, an initiative of the Institute for International Education (IIE) was particularly important for universities. IIE has been a focal point for international student exchanges, working under contracts with the department. It maintains an authoritative data base on international student exchanges that go back several decades. Each year IIE publishes *Open Doors,* which contains detailed information about students from Iran and other countries who study in the United States and also American students who study abroad. IIE sent teams of staff and university faculty members to Iran in 2015 and 2016, primarily to arrange for expanded student exchanges but also to encourage faculty-faculty interactions.[27]

[26] See http://www.exportlawblog.com/archives/5902. Accessed July14, 2016.

[27] *Reinventing Academic Ties: Opportunities for U.S.-Iran Higher Education Cooperation*, Institute for International Education, New York, July 2015. see www.iie.org/cip.

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A GOOD BEGINNING BUT A DIFFICULT ROAD AHEAD

Progress has been recorded in bringing the Iranian scientific community more directly into the mainstream of international science and in encouraging American scientists to reach out to Iranian colleagues who are often known only through their publications or through intermediaries. But follow-up activities are important if the National Academies' initial efforts set forth in this chapter are to lead to sustainable relationships. The longer that uncertainty concerning engagement dominates the political scene, the more difficult it will become to restore much of the advocacy and momentum for science-engagement that the National Academies have developed since 2000.

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4

Overcoming Barriers to Cooperation

An OFAC license is needed if a faculty member of our U.S. university is in Iran at his own expense where his actions could be interpreted as though he is acting within the scope of his university employment.
– U.S. university research administrator. 2016.

"The Department of State warns U.S. citizens of the risks of travel to Iran. This advisory reiterates and highlights the risk of arrest and detention of U.S. citizens, particularly dual-national Iranian-Americans, in Iran and notes that the Federal Aviation Administration has advised U.S. civil aviation to exercise caution when flying into, out of, within, or over the air space of Iran. All U.S. citizens should stay current with media coverage of local events and carefully reconsider non-essential travel." This commentary began the travel advisory of the Department of State (the department) on its website in March 2016, shortly after the release from prison in Tehran of three dual-national Americans.[1]

For many years, such travel warnings concerning visits to Iran have dampened enthusiasm of even the most adventurous American scientists to consider visiting colleagues in Iran. At times, U.S. citizens, and particularly dual-national citizens, have encountered travel difficulties in Iran. Fortunately, there were no interruptions of the National Academies-sponsored activities due to overly aggressive security officials in the two countries during 2010-2016. Delays at security check points involving excessive questioning have occurred, particularly at airports; and dual-national Iranian-American scientists participating in the National Academies-sponsored activities have at times been subjected to close scrutiny when visiting Iran. Still, given the

[1] Travel Advisory, March 16, 2016: https://travel.state.gov/content/passports/en/alertswarnings/iran-travel-warning.html.

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occasional apprehension in Iran of visiting Americans engaged in fields other than science, the importance of precautionary steps—usually the responsibility of the host for each visit – remains a serious concern. In the United States, occasional scrutiny of the National Academies-invited visitors has been reported to the National Academies but does not seem to be a major deterrent limiting exchanges.[2]

In 2016, the department issued instructions that no American scientist receiving funds or support related to Iran projects from the department, regardless of commitments from important and responsible Iranian organizations to ensure the safety of travelers, could go to Iran to carry out projects for the foreseeable future. The department emphasized that this position was "consistent with the travel advisory." At the same time, private travel agencies based in the United States and Europe reported that hundreds of Americans had signed up for tourism visits to Iran during 2016, and that many hotels in the country had been sold out six months in advance.[3] Arrests or confinement of tourists have not been widely reported, if they occurred.

VISA AND TRAVEL ISSUES

At times, American scientists planning to attend conferences or other events in Tehran are uncertain or even skeptical about receiving their Iranian visas in time for their scheduled departures from the United States. However, as of 2016, late approvals of visas in Tehran had been infrequent and seldom derailed travel in response to invitations to American specialists issued by Iranian partners through the National Academies. Such travel was usually planned well in advance to avoid disruption of travel plans. Visas were not an issue for Iranian-American scientists who held two passports; and the National Academies regularly learned from these scientists, who were traveling privately, about opportunities for science engagement.

Also, Iranian invitations for American scientists to speak at important international conferences in Iran were usually followed up by the hosts as soon as the invitees accept the invitations with prompt visa arrangements, even with deadlines of only several weeks between receipt of invitations and

[2] The short-term detention and interrogation of a member of the science staff of the National Academies, who was facilitating an exchange visit in Tehran in 2008, is described in Glenn E. Schweitzer, *U.S.-Iran Engagement in Science, Engineering, and Medicine* (2000-2009), National Academies Press, Washington, p. 87.

[3] Comment by senior official of Department of State and by director of Washington-based travel agency specializing in travel to Iran, May 2016.

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departures for Iran. However, such invitations seemed to have declined after a wave of invitations from 2012 to 2015, the time when newly elected President Hassan Rouhani and his associates began reaching out to well-known scientists from the United States and other countries to visit Iran. Until 2016 such invitations were frequent and important. Uncertainties concerning the 2016-2017 elections of presidents in the two countries were undoubtedly a factor in the subsequent decline in invitations from both sides.

Many American scientists travel to Iran each year pursuant to their own initiative or under the programming of tourist agencies. From time to time, they alert Iranian acquaintances of their arrivals or they succeed in having their tour guides arrange meetings with Iranian counterparts. Sometimes they have success in connecting with Iranian scientists or institutions with common scientific interests, and occasionally they stay in touch. While such visits may be important for the individuals and for science more broadly, the frequency of such interactions is far less than opportunities for American scientific experiences in many other countries.

For Iranians living in Iran—other than Iranian-Americans—who come to the United States for scientific purposes, the situation concerning visas has not been as favorable, due to both security concerns and limited visa-processing capabilities at consular sections in U.S. embassies near the periphery of Iran. In particular, during early 2016, a number of well-known Iranian scientists were seeking U.S. visas. However, the backlog of applicants was large. With no U.S. consulate located in Iran that could issue up-to-date visas, the visa-seekers were advised by their Iranian colleagues, who had also encountered visa difficulties, to travel to the consular department of a U.S. embassy in the United Arab Emirates, Turkey, or Armenia where they could be interviewed as the first step in applying for visas. But these embassies had become inundated with applicants from Iran, and their consular departments needed more than two months for visa processing. Some Iranian applicants were then advised by these embassies to apply for U.S. visas at the consular departments in embassies in Jordan, Uzbekistan, or other more distant countries, which they could reach without difficulties in obtaining visas to enter those countries. Some Iranian scientists, uncertain of the outcome of such long trips to apply for U.S. visas, were reluctant to go to these unfamiliar locations on two occasions: first to apply for a visa

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and then if the application was approved, to pick up the visa, perhaps on the way to the United States. They simply cancelled their cross-ocean trips.[4]

Thus, despite what seemed to be progress towards improving the bilateral relationship on the political front— including reaching agreement on the nuclear deal, a number of scientists in the United States and their partners in Iran with parallel research achievements had little hope that science exchanges would expand in a significant manner in the near future.

Informal rejoinders of U.S. officials to concerns of scientists in both countries about exchanges that were not supported politically in Washington have included the following. "We must be very careful in reviewing visa applications since our new analysts know so little about the inner workings of the Iranian government." "Iranian microbiologists may be associated with a biological weapons program." "Our security personnel at the points of entry into the United States are not required to accept the judgments made in Washington and/or by the U.S. consulates that supported the approval of visas for Iranian visitors." "We assume that Iranian visitors to U.S. laboratories are inspecting advanced electronics technologies."[5]

Thus, it has not been easy for an Iranian scientist to arrange a professional visit to the United States. With the enactment of new homeland security legislation in 2002, the U.S. requirements for granting American visas to Iranians and others living in countries of concern to the U.S. government, and particularly visas to scientists, engineers, and doctors, had been significantly tightened.[6] Going through the process of obtaining a visa and then passing muster with U.S. Immigration and Naturalization Service officials at JFK airport in New York or at other U.S. airports that receive international travelers is an experience that few Iranians relish—even those who consider that they are achieving success in spending time in the United States.

COMPLIANCE WITH ECONOMIC SANCTIONS

This section documents the efforts of the National Academies from 2000 to 2016 to comply with the regulations of the Office of Foreign Assets Control (OFAC) of the Department of Treasury. These regulations are in a constant state of review, amendment, and interpretation by OFAC and

[4] American host for group of Iranian scientists invited to several conferences in the United States, May 2016.

[5] Comments by senior Department of State officials, October 2006.

[6] *Patriot Act, 2002, and Enhanced Border Security and Visa Entry Reform Act*, 2002.

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other government agencies that have related interests. Therefore, other non-governmental organizations or individuals should not rely on the following discussion of the National Academies' experience and actions when they are determining their obligations to be in compliance with relevant regulations in the months and years ahead. At the same time, the discussion could be helpful to other organizations in (a) identifying aspects of proposed activities that might be subject to requirements of current and future sanction regimes, (b) formulating inquiries to OFAC or to legal experts for guidance, and (c) preparing requests for OFAC licenses. Also, the discussion is intended to provide understanding of an important context for many of the activities that have been supported by the National Academies.

Entering an Era of Economic Sanctions

The era of strict and at times unique economic restrictions on U.S. interactions with Iran significantly expanded in 1979. In the wake of the seizing of American diplomats as hostages by the revolutionary forces in Tehran, President Jimmy Carter ordered a freeze on all Iranian assets that were within the jurisdiction of the United States at that time. Estimates are that billions of dollars in assets fell under this impoundment order, although details of financial holdings at the time are not readily available. Quickly the financial freeze was extended to encompass a complete trade embargo.[7]

In 1981, the United States and Iran reached an agreement on release of the diplomat-hostages. The impoundment of Iranian assets was to be relaxed. Also, the total trade embargo was to be terminated. Still billions of dollars remained in escrow in various accounts in the United States and abroad. The disposition of these funds has been debated in U.S. and foreign courts for years.[8]

The United States imposed important new sanctions when Iran was implicated in the explosion of bombs at the U.S. marine base in Beirut in 1983. In 1992, U.S. legislation called for sanctioning any person or entity that (a) assisted Tehran in development of chemical, biological, or nuclear weapons, or (b) assisted in development or production of destabilizing numbers of advanced conventional weapons. In 1995, President Bill Clinton

[7] For background see, for example, "Iranian Assets Control Regulations," 31 CFR Part 535. This summary which addresses the history of sanctions and financial impoundments was released by OFAC on January 23, 2012.

[8] Ibid.

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expanded the partial ban on U.S. trade and investment involving Iran. Then in 2015 the Joint Comprehensive Plan of Action (JCPOA or nuclear deal) introduced both optimism in Tehran and new complications in Washington concerning release of Iran's financial assets.

