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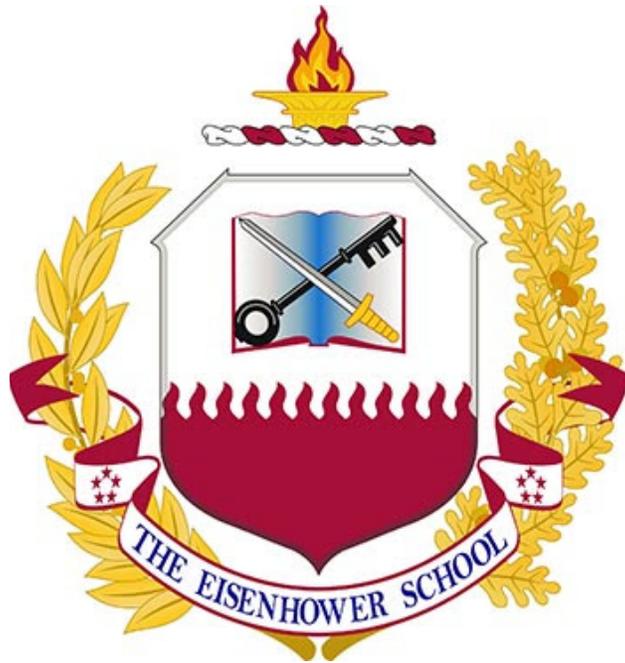
ENVIRONMENT 2017

Abstract: Environmental degradation and sustainability of basic resources presents a complex security challenge for the United States and the world. To address this challenge, the United Nations adopted an ambitious and aggressive set of Sustainable Development Goals designed to improve individual, community, and national resilience; strengthen economic and governance capacity; and address the most pressing environmental threats to health, livelihoods, and security. The United States must support this endeavor by engaging and enabling the Environment Industry, the pivotal player in developing technology, service, and process solutions to promote sustainable and efficient use of natural resources.

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Industry Study Outreach and Field Studies

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U.S. Agency for International Development, Global Health Bureau, Washington, D.C.
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U.S. Department of Defense, Office of the Secretary of Defense, Arlington, VA
U.S. Department of Energy, Sustainability Performance Office, Washington, D.C.
U.S. Department of State, Bureau of Oceans, Environment, and Science, Washington, D.C.
U.S. Environmental Protection Agency, Washington, D.C.
   - Office of Chemical Safety and Pollution Prevention
   - Office of Environmental Justice
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U.S. Mission to the United Nations, New York, NY

International Organizations and Non-Governmental Organizations
Environmental Council of the States, Washington, D.C.
Environmental Defense Fund, New York, NY
Global Environment Facility, Washington, D.C.
Greenpeace USA, Washington, D.C.
Keep America Beautiful, Washington, D.C.
Natural Resources Defense Council, Washington, D.C.
The Ocean Foundation, Washington, D.C.
Population Reference Bureau, Washington, D.C.
United Nations Environment Programme, Regional Office for North America, Washington, D.C.
United Nations Foundation, Washington, D.C.
Wildlife Conservation Society, Washington, D.C.
The World Bank, Washington, D.C.

Industry and Private Sector
CH2MHill, Washington, D.C.
Environmental Business International, San Diego, CA
Generate Capital, San Francisco, CA
Hogan Lovells US LLP, Washington, D.C.
Marstel Day LLC, Alexandria, VA
Pure Strategies, Inc., Reston, VA
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Field Studies – Domestic
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Hawaii Center for Advanced Transportation Technologies, Honolulu, HI
Hawaii Undersea Research Laboratory, Waimanalo, HI
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Humpback Whale National Marine Sanctuary, Honolulu, HI
Island Pacific Energy Company, Honolulu, HI
Kawailoa Wind Energy Site, Haleiwa, HI
Montgomery County Recycling, Derwood, MD
National Marine Fisheries Service, Honolulu, HI
Red Hill Fuel Storage Facility, Pearl Harbor, Honolulu, HI
U.S. Green Building Council, Washington, D.C.
Waianae Solar/Photovoltaic Site, Waianae, HI
Washington Aqueduct, Washington, D.C.

Field Studies – International
Canadian Embassy, Stockholm, Sweden
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SAAB Group World Headquarters, Stockholm, Sweden
The Stockholm Resilience Center, Stockholm, Sweden
Swedenergy, Stockholm, Sweden
Swedish Armed Forces Headquarters, Stockholm, Sweden
The Swedish Defense University, Stockholm, Sweden
Swedish Energy Agency, Stockholm, Sweden
Swedish Environmental Protection Agency, Stockholm, Sweden
The Swedish Institute of International Affairs, Stockholm, Sweden

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INTRODUCTION
"There is no Plan B because there is no Planet B."
- Former UN Secretary General Ban Ki-moon[1]

Poor health and well-being around the world can threaten U.S. national security by creating conditions of instability and conflict that require U.S. attention and action, or fomenting health risks that may directly impact the U.S. population. In September 2015, the United Nations (UN) adopted a set of ambitious goals titled the Sustainable Development Goals (SDGs) to "end poverty, protect the planet, and ensure prosperity for all." These goals are to be achieved by 2030[2] and call all countries to action to promote prosperity while protecting the planet. The UN embraces the concept that, "The environment plays a pivotal role in lifting people out of poverty, in ending hunger, in growing our economies, in building peaceful, just and inclusive societies, and in promoting the health of our people and this planet."[3] Thus, the majority of the SDGs focus on environmental stability, resilience, and recovery. Inclusive in the goals are strategies and resourcing plans for climate change, environmental protection and impact mitigation, resiliency, and capacity building. (See Appendix E for the complete list of SDGs.)

Achievement of the ambitious targets established by the SDGs depends upon forward-leaning and complimentary action by governments and non-state actors. Industry will play a pivotal role in developing the technology, innovation, and solutions that enable communities to make sustainable use of resources, reduce pollution, minimize and correct environmental degradation, and tackle climate change. Governments that commit to achieving the SDGs have a responsibility to establish coordinated action plans to prioritize resources, leverage available tools within and outside of government, and galvanize public support. The U.S. government must commit to global leadership in pursuit of the SDGs by finalizing a national action plan; reviewing and adjusting environmental laws as necessary; providing incentives to industry through research and development funding and tax schemes; providing development assistance to build global capacity; and actively engaging the American public.

Methodology

The Environment Industry Study undertook a broad examination of the industry over the course of four months. The group's review consisted of briefings from more than 70 experts from federal and state governments, international and non-governmental organizations, and industry executives. The group also conducted site visits in the Washington, D.C. area, Hawaii, and Sweden. The consultations and visits provided the group with a broad understanding of the national and global environmental movement, the role of the environment in human security and geopolitical stability, current environmental challenges facing the U.S. and the world, and the role of state and non-state actors in addressing these challenges. The site visits in Hawaii provided insight into the unique and complex resource sustainability challenges facing a state that is completely isolated. The site visits in Sweden enabled the group to understand the driving forces behind Sweden's success as a global leader in environmental sustainability.

Individual members of the group researched specific topics to gain a better understanding of the industry and its outlook. These topics included assessments of environmental security; the industry's definition and structure; international environmental law; the role of U.S. government and international organizations; environmental management systems; environmental technology; and the 17 SDGs. Their assessments formed the analysis and recommendations contained in this report.

THE ENVIRONMENT INDUSTRY DEFINED

The Environment Industry operates in a dynamic market that is constantly evolving. It intersects with public policy, the global economy, international law, and global population dynamics. These elements shape demand and the direction of the industry, resulting in an exceptionally broad grouping of goods and services that is nebulous and difficult to define. While there is no single definition of the Environment Industry, the Organization for Economic Co-operation and Development (OECD) broadly defines it as, "the grouping of all producers of environmental products; these consist of cleaner technologies and products, pollution management services and resource management."[4] A complementary definition comes from Environmental Business International (EBI): "All revenue generation associated with environmental protection, assessment, compliance with environmental regulations, pollution control, waste management, remediation of contaminated property, and the provision and delivery of environmental resources."[5] This study is a combination of both definitions.

The Environment Industry is a $900B global industry.[6] In the U.S., approximately 80,000 public entities and 30,000 private sector companies within the Environment Industry generated over $350 billion in annual revenue in 2016.[7] More than 1.7 million Americans work in the industry.[8] The industry divides into three broad categories: Environmental Equipment, Environmental Services, and Environmental Resources,[9] and subdivides further into 14 smaller segments of business activity. See a complete list of segments in Appendix A, Figures 1-2.

Environmental Equipment includes the tangible goods, products, and technologies utilized across the Environment Industry. There are five segments: Water Equipment and Chemicals, Instruments and Information Systems, Air Pollution Control Equipment, Waste Management Equipment, and Process and Prevention Technology. In total, 5,660 firms and entities operate in the Environmental Equipment category.[10] In 2015, this category realized nearly $58 billion in sales within the United States.

The **Environmental Services** category spans environmental management, consulting, and services. It is the largest of the three industry categories in terms of revenue, with $179 billion within the U.S. in 2015.[11] Over 43,000 entities operate in this category.[12] Clients include private companies, private property owners, and government at the local, state, and federal levels. The six segments are: Environmental Testing and Analytical Services, Wastewater Treatment Works, Solid Waste Management (includes garbage and recycling), Hazardous Waste Management, Remediation and Industrial Services, and Environmental Consulting and Engineering.

The third category of the Environment Industry is **Environmental Resources**, which generates over $121 billion in annual revenue[13] with over 66,000 firms.[14] The sectors are: Water Utilities; Resource Recovery (sales of materials recovered and converted from industrial by-products and post-consumer waste);[15] and Clean Energy Systems and Power, including hydro-electric, solar, wind, geothermal, and energy efficient technologies.[16]

CURRENT CONDITIONS AND CHALLENGES

Analyzing trends and market forces for the three Environment Industry categories provides insight into the health and current state of play for each. They do not possess perfectly aligned interests, nor are they similarly impacted by larger economic and regulatory forces.

Environmental Equipment. Environmental equipment is designed to provide environmental enhancements to various commodities, waste streams, or pollutants. This includes equipment for water, air, and waste treatments. The equipment is used to treat at either the point-source or end-of pipe location. Point-source refers to the upstream location where the waste or

commodity stream is generated, like a chemical factory. End-of-pipe refers to the discharge point where the commodity streams enter the environment, like a smokestack or pipe.

As the U.S. economy has steadily improved since the 2008 recession, the Environmental Equipment category has benefited from increased capital spending.[17] Over the past decade, manufactures and distributors of environmental equipment have captured steady and sufficient rates of return. Yet today's equipment suppliers face headwinds. Environmental regulatory drivers are not as strong today as they have been in the past.[18] Additionally, the market's allocation of end-of-pipe technology spending is in decline.[19] As these trends do not look to abate, environmental equipment manufacturers need to develop new technologies to drive sales. As EBI notes, "the more sophisticated the equipment, the higher the growth."[20] Buyers are looking to phase out older, labor-intensive systems in favor of source-specific equipment for recycling, recovery, or treatment.[21] This move toward newer technologies is highlighted in the water and wastewater sectors, where point-source treatment, desalination, recycling, and complete reuse water systems are in high demand.[22]

Environmental Services. Overall, growth in the Environmental Services category has slowed down over the last decade.[23] The market has incrementally transitioned from a sellers' market to a buyers' market.[24] The decremented growth in demand for environmental services intensified competition across each segment leading to pricing pressures and eroding profitability.[25] Predictably, firms turned their attention inward to focus on management issues in an effort to harness cost-control savings.[26]

As the Solid Waste Management segment is the highest revenue-producing stream within Environmental Services, any analysis of the category needs to include a review of the current factors in play for waste management. Two relevant developments have emerged which continue to impact the solid waste market. First, recent court decisions have favored more unrestricted interstate waste transfer.[27] The second issue is movement toward variable pricing dependent on weight or volume.[28] This will likely drive reduction of waste volumes, which concerns solid waste firms.[29] Potential reduction in waste volumes will benefit the larger businesses in the solid waste market. High barriers to entry, capital intensity, economies of scale, and national presence are all significant economic factors resident in the atmospherics of the solid waste business.[30] These forces serve to strengthen the positions of the larger incumbent firms, such as Waste Management and Republic Services. EBI forecasts a 2.5% annual growth rate in the near-term.[31]

Environmental Consulting and Engineering (C&E) is another segment within the broader category that deserves analysis. C&E includes services for reduction or clean-up of environmental hazards performed for clients on a contract basis.[32] The federal government is a significant driver to revenues in this market. The cleanup agendas at both the Departments of Defense and Energy are responsible for the major growth in this segment.[33] As a result, firms have realized increasing revenue streams from federal projects.[34] EBI does not see this trend abating in the short term.[35]

Environmental Resources. Of the three categories, Environmental Resources appears to be the best positioned for continued growth.[36] Several factors specific to the Water Utility segment buoy the overall category. First, the price of water is projected to increase between 3% and 6% per year.[37] Additionally, discharge fees are forecasted to increase into the foreseeable future.[38] The confluence of sellers commanding increasing prices at both ends of the water market (delivery and disposal) will influence more facilities to treat and reuse water on site.[39] These factors should underpin stable growth in the Environmental Resources category.[40]