Turning more directly to limitations on science-engagement, the Iran-Libya Sanctions Act of 1996 impeded people-to-people contacts by requiring OFAC licenses when *services* were provided by U.S. entities to Iranian organizations. The Act was designed primarily to deter major foreign entities from engaging in oil and gas field projects. People-to-people activities were not the focus of the act. Since that time there has been a constant debate over the definition of *services* when considering collaborative or coordinated scientific research and related activities. The more specific bans and license requirements that the United States has adopted during recent years include restrictions on many types of commercial activities, such as financial and trade restrictions, oil and gas restrictions, and strategic trade controls. Such limitations seem to have limited relevance to scientist-to-scientist exchanges. But exchanges of scientists are increasingly caught in the web of prohibitions.[9]

In recent years, the European nations also expanded limitations on dealings with Iran, while the United States continued to build its sanctions regime on a longer and more extensive history of bans and embargoes. The European restrictions have included the following approaches that have edged toward the realm of science-engagement: embargoes on dual-use technologies; embargoes on *services* in the fields of chemicals, electronics, sensors, and avionics; bans on transfer of oil and gas technologies; and export controls on sensitive goods, technologies, and *services.*[10]

Adding to the kaleidoscope of sanctions are the U.N. Security Council restrictions which reflect many of the foregoing concerns and also include the interception of banned goods *en route* to or from Iran.[11]

Important Milestones in Limiting Science Engagement

The interested scientific institutions and individuals in the two countries that participate or would like to participate in exchanges consider sanctions a significant impediment to development of professional interactions. As

[9] Available at http://legacy.armscontrol.org/print/6335 accessed June 14, 2015. For additional details see Kenneth Katzman, "Iran Sanctions," Congressional Research Service, January 10, 2013, p. 48.

[10] Cornelius Adebahr, *Easing EU Sanctions on Iran*, Atlantic Council, June 2014.

[11] See legacy.armscontrol, *op. cit.*

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the political relationship began to improve in 2013, science-engagement enthusiasts thought that perhaps steps would be taken to loosen formidable OFAC roadblocks in the way of cooperation. However, this did not happen since sanctions that affected science also had economic dimensions that limited availability of funds for international activities. A few of the significant sanctions-related actions since 2000 that have affected science-engagement are as follows:

- **2001**: Staff work within the U.S. government to develop a broad general license or set of licenses that would ease limitations on academic, educational, and cultural exchanges was terminated with the advent of 9/11.[12]
- **2003**: OFAC announced its intention to permit cooperation in response to humanitarian crises, citing as a precedent its authorization for a contribution by the U.S. government of $5 million to relief efforts following the Bam earthquake mentioned in Chapter 3.[13]
- **2004**: OFAC issued a general license for publishing activities that had previously required case-by-case licenses in response to a request from the Institute of Electrical and Electronic Engineers, which was supported by a number of other U.S. organizations. Specifically, OFAC authorized the revision and editing of papers submitted by Iranian scientists for inclusion in journals and other publications that are prepared and published in the United States.[14]
- **2004**: In connection with the general license for publishing activities, OFAC stated that for the purpose of the license the Iranian "government" did not include academic institutions. This precedent has been important since exchange activities are often more difficult to arrange if scientists from Iranian "government" institutions are directly involved.[15]
- **2005**: The American Institute of Aeronautics and Astronautics rejected 24 Iranian-authored papers for publication in its journals and cancelled related presentations at its national meeting in the

[12] Continuing discussions with U.S. government officials, 2000-2001.

[13] OFAC, "Statement of Policy on National Disasters," December20, 2003.

[14] R. Richard Newcomb, Letter to applicant re IA-209747a, April 2, 2004. See also CR 560.538, "Authorized Transactions Necessary and Ordinarily Incident to Publishing," December 10, 2004.

[15] FN 31 CFR 560.538.

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United States due to national security concerns linked to misguided perceptions of U.S. licensing requirements. However, these decisions were subsequently changed in the wake of the OFAC general license for publishing activities and of vigorous protests from American scientists.[16]

- **2006**: The American Chemical Society informed 34 Iranian members of the society that their memberships were terminated since they were receiving membership services at reduced costs (e.g., reduced-cost attendance at society meetings and free participation in society training activities) in violation of sanction-based regulations. After a lengthy delay, the society obtained an OFAC license for several membership benefits and offered these benefits to Iranian scientists. However, most of the Iranian scientists no longer had ways to transfer funds to the United States to cover costs of their memberships.[17]
- **2006**: OFAC announced it was establishing a favorable licensing regime for bilateral projects in the environmental field. Interested U.S. organizations would still have to apply for licenses for specific activities, but with increased expectations of positive decisions.[18]
- **2007**: Representatives of the National Academies met with the leadership of OFAC to review limitations on science-engagement activities. OFAC representatives confirmed that the approach being followed by the National Academies was appropriate, with an important consideration being the difference between (a) workshops for general discussions of issues of common interests, which do not involve *services* and do not require licenses, and (b) other events that provide advisory or training *services*, which require licenses. OFAC representatives stated that they were not concerned about workshops held in third countries.
- **2008**: OFAC issued a license to the American-Iranian Council to open and operate an office in Iran that would promote exchanges and educational programs and facilitate policy dialogues through roundtables, conferences, and publications. However, the Iranian

[16] "Society Bars Papers from Iranian Authors," *Science*, June 17, 2005, p. 1722.
[17] Catherine T. Hunt, Letter from ACS President to Councilors of ACS, May 17, 2007.
[18] Office of Foreign Assets Control, Iranian Transaction Regulations (31 CFR Part 560), "Guidance on Sponsorship of Certain Conferences."

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government did not approve the proposal by the Council; and the office was not established.[19]

- **2008**: OFAC denied a license for an American scientist to participate on an advisory committee established by the Iranian scientific community that provided an international perspective on how a new Iranian optical telescope could be best designed and operated to benefit the international scientific community. After interagency consultations, OFAC had determined that U.S. participation on such an advisory committee was not in the foreign policy interests of the United States.[20]
- **2009**: OFAC clarified that if an OFAC license is issued for a proposed activity, it is not necessary for the applicant to receive additional approval for compliance with the Export Administration Regulations administered by the Department of Commerce since inter-agency coordination will have taken place. One-stop shopping had become a reality.[21]
- **2012:** The White House led an initiative to limit Iranian student access to energy and nuclear courses in the United States and online, with a spillover effect limiting activities of U.S. faculty involved in higher education in Iran.[22]
- **2013:** OFAC announced that it had adopted a favorable licensing policy for activities that are designed to benefit the Iranian people through exchange programs, including educational and academic exchanges. License applications may be necessary, but presumably they would receive more favorable and more expedited consideration than in the past.[23]
- **2013**: OFAC issued a general license for personal communications that authorized American scientists and other professionals to take to Iran their laptops and other personal computing devices. While issuance of the license was motivated by the interest of the U.S. government in facilitating human-rights related communica-

[19] PRWeb, "AIC Is Granted an OFAC License To Operate in Iran," AIC, Princeton, N.J., October 4, 2008.

[20] Letter from Elizabeth W. Farrow, OFAC, to applicant for license, June 30, 2008.

[21] Department of Commerce, "License Requirements Policy for Iran and for Certain Weapons of Mass Destruction Proliferators," 15 CFR Part 746.7, Iran, January 7, 2009.

[22] See for example Public Law 112-158 and Executive Orders 1608 and 13590.

[23] Department of Treasury, "Educational and Academic Exchanges," press release, February 6, 2013.

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tions within Iran, American scientists traveling to Iran who were dependent on continuing access to their laptop computers while on professional travel unrelated to human rights issues welcomed the general license.[24]

- **2013**: OFAC issued a general license for cooperative activities directed to endangered species and wildlife and to environmental conservation.[25] Somewhat surprisingly, American environmental groups have not taken full advantage of this general license to develop programs that address environmental conservation problems in Iran.
- **2013**: OFAC informed Elsevier Publishing that the company's staff, editors, and peer reviewers based in the United States or U.S citizens living abroad could no longer be involved with publication requests from scientists who were Iranian government employees. This position was eventually changed by OFAC to permit such involvement.[26]
- **2014**: OFAC issued a general license authorizing (a) certain types of academic exchanges and exports of education services that are related to support of undergraduate Science, Technology, Engineering, and Mathematics (STEM) activities, and (b) non-degree courses and also non-fee programs that involve access to Massive Online Open Courses, with content equivalent to content of undergraduate STEM courses.[27]
- **2014**: OFAC issued a general license to facilitate personal contacts with colleagues in Iran that authorizes use of certain communication services, use of publicly available software and hardware, and involvement in publishing related activities that are incident to personal communications.[28]

Many other details about OFAC views and positions are set forth in OFAC's responses to individual applications for licenses. However, OFAC

[24] Barbara C. Hammerle, OFAC Memorandum (31 CFR Part 560), "Interpretive Guidance and Statement of Licensing Policy on Internet Freedom in Iran," March 20, 2012, Annex.

[25] Office of Foreign Assets Control, 31 CFR 5 ART 560, General License E, www.treasury.gov/resource-center/sanctions/programs/Doc.

[26] Elsevier email to its editors, April 30, 2013.

[27] CFR Part 560, General License G, 2014.

[28] CFR Part 560, General License D-1, 2014. Publicly available software defined at 15 CFR 734.3(b)(3), and publishing related activities set forth in 31 CFR 560.538.

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does not release information about such applications, and these responses must be obtained from applicants willing to share their documentation. Still, the list of activities set forth above provides some insight into the complexities in dealing with OFAC regulations. Unfortunately, strengthening of sanctions affecting science-engagement receives considerable coverage in the U.S. media while declarations concerning the relaxation of sanctions are seldom publicized beyond the formal announcements on the OFAC website.

Impacts on Science-Related Activities

The impacts of sanctions have been many fold, particularly since 2010 when sanctions increased in scope and severity. Examples of impacts with science and technology dimensions are as follows.

1. Iranian difficulties in obtaining needed industrial equipment and materials have contributed to a reduction of Iranian manufacturing activities, with attendant losses of engineering jobs that reduced opportunities to hire young university graduates who specialize in engineering.
2. Restrictions on the flow of IT equipment to Iran have hampered efforts of environmental and human rights advocates in Iran, and indeed the population more broadly, to communicate with others within the country, although recent liberalization of OFAC restrictions (cited above) is now more supportive of this communication.
3. Inflation in Iran has been directly linked to limitations on international trade and banking restrictions, and this inflation has affected financial capabilities of Iranian scientists to travel abroad.
4. Development of the energy sector, including research and development activities to enhance the competitiveness of renewable energy, has slowed down, due to a decline in domestic as well as international investments in that sector.
5. New investments in industrial activities in Iran by firms from Asia and Eastern Europe, including associated consultancy activities, have filled some financial gaps and have resulted in new S&T contacts of Iranian organization with these countries.
6. Shady Iranian firms have expanded illicit activities, and black market activities have thrived in search of technologies of U.S. origin.[29]

[29] Katzman, *op. cit.*, p. 52.

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As to additional impacts of sanctions and related policies on the science community of Iran, some American analysts point out that brain drain from Iran of researchers in sensitive areas slowed down as the Iranian government erected travel barriers to keep some of the best scientists working at home. Government officials and institution directors have probably reoriented some research activities to defense-related areas due to reduced opportunities to receive support for civilian-oriented research. Finally, some Iranian scientists may simply decide to stick to their original research interests, regardless of the hard times they encounter.[30]

Other specific enhancements of sanctions and related restrictions that have more immediate impact on cooperation are as follows:

1. Cooperation in scientific research in physics, chemistry, and biology has become increasingly difficult as the U.S. government intensifies efforts to prevent cooperation that could possibly feed into military applications over the long term. In the past, American professors in most fields of basic science could give lectures and teach courses in Iranian universities without the need for OFAC licenses. Such activities are now usually characterized as *services*, and the necessity to obtain OFAC licenses has become a strong deterrent that at times squelches U.S. professional enthusiasm for attempting to travel to Iranian universities.[31]
2. While OFAC has issued a general license for medical supplies that have been needed on an emergency basis in Iran, restrictions on international transfers of funds and limits on availability of hard currency have hindered Iranian ability to order and then pay for such purchases. Also, insurance companies and shippers are hesitant to become involved in shipments of medical and other science needs since they do not fully understand the scope of sanctions and the penalties for violating sanctions. The Iranian Academy of Medical Sciences has long had a list of medications that the Iranian government is prepared to purchase from abroad to combat both common and rare medical problems. However, purchases have often been delayed in sorting out the mechanisms for ordering, financing, and

[30] Keyvan Vakili and Navid Ghaffarzadegan, "The Asymmetric Impacts of Sanctions on Iran's Scientific Progress," Unpublished manuscript based on analyses of Scopus data base through 2012, available from kvakili@london.edu, obtained from authors, June 2014.

[31] Experience of National Academies of Sciences, Engineering, and Medicine (The National Academies), 2008-2014.

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shipping medications. Meanwhile, large quantities of medicines of poor quality from both local and international sources are reaching Iranian pharmacies through black market activities. Reliance on Chinese and Indian imports has not been satisfactory. Chinese pharmaceuticals often do not have the desired potency, and Indian products are increasingly going to more accessible markets.[32]

3. Many U.S. organizations have long been interested in addressing environmental problems in Iran which offer important lessons-learned for the global community. Environmental conditions in Iran have deteriorated to the point that several of the world's most polluted cities are located in Iran. At the top of the world-wide list is Zabol, Iran. While there have long been adverse conditions from lack of effective environmental management throughout the country, sanctions have reduced opportunities for purchasing equipment and products to hold such problems in check. Iranian motorists rely at times on leaded gasoline despite requirements to use unleaded gasoline, since sanctions limit import of unleaded fuels. Sanctions-induced gasoline shortages have at times forced the country to use petro-chemical facilities for producing highly contaminated gasoline, and a host of dangerous toxic chemicals are then released. Finally, lack of funds available to industrial firms due to declines in sales of their products has led to widespread tolerance of malfunctioning equipment that control both air and water discharges at levels which greatly exceed environmental standards. In short, purchases of advanced pollution control technology from abroad has been difficult, even when Iranian funds are allocated for this purpose.[33]

More broadly, the widespread economic effects of sanctions, buttress a belief of many Iranian officials that the West is trying to deny Iran access to technologies in all fields of endeavor as proclaimed by the Supreme Leader.[34] While Iran has resorted to many approaches to limit the impacts, particularly resorting to trade based on barter rather than cash, the economic squeeze has been felt at all levels of society. Still, it may be an exaggeration to call the

[32] Siamak Namazi, "Sanctions and Medical Supply Shortages in Iran," Woodrow Wilson International Center, Washington, D.C., April 2013.

[33] Tasnim News Agency, "Official Warns Against Environmental Impacts of Anti-Iran Sanctions," November 11, 2013.

[34] Press TV, "West Uses Sanctions To Monopolize Science: Iranian Minister," January 30, 2013.

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actions "crippling" sanctions, as is so often the case in Washington. Visitors to Iran continue to comment on the liveliness of activities in the major cities of the country despite the economic isolation.

Reflecting an important assessment of sanctions and the economy, an analysis by a leading western expert on Iran's economy argues that Iran's economic woes in 2015 were only partially due to sanctions. He notes the negative effects of populist economic policies, mismanagement, corruption, and collapse of the international price of oil. He reports the positive aspects of the Iranian response to the economic crisis can now be seen, including the beginnings of (a) empowerment of domestic industry, (b) reduction of dependency on oil export revenues, (c) reform of cash handouts, (d) tax reform, and (e) establishment of a legal framework that will lead to a business-friendly economy. In short, lifting sanctions may help boost the Iranian economy; but it is not the only step that is needed as was discussed in Chapter 2.[35]

In summary, for several years, there was widespread belief in Iran that reaching agreement with the west, and particularly the United States, on the nuclear issue would result in immediate relief from sanctions even though it would take time for that relief to be translated into more and better jobs. Public expectations in this regard have run well ahead of reality as the difficulties in unraveling the sanctions become increasingly evident and as U.S. missile-related sanctions receive increasing publicity in the two countries. But some economic progress should be gradually realized as commercial activities within Iran become unbridled in a few sectors as a result of the nuclear deal.

OBTAINING OFAC LICENSES

In 2000, the National Academies together with the Iranian Academy of Sciences and Iranian Academy of Medicine agreed to sponsor four workshops on selected scientific topics as soon as possible. All of the workshops could have been held without licenses, but for one unique aspect of the workshops. The National Academies decided that in order to promote sustainability of this engagement initiative, a published proceedings for each workshop would be important. Also, since all participants in workshops were expected to make presentations, a proceedings would help ensure the workshop attendees were truly scientists and not "minders," who had other

[35] Bijan Khajehpour, "The Economic Significance of the Nuclear Deal for Iran," Wilson Center, June 2, 2015.

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responsibilities. Publication of such proceedings required OFAC licenses. Fortunately, many months were available to obtain the four licenses; and OFAC approved all applications on time.

Then, as previously noted, in 2004, OFAC issued a general license concerning joint efforts in preparing scientific publications, such as proceedings. For several years, the National Academies conducted workshops without obtaining licenses. Eventually, as discussed below, at times the National Academies obtained licenses even though there was no legal requirement for the licenses.

At the outset of cooperation, in the early 2000's, the National Academies dedcided not to be involved in (a) transferring funds in either direction other than funds for professional travel, lodging, interpreting services, and support of other administrative aspects of meetings, (b) transferring equipment to Iran, or (c) transferring export-controlled information to Iranians. As the program developed, licenses were required for training programs to upgrade Iranian skills, which were important to sustain mutually beneficial cooperation.

Also of considerable importance, operational reasons for obtaining licenses for workshops and other events even when licenses were not legally required emerged early in the program. For example, some U.S. officials who routinely reviewed and then approved or rejected applications by Iranian scientists for U.S. visas were not familiar with OFAC requirements. At times, they denied requests for visas by Iranian participants on the grounds that travel to the United States was not being carried out pursuant to authorization set forth in an OFAC license, even though OFAC licenses were not required in the cases under consideration. In addition, sometimes American travelers to Iran were concerned that their travel had not been officially endorsed by the U.S. government, and providing them with a copy of an approved license eased their concerns and the concerns of their institutions. In recent years, U.S. universities have increasingly required that faculty members could travel to Iran only if the activity was covered by a license, usually not knowing when licenses were required. Also, at times it has been useful for the National Academies to provide American hosts for visits by Iranians to the United States copies of licenses so they could show Iranian counterparts that the U.S. government supported the activity.

Finally, on occasion an activity which begins simply as an exploratory activity can lead into a more serious engagement that requires a license. Perhaps the purchase of equipment, the collection and exchange of soil or biological samples, or the provision of grants to Iranian scientists are compo-

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nents of a second-phase of a project that began as an exploratory workshop. Having a license for the first phase strengthened the case for a license for a second phase, which might require a license.

In summary, at times the National Academies obtained OFAC licenses that were not required in order to (a) facilitate the issuance of U.S. visas to Iranians, (b) ease concerns of American travelers, (c) convince Iranian officials that the U.S. government supports, or at least does not oppose, an activity, or (d) ease the process of obtaining subsequent licenses for more ambitious but related cooperative efforts.

Applying for a License

"We engaged a U.S. law firm for tens of thousands of dollars to prepare our request for an OFAC license so that our faculty members could visit an Iranian university and arrange for Iranian graduate students to study and conduct research at our university." A senior official at a prestigious U.S. university was complaining to a group of visiting American colleagues about the complexities in dealing with Iran. He clearly was worried about not crossing into forbidden territory, which could cause his university problems. Having a license obtained through legal channels was to be his insurance policy.[36]

As previously noted, the National Academies have requested licenses when interactions go beyond simply exchanges of ideas and readily available information. The usual reason for requesting a license has been the inclusion of training activities as a component of the interactions since training would involve the provision of *services,* an activity that requires a license as previously noted. The request for a license has always emphasized the scientific benefits to the United States from the planned activities, since the department must certify that the activities are consistent with U.S. foreign policy interests in order for OFAC to grant a license.

Two requests for licenses were not approved, as previously noted, and the applications were withdrawn when the National Academies learned of difficulties within the government in approving the requests. In one case, the U.S. government considered that the proposed Iranian partner for a discussion of science policy was too deeply embedded in defense activities to participate in a civilian project with the possibility of providing Iranian participants with information on access to dual-use technologies. In the other case, the U.S. government was not prepared to authorize collaboration

[36] Senior official of highly respected U.S. university, February 2009.

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that included development of mathematical models for studies of economic aspects of the energy sector of Iran, even though the Iranian investigators had published articles showing that nuclear power was not a wise investment in Iran.

The documents prepared by others to support requests for licenses for academic and research exchanges that have been shared with the National Academies have usually cited at length the relevant OFAC regulations. They often discuss the political benefits for the United States in building bridges with Iran. These issues are interesting, but the U.S. government is well informed on these two topics; and presentations of such arguments may contain inaccuracies or raise questions that delay or complicate the review process.

OFAC and other interested U.S. government agencies are rightfully concerned as to whether science-engagement will result in leakage of sensitive U.S. technology to Iranian partners that enhances Iran's national security interests or industrial production capabilities. Also, the U.S. government focuses on the technical benefits to the United States from the proposed activity. Thus, the National Academies addresses the following questions in its applications for licenses. "What are the mission, interest, and technical capabilities of the Iranian partner?" "What are the full dimensions of cooperation?" "How will the United States benefit from the activity?" "How will the costs of the collaboration be covered?"

Multi-year Licenses

Early in implementation of the program, the Naitonal Academies launched a pilot project to improve the surveillance for food-borne diseases in Iran, as discussed in Chapter 2. This project was to demonstrate how personal skills of a large number of Iranian medical assistants, particularly unpaid but well educated female medical assistants in small towns and villages, could be upgraded to cope with the maladies of food poisoning. The American specialists would learn how a centrally controlled, but regionally implemented, Iranian public health system was reducing common illnesses that plague every country. This project had many facets, and it would take several years to carry out. Since obtaining a license at that time would take at least four months, the National Academies decided to apply for a three-year license to cover a wide variety of activities. OFAC issued the license without excessive delay and set a good precedent as to the advantages of multi-year licenses. Indeed, the license was easily extended for a fourth year.

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Based on this experience, the National Academies soon shifted to applying for licenses that cover a number of directly related events over periods of two to three years. With such multi-year licenses, it is easier to ensure sustainability of efforts after successful completion of initial project activities than having to apply for a new license.

Finally, the National Academies has encouraged the department to seek support within the government for the issuance of OFAC general licenses for cooperative efforts in a variety of non-sensitive fields that will ease the administrative burden of initiating and continuing joint scientific efforts by the National Academies and other interested U.S. organizations and individuals. As previously noted, a good start has been made with the issuance of general licenses by OFAC for cooperation with regard to (a) publishing activities, (b) programs directed to endangered species and wildlife, (c) environmental conservation, and (c) use of personal computing equipment in Iran.