An important trend to watch in the Resource Recovery segment is the so-called "Walmart effect."[41] Walmart has great influence over the supply chain of the products it sells; by leveraging its buying power, Walmart imposes standards across the supply chain to exert better stewardship

of electronic and organic waste as part of its goal to enhance overall sustainability practices.[42] Mr. Bob Kerr, the co-founder of Pure Strategies Inc., called Walmart the "commercial regulator" of the supply chain.[43] He stated that Walmart's chief buyers conveyed a direct message to their suppliers that if they wanted to do business with Walmart, they needed to embrace and promote a "greener" supply chain.[44] For example, Walmart refuses to sell computers whose default factory setting is not set to energy saver mode.[45] Private sector influence such as this will help compel environmentally-friendly business.[46] Sustainability-focused companies in the private sector will remain ahead of regulation as a driver for resource recovery.[47]

Setting the Scene: Environmental Security Landscape and the SDGs

According to the National Aeronautics and Space Administration (NASA), the main cause of global warming is human expansion of the "greenhouse effect" – warming that results when the atmosphere traps heat radiating from earth toward space. [48] Rising global temperatures are widely considered to be causal factors in environmental degradation, varying precipitation patterns, increases in sea level, loss of biodiversity, and ozone layer depletion. These environmental challenges threaten availability of resources, creating more frequent extreme weather events, and exacerbating hunger, poverty, and instability due to conflicts over resources. As early as 1994, the U.S. National Security Strategy recognized the security concerns posed by environmental degradation, asserting, "Not all security risks are military in nature….an emerging class of transnational environmental issues are increasingly affecting international stability and consequently will present new challenges to U.S. strategy."[49] The environmental challenges facing the globe today are complex, ranging from drought, which can have devastating implications for food security and livelihoods, to large-scale ecosystem damage from industrial pollution, deforestation, loss of biodiversity, ocean pollution, and climate change.[50] Stresses are compounded by the inability of governments to support investments in sustainable development.

In 2015, the UN adopted the 2030 Sustainable Development Agenda to transform the world into a safer and more sustainable planet. The centerpiece of the 2030 Agenda is the 17 SDGs, supported by 193 member states. The goals aim to end poverty and hunger, combat global inequalities, build peaceful and inclusive societies, protect and promote human rights and gender equality, and protect the planet and its natural resources.[51] While the SDGs are not legally-binding, each nation is expected to adopt a national agenda to ensure they progress toward achieving all 17 goals and accompanying targets. The SDGs are not just important to nation states, but for organizations in all commercial sectors as well. Organizations may adopt a program to work towards the SDGs for altruistic reasons or for their long-term competitiveness and access to new markets.

Achieving the SDGs: Environment Industry Challenges

The challenges the industry faces in supporting SDG implementation in developing country markets include weak infrastructure,[52] regulatory and policy complexities,[53] inability to finance projects[54], and political impediments.[55] A 2016 Global Opportunity Network report states that low perceived political will can drive businesses away from a country or region, especially considering that trust is necessary for citizens and businesses to operate in a market.[56] The following SDGs illustrate the challenges facing the industry: clean water and sanitation, renewable energy, and climate action.

Challenges: Clean Water and Sanitation (SDG 6). Clean Water and Sanitation (CWS) dominates the Environment Industry, primarily comprised of geographically defined monopolies.[57] Customers are rarely able to choose their water supplier, which greatly limits buyer power. Given the rapidly increasing number of market buyers for CWS, buyer power will continue

to weaken, driving higher global costs. Newer technological innovations that increase regional capacity or supranational government policies and oversight management are required to combat this challenge. Unless global buying power improves, increasing costs will have significant economic and security implications for struggling economies and emerging states that need new or improved CWS infrastructure. A 1999 UN study reported by the BBC predicted "access to water may be the single biggest cause of conflict and war in Africa in the next 25 years."[58] Appendix A, Figure 3: Water Conflict Spots in Africa highlights eight enduring conflicts and two potential flash points of conflict within Africa since this prediction.[59] Today, 783 million people do not have access to clean water.[60] Over the last century, the rate of water use is estimated to have more than doubled when compared to that of population growth.[61] As a result, "about 1 out of every 6 people living today do not have adequate access to water, and more than double that number lack basic sanitation, for which water is needed."[62] Most of these people are in poorer economies, which cannot afford expensive infrastructure or service rates. The demands for CWS infrastructure and services offer growth opportunities for industry. However, working in developing nations and finding government partners willing and able to afford the investments will be a challenge, as will establishing the appropriate pricing structures that enable poorer communities to pay for the services.

  Challenges: Affordable and Clean Energy (SDG 7). Markets for renewable energy appear strong, but this sector is not without challenges. In this highly-regulated sector, companies must pass time-consuming hurdles, such as permitting, safety and environmental assessments, and zoning. They must also have a large amount of available capital to overcome these obstacles. Private sector renewable energy firms must rely on government-owned utility companies to support their operations and profitability. With electricity storage still under development, renewable sources of energy may not be used to their full potential, as electric companies balance energy needs with alternative energy sources and fossil fuel availability. Without the support of U.S. businesses promoting clean energy, domestic and international renewable energy markets would likely fail. These failures would have deleterious effects on the economy, the environmental sector, the environment, and developing nations. Strong environmental coalitions such as *We Mean Business,* which partners with companies and investors (over 700 to date) to take action on climate change, would suffer without support from U.S. businesses.[63] Without support from companies such as Coca-Cola, Apple, and Microsoft, which have large carbon footprints and international reach, the outcomes the UN is seeking will be nearly unattainable.[64]

  Challenges: Climate Action (SDG 13). The market for climate action abounds with opportunity, but is wrought with challenges. This sector is highly provocative, colored by public debates on whether or not climate change is occurring, its causes and effects, and what, if any, action can and should be taken to reduce its impacts. The challenges for industry include developing technologies that reduce the production of greenhouse gasses, and reduce, eliminate, or substitute the introduction of harmful substances into the environment.[65] In order to reduce climate change impacts, businesses may have to balance profitability pursuits with energy efficiency efforts.[66] Businesses will also be challenged to reduce the carbon footprint of their products, services, and processes.[67] Industry leaders like Amazon and Walmart will significantly impact numerous players within their supply chains. Some industries will also be challenged by the introduction of emission targets that negatively impact production output or increase the expense of production.[68] These challenges will likely have to be met by increasing investment in renewable energy technology.[69] Ultimately, businesses must prepare for and adapt to climate change by building resiliency into their processes and procedures.[70]

OUTLOOK FOR THE ENVIRONMENT INDUSTRY

While the overall Environment Industry remains healthy, it faces a mixed future. The new U.S. presidential administration heralds change, and offers challenges and opportunities. Potential benefits to the industry include President Trump's pro-business policies and promise to increase spending on infrastructure.[71] Unshackling business regulation will likely spur American industry to invest more than in the past. Stimulating public investment in bridges, roads, and airports, coupled with private investment in domestic energy production and buildings, should serve as an economic catalyst for the Environment Industry's service segments.[72] However, there are potential negative developments. There may be a decrease in federal funding for programs that drive work for environmental firms – from climate science to remediation.[73] Additionally, the dismantling of regulatory programs such as the Clean Power Plan and Waters of the United States may erode future industry revenues.[74] Potential headwinds such as a significant stock market readjustment, isolationist policies, and flat-line economic growth could generate challenges for industry.[75]

One growing trend that will impact the trajectory of the industry is the march toward a circular economy. A circular economy is a system in which resources are reused and recycled, thereby reducing waste and pollution, all in a manner that is economically self-sustaining.[76] The shift toward a circular economy parlayed with ever-growing state recycled content laws could lead to increased public pressure for legislation to extend producer responsibility.[77] If this extended producer responsibility – specific to packaging and waste during a product's lifecycle – comes to fruition, it may lead to growing revenues.[78] U.S. companies now take a more positive approach toward environmental stewardship, largely due to forcing mechanisms such as government policies, environmental standards, advocacy groups, public pressure, and market drivers. They have fostered partnerships with the government, environmental organizations, and the public that contribute to valuable progress towards U.S. efforts to support the SDGs.

Organizations must also be cognizant of containing their own internal costs amid increasing external pressures to operate sustainably. It is possible for organizations to lower operating costs by reducing usage of natural and manmade resources while minimizing the impact the organization's operations have on the environment. An organization can adopt an Environmental Management System (EMS) to assist in managing environmental risk mitigation. The EMS may be as simple as internal data collection and monitoring or the more formal International Organization for Standardization 14001 standard. This standard follows a 'plan-do-check-act' construct for continuous improvement.[79] The standard assists organizations to develop a program to meet compliance requirements and achieve reductions in consumption and environmental impact. An effective EMS addresses risks from environmental impacts and shortages of resources in its operations. This may lead to innovative reduction or true conservation for the long-term viability of the organization. When the risks are identified and the organization's preservation is at stake, the SDGs will become more than a nation-state goal.

Good for Business: Industry Implications of the SDGs

Implementation of global SDGs has strategic implications not only for U.S. national security and the environment, but for the U.S. economy as well. Each of the 17 SDGs represents new and emerging market opportunities for businesses, particularly in developing countries. According to the "Better Business, Better World" report published by the Business and Sustainable Development Commission, achieving the SDGs opens up $12 trillion of market opportunities in four key sectors: food and agriculture, cities, energy and materials, health and well-being.[80] Together, these four markets represent 60% of the real economy.[81] U.S. companies are creating

business cases for sustainable development, recognizing new opportunities and big efficiency gains, innovation, and enhanced reputations. [82]

Strong engagement by businesses is consistent with the implementation plan for the SDG Agenda that promotes integration of the economy, environment, and society.[83] New and expanded opportunities for businesses are created with sustainable development; as highlighted by the United States Council for International Business, "the scale and ambition of the UN SDGs create a tremendous opportunity for the private sector to demonstrate the central role it plays in human prosperity. Business will serve as an essential partner to meet the challenge of achieving the SDGs."[84] In addition, the 2016 Development Co-operation Report published by the OECD states that businesses are a "powerful promoter of sustainable development" and investments in developing countries have proven to be smart business opportunities, despite the risks involved.[85]

The SDGs offer a pipeline of potential opportunities for the private sector to partner with public organizations to address sustainable development challenges. According to the 2016 OECD Development Co-operation Report, in the coming decade "billions will be invested annually by the public and private sectors."[86] The report further states that this significant investment to implement and support the global SDGs will provide local firms access to new international markets.[87] Other benefits for the private sector resulting from prospective SDG business opportunities include increased efficiency and profits due to transfers of technology, reduced risk, market and portfolio diversification, increased revenue, reduced costs, and improved profits.[88] Below are examples of the outlook for specific sectors supporting the SDGs.

Outlook: Clean Water (SDG 6) and Agriculture (SDG 2). The primary global customer for water utilities is the agriculture sector, comprising 63.7% of the global water utility market.[89] Agriculture share growth also correlates to the most promising *geographic* water utility market by growth: the European Union (EU). The EU comprises a majority 38.2% of the geographic market, and was valued at $290 billion in 2015.[90] Although farmers represent only 4.7% of the EU's trade population, agricultural-managed land covers almost half of the EU's overall land area.[91] In addition, the EU Common Agricultural Policy – which accounts for almost half of the EU budget – routinely encourages rapid modernization and intensification within the EU agricultural sector.[92] Leading EU companies like Suez Environment are joining forces with agricultural cooperatives like Terrena with a focus on solving the challenges of climate change and population growth, driving the need for clean water and sanitation. Efforts focused primarily on creating food crop industry innovative solutions also optimize the entire water-cycle, from consumption and treatment to sustainable reuse.[93]

Outlook: Affordable and Clean Energy (SDG 7). Local, state, and federal tax incentives and policy initiatives motivate the use of renewable energy. Although the 30% tax credit for companies to invest in renewable energy expired in 2016, there is still a 30% individual federal Energy Star tax credit through 2021 for purchases of individual solar and geothermal energy installation for existing homes and new construction.[94] An example of a state initiative driving toward renewable energy generation is the Hawaii Clean Energy Initiative that has a goal to have 100% clean energy by 2045. By creating tax incentives and partnering with stakeholders across the government and the private sectors, Hawaii is steadily moving toward this aspirational goal.[95] This type of domestic initiative not only counts toward achieving SDG 7, but also drives innovation. Numerous companies worldwide, such as Ocean Power Technologies and Aquamarine Power, are in the process of developing wave technology. If this technology is successful, it could serve as another source of renewable energy power generation.

Despite the challenges that exist, they are not so daunting that U.S. businesses will cease to compete for market share. Companies need to examine the risks, company values and mission set alignment, and profitability variables. In the heavy engineering construction market sector, which accounts for building large-scale renewable energy infrastructure such as hydroelectric and nuclear power facilities, there appear to be no defined major players. Instead, there are several companies that compete for market share, and although the market share concentration for this industry is low, even a low level of market share equates to significant profits.[96] AECOM, for example, holds less than 2% market share, but had more than $6.5 billion in profits in 2016. With 4% projected growth through 2022, this will generate more than 100,000 jobs, and projected profits of over $30 billion annually.[97] This serves as an indicator that U.S. businesses will continue to compete across renewable energy market sectors.