Recognition of the importance of general licenses in other fields is long overdue. For example, general licenses would be appropriate for activities that involve (a) assessing and monitoring environmental pollution, (b) estimating impacts of the effects of climate change on health and the environment, (c) developing and deploying solar energy systems, (d) assessing and treating infectious diseases, (e) research on the genetic aspects of selected diseases, (f) exchanging experiences on science, technology, engineering, and mathematics education, (g) conducting agriculture, food, and nutrition research, and (h) collaborating to preserve forestry resources in arid lands. The likelihood of such general licenses leading to unacceptable outflows of U. S. technology is low. In all of these areas, American scientists would have opportunities to learn from Iranian colleagues as well as sharing their own experiences.

Additional Issues

In August 2015, the Institute for International Education (IIE) published an informative document concerning impacts of sanctions and export controls on U.S. higher education institutions.[37] Several issues addressed in the document, including but beyond issues previously covered in this chap-

[37] Institute of International Education, *Reinventing Academic Ties and Opportunities for U.S. Iran Higher Education Cooperation*, July 2015 (www.iie.org/cip) See pages 20-35, "Rules and Regulations: Frequently Asked Questions about the Impact on U.S. Educational Institutions of U.S. Sanctions on Iran and U.S. Export Controls." This document contains a detailed legal analysis of the regulations of the Office of Foreign Assets Control that are relevant to exchanges involving students and university faculty members.

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ter, follow. Since student exchanges are beyond the scope of this report, the provisions of the document concerning student exchanges are not included.

1. While authorization is not required for U.S. persons to travel to Iran, participation in educational courses or academic research in Iran needs to be licensed by OFAC. To this end, a general license limited to several specific types of activities has been issued which enables American academics to support not-for-profit activities related to increasing access to education, combating illiteracy, or assisting in educational reform projects.
2. U.S. degree-granting higher education institutions can provide services related to the recruitment, hiring, or employment of Iranians employed in a teaching capacity in Iran pursuant to a general license.
3. Articles prepared by Iranian academics can be refereed and included in U.S. journals pursuant to a general license. The following activities are explicitly authorized: advance payments for written publications; collaboration with American colleagues in writing or enhancing publications, including embedding software for reading or searching; payment of royalties; and marketing of publications.
4. Iranians can serve on organizing committees of U.S. universities for workshops and on dissertation committees, subject to acquisition of appropriate U.S. visas.
5. Americans can serve on joint organizing committees of Iranian universities.
6. OFAC licenses are required for American universities to provide grants to Iranian universities for *services* related to research. There may be other requirements if the funds are provided by a U.S. government agency. Also, one-half of U.S. states have their own sanctions laws; and care is needed not to violate those laws.
7. Almost all shipments of equipment or material to Iran require licenses. While there are generally no controls on shipment of results of non-sensitive basic research, each case is different; and consultation with OFAC is advised.

An important issue not addressed in the foregoing document concerns attendance by American citizens at conferences in Iran. The language developed by OFAC in 1997 that was intended primarily to control energy-related activities is as follows: "The *Iranian Transaction Regulations* prohibit spon-

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sorship by U.S. persons of conferences or events at conferences organized or co-organized by the Government of Iran or persons in Iran."[38] While the National Academies has participated in many meetings, and workshops in Iran, the National Academies ensured that the Iranian hosts assumed full responsibility for organizing the events.

FINANCIAL SUPPORT

This chapter has addressed primarily personal safety concerns, visas, and OFAC license issues. In addition, financial resources are required to support science-engagement. Indeed, without more funding from the governments or private sources, significant growth in science-engagement is unlikely, regardless of the potential payoff—scientifically, economically, or politically—from cooperation in this sphere.

Much of the attention of government agencies in Tehran and Washington in the near future will probably be focused on implementation of the provisions of the nuclear deal, which will require additional financial support for the activities set forth in the JCPOA. The likelihood of significant growth in the funds available for other activities seems low, even if there are pronouncements of global leaders as to the importance of and opportunities for expanding science-engagement between Iran and the industrialized world, including the United States.

Other U.S. organizations interested in carrying out exchanges also have financial limitations. But a major funding organization which is prepared to make a substantial and sustained financial commitment to the support of science-engagement with Iran has yet to step forward.

In Iran, financial resources for supporting cooperation with U.S. institutions seem to be in short supply. Nevertheless, when an American arrives in Tehran on a scientific mission, the Iranian host immediately assumes financial responsibility for many aspects of the visit. The sources of these funds are usually unknown to the visitor. Often the money comes from the private bank accounts of the hosts, who accept the funding responsibility with a smile and with a great source of pride and determination to show the positive aspects of life in Iran. And as confidence in the reliability of cross-border partners increase, financial shortfalls are overcome with the sense of professional achievements and comradery.

[38] Barbara Hammerle, "Statement of Licensing Policy," OFAC, July 17, 2006.

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5

Uncertain Future for Science-Engagement

We are prepared to consider all serious proposals for U.S.-Iran cooperation in science and technology
– Iran's Vice President for Science and Technology. 2015.

In mid-2017, the National Academies of Science, Engineering, and Medicine were uncertain whether a continuation of meaningful science-engagement activities involving American and Iranian colleagues would be possible in the near term.

As discussed in Chapter 2, political concerns of the U.S. government had led to a temporary suspension of the National Academies' science-engagement program in 2009, following the election of Iranian President Mahmoud Ahmadinejad for a second term. Despite the continuing decline in the political relationship between the two governments, nongovernmental science-engagement endorsed by the U.S. government rebounded. The National Academies' program then again became a limited but nevertheless important component of the overall relationship between the two countries.

However, by 2017 the political conditions for science-engagement had become much starker than in earlier years, even with (a) an upsurge in the National Academies' program from 2012 to 2016, (b) growth in the Iranian student population in the United States, and (c) successful conclusion of negotiations that led to signing by seven countries of the Joint Comprehensive Plan of Action (JCPOA or Nuclear Deal).

As noted throughout this report, the National Academies have not been involved in exchanges in the nuclear or other security-sensitive fields. Nevertheless, the limitations on issuance of visas, the reach of sanctions, and security concerns in both countries have at times blurred the distinctions

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between civil-oriented exchanges and national security-related endeavors, including exchanges in a number of fields that might touch on developments of interest to defense-oriented organizations.

In 2016, the implementation of commitments by the United States, Iran, and other countries pursuant to the Nuclear Deal was underway. At the same time, critics of the JCPOA in the United States and Iran often challenged the claims of their adversaries in the other country that "sufficient" compliance with the JCPOA had been achieved, while also pointing to provocative acts in other areas, such as reckless naval maneuvers in international waters. The most extreme critics in both countries argued that provocations provided a basis for withdrawal from the Nuclear Deal.

Meanwhile, with regard to implementation of Annex III of the JCPOA that identifies topics for civil nuclear science exchanges should the parties to the JCPOA or international organizations be interested, several European countries promptly launched a number of initiatives to collaborate with Iranian counterparts. The United States has waited for an appropriate time to take steps toward implementation of Annex III through involvement of American scientists in civil nuclear exchange activities. The Iranian government may be simply awaiting the first move toward bilateral engagement pursuant to Annex III to be taken in Washington.

This chapter reviews the experience of the National Academies during recent years of science-engagement in developing a basis for continued collaboration in non-nuclear activities, should there be opportunities in the near future for renewal of science-engagement. The initial emphasis of the chapter is on the important implementation role of U.S. partners—and particularly U.S. universities—that will probably continue their interest in collaborating with Iranian organizations to the extent possible. The chapter then turns to implementation of Annex III, which could become a milestone in development and expansion of science-engagement activities. Three additional topics relevant to exchanges are also addressed: (a) the overarching challenge of limiting economic development activities that stress the Iranian environmental landscape and the role of international cooperation in addressing these stresses, (b) the opportunities for regional cooperation in several areas which should be of particular interest to both Iran and the United States, and (c) the importance of improved understanding in the United States of the development of Iran's science, technology, and innovation approaches and capabilities that were briefly discussed in Chapter 2 and increasingly have international dimensions. Finally, the chapter describes several high

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visibility cooperative events that have been suggested by American and Iranian scientists in recent years and may warrant consideration in the future.

THE NATIONAL ACADEMIES' SELECTION OF FIELDS AND ENGAGEMENT OF UNIVERSITY PARTNERS

Chapter 2 noted that during the early years of the National Academies' science-engagement with Iranian institutions, the programming concept was to initiate exchanges as quickly as possible in a wide variety of fields of mutual interest. As a result, by 2010 the National Academies' program had supported exchanges in more than 15 fields of science, technology, and medicine. Then, in recognition of the importance of sustaining contacts that had been established, the strategy began to change in view of limitations on financial support. The evolving concept was to focus on only a few fields for exchanges and then to scale up cooperation in these fields over the long term.

The National Academies' access to financial support, while limited, has often been more favorable than pathways for financing cooperation that are available to Iranian institutions. Therefore, the National Academies usually have taken the initial step in proposing an activity. The Iranian partners have then been able to cite the National Academies' success in obtaining political and financial support in the United States for a specific activity as leverage in arranging financing by their side. Clearly, the financial aspect has been a particularly significant factor in selection of topics and venues.

An important aspect of the evolving program strategy called for the National Academies to work with interested U.S. universities that were prepared to devote some of their own resources, plus external resources that they could obtain, to activities in fields that reflected Iranian as well as U.S. interests. Then the National Academies gradually transferred the U.S. responsibility for organizing sustained cooperation in a particular field to a collaborating U.S. university, with the National Academies playing a supporting role when this would be helpful. For example, the National Academies could assist in obtaining licenses from the Office of Foreign Assets Control (OFAC) as discussed in Chapter 4 and in identifying the limited opportunities for external financial support.

By 2016, the National Academies have joined with three U.S. universities in supporting exchanges in three important fields highlighted in Chapter 3; and these partnerships soon resulted in significant achievements.

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1. Seismic science and engineering, in cooperation with the Pacific Earthquake Engineering Research (PEER) Center, University of California at Berkeley. The National Academies began working with the PEER center in 2004. By 2010 the center was operating largely independently in collaboration with Sharif University of Technology, and through that university with a number of other institutions in Iran. This program became a model for cooperation of considerable interest to the National Academies, and indeed to the United States and Iranian scientific communities broadly, as discussed in Chapter 3.
2. Conservation and effective use of water resources, in cooperation with the University of California at Irvine. The university hosted several workshops in cooperation with the National Academies while also organizing other workshops and individual visits carried out in the United States and Iran. The university has effectively organized a variety of water-related activities in cooperation with scientists at a number of Iranian universities and has played a particularly important role in supporting efforts focused on Lake Urmia and on several other water-deficit areas of Iran.
3. Resilient Cities, in cooperation with the University of Arizona. While the university has cooperated with the National Academies in organizing a variety of collaborative activities in the United States and Iran, its most innovative approaches have been carried out through a focus on resilience of cities, a relatively new concept in Iran. The university organized bilateral workshops on resilience in both the United States and Iran, and Sharif University of Technology then established a counterpart center on one of its campuses with an emphasis on research on resilience of cities. During a subsequent visit to Tehran, American scientists worked closely with Iranian counterparts in developing significant research opportunities.

Two other National Academies-promoted university-based collaborations were in their formative stages in 2016, but due to difficulties in obtaining financial support the proposed collaborations had not led to sustainable relationships between U.S. and Iranian counterpart universities. Duke University sent a leading specialist in air pollution to Iran where he and a colleague from the University of California in Berkeley had an enthusiastic reception during keynote presentations at a conference led by specialists

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from the University of Tehran. Tentative plans for sustained collaboration were discussed in Tehran but were stymied by the lack of financial support on the U.S. side. In another field, the University of Maryland hosted a visit by Iranian specialists in the conservation of wetlands, and the university was prepared to expand this embryonic relationship in response to an invitation to send experts to Ramsar, Iran, the birthplace of the International Convention on Wetlands. However, the university program also stalled due to lack of funds.

The issue of financial support needs to be resolved if U.S. universities are to play a long-term role in sustaining cooperation. The level of support does not need to be high, but some funding is required to offset direct costs.

Given financial constraints, the National Academies should decide whether it will continue its leadership role in science-engagement with Iran as the intergovernmental political standoff continues to litter the landscape with high barriers to effective cooperation. A key issue is whether the strategy should continue to focus on (a) helping to ensure long-term support of a few cross-ocean partnerships managed by the National Academies' partners, or (b) undertaking by the National Academies of exploratory activities in a larger number of fields, with the expectation that some of these small efforts could continue under the auspices of other U.S. institutions, as was the approach in the early 2000's.

ANNEX III OF THE NUCLEAR DEAL

From the outset of the National Academies' program, overlaps between nuclear and other scientific disciplines were evident. Also some American exchange scientists had a general awareness of the nuclear controversy although during visits to Iran they were focusing on non-nuclear issues. At times in private discussions, Iranian and American scientists would air concerns about the nuclear standoff. The Americans would usually argue that given the vast oil and gas resources of Iran, nuclear power was not necessary. The Iranians would almost always agree; but they nevertheless were adamant in insisting that Iran not be denied the right to have nuclear power. They regularly interpreted the diplomatic position of the United States as denying Iran that right. "You do not understand the Iranian mentality" was a frequent rejoinder of Iranian colleagues when this Iranian right came into question. They often noted that as a signatory to the Non-Proliferation Treaty, Iran is guaranteed that right.

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A common interest of a number of American scientists who visited Iran was the widely publicized, but frequently delayed, construction of the Bushehr nuclear power plant, which in the 1970's had involved German engineers and more recently Russian scientists and engineers. Remembering the devastating accident at Chernobyl, very few Americans were comfortable in entrusting Russia to be the guardian of safety at Bushehr. Thus, the National Academies received occasional suggestions from American Iran-watchers that a science-engagement program should address nuclear safety issues in Iran. The National Academies were not interested in becoming involved in nuclear activities and argued that the primary responsibility belonged to the Russian government as the provider of the nuclear technology that was being installed. However, in 2017 the European Atomic Energy Commission became involved in promoting nuclear safety in Iran.[1] Meanwhile, the National Academies took note of the relevance of the National Academies' earlier experiences in Iran and other countries to some of the provisions of Annex III.

Early in the National Academies' science-engagement activities, a senior Iranian researcher working at the Atomic Energy Organization of Iran urged joint efforts to improve radiation therapy facilities in Tehran. He complained about the primitive state of facilities that were available to the general public. But the National Academies set aside the idea at that time as being too close to nuclear concerns. This topic then reappeared in Annex III.

Also, in 2009, the Atomic Energy Organization of Iran had announced a plan to build a large modern radiation therapy center in Tehran, with a projected cost of $200 million. Iranian newspapers published sketches of the proposed center.[2] The accompanying commentaries heralded this center as filling an important gap in the nation's health-care system and argued that a new center was urgently needed to treat cancer. However, as Iran's economic situation continued to decline, the proposed project quickly disappeared from sight.

As in the case of nuclear safety, during advancement toward a nuclear deal radiation therapy again was on the table as a topic for cooperation during implementation of the JCPOA. Informal discussions with Iranian physicists indicated that a more modest effort than a new center seemed to be a reasonable first step.

[1] EU Project for Nuclear Safety for Iran, April 4, 2017. http://europa.eu/press-release_MEX-17-10031003_en.htm.

[2] "Radiation Therapy Center," *Tehran Times*, p. 2, March 23, 2008.

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Also, as the nuclear negotiations unfolded, concern of the U.S. government began to focus on the importance of new job opportunities for Iranian scientists and engineers who would be forced to abandon their weapons-oriented careers. Informal estimates by U.S. government officials indicated that thousands of former weapon-oriented scientists would become under-employed. They noted that a precise estimate could only be made by the Iranian government. By the end of 2016, better estimates had not been offered informally or through published documents.[3]

As interest in this topic increased in Washington, American officials with experience in Russia two decades earlier reflected on the relevance of the efforts that were undertaken by the U.S. government and other interested governments to redirect Russian weapon scientists—and particularly nuclear scientists—from designing and developing components of military systems to working on civilian-oriented tasks. A number of these redirection programs sponsored by the United States, European, and Japanese governments as well as by the Russian government were considered quite successful, at least for the short term. They seemed to offer a number of lessons-learned concerning redirection of significant numbers of talented weapon scientists to new careers that deserved consideration in assessing the situation in Iran.

The National Academies was involved in designing and implementing several of the aforementioned programs to redirect talents of weapon scientists in Russia and other states that emerged with the break-up of the former Soviet Union, beginning in 1991. The National Academies' activities, supported by the U.S. government, continued for more than a decade. Thus, it was not surprising that the department began informal consultations with the National Academies in 2016 concerning the feasibility of reorienting career paths for Iranian weapon scientists 30 years later, even though the National Academies had until that time assiduously avoided participating in such discussions with Iranians or proposing cooperative projects to U.S. officials involving nuclear-weapon expertise.[4]

Focal points of the informal discussions were the least sensitive approaches called for in the Annex that could be carried out quickly by non-governmental institutions as a first step in U.S. involvement in implementing Annex III. Then if confidence on both sides developed pursuant

[3] Informal discussion with Department of State officials, August 17, 2016.

[4] Relevant experience of the National Academies in addressing the issue of underemployed Russian weapon scientists provides much of the basis for the book Glenn E. Schweitzer, *Containing Russia's Nuclear Firebirds*, University of Georgia Press, 2013.

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to implementation of the annex and it became clearer to all that exchanges could advance science and not simply provide access to sensitive facilities, the governments could gradually take on more sensitive implementation responsibilities. Individual American Scientists have indicated to the National Academies their interest in participation in the provisions of Annex III, should the U.S. and Iranian governments decide to move forward with implementation of Annex III. Given the uncertainty concerning implementation of Annex III, the National Academies have not begun the process of analysis and consultations about the priority that should be given to these or any other provisions of Annex III (see Appendix H).

In one area linked to Annex III, since 2015 the National Academies have been interested in including desalination exchanges in their science-engagement program, with the focus on desalting technologies and not on the source of energy to drive the process (such as small nuclear power reactors). The first exchange activity has long been scheduled to take place in the United States "as soon as possible," but the next step depends on the policies of the two governments.

In December 2016, the Minister of Energy announced that the Iranian government planned to construct 50 desalination units straddling the southern coasts of the country, each with a capacity of 200,000 cubic meters of fresh water per day. In addition a desalination unit is to be built in conjunction with the construction of two new nuclear units at Bushehr, which will be the power source for the plant. The Bushehr project is to be carried out by Iran in cooperation in with Russian experts.[5]

Meanwhile, in 2016 the European Union (EU) set a fast pace in promoting cooperation in areas set forth in Annex III of the JCPOA and in other science and energy areas of mutual interest. Appendix I includes key provisions of two EU-Iran agreements to this end. As of June 2017, there was no indication that the Iranian or the U.S. governments were interested in U.S.-Iran bilateral agreements to carry out the provisions of Annex III or to support other science exchanges at the inter-governmental level.

[5] Available at https://financialtribune.com/articles/energy/56502/water-desalination-in-southern-iran-on-agenda.

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PRIORITY FOR COLLABORATIVE ENVIRONMENTAL PROGRAMS

Of all the difficulties being faced by the general population of Iran, none is more devastating than the continued decline in the quality of the environment in many areas of the country. The following challenges have been repeatedly set forth by leading scientists from Iran and from abroad.

> *Droughts, increased population, war, air pollution, climate change, industrial and agricultural production, sanctions, inefficient water and natural resource use, and lack of enforcement of existing environmental regulations have contributed to Iran's current environmental crisis. Insufficient water resources are forcing people to migrate, putting pressure on others. Aquifers are being drained. Air pollution has made living conditions in Iran's cities increasingly challenging. Wind erosion is furthering the desertification of agricultural lands, creating greater production demand on remaining arable areas. Biodiversity is under threat. On the other hand, Iran's environmental future can be positively influenced by the collaboration of the public, private, and nonprofit sectors. Awareness and education, along with greater financial and human resources, will be necessary to tackle the problem.*[6]

There are several reasons for putting environmental protection near the top of the list of areas for bilateral and multilateral cooperation in the future.

- The United States and Iran are members of a number of international environmental agreements—including agreements that address biodiversity, migration of birds, protection of wetlands, and protection of endangered species, for example. The stronger the compliance of some of the parties with obligations set forth in an international agreement, the greater the likelihood that others will follow suit with their actions.
- The United States has important political and economic interests in environmentally sensitive areas bordering Iran, including the borders with Iraq and Afghanistan and the coastal areas adjacent to the Caspian Sea and the Persian Gulf.

[6] Morad Tohbaz, "Environmental Challenges in Today's Iran," *Iranian Studies*, Volume 49, Number 6, November 2016, Routledge, UK, p. 943.

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- American scientists who have participated in environmental meetings with Iranian scientists sponsored by the National Academies have usually reported that they expanded their areas of professional expertise through participation in the discussions. There have been a number of useful science exchanges with few problems in holding bilateral or trilateral meetings on environmental issues, and with little reluctance by participants to discuss both successful and inadequate approaches in addressing important issues.
- As indicated in Appendix J, the Supreme Leader of Iran appears to be committed to protection and conservation of the environment, which should facilitate Iranian government endorsement of joint efforts in this field.

REGIONAL PROGRAMS

In a variety of fields, including the environmental field, exchanges that emphasize regional approaches should be of interest to the National Acadmies and other U.S. organizations for a number of reasons, including several environmental-based reasons set forth in the previous section. The United States has interests in improving living conditions in a number of Middle Eastern states, including several countries that cooperate with Iran in scientific endeavors. Important scientific benefits often result from addressing important issues in a geographically holistic manner. The National Academies has ongoing cooperative programs in several countries that are near neighbors of Iran. Finally, the National Academies participates in regional programs that involve Iranian scientists.

Four examples of challenges of cross-border interest are as follows:

1. Water Conservation: As discussed in Chapter 3, the National Academies has carried out several workshops concerning steps that might lead to reducing the rate of evaporation of Lake Urmia near the Azerbaijan border, a topic that is of scientific interest to American researchers in California and Utah who focus on saline lakes. Meanwhile to the east and south, two challenges have been of interest to the U.S. Army Corps of Engineers. As noted in Chapter 3, the diversion of water flowing down the Helmand River of Afghanistan into the Hamouns of Iran is significant not only because of its devastating impact on the dried-out area of Iran but also because of the water diversion that sustains the heroin poppy trade within and beyond Afghanistan. Second, the absence of recycling water flowing along the border

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between Iraq and Iran into the Persian Gulf results in avoidable losses of desperately needed water in both countries.