Outlook: Innovation and Infrastructure Improvement. Manufacturing jobs across the globe present employment opportunities and accounted for approximately half a billion opportunities for infrastructure building and improvement projects worldwide in 2013.[98] Small- and medium-sized enterprises engaging in industrial processing and manufacturing have been critical at the early stages of industrialization; they make up over 90% of the worldwide business and account for between 50% and 60% of employment.[99] Current estimates indicate that 2.3 million people are employed in the renewable energy sector. Demand estimates indicate that by 2030 there will be 20 million jobs available in the renewable energy sector, presenting great opportunity for developing states.[100]

Attention will be given to encourage innovation by increasing the number of research and development workers per one million people through both private research and development spending.[101] Another area that will be given attention is in domestic technology development, where developing countries will be stewarded in the creation of policies that foster industrial diversification and exploration of value-added commodities.[102] Ultimately, these measures should create the backbone to facilitate the building of resilience in infrastructure platforms that promote sustainable industrial development and foster innovation.

Overall, the Environment Industry looks well positioned to offer innovation through new technology, efficient processes, and integrated solutions that will support achievement of the SDGs.

GOVERNMENT ROLE AND POLICY RECOMMENDATIONS

Government policies and regulations can protect the health and well-being of the American public and provide for the security and prosperity of the nation. Linkages between government regulations and the environmental industry are essential for sustainability. In the first half of the 20th century, states regulated environmental law as they saw fit. In the 1950s, America experienced a surge of domestic environmental law that lasted four decades (see Appendix A, Fig. 4). Several events starting in the late 1950s and 60s led the federal government to supersede state policies, which were lax and problematic. Several consequential laws were enacted to protect water, air, soil, plants and wildlife; regulate pollutants; and remediate contaminated sites. The most significant law reorganized several federal agencies' environmental oversight and regulation duties into one organization, the Environmental Protection Agency (EPA).[103] The EPA generally has the power to set limits and monitor the performance of state agencies who are delegated the power to enforce and implement these statutes. (See Appendix D for a list of relevant government organizations.) The U.S. government can play a central role in championing the SDGs and spurring industry action. The success of the SDGs requires coherent and coordinated government

action and partnership with non-state actors including industry, NGOs, international organizations, academic institutions, and the public. The U.S. government should take the following steps to reinforce its leadership and commitment to achieving the SDGs.

       Create a Sustainable Development Goals National Action Plan. Based on an analysis presented in the *SDG Index and Dashboards – Global Report*, the U.S. ranks 25th among 149 developed countries and received a performance rating of red (not meeting the target) for 12 of the 17 SDGs.[104] The full report card for the U.S. is included in Appendix A, Fig. 6. The U.S. SDG report card raises questions about whether the U.S. has fully committed to domestic implementation of the 2030 Agenda.[105] The U.S. government must commit to achieving the SDGs by developing a cross-agency national action plan that includes: 1) national indicators, 2) reporting requirements and timelines, 3) a schedule of evaluations, 4) a communications strategy for engaging the public and key stakeholders, 5) a strategy for engaging non-state actors, including industry, and 6) commitments for assistance to developing nations to achieve their SDG targets. A U.S. national action plan will align federal agency efforts, improve accountability of domestic progress toward the SDGs, and guide prioritization of U.S. resources.

       Review and Adjust Approach to U.S. Environmental Laws. The U.S. is experiencing a phenomenon akin to the international community's *treaty congestion* by which there are too many laws pursuing similar ends in an asynchronous way. Domestic environmental laws display commonality at the federal level but differ substantially at the state and local levels because each state has a unique governing philosophy.[106] A review and simplification of U.S. environmental law will lead to a comprehensive list of pollutants, an agreed upon method for measurements, and limits for toxicity of harmful substances[107] that reach across domestic political boundaries.[108]

   Current U.S. environmental policy is largely based upon the *command and control* type of legislation enacted in the 1970s. These regulations mandate that polluters reach a certain goal or threshold to avoid a penalty, but offer no incentives for innovation to continue the reduction of negative environmental impacts. A shift to the *reflexive* type laws championed by the UN would be beneficial. This type of policy is intended to motivate dialogue about environmental impacts and responsibility within organizations by forcing disclosure of damages. The U.S. government could potentially levy this type of full disclosure reporting on states, that in turn, would have to apply to municipalities, spurring positive competition at the state and local levels.[109]

       Incentivize Private Sector Engagement. Market demand is driving solutions to some of the world's most challenging environmental issues. However, the OECD asserts that government has had a much larger role in determining the path of technology development than many admit.[110] The U.S. government must identify ways to align profit generation with social goals to draw private investment.[8] The private sector tends not to fund research for public goods – goods that benefit society at large regardless of the source of use or funding. Public environmental goods include products that reduce pollution, renewable energy infrastructure, and improved ways to conserve existing "green spaces". Where slim profit margins exist for industry, the government should consider establishing incentives to promote industry engagement in achieving the SDGs, specifically to advance research and development. Assistance may include direct government funding of new biotechnologies for cleaner production, partnerships with industry and universities to develop clean cars and improved renewable energy sources, and additional tax credits to promote environmental research in cutting-edge "green" technology.[111]

       The U.S. government must also create and enforce sustainability goals and standards. Determining what the standards should be, how much funding to provide to research and development, and which technologies to fund is not an easy task. There are two desired attributes

for impactful environmental regulations that result in meaningful reduction of GHG. They must be self-sustaining from a budget perspective, and must trigger minimal negative consequences to domestic business. A carbon tax can fulfill both of these ends. Sweden and Canada's Quebec and British Columbia Provinces have instituted a carbon tax and experienced positive economic growth while reducing GHG emissions. This tax is levied upon industrial processes and fossil fuels to generate revenues for environmental programs while providing an economic incentive for industries to innovate toward cleaner solutions. A carbon tax is the simplest instrument to implement GHG-reducing policies that provide the predictability necessary for business planners.

The U.S. government should also renew support for cap and trade mechanisms to reduce GHG emissions. The Clean Power Plan, currently under review by the Trump Administration, encourages states to consider such trading plans to reduce power plant emissions.[112] The scheme is based upon a discreet GHG limit established by the government that typically gets stricter each year. Carbon credits are then allocated to industry who must meet their limit or purchase carbon credits from those who do. This system provides government policy makers predictability in the amount of GHG emissions annually while empowering the market to determine the price of carbon emissions. Industry is incentivized to meet and even exceed their emissions goals so they can sell excess carbon emissions credits to those who have not yet innovated. The U.S. has previously used this mechanism to reduce acid rain-causing gases in the past.[113]

Maintain U.S. Leadership and Development Commitments. The Administration should provide development assistance that supports national security goals by addressing global economic, social, and environmental challenges. Key objectives of the SDGs include strengthening domestic resource mobilization and seeking additional funding for developing countries, implementing development assistance commitments, assisting developing countries to attain long-term debt sustainability, and adopting and implementing investment promotion strategies for the least developed countries.[114] The U.S. has multiple mechanisms at its disposal to advance the SDGs. Through the Partnership for Growth model, the U.S. engages host-country governments of developing nations, the private sector, and NGOs to find appropriate projects for development aid. The U.S. Agency for International Development utilizes its Development Credit Authority to provide loan guarantees, and typically prioritizes investments in innovation that multiply the effects of development aid. The U.S. Overseas Private Invest Corporation (OPIC) targets U.S. private capital toward economic and social development of select developing countries by providing loans, guarantees, and insurance. The U.S. provided roughly $10 billion from 2012 to 2014 in private funding to developing countries and their economies, and OPIC was the largest aggregator.[115] The Export-Import (Ex-Im) Bank facilitates economic growth for U.S. environmental businesses by providing competitive financing to international buyers seeking to purchase renewable energy equipment, energy efficiency technologies, wastewater treatment projects, air pollution technologies, and waste management service, and other various environmental goods and services from US businesses.[116] Through loans, guarantees, and insurance programs, the Ex-Im Bank provides services in high-potential emerging economies. [117] As developing countries implement strategies for achieving SDGs, these U.S. programs can provide critical support and incentives for businesses looking to take advantage of the opportunities.

Raise Public Awareness. The U.S. must engage the public on the purpose and value of the SDGs and of government financial support for private industry incentives and foreign aid. The government must generate public interest in support of this UN initiative, since interest inspires public action. Stronger public engagement may spur continued U.S. financial support to the UN,

private industry, and the developing world. Leaders must also raise awareness of the benefits of sustainable consumption and lifestyles, and provide consumers with information about standards and procurement and consumption practices.[118]

CONCLUSION

Environmental sustainability is a security challenge for the U.S. and the world. Destructive patterns resulting from economic, social, and environmental challenges often facilitate cycles of violence and migration that accelerate the breakdown of fragile states.[119] As noted in the U.S. Department of Defense 2014 Climate Change Adaptation Roadmap, "Rising global temperatures, changing precipitation patterns, climbing sea levels, and more extreme weather events will intensify the challenges of global instability, hunger, poverty, and conflict."[120] The global population is estimated to grow to nearly 10 billion people by 2050, which will put exceptional strains on basic resources and on governments' ability to provide for their citizens.[121] There will be increasing risks of food and water shortages, pandemic diseases, disputes over resources, and environmental destruction as nations seek to accelerate their development. To address these challenges, the UN adopted the SDGs, setting an ambitious target of 2030 to strengthen national resilience and economic prosperity, while protecting critical natural resources that are essential to human existence. If left unaddressed, environmental impacts from industrial and commercial development will compromise the sustainability of basic resources, livelihoods, and public health across the globe.

The SDGs present a unique opportunity for collaboration between government and industry to jointly address global security and stability concerns. The U.S. must support the achievement of the SDGs through the following steps: 1) develop and commit to a national action plan that engages non-state actors to create solutions; 2) review and adjust the approach to U.S. environmental law; 3) incentivize private sector engagement; 4) maintain U.S. leadership and development commitments; and 5) raise public awareness. The SDG national action plan should weave together these steps to ensure alignment and coordination of priorities, funding, and solutions across government agencies. The Environment Industry will be an indispensable player in achieving the SDGs. Government incentives and cooperation with industry will facilitate development of the technologies, services, and process solutions necessary to achieve sustainable and efficient use of natural resources. Industry players who pursue such innovations will benefit from expanded access to global markets and stronger competitive positioning.

With more than half of the SDGs having an environmental or natural resource focus – poverty, health, food and agriculture, water and sanitation, human settlements, energy, climate change, sustainable consumption and production, oceans and terrestrial ecosystems – the 2030 Agenda is strongly grounded in sustainable and equitable economies for the benefit of everyone, recognizing a clean environment as a public good and natural right.[122] As companies adopt more sustainable practices and the world progresses toward achieving the goals set forth in the SDGs, the results will be environmental improvement and strengthened economies. A comprehensive and collaborative U.S. approach to implementing the SDGs will not only improve the quality of life for U.S. citizens, but will help to reduce and address resource-driven conflicts across the globe.

ESSAYS ON MAJOR ISSUES

The following essays examine environmental laws and the outlook for environmental technologies. They delve into six of the most consequential SDGs and the role of the Environment Industry.

Environmental Law: Historical Foundation

Law historians often compartmentalize environmental law into three eras – traditional, modern, and postmodern – which are separated by key environmental conventions.[123] The traditional period encompasses international environmental law before the 1972 UN Stockholm Conference on the Human Environment. Internationally, the "good neighbourship" or "vicinage" laws governing regional matters like water rights, fisheries, and wildlife are thought to be the first treaties between different nations relating to the environment.[124] The rise of these ordinances commenced shortly after ideas about the *global commons* and *shared resources* became popular and the use of the judiciary to clarify the interests of parties claiming rights to resources. Bilateral agreements grew broader in scope with the growing awareness of humankind's impact on the environment, evolving into multilateral agreements, with approximately 36 international environmental agreements enacted before 1972.[125] This period incubated the formation of international organizations chartered to address environmental concerns, including the International Union for the Protection of Nature, International Maritime Consultative Organization, International Convention for the Prevention of Pollution of the Seas by Oil, the International Atomic Energy Agency; the Food and Agriculture Organization; and the World Health Organization.[126]

The period between 1972 and the 1992 U.N. Rio de Janeiro Conference on Environment and Development is considered the modern era for international environmental law.[127] Environmental treaties morphed beyond conflict resolution between nations to cooperation. These agreements sought consensus on a myriad of topics with global impacts, instead of focusing on single-issues relating to national sovereignty.[128] Empowering this transformation were multiple high profile environmental disasters that elevated the public consciousness, particularly the 1952 Cuyahoga River fire in Cleveland, OH;[129] the 1967 Torrey Canyon North Sea Oil Spill; the 1971 Minimata incident, in which a Japanese river was polluted with heavy metal;[130] and the Soviet Union's Chernobyl nuclear plant accident in 1986.[131] The UN's Environment Programme sponsored conventions and leveraged environmental interest into the creation of over 100 additional international treaties by 1989.[132] These conventions placed greater emphasis on management of hazardous waste and pollution prevention and less on resource conservation.[133] This change of focus implied a preference for environmental disaster avoidance over remediation and clean-up activities.[134] Additionally, treaties were increasingly being viewed as living documents, crafted with built-in reviews and periodic updates to address unforeseen conditions.[135] See Appendix A, Fig. 5 for trends in multilateral treaties and agreements.