2. Dust Storms: The severity of dust storms in southern Iran defy exaggeration, and even Tehran and other major Iranian cities in the northern parts of the country are subjected to enormous amounts of dust pollution with origins in Iraq, Syria, and at times other neighboring countries. Various remedies such as spraying oil and other retardants on the desert floor or growing trees in desert areas to the west of Iran have frequently been suggested. The problem is sufficiently severe to warrant increased effort by the global community, even though feasible solutions have yet to be developed.

3. Arid Land Agriculture: With the closing of the facilities of the Center for Agricultural Research in the Dry Areas (ICARDA) in Aleppo, Syria, the absence of concerted attention among Middle East states to improve arid land agriculture stands out. Iran has long focused on drought management and over many decades has developed innovative irrigation techniques. Other water-deficient countries in the Middle East face similar problems, and the National Academies' history in addressing these problems throughout the world should be useful in providing leads to improved management and technological approaches.

4. Spread of Diseases: The World Health Organization, and particularly its office in Cairo, has long been interested in reducing cross-border transmission of diseases in the Middle East; and Iran has been an important leader in the region in addressing human diseases of regional concern, including health problems associated with migrants carrying diseases across borders. Iran has for many years focused on the spread of hepatitis. Among the neglected diseases of growing concern that are also being addressed by Iranian specialists are leishmaniasis, dengue, and Chagas disease. The case for "vaccine diplomacy" has often been made by western scientists.[7] Several Iranian universities would like to expand health oriented student exchanges with neighboring countries and to launch joint research programs in fields such as molecular epidemiology. A modest but focused effort, perhaps encouraged by the National Academies, to develop region-wide university courses with international inputs in a few selected medical fields could be attractive within the region.

[7] See for example, The Henry Kaiser Family Foundation, "U.S., Iran Should Consider Employing Vaccine Diplomacy," November 11, 2013.

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UNDERSTANDING THE SCIENCE, TECHNOLOGY, AND INNOVATION POLICIES OF IRAN

A number of American political scientists and economists for decades have given considerable attention to the internal organizational responsibilities and the associated national policies that guide the social and economic development of Iran. However, few American specialists follow the evolution of science, technology, and innovation policies and related organizational responsibilities in Iran for formulating and implementing approaches that impact on research and innovation activities. This topic was briefly mentioned in Chapter 2. Until 2013, there were few in-depth analyses by Iranian specialists in the field of science policy available in English for international audiences. However, many organizational and policy steps of considerable interest have been taken in Tehran to adjust and upgrade Iran's approaches to becoming a stronger and better known technology-oriented country, despite sanctions and economic slumps.[8]

In the early 2000's, the National Academies supported several brief exchange visits to Tehran devoted to science and technology policy. These efforts were limited. The American visitors to Iran were hampered due to an absence of English-language books and reports that documented the many steps that Iran had taken in this field. Also, most of the best informed Iranian analysts were working in institutions that were largely closed to outsiders—for example, the Planning and Management Office, the Budget Office, the Office of the Supreme Leader, the financial offices of the ministries, and high-level think tanks that operated behind closed doors.

The number of young Iranian researchers with interest in science and technology policy is increasing at several universities. Thus, both young and senior scientists with relevant interests should be more accessible as their publications begin to reach international audiences. A number of these analysts probably would welcome engagement with American colleagues who are steeped in the topic of science and technology policy as practiced not only in the United States and Europe but also in Asia (e.g., South Korea) and the Middle East (e.g., Turkey), which may offer models for emulation in Iran.

The reason for promoting exchanges in the realm of science and technology policy seems clear. The more that each side knows about the structure, openness, interests, and activities of the dozens of analytical groups in each

[8] For an overview of recent science and technology developments in Iran of particular interest to academics as well as government officials, see Abdol S. Soofi and Mehdi Goodarzi (editors), *The Development of Science and Technology in Iran*, Palgrave Macmillan, New York, N.Y., 2017.

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country that focus on science and technology policy, the more likely scientists with common interests will connect and in time begin preparing joint analyses. These connections should contribute to improved understanding of the approaches of the two countries when encouraging exchanges in various fields, ranging, for example, from nanotechnology, to personalized medicine, to computer modeling of societal interactions. Also, it may become easier for researchers to assess the long-term as well as the near-term economic impacts in Iran of sanctions, since sanctions often encompass limitations on acquisition of technologies that in time affect economic productivity when new technologies come into play.

HIGH VISIBILITY EVENTS IN IRAN

The National Academies encouraged individual visits to Tehran by five American Nobel Laureates during the early 2000's. Also, the National Academies helped launch a group-visit by seven university presidents to Iran. Each individual visit and the group visit were well organized, highly publicized, and enthusiastically received in Tehran. The visitors undoubtedly inspired interest among students beginning their scientific careers in Iran. However, the lasting impacts have been limited since the visitors had crammed schedules at home with little time or incentive to stay in touch or to encourage follow-on activities. This is not to suggest that visits by leaders of science are not helpful, but rather to emphasize that such visits should be organized in a way that helps stimulate long-term engagement. This approach generally means participation in such visits of energetic early career scientists who are eager to follow up with important contacts made by eminent American scientists.

In addition, consideration could be given to the following types of activities in Iran. They could be modeled after approaches in the United States while linking the events directly to practical needs of Iran. Of considerable importance, the ideas for these initiatives came from Iranian colleagues who considered that American specialists could play important roles in carrying out the activities.

Solar Decathlons: For a number of years, the U.S. Department of Energy has sponsored annual and biannual competitions among universities to demonstrate how solar energy can be incorporated into the design and structure of small houses in ways that maximize the generation of solar-based power, both to support activities within the houses and to provide excess

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electricity to local grids. Single projects have involved as many as 200 architectural and engineering students who develop innovative ways to conserve and generate electricity through clever designs and selection of materials.[9]

Innovation Boot Camps: A number of organizations in the United States regularly sponsor short-term training programs that focus on innovation. These programs develop skills for organizing, conducting, and replicating novel approaches to providing improved goods and services that find niches in the public or private marketplaces. Of special interest are approaches which enhance the quality, reduce the costs, and improve the commercial attractiveness of products and services.[10]

Shakeouts: The U.S. Geological Survey along with counterpart agencies in earthquake-prone states such as California organize shakeouts to rehearse responses to earthquakes that could affect the lives of large populations. The simulated events at times involve hundreds of organizations that detect, monitor, and respond to seismic eruptions. Overall, 21 million U.S. residents were involved in these earthquake simulations in 2016.[11]

NEXT STEPS

This report has chronicled achievements of the National Academies from 2010 to 2016, which in a number of cases have built on cooperative efforts during the previous 10 years. The scientific benefits of collaboration in the short run have seemed modest, but nevertheless tangible and important. According to well-informed American and Iranian government officials and advisers, the diplomatic significance of sustained collaboration has been quite significant. In short, this report should contribute to wider appreciation of the contributions and limitations of bilateral cooperation in strengthening the global science and technology ecosystems and of the opportunities for slowly but steadily transcending the U.S.-Iran political stalemate through science-engagement.

[9] See for a description of the 2017 Solar Decathlon in the United States, which has been replicated in other countries, see www.solardecathlon.gov.

[10] For an example of an innovation boot camp focused on the role of start-up firms see www.mckinsey.com.

[11] For an example of earthquake drills that involved 21 million people in United States during 2016, see www.Shakeout.org.

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Appendix A

Timeline for Selected Activities of the National Academies of Sciences, Engineering, and Medicine (1999-2016)

1999—Regional Workshop in Moscow on Ecology of Caspian Sea under auspices of Russian Academy of Sciences, with American and Iranian scientists participating.

1999—Exploratory National Academies staff visit to Iran.

2000—Officers of Iran Academies of Science and Medicine visit Washington under auspices of Federation of American Scientists.

2001—Presidents and officers of U.S. Academies of Sciences and Engineering and Institute of Medicine (now National Academy of Medicine), including Nobel Laureate Sherwood Rowland, travel to Iran and reach agreement with presidents of Iran Academies of Science and Medicine on topics and modes for engagement.

2001—Following 9/11, U.S. government officials stop work on developing a general Office of Foreign Assets Control (OFAC) license that would facilitate people-to-people exchanges with Iran.

2002—First four U.S.-Iran workshops held in Iran (2), Italy, and Tunisia.

2002—Beginning of long-term collaborative program on earthquake science and engineering.

2003—Bam earthquake; National Academies of Sciences, Engineering, and Medicine develop follow on program.

2003—First of five workshops held in Tourtour, France, over 12 years, with support of Fondation des Treilles.

2003—Beginning of cooperative pilot project on foodborne diseases that continued for four years.

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2004—Beginning of program of individual exchanges in both directions.
2005—Iran Academy of Sciences presents medal to President of National Academy of Engineering for support of bilateral program.
2006—Department of State initiates International Visitors Leadership Program (IVLP) for Iran, with participation of National Academies beginning in 2007.
2006—OFAC issues general license for publishing activities pursuant to request from Institute for Electrical and Electronic Engineers.
2006—Visit to National Academies by former president of Iran Khatami.
2007—OFAC confirms appropriateness of the National Academies' approach with regard to licenses.
2007—Nobel Laureate Joseph Taylor visits Tehran.
2007—The National Academies decides not to seek or accept government funds for engagement program due to linkages of funds with democracy-building activities.
2008—President of Institute of Medicine (now National Academy of Medicine) visits Tehran.
2008—National Academies staff member detained in Tehran for nine hours.
2008—Nobel Laureates Thomas Schelling and Burton Richter independently visit Tehran.
2009—Department of State suspends all people-to-people science programs following turmoil in Iran associated with election of President Mahmoud Ahmadinejad for a second term.
2009—Department of State encourages the National Academies to restart exchange program as pilot effort that was subsequently emulated by several other U.S. organizations.
2010—Report published by the National Academy Press on U.S.-Iran Cooperation 2000-2009.
2012—Nobel Laureate Peter Agre visits Iran.
2012—OFAC issues general license for cooperation that addresses either wildlife or environmental conservation.
2012—U.S. consulate in Dubai tightens controls on IVLP by requiring two visits by Iranian participants to Dubai to apply for and obtain U.S. visas.
2012—Meeting between National Academies staff and Iranian Foreign Minister in New York.

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2013—University of Tehran publishes Farsi translation of National Academies Press publication on program of the National Academies for cooperation with Iranian institutions.

2013—Meeting between National Academies staff and Iranian Foreign Minister in New York.

2014—The National Academies accept government funding for one exchange.

2014—In response to request from Foreign Minister of Iran, the National Academies initiate a project to assess impacts of increasing salinity on conditions in and around Lake Urmia.

2015—Joint Comprehensive Plan of Action, with civil nuclear science cooperation Annex, signed.

2015—Iran begins to organize historical seismic data for posting on Internet.

2015—Meeting between National Academies staff and Iranian Vice President for Science and Technology in New York.

2016—Department of State stops endorsement of visits by Americans to Iran due to concerns over arrests of Iranian-Americans in Iran.

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Appendix B

Workshop Proceedings and Other Documents about Meetings Sponsored by the National Academies (1999-2016)[1]

Proceedings and Reports Published by the National Academies Press

- The Experiences and Challenges of Science and Ethics, 2002
- Water Conservation, Reuse, and Recycling, 2002
- *Food Safety and Foodborne Disease Surveillance Systems, 2004*
- Science and Technology and the Future Development of Societies, 2006
- **Foodborne Disease and Public Health, 2007**
- *Science as a Gateway to Understanding, 2007*
- **U.S.-Iran Engagement in Science, Engineering, and Health (2000-2009), 2010*;*** *(Persian Language Version Published by University of Tehran Press, 2014)*

Proceedings Published by Iran Academy of Sciences

- *Higher Education, 2002*
- *Ecology of Caspian Sea, 2002*
- *Drought Forecasting and Management, 2005*

[1]The date indicates when event was held. The location of event is indicated by: **Bold** in United States; *Italics* in Iran; Roman in other countries.