The post-modern era (1992 until present) for international environmental law was ushered in during a period of unprecedented environmental awareness. Globally, actors of all levels and nationalities were cognizant of ozone layer depletion, climate change, and the loss of bio-diversity.[136] Accordingly, an impetus for collective accountability for the global environment[137] grew alongside an expectation of increased transparency from government and private institutions under the idea of "right to know."[138] The global environmental awakening and the activism it

spawned resulted in the wide-spread *"greening"* of national laws and a greater acceptance of international treaties intended to support the environment.

- Lt Col Sidney Harris, US Army

Environmental Technology: The Future is Looking Green

The term "environmental technology" takes several meanings. One definition is any technology that improves efficiency and is deemed environmentally friendly. This can include a wide range of products, from those items that generate energy to non-toxic cleaning products.[139,140] Other meanings of the term refer not only to tangible products, but include methods and services that help protect, mitigate damage, or aid the recovery of the environment.[141] A third definition to consider is provided by the U.S. Department of Commerce. They define environmental technologies as goods and services that: 1) foster environmental protection and physical resource efficiency; 2) generate compliance with environmental regulations; 3) prevent or mitigate pollution; 4) manage or reduce waste in streams; 5) remediate contaminated sites; 6) design, develop and operate environmental infrastructure; and 7) afford the provision and delivery of environmental resources.[142] Using these definitions, environmental technologies can be put into four broad categories: water, air, waste, and other.

Water technologies include an array of capabilities that help recover, reuse, and conserve water. One example in this segment are those technologies that allow sea water to be used to irrigate lands and be consumed by people. Other technologies in this category are those that advance mankind's ability to adapt to changing climates such as innovative farm irrigation methods. **Air technology** is a vast category that includes any product that aids in air pollution control. Most renewable energy sources would be placed in this category, the most familiar being wind and solar energy. However, there are others like advancements in batteries as well as harnessing energy from footsteps. Reducing pollutants, especially carbon dioxide, from the air also means technologies associated with emissions control are in this category. Some example are products that are used in coal-fired power plants or advanced "scrubbers on smoke stacks".

The third category is waste; more specifically, it is **waste management technology.** Technologies in this category include those that convert waste into energy. They are those that make recycling more efficient and effective. This is done not only with physical products but also with techniques, processes, and computer algorithms. Sustainable materials management is another segment of the waste category. An interesting example of this is "green burials," the process of using bio-degradable products to entomb a body after a person has died.

The final category of "**other green technologies**" is used because the growing market is increasing beyond air, water, and waste. This category includes technologies that cut across the other categories and can be used to assist products in any one of the categories. This includes monitoring, instrumentation, consulting and engineering. Making a hydroelectric facility more efficient may fit in the "water" category, but if a new technology can make a whole building "green" then it is placed in this "other" category.

Development of new technologies requires funding. Even the most altruistic company needs resources to produce a "green" product. For companies that want to enter or remain in the market of providing environmental technologies and solutions, the outlook is good. Trends in consumption, government policy, and costs indicate many green business opportunities in the future.[143] The International Trade Administration estimates the global market of environmental technologies was more than $1 trillion in 2015 (Appendix A, Fig. 7),[144] with U.S. companies

accounting for more than one-third of the market.[145] Forecasters estimate the environmental industry will continue to grow as much as 3-4% over the next several years.[146]

In a thriving, market-driven environmental industry, companies must invest in the development of technology to outperform their competition. But what technologies should companies pursue? Just like "non-green" businesses, environmental companies will not find a simple answer. Companies likely will continue to develop technologies associated with energy, nanotechnology, "green" chemicals, and pollution and waste control. Many experts believe continued development and innovation will occur in technologies such as photovoltaics and other solar gadgets; fuels cells, especially those related to electric cars and charging stations; "smart home" automation to make better use of energy; and connective sensors that make everything from trucking routes to plant turbines run more efficiently thus reducing carbon dioxide emissions.

Innovation in environmental technology is occurring at every level: water, air pollution, and waste management. Business leaders are keenly aware that becoming more efficient is good for the environment, and it is also good for the bottom line. However, environmental research and development will not occur at an optimal level without continued government intervention. Elected officials can debate what policies to enact and how much resourcing the government should provide, but they should not question whether they need to be involved.

- Lt Col Ken Kuebler, U.S. Air Force

Zero Hunger (SDG 2)

The goal of eradicating world hunger by 2030 will be achieved through improved and sustainable agricultural practices and productivity, as well as investments in infrastructure and technology. Presently, nearly 800 million people (one in nine) are chronically undernourished, most of which live in developing countries. Asia accounts for nearly two-thirds of that number, and sub-Saharan Africa represents the largest rate of undernourishment, 23%.[147]

Achieving food security – the availability of and reliable access to nutritious food – is a complex challenge with many components.[148] There are an estimated 500 million small farms worldwide, which provide the vast majority of food in the developing world. Most of these are solely rain fed and susceptible to drought. Environmental factors, including environmental degradation, loss of biodiversity, and drought, are cited as leading contributors to food insecurity.[149] The UN estimates that there has been a 75% crop diversity loss over the past 100 years, further reducing available food and nutrition in the world's poorest regions. [150]

SDG 2 - Select Targets for 2030
• **Doubling agricultural productivity and incomes** of small-scale farmers and food producers through more productive inputs and resources, financial services, and knowledge.
• **Increasing and proliferating resilient and sustainable agricultural practices** that lead to increased productivity and production, maintain ecosystems, are resistant to extreme weather, and improve soil quality.
• **Establish plant and seed banks, as well as livestock gene banks**, at the national, regional, and international levels to assist the least developed countries, sharing benefits from genetic resources and knowledge.

The crisis in Syria provides a recent cautionary tale, as severe drought forced many Syrian farmers into cities in search of jobs in 2006. The frustration of not being able to find jobs directly fed the revolution that was already brewing below the surface of Syrian society, which broke into open conflict and has resulted in the death or displacement of nearly half the country.[151] Tensions

in the region are further exacerbated by Turkey constructing dams, which have cut water flow to Syria by 40% and Iraq by 80%. In fact, the earliest known water war happened in the same locations, the Tigris and Euphrates rivers, after an irrigation canal was drained 4500 years ago.[152]

Food insecurity is a multi-faceted problem that has ample room for profit-driven solutions. Per the US Department of Agriculture, US commodity exports to sub-Saharan Africa increased 200% over the last ten years; additionally, US farmers now sell more commodities in North Asia than in North America.[153] This seems to indicate a positive trend and opportunity that US industry, businesses, and farmers are currently taking advantage. Further, low-technology solutions provide business opportunity as well. Roughly 20-30% of food ends up wasted, often before even moving to market. In India and Rwanda, simple technologies like small metal silos and plastic crates have reduced such losses by nearly 60%, with a resultant increase in the small farmers' revenues of greater than 30%.[154]

Private sector engagement that improves food security is predicated on developing countries attaining a level of self-sufficiency and stability to offer an attractive environment for investment. U.S. government development assistance and diplomatic advocacy may be necessary to foster an environment that incentivizes private sector investment. Agricultural development funding, specifically, has proven to be more than twice as effective as similar investments in other sectors in reducing poverty. As an example, Rwanda now has one of the highest GDP growth rates in the world, and conflict has not reemerged, attributable to international developmental aid.[155] Continued U.S. government support for international aid organizations, including the UN, World Bank, International Monetary Fund, as well as U.S. government agencies such as USAID, the Department of State, and the Peace Corps are all worthwhile investments.

- CDR Eric Little, US Navy

Clean Water and Sanitation (SDG 6)

The Clean Water and Sanitation (CWS) Sustainable Development Goal aims to "Ensure availability and sustainable management of water and sanitation for all."[156] The top three sub-targets are 1) to provide universal access to drinking water, 2) adequate access to hygiene through the availability of sanitation and the elimination of open defecation, and 3) the reduction of pollution through the elimination of dumping waste and hazardous materials and the reuse of natural resources.[157] A 2016 sustainability study published by the Multidisciplinary Digital Publishing Institute in Basel, Switzerland, noted, "Clean water and sanitation, when done with a resource recovery and reuse focus can contribute towards achieving at least fourteen of the SDGs, especially in an urban context."[158]

In 2002, four out of every ten people lived without improved sanitation.[159] By 2010, little progress had been made. According to The Pacific Institute, 2.5 billion people – almost 46% of the world population at the time – lived without improved sanitation and access to clean water in 2010. Studies by UNICEF and the UN estimate more than 600 million children will die by 2040[160] due to limited access to clean water and sanitation, and 2.5 billion people still do not have access to combined CWS services and infrastructure.[161] This data suggests significant gaps in capacity will subsist between existing volume requirements and market growth when addressing future population CWS demands.

CWS infrastructure development must play a major role in every nation's plan for development. A 2005 CWS-focused report sponsored by the U.N. Commission on Sustainable Development discussed the importance of CWS as a critical enabler of national economic growth, particularly for developing states.[162] The report notes emerging state economies like Nigeria's

seeking to gain global acceptance and improved domestic quality of life standards require larger scale CWS investments in order to create jobs. A 2013 UNICEF study on Nigeria's CWS infrastructure reported "70 million Nigerians lacked access to safe drinking water, and over 110 million lacked access to improved sanitation…while 124,000 children under the age of five die annually because of dysentery, primarily due to unsafe water, sanitation and hygiene."[163] The issue of CWS infrastructure development has forced combined multilateral strategic efforts in Africa to attain resilient security solutions across state borders and consolidate national resources. In 2016, the 10th General Assembly of the African Ministers' Council on Water, comprising 30 African water ministers and high-level delegations from 53 African nations, met to develop a strategic roadmap enabling water security and sanitation efforts.[164] The effort focuses on "achieving sustainable services and creating a conducive investment climate, as well as integrating the agenda for water, sanitation and climate to improve health and nutrition outcomes by 2030."[165] It is through these efforts that emerging states in Africa and other regions will overcome the national security threats and implications associated with CWS.

The global market for clean water and sanitation nests within the Environment Industry as the Global Water Utilities market.[166] This market consists of all water collected, treated, and distributed to agricultural, industrial, and residential end-users. Market value has grown steadily over the previous five years, with a Compound Annual Growth Rate (CAGR) of 4.2% from 2012-2016 and $761 billion in revenue in 2015.[167] Future value growth in this market is estimated to remain steady, with $934 billion in revenue projected by the end of 2020.[168] Market growth by volume is less impressive given the aggressive SDG sub-target goals and 2030 timeline. Volume growth is averaging 1% over the previous five years, which correlates to almost 3.1 billion cubic meters annually.[169] The same low CAGR by volume is also predicted through 2020.

While emerging countries focus on sustainable urban water infrastructure development, countries like the U.S. are facing extreme challenges with existing recapitalization costs. Many of the U.S. pipes that were laid in the mid-20th century carry only a 75-to-100-year lifespan.[170] Areas like Flint, Michigan are a sobering reminder that even advanced societies like the U.S. can mismanage precious water infrastructure. When crises like Flint occur, public outcry reaches the highest levels of government, and costs are significant. The U.S. faces large challenges in modernizing its domestic water infrastructure, which fails on average 240,000 times per year at a significant loss of two trillion gallons of potable water. The American Water Works Association estimates costs to prevent these breaks, minus new infrastructure development, is a staggering $1 trillion over the next 25 years.[171]

The necessary domestic and international investments in clean water and sanitation infrastructure and services to reach SDG targets pose daunting challenges, especially for struggling economies and for donor nations, like the U.S., facing constrained budgets. Potential solutions center around green infrastructure technologies and renewable sources like rainfall capture, which improves efficiency while limiting damage to current water systems.[172]

- Lt Col Anthony Mullinax, US Air Force

Affordable and Clean Energy (SDG 7)

The UN established an ambitious Sustainable Development Goal to "Ensure access to affordable, reliable, sustainable and modern energy for all."[173] The UN estimates that over 1.1 billion people in the world are living without electricity, predominantly in Asia and Africa.[174] The lack of access to electricity has both human and economic tolls that prevent developing countries and their people from reaching their full potential. For many impoverished people and

communities, having electricity will improve public health, increase local business viability, and may take some out of extreme poverty, or at the very least ease the burdens they face on a daily basis without it. Although there has been demonstrated success in many target areas of the overarching goal, there is still a long way to go to achieve the desired outcomes.

The UN also set a target for energy access to be via clean and renewable sources, such as solar, wind, hydroelectric, biofuels, and geothermal. This target is measured by the mix of energy sources used to satisfy global consumption. In addition to gaining access to electricity, the UN further stresses the need to transition billions of people from indoor air polluting energy sources to clean energy that does not have detrimental health effects. The UN currently estimates that indoor air pollution is responsible for over four million deaths annually.[175]

Access to sustainable energy has clear implications for U. S. national security interests. Extreme poverty and a lack of energy resources does not afford people and communities the resiliency required to overcome natural or manmade crises. Lack of resiliency can lead to civil discord and mass population movements that can have deleterious consequences to national stability,

> ### SDG 7 - Progress on Selected Targets
>
> - **Increase access to energy**: improved from 79% to 85% of the global population <u>with</u> access in 2012.
> - **Increase renewable energy consumption**: a 4% annual increase shown between 2010-2012 through increase use of solar, wind, and hydropower sources. The U.S. reported renewable energy consumption at a 2016 projected 9.7%, demonstrating a slow but steady increase from 9.1% reported in 2011.
> - **Decrease energy intensity**: there has been a 1.7% decrease from 2010-2012, with industry being the largest contributor to this reduction.
> - **Increase access to clean indoor energy sources**: rose from 51% to 58% between 2000 and 2014. However, the UN notes that this increase, when world population increases are accounted for that are using polluting heating and cooking sources, the actual absolute numbers of those using indoor polluting source has increased to over three billion.

particularly in already fragile developing nations and regions. This potential instability impacts U.S. diplomatic and military objectives, as well as those of its allies and regional partners.

U.S. companies are major players in the renewable energy market, and have an opportunity to take advantage of the increased focus that the SDGs place on renewable energy. Currently, U.S. companies seek market share across the renewable energy business sectors, driven by opportunities for large profits. In the solar power and hydroelectric power sectors, U.S. industry profits for 2016 are approximately $3.2 billion and $3.7 billion respectively.[176] Competition for products and projects focused on renewable energy appears to be strong with a diverse mix of companies competing for business. With increasing public demand for cleaner sources of energy, as well as U.S. and foreign government programs and policies that target improved energy efficiency, the overall demand for projects and money spent within the renewable energy sector is also expected to increase.   Additionally, increased consumption of electricity worldwide also increases opportunities for companies.[177]

Although progress is being made on achieving the targets established by SDG 7, it is imperative that the U.S. serves as a leader in pursuing renewable energy solutions. To do so, the U.S. must continue building partnerships both domestically and internationally between government, businesses, environmental organizations, scientists, and academia. U.S. local, state, and federal governments must promote and incentivize renewable energy policies and initiatives

that drive environmentally responsible public and industry behaviors. One of the most effective ways to do so is through renewing the 30% federal corporate tax credit for renewable energy, and continuing tax credits to individuals who install renewable energy sources in their homes. These programs serve to increase renewable energy sources while reducing carbon reliance and output.

There is one final commitment the U.S. has made that has the most far reaching implications toward achieving Goal 7. The U.S. made a collective $100 billion a year commitment, as a signatory to The Paris Agreement, to tackle the threat of climate change.[178] The annual donation, which begins in 2020, will be derived through a combined UN effort by the signatory nations, and supported by public and private donors. This money is in addition to normal annual commitments given on behalf of the U.S., and if it is honored by the current Administration, the funds would be specifically used to "enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology, which is a target of Goal 7." [179]

- Eileen Granfield, Defense Logistics Agency

Responsible Consumption and Production (SDG 12)

Responsible consumption and production promotes resource and energy efficiency, sustainable infrastructure, access to basic services, green jobs, and a better quality of life for all.[180] Sustainable consumption increases the net welfare gains from economic activities by reducing resource use, degradation, and pollution throughout a product's lifecycle.[181] Stakeholders involved in creating an environment rich in responsible consumption and production include businesses, consumers, policy makers, researchers, scientists, media, and development cooperation agencies.[182] Stakeholders solicit cooperation from actors operating within the supply chain ranging from producer to final consumer.[183] These efforts require leaders to engage consumers through awareness-raising on the benefits of sustainable consumption, lifestyles, and providing consumers with adequate information through standards, labels, and information on procurement and consumption.[184]

The global population continues to grow, creating new challenges and demands on critical resources. If the world population reaches 9.6 billion people by 2050, the equivalent of almost three planets of current production of water, energy, and food will be needed to sustain current lifestyles.[185] However, current consumption does not maximize efficient resource use. Each year, approximately one-third of all food produced (equivalent to 1.3 billion tons, worth approximately $1trillion) was wasted and ends up rotting in bins of both consumers and retailers or spoiling due to poor transportation and harvesting.[186] Additionally, switching to energy efficient light bulbs worldwide would save consumers and businesses approximately $120 billion annually.[187] The most critical resources for targeting consumption improvements are water, energy, and food.

Water: Less than 3% of the world's water is drinkable and 2.5% is frozen in Antarctica, the Arctic, and glaciers. This means that humanity relies upon a fraction of Earth's available water for all of man's ecosystems and fresh water needs.[188] The impact of water scarcity is amplified because water pollution occurs faster than nature can recycle and purify its rivers and lakes.[189] While water is free from nature, the infrastructure required to move it is expensive. This contributes to water scarcity in some portions of the world (more than one billion people do not have access to fresh water) and excessive consumption in other parts.[190]

Energy: Energy use in developing countries will grow by 35% by 2020, even as technology advances and energy efficiency continues to be promoted.[191] Commercial and

residential energy use is the second most rapidly growing area of global energy consumption after transport.[192] Vehicle ownership is expected to increase by 32% by 2020 and the distance traveled by motor vehicles is expected to increase by 40%.[193] Global air travel is also expected to triple by 2020. Additionally, households consume 29% of global energy and contribute 21% of CO2 emissions.[194]

Food: Over one billion tons of food is wasted every year, while approximately one billion people are undernourished.[195] Conversely, two billion people globally are overweight or obese and overconsumption of food is detrimental to the environment.[196] The food sector accounts for approximately 30% of the world's total energy consumption and produces approximately 22% of total greenhouse gas emissions.[197] The environmental impacts from food occur in the production phase, consumption phase, and in waste generation.[198]

By 2020, the UN hopes to implement sound environmental management of chemicals and wastes throughout their life cycle, congruent with international frameworks to reduce the release of harmful toxins into the air, water, and soil.[199] The management of a system this complex is wrought with numerable challenges including differences in international laws, reporting requirements, and varying degrees of enforcement capacity. Enforcing adherence may actually sub-optimize production efforts by replacing a less expensive, yet environmentally irresponsible ingredient, with a more expensive, environmentally responsible ingredient. Compliance will require updates to local, national and international laws to encourage companies to adopt sustainable practices and to integrate sustainability information into their reporting cycle.[200]

By 2030, the UN expects to achieve the sustainable management of efficient use of natural resources.[201] The UN also seeks to halve the per capita global food waste at both retail and consumer levels and to reduce food losses along production and supply chains.[202] These efforts will be enabled by the introduction of tools that will monitor sustainable development impacts that creates jobs and promotes local culture and products. Industry opportunities like introducing small metal silos or plastic crates into the supply chains can make significant impacts.[203] These innovations can mitigate post-harvest losses by 60% in places like India and Rwanda and increase smallholder farmers' incomes in excess of 30%.[204] Local breakthroughs like these should be introduced incrementally and within each country's or region's capacity to adopt and implement new procedures, techniques, or technology. The UN will support developing countries' endeavors to strengthen scientific and technological capacity to move toward more sustainable patterns of consumption and production.[205] These efforts will be fueled by technology platforms that aid in the promotion of public procurement practices that are sustainable and enable policy makers to communicate information that generates sustainable development awareness and the ability to measure one's lifestyle against its impact on nature and the environment.[206]

- LtCol Sidney Welch, US Marine Corps

Climate Action (SDG 13)

Climate change impacts every country and every continent. Its impacts disrupt national economies, and affect lives at the individual, community, and State level.[207] The impacts of climate change include changing weather patterns, rising sea levels, and more extreme weather events.[208] Greenhouse gas (GHG) emissions drive climate change; they are now at their highest levels in history and continue to rise.[209] Without intervention, the world's average temperature is expected to surpass 3 degrees Celsius this century, and some parts of the world are expected to get even hotter.[210]

Climate change challenges happen irrespective of national borders. Emissions anywhere have impacts everywhere.[211] Climate change issues require solutions that must be coordinated at the international level and require cooperation of strong partners to help developing countries move towards and build low-carbon economies.[212] Affordable and scalable solutions that are available now and are in development should enable developing countries to propel themselves into cleaner, sustainable, and environmentally friendly and resilient economies.[213] Stakeholders will have to make strides towards adaptation or mitigation solutions such as: unlocking new land or better using space during development, reducing the waste of building material during construction (usually 10-15%), and working towards pollution reduction efforts, particularly within cities (which account for 70% of global energy use and energy-related GHG emissions).[214] This efforts will create business opportunities across multiple domains including law, construction, health care, transportation, and multiple technology areas.

Actions taken at the international level to address climate change include the adoption of the Paris Agreement, wherein on December 12, 2015, all 195 signatories agreed to work to limit global temperature rise to less than 2 degrees Celsius (pre-industrial levels) and to strive for 1.5 degrees Celsius.[215] The UN sees implementation of the Paris Agreement as essential for the achievement of all SDGs, as it provides a roadmap for climate action to reduce emissions and build climate resilience.[216] International efforts to work towards reducing rising temperatures can be enhanced as people worldwide look towards renewable energy and a range of targeted measures to reduce emissions and increase climate change adaptation efforts.[217]

The UN purports that the UN Framework Convention on Climate Change (UNFCCC) is the primary vehicle for negotiating international, intergovernmental, and global response to climate change.[218] Through this framework, the UN hopes to create and promote mechanisms that increase capacity to implement effective climate change-related planning and management in less developed countries.[219] Planning and other ancillary activities should build resilience and the capacity to adapt to climate-related hazards and natural disasters in all countries.[220]

As capacity increases, mitigation measures ought to be integrated into national policies, strategies, and follow-on planning.[221] Through exposure to planning and awareness-raising efforts, institutional capacity should grow, and both evolutionary and revolutionary development of adaptation, impact reduction, mitigation, and early warning strategies should ensue. The UN has committed, through the UNFCCC, to a goal of mobilizing $100 billion annually by 2020 to address the needs of developing countries and to fully operationalize the Green Climate Fund, which is a UN mechanism to provide assistance to developing countries to enhance adaptation and mitigation practices to counter climate change.[222] Rapid capitalization of this fund is a critical first step to support achievement of the SDG.

- LtCol Sidney Welch, US Marine Corps

Life Below Water (SDG 14)

Oceans are a necessity for life on earth. They provide security, sanitation, food, transportation, and serve as a filter for the earth's atmosphere. According to the Ocean Foundation, 1 in 7 people depend on water for their source of protein (fish). More than half of the earth's population lives within 50 miles of the coast.[223] Water helps the earth regulate temperatures, and provides oxygen while absorbing excess carbon dioxide.

There are several reasons why "conserve and sustainably use the oceans, seas, and marine resources,"[224] is a critical component of the UN's agenda. The oceans have a direct link to national security. For small island developing states who depend on the ocean for their main source of

food, it represents stability and peace. Fisheries contribute to global food security and the economy. "Ultimately, overfishing impairs the functioning of ecosystems and reduces biodiversity, with negative repercussions for sustainable social and economic development."[225] Nations must be able to protect their fisheries to ensure a sustainable food source. When food becomes scarce, populations become unruly, creating a dangerous environment.

The oceans are also impacted by industrialization. A by-product of industrialization and development is an increase in humanity's carbon footprint. The earth's water acts as a sponge by absorbing excess carbon, helping keep the atmosphere livable; however, the amount of carbon dioxide that is absorbed by the oceans is creating a toxic environment within the waters. The ocean absorbs "about one third of the carbon dioxide released by human activities, thereby mitigating the full impact of climate change. But this comes at a steep ecological price, as dissolved carbon dioxide in seawater lowers the pH level of oceans, thereby increasing acidity and changing the biogeochemical carbonate balance."[226] If nations cannot safely regulate the control of excess carbon, it is possible the oceans will become over-polluted, killing off marine life and eliminating a major global food source. This would have dire implications for national security as more nations would experience critical food shortages. Fertilization run-off, coastal flooding, and storm surges sweep contaminants into the water, as well as off-shore dumping and oil or chemical spills that also create toxic hazards to the ocean ecosystems.

There are multiple industries geared toward facilitating the achievement of SDG 14. Some include irrigation technology, hydroponics/aquaponics agriculture, and fish hatcheries. Through the use of irrigation technology, water can be better regulated, preventing wasteful use. Irrigation technology can bring water to areas that previously did not have access, which enables the growth of agriculture in challenging places, helping to solidify food sources. Through hydroponic/aquaponic technology, agriculture is grown vertically, in soil-free environments. Not only does this facilitate a dependable food source, it prevents over-fertilization and run-off into waterways. Less pollutants in the water help keep the aquatic ecosystems in balance. The use of fish hatcheries helps to decrease over-fishing in waterways, especially for nations that rely on fish as their main source of protein. Having the ability to maintain fish hatcheries protects the fragile balance of fish populations and provides a constant and reliable food source.