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Proceedings Published by Other Partner Organizations

- Ecological Problems of the Caspian Sea, Russian Academy of Sciences, 1999
- Roots and Routes of Democracy and Extremism, University of Helsinki, 2006
- *Seismic Performance of Adobe and Masonry Structures, Sharif University of Technology, Tehran, 2008*
- **Improving Earthquake Mitigation through Innovations and Applications in Seismic Science, Engineering, Communication, and Response, Pacific Earthquake Engineering Research Center, University of California, Berkeley, 2009**
- Towards New Solutions in Managing Environmental Crisis, University of Helsinki, 2010
- *Earthquake Science and Engineering, Sharif University of Technology, 2010*
- Seismic Risk Management in Urban Areas, Pacific Earthquake Engineering Center, University of California, Berkeley, 2010
- **Water Management in Iran and the United States, Rosenberg International Forum on Water Policy, University of California, 2010**
- **Challenges in the Development of Solar Energy, University of California, Irvine, 2011**
- *Urban Earthquake Engineering, Pacific Earthquake Engineering Center, University of California, Berkeley, 2012*
- **Wildlife Conservation and Habitat Management, University of California, Irvine, 2012**
- **Air Pollution in Megacities, American Association for the Advancement of Science, 2013**
- **Challenges of Mathematical Education, University of California, Irvine, 2014**
- **Resilient Cities, University of Arizona, 2014**
- **Climate Change, University of Arizona, 2015**
- **Wetlands, University of Arizona, 2016**

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Compendia of Informal Papers Prepared by National Academies of Sciences, Engineering, and Medicine

- U.S.-Iranian Cooperation in Addressing Global Issues, 2003
- Science, Ethics, and Appropriate Uses of Technology, 2009
- **Global Perspectives on Transportation, 2011**
- U.S., Iran, and European Experience in Assessing and Managing Water Resources: An Emphasis on Lake Urmia, 2013
- Impacts of Climate Change, 2015

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Appendix C

Strategic Science and Technology Approaches of Iran (2015)

Goal: *S*econd Place in Science and Technology in the Region (following Turkey)

- A system for monitoring, evaluating, and ranking universities and research institutes.
- At least 50 percent of academic research oriented to socio-economic needs, including activities at university research centers with linkages to industry.
- Increased number of graduate programs in applied disciplines.
- Academic boards at universities that oversee academic programs.
- Applied laboratories at universities, science and technology parks, and incubators.
- Increased government investment in research to four percent of GDP.
- Increased foreign direct investment in technology development.
- Linkages with prestigious international educational and research institutions.
- Better science and technology indicators in government planning: revenues from exports of high-tech and medium-tech goods, patents granted, and knowledge-based companies.

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Priority: Technology Diffusion and Support of Knowledge-Based Companies

- Increased R&D budgets that support demand-driven research and development of private and of cooperative small and medium enterprises to commercialize knowledge in export products.
- Encouragement of private sector to set up business incubators and science and technology parks and encouragement of foreign partners to invest in R&D and finance patents.
- Government support of universities to establish knowledge-based private companies.
- Funding for individual innovators and science leaders to support commercialization of their inventions.
- Financing of patents at national and international levels and assistance with arrangement for commercial sales of new products.
- Ministry of Communications and Ministry of Information to develop infrastructure to ensure broadband internet that enables universities and research institutions to share information and data on research projects and intellectual property.
- National development fund to diversify economy while preserving part of oil and gas rents for future use increasing income on accumulated savings.
- New product-oriented campuses of public and private universities in special economic zones.
- New product-oriented campuses of public and private universities in special economic zones.
- Establishment of industrial clusters with closer ties between industry and science and technology parks in order to develop capacity for industrial design, innovation, and procurement.

Financial Support*:* Innovation and Prosperity Fund

- Eight billion rials in 2015.
- Initial applications from universities to set up knowledge-based companies in special economic zones (Tehran Esfahan, and Mashad).
- Support of small and medium enterprises through tax incentives, partial payment of commercialization costs, and payment of interest on bank loans for purchase of equipment.

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- Support of private companies through business incubators, cost-free premises, and tax incentives.

Source: Koomars Ashtarian, "Iran," *UNESCO Science Report*, 2015, p. 389.

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Appendix D

Key Science and Technology Policies of Iran (2010-2016)

2010: Office of Vice President for Science and Technology firmly established with (a) 16 affiliated technology councils and (b) Center for Technology Cooperation focused on international cooperation.
2010: Law on Support of Knowledge-Based Companies
2011: National Plan for Education and Science
2011: Establishment of Innovation and Prosperity Fund
2011: Statute of National Science Foundation
2011: National Plan for Cognitive Science and Technology
2011: Law on Improvement of Business Environment
2013: National Plan for Aerospace Industry
2013: National Plan for Medicinal Plants and Traditional Medicine
2014: National Plan for Resilient Economy
2014: National Plan for Stem Cell Science and Technology
2015: National Plan for Renewable Energy
2015: National Policies for Science and Technology
2015: National Plan for Science and Technology Diplomacy
2016: National Policy on International Technology Contracts (local content requirements)

Sources: Abdol S. Soofi and Mehdi Goodarzi (editors), *The Development of Science and Technology in Iran*, Palgrave Macmillan, New York, N.Y., 2017, p. 22; United Nations Conference on Trade and Development, *Science, Technology, and Innovation Policy Review, Iran*, Geneva, 2016.

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Appendix E

National Academies of Sciences, Engineering, and Medicine's Search of Scopus Data Base for Iranian Publications (2014)

In 2014, the National Academies of Sciences, Engineering, and Medicine designed a search of the Scopus data base to (a) ascertain the number of articles published in internationally endorsed ISI journals by Iranian authors in the natural sciences, engineering, and medicine during the period 2000 to 2012, and (b) identify the associated Iranian institutions. The many articles published by social scientists were not included in the survey. The results were as follows.

1. Total number of publications: 21,285 with Iran ranking 22 in the world in each year.
2. Leading fields of research (in order):
   - Medicine (12,550)
   - Agriculture and Biological Sciences (4,051)
   - Biochemistry, Genetics, and Molecular Biology (2,445)
   - Environmental Science (2,217)
   - Earth and Planetary Science (1,778)
3. Leading Iranian universities where authors were based (in order):
   - Tehran University of Medical Sciences
   - Daneshgahe Azad Eslami
   - University of Tehran
   - Shahid Beheshti Medical University
   - Shiraz University of Medical Sciences
   - Daneshygahe Tarbbiat Modares University

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- Isfahan University of Medical Sciences
- Shiraz University
- Shahid Beheshti University
- Iran University of Medical Sciences

Then the involvement of co-authors from both Iran and the United States in English language journals including but beyond ISI journals during 2000-2012 was investigated. The results were as follows.

1. Publications with Iranian authors and authors from other countries: 37,862
2. Publications with co-authors from Iran and United States: 7,898
3. Leading fields of research involving U.S. and Iran co-authors (in order)
   - Engineering
   - Medicine
   - Physics and Astronomy
   - Computer Science
   - Biochemistry, Genetics, and Molecular Biology
4. U.S. universities where co-authors were located (in order)
   - University of Wisconsin, Madison
   - University of California, Davis
   - Texas A&M University
   - Ohio State University
   - University of Illinois, Chicago
5. Iranian universities where co-authors were located (in order)
   - University of Tehran
   - Sharif University of Technology
   - Tehran University of Medical Sciences
   - Amirkabir University of Medical Technology
   - Daneshgahe Azad Eslami

With regard to the upsurge in co-authored papers, a survey carried out in 2011-2012 by others of 320 non-Iranian co-authors who published joint papers with Iranian colleagues provided useful insights as to the basis for such collaboration.[1]

[1] Mojtaba Shamsipur, "The Role of Chemistry and Biology in the Future Development of Iran," *Science and Technology and the Future of Development of Societies*, U.S. National Research Council, 2008.

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- Studying abroad was the most important factor that led to joint publications involving Iranian co-authors in all areas of science.
- Collaboration had usually been underway for at least five years prior to the joint publications. In this regard, student-supervisor relations following graduation often led to further research collaboration.
- The most important reason for co-authorship was the search for new ideas. Iranian students and scholars were very active, creative, and well-educated; and cooperation of western scientists with colleagues who lived in Iran improved the quality of the papers.

Negative comments concerning cooperation in preparing papers were also included, such as the following. "The level of Iranian education is not sufficiently high to be able to always aim for very good journals." "Iranians are weak in teamwork, and they need training in collaboration." "Iranian researchers just want to publish, but they should try harder to publish in high quality journals even though it may take a bit more time." "Iranians are not good enough in English." "Iranians cannot adjust to deadlines."

An earlier investigation by others focused on ISI publications during the period 1995-2005 revealed the following information concerning citations of Iranian papers in other publications. The fields considered were as follows: Chemistry (6,100 papers/24,176 citations), engineering (2,906/5,042), clinical medicine (1,986/7,565), physics 1,933/7,565), and plant and animal science (1,167/1,705). This study also revealed the principal co-authors were, in order, from the United States, Canada, England, Germany, and France. A related study in 2007 indicated that the citations per paper for Iranian papers were quite low by international standards.[2]

In summary, Iranian authors have made significant contributions to the international scientific literature. The importance of Iranian students studying abroad cannot be exaggerated when considering the potential for co-authorship in the future. Given the reduction of Iranian scientists (other than students) traveling to the United since 2010, it is likely that the rate of growth of joint publications has declined and may continue to decline in the near term.

[2] *Encyclopedia Iranica*, www.iranica.com/newsite/articles/v6f6/v6f6a086.html.

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Appendix F

Project Opportunities Identified During Workshop on Climate Change (2015)

Individual Views of Eight Participants from United States, Eight from Iran, and Four from France; Workshop in Tourtour, France, 2015

STRATEGIC APPROACHES OF IRAN

1. Encourage the Iranian government to support a broadly based climate assessment of current and future conditions in a selected region of the country, in cooperation with scientists who are familiar with similar efforts in other countries that in time spread to encompass the entire country.
2. Prepare articles on "New Directions" for the journals *Science* and *Nature* that summarize the outlook on selected climate change issues and suggest strategies for Iran.
3. Install water catchment tanks in mountains and valleys of wildlife parks and protected areas to catch winter/spring runoff, thereby saving costs of importing water for animals by tankers.
4. Work with the U.N. office in Tehran in establishing private sector entities for addressing specific environmental problems that are well suited for management and/or advisory services by nongovernmental institutions.
5. Establish a national association of climate change specialists and interested organizations as an important focal point for discussions

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with Iranian government individuals and organizations about the causes and impacts of climate change.