- Lt Col Erica Rabe, US Air Force

APPENDIX

APPENDIX A: REFERENCED CHARTS, GRAPHS, AND ILLUSTRATIONS

Figure 1: Environmental Industry Segments

Segment	Description	Examples of Clients
Environmental Services		
Environmental Testing & Analytical Services	Provide testing of "environmental samples" (soil, water, air and some biological tissues)	Regulated industries, Gov't, Environmental consultants Hazardous waste and remediation contractors
Wastewater Treatment Works	Collection and treatment of residential, commercial and industrial wastewaters. These facilities are commonly know as POTWs or publicly owned treatment works.	Municipalities, Commercial Establishments & All industries
Solid Waste Management	Collection, processing and disposal of solid waste	Municipalities & All industries
Hazardous Waste Management	Manage on-going hazardous waste streams, medical waste, nuclear waste handling	Chemical companies Petroleum companies Government agencies
Remediation/Industrial Services	Physical cleanup of contaminated sites, buildings and environmental cleaning of operating facilities	Government agencies Property owners Industry
Environmental Consulting & Engineering (C&E)	Engineering, consulting, design, assessment, permitting, project management, O&M, monitoring, etc.	Industry, Government Municipalities Waste Mgmt. companies, POTWs
Environmental Equipment		
Water Equipment & Chemicals	Provide equipment, supplies and maintenance in the delivery and treatment of water and wastewater.	Municipalities & All industries
Instruments & Information Systems	Produce instrumentation for the analysis of environmental samples. Includes info systems and software.	Analytical services, Gov't Regulated companies
Air Pollution Control Equipment	Produce equipment and tech. to control air pollution. Includes vehicle controls.	Utilities, Waste-to-energy Industries, Auto industry
Waste Management Equipment	Equipment for handling, storing or transporting solid, liquid or haz. waste. Includes recycling and remediation eqmnt.	Municipalities Generating industries Solid waste companies
Process & Prevention Technology	Equipment and technology for in-process (rather than end-of-pipe) pollution prevention and waste treatment and recovery	All industries
Environmental Resources		
Water Utilities	Selling water to end users	Consumers, Municipalities & All industries
Resource Recovery	Selling materials recovered and converted from industrial by-products or post-consumer waste	Municipalities Generating industries Solid waste companies
Clean Energy Systems & Power	Selling power and systems in solar, wind, geothermal, small scale hydro, energy efficiency and DSM	Utilities All industries and consumers

Source: Environmental Business International, EBI Report 2020B

Figure 2: Environmental Industry Segments and Number of Companies

Environmental Industry Segment	Companies or Entities
Services	
Analytical Services	910
Wastewater Treatment Works	*26,470*
Solid Waste Management	9,950
Hazardous Waste Management	460
Remediation/Industrial Svcs.	2,020
Consulting & Engineering	3,310
Equipment	
Water Equipment & Chemicals	2,030
Instruments & Info. Systems	860
Air Pollution Control Equipment	1,610
Waste Management Equipment	740
Process & Prevention Tech.	420
Resources	
Water Utilities	*61,800*
Resource Recovery	4,550
Clean Energy Systems & Power	2,370
Total	117,500

Source: Environmental Business International, EBI Report 2020B

Figure 3: Water Conflict Spots in Africa

Source: www.africareview.com

Figure 4: Growth of U.S. Domestic Environmental Statutes
Depiction of domestic environmental statutes. Note the watershed decade of the 1970s in which the majority of important legislation was enacted.
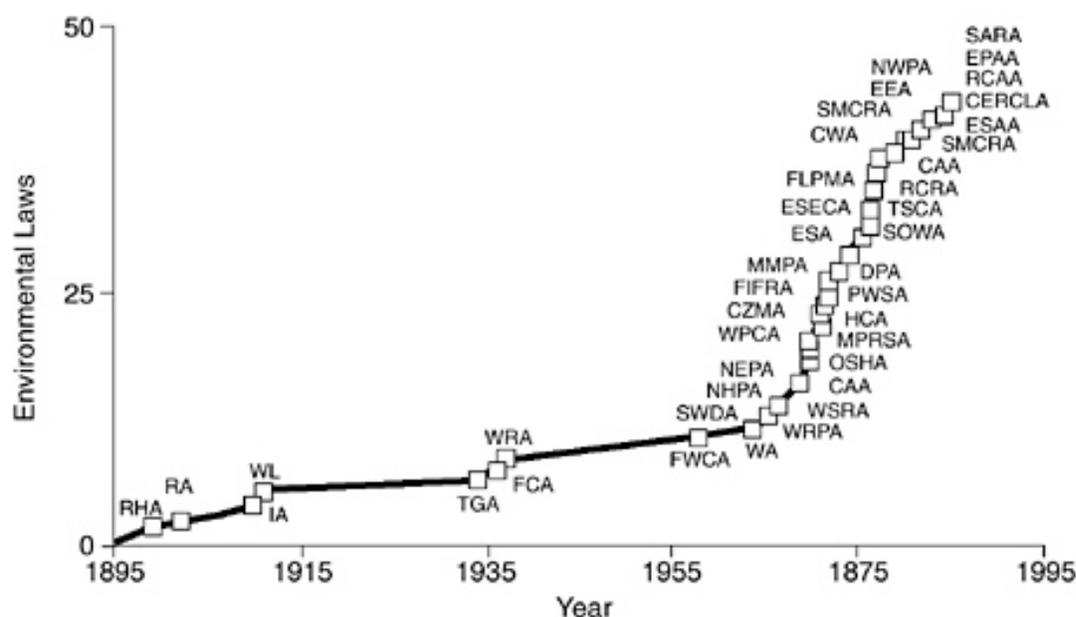
1899 - River and Harbors Act (RHA)
1902 - Reclamation Act (RA)
1910 - Insecticide (IA)
1911 - Weeks (WL)
1934 - Taylor Graring Act (TGA)
1937 - Flood Control Act (FCA)
1937 - Wildlife Restoration Act (WRA)
1958 - Fish and Wildlife Coordination Act (FWCA)
1964 - Wilderness Act (WA)
1965 - Solid Waste Disposal act (SWDA)
1965 - Water Resources Planning Act (WRPA)
1966 - National Historic Prerservation Act (NHPA)
1968 - Wild and Scenic Rivers Act (WSRA)
1969 - National Environmental Policy Act (NEPA)
1970 - Clean Air Act (CAA)
1970 - Occupational Safety and health Act (OSHA)
1972 - Water Pollution Control act (WPCA)
1972 - Marine Protection, Research and Sanctuaries Act (MPRSA)
1972 - Coastal Zone Management Act (CZMA)
1972 - Home Control Act (HCA)
1972 - Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)
1972 - Parks and Waterways Safety Act (PWSA)

1972 - Marine Mammal Protection Act (MMPA)
1973 - Endangered Species Act (ESA)
1974 - Deepwater Port Act (DPA)
1974 - Safe Drinking Water Act (SDWA)
1974 - Energy Supply and Environmental Coordination Act (ESECA)
1976 - Toxic Substances Control Act (TSCA)
1976 - Federal Land Policy and Management Act (FLPMA)
1976 - Resource Conservation and Recovery Act (RCRA)
1977 - Clean Air Acts Ammendent (CAAA)
1977 - Clean Water Act (CWA)
1977 - Surface Mining Control and Reclamation Act (SMCRA)
1977 - Soil and Water Resources Conservation Act (SWRCA)
1978 - Endangered Species Act Amendments (ESAA)
1978 - Environmental Education Act (EEA)
1980 - Comprehensive Environmental Response Compensation and Liability Act (CERCLA)
1982 - Nuclear Wasste Policy Act (NWPA)
1984 - Resource Conservation and Recovery Act Amendments (RCRAA)
1984 - Environmental Programs and Assistance Act (EPAA)
1986 - Safe Drinking Water Act Amemndments (SDWAA)
1986 - Superfund Amendments and Reorganization Act (SARA)

Source: Richard E. Balzhiser, "Meeting the Near-Term Challenge for Power Plants," *Technology and Environment* (Washington, DC: The National Academies Press, 1989), 101, accessed April 17, 2017, http://www.nap.edu/read/1407/chapter/4#101.

Figure 5: Multilateral Environmental Agreements
Environmentalists value *treaty effectiveness* over *treaty quantity*. Note the overall reduction in treaties and the increase of signatories.
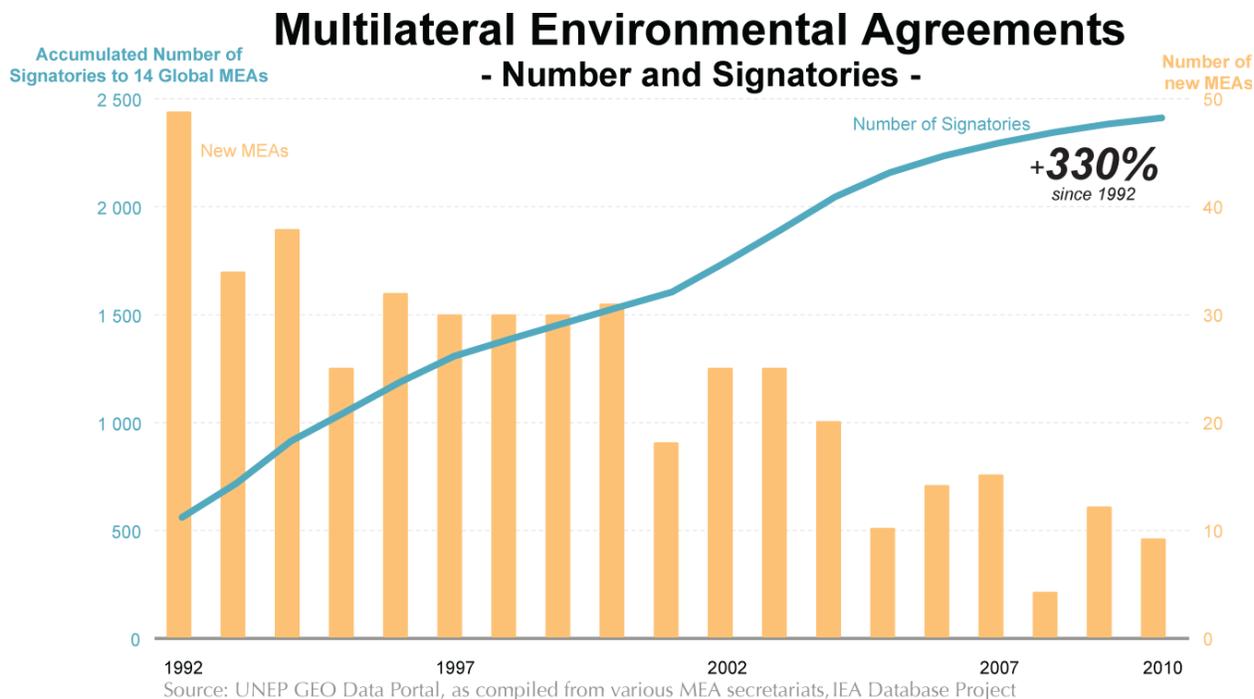
Source: UNEP, "Keeping Track of Our Changing Environment from Rio to Rio +20 (1992-2012)," by Stefan Schwarzera, May 2012. Accessed April 16, 2017.
http://www.na.unep.net/geas/getUNEPPageWithArtileIDScript.php?article_id=82.

Figure 6: U.S. Sustainable Development Goal Report Card

United States – Performance by indicator

Indicator	Value	Rating
SDG1		
Poverty headcount ratio at $1.90 a day (%)	0	green
Poverty line 50% (%)	17	red
SDG2		
Prevalence of undernourishment (%)	1.2	green
Cereal yield (t/ha)	7.6	green
Prevalence of stunting, under-5s (%)	2.1	green
Prevalence of wasting, under-5s (%)	0.5	green
Sust. Nitrogen Management Index (0-1)	0.3	yellow
Prevalence of adult obesity (%)	33.7	red
SDG2		
Under 5 mortality (per 1000 live births)	6.5	green
Maternal mortality (per 100,000 live births)	14	green
Neonatal mortality (per 1000 live births)	3.6	green
Physician density (per 1000)	2.5	green
Incidence of tuberculosis (per 100,000)	3.1	green
Traffic deaths (per 100,000)	10.6	yellow
Adolescent fertility (births per 1000)	26.6	yellow
Subjective wellbeing (0-10)	7.1	green
Healthy life expectancy at birth (years)	69	green
Infants who receive 8 WHO vaccines (%)	91	green
Daily smokers (%, aged 15+)	13.7	green
SDG4		
Expected years of schooling (years)	16.5	green
Literacy rate of 15-24 year olds (%)	n/a	gray
Net primary school enrolment rate (%)	91.4	yellow
Population with tertiary education (%)	42.4	green
PISA score (0-600)	492	yellow
Share upper secondary education (%)	89.1	green
SDG2		
Women in national parliaments (%)	19.4	red
Female years of schooling (% male)	100.6	green
Female labor force participation (% male)	82.4	green
Unmet demand for contraceptives (%)	15.2	green
Gender wage gap (% male wage)	19.1	yellow
SDG6		
Access to improved water (%)	99.2	green
Access to improved sanitation (%)	100	green
Freshwater withdrawal (%)	13.6	green
SDG2		
Access to electricity (%)	100	green
Access to non-solid fuels (%)	95	green
CO_2 from fuels & electricity (MtCO$_2$/TWh)	1.2	yellow
Renewable energy in final consumption (%)	6.3	red
SDG8		
Automated teller machines (per 100,000)	173.1	green
Adjusted growth rate (%)	0	green
Youth not in emp., education, training (%)	15	red
Child labor (%)	0	green
Employment-to-population ratio (%)	62.2	green

Indicator	Value	Rating
SDG6		
R&D expenditures (% GDP)	2.8	green
R&D researchers (per 1000 employed)	8.7	green
Logistics Performance Index (1-5)	4.2	green
Quality of overall infrastructure (1-7)	5.8	green
Mobile broadband subscriptions (per 100)	98	green
Internet use (%)	87.4	green
Patent applications (per million)	161.9	green
SDG10		
Gini index (0-100)	40.8	red
Palma ratio	1.7	red
PISA Social Justice Index (0-10)	n/a	gray
SDG11		
PM2.5 in urban areas ($\mu g/m^3$)	10.7	yellow
Rooms per person	2.4	green
Improved water source, piped (%)	99	green
SDG12		
Wastewater treated (%)	63.7	green
Non-recycled municipal solid waste (kg/person/year)	1.7	red
SDG12		
CO_2 emissions from energy (tCO$_2$/capita)	17	red
Climate change vulnerability (0-1)	0	green
SDG14		
Ocean Health Index - Clean waters (0-100)	84.8	green
Ocean Health Index - Biodiversity (0-100)	79.7	red
Ocean Health Index - Fisheries (0-100)	53	red
Marine sites, completely protected (%)	18.2	yellow
Fish stocks overexploited or collapsed (%)	51.6	red
SDG12		
Red List Index of species survival (0-1)	0.8	yellow
Annual change in forest area (%)	10.4	red
Terrestrial sites, completely protected (%)	10.6	yellow
SDG16		
Homicides (per 100,000)	4.7	red
Prison population (per 100,000)	716	red
Feel safe walking at night (%)	73.9	yellow
Corruption Perception Index (0-100)	76	green
Registered births (%)	100	green
Government efficiency (1-7)	4.3	yellow
Property rights (1-7)	5.5	green
SDG12		
Official development assistance (% GNI)	0.2	red
Tax revenue (% GDP)	n/a	gray
Health, Education & R&D spending (% GDP)	25.1	green

Source: www.sdgindex.org

Figure 7: Size of Environmental Technologies Market
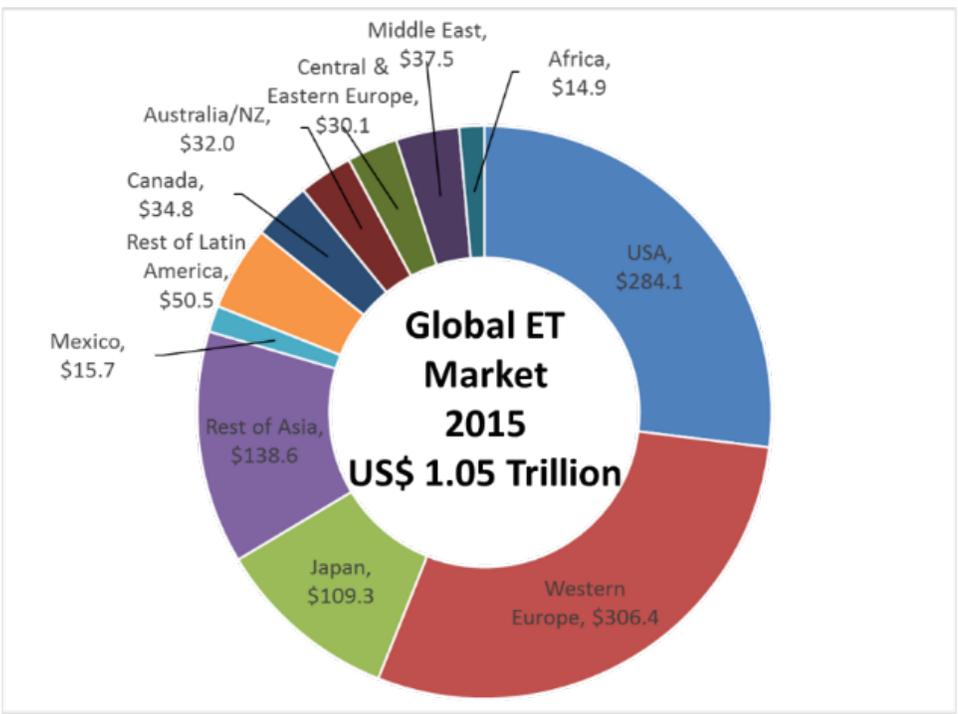
Source: International Trade Administration. "2016 Top Markets Report Environmental Technologies." Accessed May 9, 2017.
http://trade.gov/topmarkets/pdf/Environmental_Technologies_Top_Markets_Report.pdf

APPENDIX B: GLOSSARY OF TERMS

Abatement. Reducing the degree or intensity of, or eliminating, pollution.

Air pollution. The presence of contaminant or pollutant substances in the air that do not disperse properly and interfere with human health or welfare or produce other harmful environmental effects.

Biodegradable. The ability to break down or decompose rapidly under natural conditions and processes.

Biodiversity. The variety of life on Earth, including diversity at the genetic level, among species and among ecosystems and habitats. It includes diversity in abundance, distribution and in behavior. Biodiversity also incorporates human cultural diversity, which can both be affected by the same drivers as biodiversity, and itself has impacts on the diversity of genes, other species and ecosystems.

Carbon footprint. Measure of the impact our activities have on the environment, especially climate change, often reported as the units of tons (or kg) of carbon dioxide each of us produces over a given period of time.

Carbon neutral. A situation that arises when the amount of carbon dioxide released into the air equals the amount of carbon dioxide removed from the air, for example by planting trees, or the amount saved by using renewable energy sources to produce the same amount of energy.

Carbon offset. A unit, equal to one ton of carbon dioxide, that individuals, companies or governments buy to reduce short-term and long-term emissions of greenhouse gases. The payment usually funds projects that generate energy from renewable sources such as wind or flowing water. Individuals can choose whether to buy an offset (for example to compensate for air travel), but governments and large industries are sometimes required to buy them to meet international targets aimed at reducing greenhouse gases.

Carbon tax. A tax on fuels according to their carbon content, which aims to encourage people and businesses to use fuels with less carbon and reduce the amount of energy they use.

Chlorofluorocarbons (CFCs). A family of inert, nontoxic, and easily liquefied chemicals used in refrigeration, air conditioning, packaging, and insulation or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere, they drift into the upper atmosphere, where their chlorine components destroy ozone.

Cleanup. Actions taken to deal with a release or threat of release of a hazardous substance that could affect humans, the environment, or both. The term is sometimes used interchangeably with the terms remedial action, removal action, response action, or corrective action.

Climate Change. Any change in climate over time, whether due to natural variability or as a result of human activity. (The UN Framework Convention on Climate Change defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.")

Contaminant. Any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil.

Deforestation. Conversion of forested land to non-forest areas.

Ecosystem. The interacting system of a biological community and its nonliving environmental surroundings.

Environment. The sum of all external conditions affecting the life, development, and survival of an organism.

Environmental Assessment (EA). A process whose breadth, depth, and type of analysis depend on the proposed project. EA evaluates a project's potential environmental risks and impacts in its area of influence and identifies ways of improving project design and implementation by preventing, minimizing, mitigating, or compensating for adverse environmental impacts and by enhancing positive impacts.

Environmental Management Systems. A set of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency.

Fertilizer. Materials such as nitrogen and phosphorus that provide nutrients for plants. Commercially sold fertilizers may contain other chemicals or may be in the form of processed sewage sludge.

Food Security. the state of having reliable access to a sufficient quantity of affordable, nutritious food.

Fossil Fuels. Coal, natural gas and petroleum products (such as oil) formed from the decayed bodies of animals and plants that died millions of years ago.

Greenhouse effect. The warming of the Earth's atmosphere caused by a buildup of carbon dioxide or other trace gases; many scientists believe that this buildup allows light from the sun's rays to heat the Earth but prevents a counterbalancing loss of heat.

Industrial Pollution. The presence of minerals, chemicals or physical properties at levels that exceed the values deemed to define a boundary between "good or acceptable" and "poor or unacceptable" quality, which is a function of the specific pollutant.

Landfills. 1. Sanitary landfills are land disposal sites for nonhazardous solid wastes at which wastes are spread in layers, compacted to the smallest practical volume, and covered at the end of each operating day. 2. Secure chemical landfills are disposal sites for hazardous wastes that are selected and designed to minimize the chance of release of hazardous substances into the environment.

Pollutant. Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the U.S. Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, and radiological integrity of water.

Recycle/reuse. The process of minimizing the generation of waste by recovering usable products that might otherwise become wastes. Examples are the recycling of aluminum cans, waste paper, and bottles.

Renewable Energy. Any naturally occurring source of energy, as biomass, solar, wind, tidal, wave, and hydroelectric power, that is not derived from fossil or nuclear fuel.

Resilience. The capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly

Resource Recovery. Selective extraction of disposed materials for a specific next use, such as recycling, composting or energy generation in order to extract the maximum benefits from products, delay the consumption of virgin resources, and reduce the amount of waste generated.

Solid Waste. Any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, resulting from industrial, commercial, mining, and agricultural operations, and from community activities.

Stewardship. The responsible overseeing and protection of something considered worth caring for and preserving:

Sustainability. A characteristic or state whereby the needs of the present and local population can be met without compromising the ability of future generations or populations in other locations to meet their needs

Sustainable Development. Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

Sustainable Development Goals. A set of 17 "Global Goals" with 169 targets between them. Spearheaded by the United Nations through a deliberative process involving its 193 Member States, as well as global civil society, the goals are contained in paragraph 54 United Nations Resolution A/RES/70/1 of 25 September 2015.

Urbanization. An increase in the proportion of the population living in urban areas.

Wastewater. Spent or used water from individual homes, communities, farms, or industries that contains dissolved or suspended matter.

Water pollution. The presence in water of enough harmful or objectionable material to damage water quality.

APPENDIX C: NOTABLE ENVIRONMENTAL LAWS, CONVENTIONS, AND TREATIES

Landmark United States Environmental Legislation and Notable Multilateral Conventions Addressing Global Environmental Concerns

Landmark United States Legislation

National Environmental Policy Act (1969) The act created the Federal Government's Council on Environmental Quality (CEQ) and compelled the generation of Environmental Assessments by the proponent agency and their review by the CEQ (and shortly thereafter the Environmental Protection Agency) before governmental projects are undertaken. This mechanism is used to predict impacts to ecosystems and inform decision making. [227]

Executive Order Creating the Environmental Protection Agency (1970) President Richard Nixon reorganized several federal agencies' environmental oversight and regulation duties into one organization, the Environmental Protection Agency (EPA). Within EPA's portfolio are several notable (punitive) laws. The EPA generally has the power to set limits and monitor the performance of state agencies who are delegated the power to enforce and implement these statutes.[228]

Clean Air Act (1970) This act aspires to improve human health and protect the environment by maintaining areas with high quality air and improve those already contaminated by reducing, and eventually eliminating, fixed and mobile sources of airborne emissions. Further, it seeks to prevent airborne pollutants that degrade the layer of ozone in the stratosphere and acid rain. The act empowers the EPA to establish emissions standards and administer cap and trade policy for emissions.[229]

Clean Water Act (1972) This act is intended to improve domestic water quality (render waters "fishable and swimmable") and empowers the EPA to govern pollutant discharge of materials into U.S. waters.   The EPA establishes water quality standards and is authorized to conduct enforcement over a broad spectrum of regulations that oversee navigable, intrastate, and interstate waters. This statute authorizes the use of federal funds to improve municipal and industrial waste water treatment with a goal of eliminating all pollutant discharge.[230]

Ocean Dumping Act (Marine Protection, Research and Sanctuaries Act, 1972) This act was crafted to authorize research related to the impacts of marine pollution and to regulate the deliberate disposal of materials at sea. The act contains regulation, monitoring, and permit authorities, as well as provisions for the establishment of marine sanctuaries.[231]

Federal Insecticide, Fungicide & Rodentcide Act (FIFRA, 1972) This act regulates the production, sale, and use of pesticides within the U.S. in order to reduce the risks posed to persons and the environment. [232]

Endangered Species Act (1973) This act provides for the protection of threatened habitat which supports animal and plant species considered *at risk*. Generally, this law prohibits the harvesting of any listed species and harm to its endemic range. The implementing agencies are the Fish and Wildlife Service and the U.S. National Oceanic and Atmospheric Administration Fisheries Service.[233]