6. Before launching major climate change projects in Iran, give careful consideration to availability of essential meteorological parameters and information; and to this end, equip remote areas including national ecosystems such as forests with data collection equipment
7. Install in Iran monitoring stations that can be focal points for collection, compiling, and sharing of international and local data, including data to be used by graduate students in carrying out their assignments

INTERNATIONAL-ORIENTED ACTIVITIES

8. Encourage international organizations to become more active in supporting pilot projects in the Lake Urmia Basin that reduce agricultural water demands while transferring water to meet environmental needs.
9. Install adequate networks of air and water monitoring stations along the borders of Iran and in nearby geographic neighborhoods for acquisition of missing data.
10. Emphasize "regional" modelling of pollution in specific areas of Iran and its geographical neighbors.
11. Promote collaboration between U.S. and Iranian universities in promoting urban areas that can effectively cope with impacts of climate change.
12. Establish summer schools in technical fields, including observations and modeling, that involve post-doctoral and graduate students, both in Iran and abroad, in convenient locations such as areas near Ecole Polytechnique in Paris.
13. Provide seed-funding for American scientists to conduct 1-2 year research efforts at Iranian universities in cooperative efforts that can provide sustained contributions to international science for decades.
14. Ensure that sanctions do not inhibit efforts by American and French scientists to work with Iranian counterparts in carrying out research and in contributing to capacity building.
15. Encourage French-Iranian cooperation in building on international experience in the training of children on climate change.
16. Increase the number, frequency, and variety of international climate-change conferences in Iran.

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17. Encourage international efforts to consider whether and how countries in northern and other latitudes where water supplies are stable or increasing could develop innovative approaches to water-sharing with water-deficit countries, including possible diversion of water resources across international boundaries.
18. Encourage the Iranian government to reach out to other governments in efforts to improve science education in Iran, beginning with an international conference on climate-change education as an example of the importance of applications of science, with a near-term objective of establishing prototype courses in Iranian schools.

TECHNOLOGIES AND TECHNICAL APPROACHES OF SPECIAL INTEREST TO IRAN

19. Establish Iranian cooperation with international scientists in establishing joint centers to conduct research on renewable energy sources, such as biofuels.
20. Collaborate in improving desulfurization technologies.
21. Conduct pilot studies on selected techniques to restore and preserve wetlands.
22. Investigate selected aspects of solar energy beyond those of current interest.
23. Investigate controlled environmental agriculture (greenhouses and hydroponics) in arid regions.
24. Develop demonstration projects for recycling waste-water through infiltration basins.
25. Emphasize paleo-climatic studies that enable Iranian scientists to become familiar with modern instruments and methods, including those used abroad.
26. Undertake dendrochronological studies that are important for reconstruction of missing data of critical importance in understanding climate change.
27. Provide grants for Iranian students to prepare masters/doctoral theses on specific technical aspects of climate change.

Source: "*U.S.-Iran Symposium on Climate Change: Impacts of Mitigation, March 30 – April 1, 2015*," Prepared and Published by University of Arizona, 2016.

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Appendix G

Management of Land and Water Resources: Lessons Learned from Alborz Pilot Effort Supported by World Bank (2005-2013)

In 2005, the World Bank launched the project *Alborz Integrated Land and Water Management,* based on a loan of $120 million to the government of Iran. The purpose was to carry out a basin-wide pilot project in Mazandaran Province that demonstrated effective approaches to management of water and land resources. An important aspect of the project was to document lessons learned that could be applied in other areas of the country.

Objectives of the project were as follows.

- Sustain increasing agricultural productivity through improved irrigation and drainage systems, with particular attention to participatory management.
- Reduce soil erosion and sediment yields impacting on the Alborz dam, which was then under construction, through improved upper-watershed management.
- Protect the water environment downstream of the Babol River and other water bodies through improved hydrological/water quality monitoring of reservoir operations and through pest management.

The government had invested heavily in more than 100 dams, with complementary water distribution systems for both irrigation water and drinking water for urban areas. However, there were not adequate investments in these systems. Water management responsibilities had been decentralized with formation of separate water companies for various regions that

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were responsible for developing their own irrigation infrastructures. Not surprisingly, operation and maintenance services were very uneven. Overall, despite these and other investments, the country faced rapid depletion of aquifers, the water quality in many regions was deteriorating, and growing urban settlements were demanding more water as previously noted. At the same time farmers were changing to production of higher-value crops, with greater demands for water.

In carrying out the pilot project against this background, the World Bank adopted three principles: (1) Land and water in a river basin should be managed holistically to protect the entire environment. (2) Integrated water resource management requires participation of all stakeholders. (3) Water is a scarce resource and should be managed as an economic good with appropriate incentives that improve allocation and enhance quality.

These principles had seldom been fully followed in Iran's previous investments. For example, irrigation water pricing did not generate incentives for resource conservation. Water allocation did not meet any market tests. Pollution standards were largely ignored. Enforcement against unsustainable exploitation by loggers and herders was very weak.

Nevertheless, even with this background, the World Bank project succeeded in a number of ways. Most important, it generated the following lessons learned that were heard at the highest level of the Iranian government.

1. Integrated and effective water resource management can promote coordination between many stakeholders but requires experienced and motivated staff within key government ministries and other important participating institutions.
2. Land acquisition requirements must be identified in advance, and acquisition must be completed at the outset of the project.
3. Irrigation and drainage projects need detailed designs and up-to-date project cost estimates when the project begins.
4. A strong government agency should carry out monitoring and evaluation activities which are keys to success.
5. Financial and economic analyses deserve prominent places during all stages of the project.
6. Direct involvement of the potential beneficiaries of the project during the planning and implementation creates an important sense of ownership among farmers and other consumers of water.

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U.S.-Iran Engagement in Science, Engineering, and Health (2010-2016): A Resilient Program but an ...

The World Bank's summary assessment of this pilot project is as follows: "The economic rate of return has shown that the investment, despite all of the implementation problems, has been a good investment for the government and for the people."

Source: The World Bank, "Implementation Completion and Results Report (IBRD-47820), Alborz Integrated Land and Water Project," Management Report Number ICR 2589, April 25, 2013.

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Appendix H

Selected Provisions of Annex III of Joint Comprehensive Plan of Action: Civil Nuclear Cooperation (2015)

Individual American Scientists have indicated to the National Academies their interest in participation in the provisions of Annex III, should the U.S. and Iranian governments decide to move forward with implementation of Annex III. Given the uncertainty concerning implementation of Annex III, the National Academies have not begun the process of analysis and consultations about the priority that should be given to these or any other provisions of Annex III.

Component C: Research and Development Practices

1. Accelerator-based nuclear physics and nuclear atmospheric research; stable isotope production at the Fordow facility, recognizing that Russia has the lead in transitioning to stable isotope production.
2. Plasma physics and nuclear fusion.
3. Research reactor applications at the modernized Arak reactor, including (a) training, (b) radio-isotope production and utilization, (c) nuclear desalination, (d) neutron transmutation doping, (e) neutron activation analysis, (f) neutron capture therapy, and (g) neutron imaging and materials characterization using neutron beams
4. Exploration of cooperation in design, manufacture, and assembly of in-core measuring instrumentation and technologies; nuclear measurement and control systems; fusion technology and plasma

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physics and contributions to the International Thermonculear Experimental Reactor (ITER); neutrino astronomy; design manufacturing and supply of different types of accelerators and related equipment; and data acquisition and processing software and interface equipment.

Component D: Nuclear Safety, Safeguards, and Security

1. Training on best practices for safe reactor operations, emergency preparedness, severe accident management, and development of a nuclear safety culture.

Component G: Other Projects

1. Design of a nuclear desalination infrastructure.
2. Development of laser technologies for medical applications (e.g., eye surgery).

Other Aspects of Possible Interest

1. Cooperation through International Science and Technology Centers (Component A).
2. Cooperation between hospitals in use of imaging and radiotherapy equipment for treatment of individual patients (Component E).
3. Cooperation in occupational and patient radio-dosimetry procedures (Component E).

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Appendix I

European Union Agreements with Iran on Cooperation in Science and Technology (2016)

This Appendix sets forth a few of the science and technology topics for cooperation of interest to the EU and Iran. The Appendix identifies topics that may overlap with exchange activities that may be considered by U.S. nongovernmental organizations. Many additional nuclear topics included in Annex III of the Joint Comprehensive Plan of Action (JCPOA) have been identified by the EU as fertile ground for collaboration.

1. Cooperation in the Field of Nuclear Energy
   Several areas are included in the Euratom Call for Proposals in 2015-2016, namely, plasma physics and fusion, nuclear desalination, nuclear medicine, radiation protection—low doses; and waste management.

2. Cooperation in Other Aspects of Energy

- Information exchange on policies, strategies, and supply/demand forecasts.
- Discussion of conditions for investment in the Iranian energy sector, including legal and regulatory frameworks.
- Development of oil and gas export infrastructure to contribute to EU's energy security.
- Cooperation in multilateral settings related to Europe's contribution to energy security globally and regionally.

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- Consideration of Iran's oil and gas industry upstream, midstream, and downstream activities that increase efficiency in the electrical and renewable energy areas.
- Development of transparent and stable regulatory frameworks and institutional capacity for attracting investments in power generation, transmission, and distribution.
- Cooperation in renewable energy and energy efficiency.
- Improvement of data collection and standards in energy efficiency activities.
- Follow up to COP21 Paris Agreement on Climate Change.

3. Cooperation in Science, Technology, Research, and Innovation

- Participation of Iran in Horizon 2020, through expansion of bridge-building contacts, training for Horizon contact points, participation of Iranian experts in evaluations of responses to calls for proposals, and removal of barriers to mobility.
- A working group to create a platform for exchanges and cooperation.
- Enhanced cooperation in renewable energy, climate change, water desalination, food security, bioeconomics, and health. Specifically, Iranian stakeholders should be encouraged to join ongoing project platforms, research infrastructures, health alliances, energy for sustainable process industries, water knowledge and innovation projects, climate change investigations within the Global Earth Observation Initiative, the bioeconomy forum for agriculture, and nutrition and ocean resource programs.
- Science and technology diplomacy including cooperation in SESAME.
- Good innovation practices—policy, funding, and support to encourage expansion of start-up companies.
- Participation in EU Research Councils.
- Joint efforts in nuclear research.
- Iranian collaboration with the EU Joint Research Center. This could involve disaster management and urbanization. Additional areas could include agriculture and crop monitoring, food safety, water resources management, air quality, and green transport.

Source: Documents made available to the public by EU in April 2016: http://europa.eu/rapid/press-release_STATEMENT-16-1441_en.htm.

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Appendix J

Priority Environmental Interests of Supreme Leader and Opportunities for Cooperation (2015)

1. Preparation of ecological atlases of Iran as the basis for conservation, restoration, improvement, and development of resources such as lakes, rivers, dams, wetlands, underground water, forests, rangelands, biodiversity, and wildlife.
2. Conservation of genetic resources and improvement of these resources to attract international interest.
3. Management of environmental threats such as desertification, dust storms, droughts, and carriers of infectious agents.
4. Establishment of low-carbon industries, clean energy, healthy and organic agriculture, and effective waste management.
5. Development of green, non-fossil fuel as the basis for public transportation systems.
6. Balancing use of ground-water while preserving its availability and quality through watershed and aquifer management together with reduction of water usage, evaporation, and seepage of pollutants into aquifers.
7. Preparation of an environmental code of ethics and promotion of an environmental culture based on Iranian-Islamic values.
8. Establishment of regional organizations to combat dust storms and water pollution.

Source: Declaration by Supreme Leader on November 15, 2015. These eight points were selected from a longer list of points, based on their relevance to interests of the United States.

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