Safe Drinking Water Act (1974) This law is designed to ensure the quality of the drinking water supply within the United States. In general, the law provides the EPA the power to establish standards for the injection of wastes and quality thresholds for surface and subsurface water

sources. The EPA is also empowered to finance infrastructure projects related to drinking water and delegate some authorities to state level under the Public Water Supply Supervision Program.[234]

Solid Waste Disposal Act (1965)/ Resource Conservation and Recovery Act (RCRA, 1976) The RCRA superseded the earlier enacted Solid Waste Disposal Act and the names were combined for continuity. This act authorizes the EPA to establish standards which apply to sites that manage or generate hazardous waste. The EPA sets thresholds for site permitting, underground storage, and disposal. Furthermore, the agency can assess corrective actions to remedy improper handling.[235]

Toxic Substances Control Act (TSCA, 1976) This law assigns the EPA responsibility for safety screening of natural and synthetic materials used for manufacture of goods not already regulated. Based upon screening results, the agency establishes regulations that govern the import, use, manufacture, and disposal of any substances deemed harmful to humans or adversely affects the environment. The range of options for management of dangerous substances under this statute range from warning labels to outright bans on production or import.[236]

Comprehensive Environmental Response, Compensation and Liability Act (1980 *Superfund*) The law allows for the remediation of sites already contaminated by pollutants by the U.S. government in cases where public or environmental health is threatened. Provisions in this statute allow for liability determination against former or current site owners so that fines and associated clean-up costs can be levied against the liable party.[237]

Superfund Amendments and Reauthorization Act (SARA 1986) This act amended the Comprehensive Environmental Response, Compensation and Liability Act by expanding the scope of polluted sites requiring the same liability and remediation to U.S. government-owned and operated facilities (with special provisions for the Department of Defense).[238]

Emergency Planning and Community Right-to-Know Act (EPCRA, 1986) This act (a spinoff of the CERCLA and SARA) mandates the yearly reporting of hazardous chemical releases, and supports earlier efforts under existing state and local laws to prepare immediate response and mitigation measures.[239]

Pollution Prevention Act (1990) This act levies waste and recycling reporting requirements upon industry and other polluters to better inform the EPA's policy makers. Under this legislation, the EPA's charter is to reduce the number and magnitude of pollution incidents. The EPA can offer matching grants and other incentives to enable positive control of pollutants and avoid a spill. [240]

Notable Multilateral Agreements

The Stockholm Conference (the United Nations Conference on the Human Environment) of 1972 is regarded as the first substantial effort undertaken by the United Nations to address environmental concerns, hence its consideration as a landmark convention. This convention asserted that mankind has dominion over the planet and is responsible for stewarding resources for future use.[241]

The Rio Conference on Environment and Development (sometimes referred to as The Rio Earth Summit) of 1992 was the largest environmental conference ever conducted at the time. This conference sought to leverage data derived from the Brundtland report (sustainable Development document published in 1987 calling for balance between economics and stewardship of resources for future generations) to create *Agenda 21* and generated additional conferences to address biodiversity, climate change, and forest management.[242]

The Kyoto Convention (the United Nations Convention on Climate Change) of 1997 was the initial attempt by the United Nations to globally reduce Green House Gas (GHG) emissions. The

convention sought binding agreements from industrialized nations to reduce emissions, particularly those designated GHGs. Industrialized nations were expected to voluntarily commit to a higher reduction of emissions because they were responsible for the majority of the pollution.[243]

The Johannesburg Conference of 2002 (sometimes referred to as The World Summit on Sustainable Development) was focused on accelerating the United Nations' goals established in the Agenda 21 document. To increase the rate of progress, this conference adopted a whole-of-society approach to address environmental issues (departing from the earlier held idea that environmental reforms must be enacted by governments).[244]

The Paris Agreement of 2015 (The United Nations Framework Convention on Climate Change) was focused on the worldwide reduction of fossil fuels for energy production. The convention is seeking to lower the emissions of greenhouse gasses and thereby slow the global warming effect. The conference also sought binding financial commitment from U.N. members who are party to the agreement.[245]

APPENDIX D: FEDERAL EXECUTIVE AND LEGISLATIVE AGENCIES, COMMITTEES, AND ORGANIZATIONS

The following organizations play a major role in developing, implementing, and overseeing national and international environmental laws, policies, and programs.

Federal Executive Branch Organizations

Bureau of Land Management (BLM): The BLM, responsible for more land than any other Federal agency with 245 million acres, is responsible for preservation of public lands.

Council on Environmental Quality (CEQ): "The Council develops policies which bring together the Nation's social, economic, and environmental priorities, with the goal of improving Federal decision making. . . CEQ also oversees Federal agency and department implementation of [National Environmental Policy Act] NEPA."[246]

Department of Agriculture (USDA): USDA houses multiple agencies that work on environmental issues such as the Environment and Public Works Council and the Economic Research Service (ERA) focusing on financial and policy decisions related to the environment.[247]

Department of Defense (DOD): The office of the Assistant Secretary of Defense (Energy, Installations & Environment) has the primary role within DOD for environmental issues. Responsibilities include managing "DOD's policies and programs related to compliance with environmental laws; management of natural and cultural resources, cleanup of contaminated sites; green/sustainable buildings; international environmental compliance and cleanup efforts; climate change adaptation planning; strategic sustainability planning; and international defense environmental cooperation."[248]

Department of Interior (DOI): DOI is responsible for the management of our Nation's "public lands and minerals, national parks, national wildlife refuges, and western water resources."[249] Responsibilities also cover conservation of migratory wildlife, historic sites and endangered species.[250]

Department of Justice (DOJ): The DOJ's Environment and Natural Resources Division is the United States' environmental lawyer. Responsibilities include civil and criminal environmental law enforcement in order to protect the environment and well-being of the American people.[251]

Department of State (DOS): Within DOS, The Bureau of Oceans and International Environmental and Scientific Affairs (OES) engages in foreign policies that govern our globe's oceans as well as efforts that support the environment and related science. "OES projects, protects, and promotes U.S. global interests in these areas by articulating U.S. foreign policy, encouraging international cooperation, and negotiating treaties and other instruments of international law."[252] The bureau also promotes the diplomatic pursuance of outer space exploration.

Environmental Protection Agency (EPA): The EPA has the Nation's primary responsibility to carry out the implementation and enforcement of the laws established by the legislative branch. They also shape the international field as the EPA is a universally-recognized expert in environment and environmental science with a mission "to protect human health and the environment."[253]

National Aeronautics and Space Administration (NASA): NASA's Environmental Management Division (EMD) manages NASA programmatic and institutional requirements to advance environmental stewardship and sustainability.

National Oceanic and Atmospheric Administration (NOAA): NOAA conducts assessments and predictions of the environment, and promotes overall environmental responsibility.

Additionally, they are "dedicated to monitoring and assessing the state of the environment in order to make accurate and timely forecasts to protect life, property, and natural resources, as well as to promote the economic well-being of the United States and to enhance its environmental security."[254]

Nuclear Regulatory Commission (NRC): The NRC certifies that those nuclear facilities and materials for civilian use are handled in accordance with "public health and safety, environmental quality, national security, and antitrust laws."[255]

Office of Surface Mining Reclamation and Enforcement: "The Office's primary goal is to . . . [protect] society and the environment from the adverse effects of coal mining, while ensuring that surface coal mining can be done without permanent damage to land and water resources."[256]

United States Agency for International Development (USAID): USAID works to improve environmental sustainability through a number of programs such as the Office of Maternal and Child Health and Nutrition.

United States Fish and Wildlife Service: This is the primary Federal agency responsible for fish and wildlife conservation. Their mission includes "conservation, protection, and enhancement of fish, wildlife, and their habitats for the continuing benefit of the American people."[257]

Federal Legislative Committees

House Committee on Energy and Commerce: This committee provides oversight and legislation for issues ranging from clean air, drinking water, noise, radiation, to issues such as solid waste, and toxics.

House Committee on Natural Resources: "The House Committee on Natural Resources considers legislation about American energy production, mineral lands and mining, fisheries and wildlife, public lands, oceans, Native Americans, irrigation and reclamation."[258]

House Committee on Transportation and Infrastructure: (Subcommittee on Water Resources and Environment). The subcommittee concentrates on issues related to development of water resources; water conservation and management; water infrastructure and pollution control as well as hazardous waste cleanup.[259]

House Committee on Science, Space, and Technology: (Subcommittee on Environment): The subcommittee provides oversight to "EPAs research and development; environmental standards; climate change research and development; the National Oceanic and Atmospheric Administration, including all activities related to weather, weather services, climate, the atmosphere, marine fisheries, and oceanic research.[260] The subcommittee also oversees NASA's science research that leads to environmental policy to include those issues affecting climate change.[261]

Senate Committee on Agriculture Nutrition and Forestry, which among other elements of protecting our nation's forests also regulate pesticides.

Senate Committee on Commerce, Science, and Transportation (Subcommittee of Oceans, R&D, Radiation, Toxics): The subcommittee is "responsible for legislation and oversight of matters that impact our oceans and coasts including: coastal zone management; marine fisheries and marine mammals; oceans, weather and atmospheric activities; marine and ocean navigation; ocean policy and NOAA."[262]

Senate Committee on Energy and Natural Resources: The committee provides oversight on energy issues such as nuclear energy, public lands and their renewable resources as well as surface mining and other natural materials such as coal, oil and gas as well as protection of water resources.[263]

Senate Committee on Environment and Public Works: This committee provides oversight and legislation on environmental issues that impact our air, drinking water, noise, nuclear energy, ocean dumping, OCS, R&D, solid waste, toxics, and water.

U.S. State Organizations

Environmental Council of the States (ECOS): ECOS fully supports empowering state agencies to work toward environmental protection through both federal and state law. The agency, through their seven standing committees, provide guidance and facilitation between states and federal agencies to include the EPA and legislative committees.[264]

International and Multilateral Organizations

Asian Development Bank (ADB): The mission of the ADB is "to help developing member countries reduce poverty and improve the quality of life of their people."[265] One of ADB' three agenda items focuses on environmentally sustainable growth with the other two listed as economic growth, and regional integration.

Global Environment Fund (GEF): The GEF sits within the World Bank and serves as a financial mechanism for international conventions. The organization financially funnels aid from developed to developing countries in order to benefit global environment.[266] Grants provide direct support for those issues that address "climate change, loss of biodiversity, polluted international waters, land degradation and desertification, and persistent organic pollutants, as well as stimulate green growth."[267]

International Monetary Fund (IMF): The IMF promotes fiscal reform efforts to tackle environmental problems through analytical work (e.g. designing fiscal policy to mitigate greenhouse gases). They also provide expert assistance in environmental tax reform to their member countries.[268]

Organization of American States (OAS): This organization represents the 35 individual states that make up North and South America. Their goals include "promoting sustainable development–which entails balancing economic growth, social equity and environmental protections–throughout the Western Hemisphere."[269]

UN Development Program (UNDP): The UNDP is the UN's lead agency within the development system. The UN site lists the UNDP's objectives as "to build inclusive, sustainable and resilient societies."[270] One of the UNDP's five focus areas is environment and energy assisting developing countries find solutions to challenges in this area.[271]

UN Environment Program (UNEP): UNEP is a normative agency and subsidiary organ of the UN General Assembly. Within the UN they are an established program with elevated status where all member states have a role. UNEP "aims to provide leadership and encourage partnerships in caring for the environment by inspiring, informing and enabling nations and people to improve their quality of life, without compromising that of future generations."[272]

World Bank Group (WBG): An arm within the World Bank is the Environment and Natural Resources Global Practice World Bank Group sees "sustainable management of the environment and natural resources [as] vital for economic growth and human wellbeing."[273]

APPENDIX E: SUSTAINABLE DEVELOPMENT GOALS

Goal 1 – No Poverty. End poverty in all its forms everywhere

Goal 2 – Zero Hunger. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Goal 3 – Good Health and Well-being. Ensure healthy lives and promote well-being for all at all ages

Goal 4 – Quality Education. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Goal 5 – Gender Equality. Achieve gender equality and empower all women and girls

Goal 6 – Clean Water and Sanitation. Ensure availability and sustainable management of water and sanitation for all

Goal 7 – Affordable and Clean Energy. Ensure access to affordable, reliable, sustainable and modern energy for all

Goal 8 – Decent Work and Economic Growth. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Goal 9 – Industry, Innovation, and Infrastructure. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Goal 10 – Reduce Inequalities. Reduce inequality within and among countries

Goal 11 – Sustainable Cities and Communities. Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 12 – Responsible Consumption and Production. Ensure sustainable consumption and production patterns

Goal 13 – Climate Action. Take urgent action to combat climate change and its impacts

Goal 14 – Life Below Water. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Goal 15 – Life on Land. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Goal 16 – Peace, Justice, and Strong Institutions. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Goal 17 – Partnerships for the Goals. Strengthen the means of implementation and revitalize the global partnership for sustainable development

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