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Industry Study

Industry Report
Environment Industry Study

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ENVIRONMENT INDUSTRY STUDY 2018

ABSTRACT: The Environment Industry provides services, equipment, and resources, specializing in the environment and humanity's relationship with the earth, sea, and air, all of which are strategic and enduring components of national security. Environment Industry firms face evolving challenges in recognizing and mitigating today's security threats from environmental conditions and planning for future conditions. The United States is most secure when it recognizes the value this industry brings to planning for, as well as reacting to, the effects of a changing environment on emergent events, and incorporating industry resources into comprehensive strategic planning to advance America's security interests.

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Industry Study Outreach and Field Studies

On-Campus Presenters (Eisenhower Hall, Fort McNair):

Bechtel Corporation
Center for International Environmental Law
CH2M Hill
Daniel Morgan Graduate School
Environmental Business International, Inc.
Environmental Council of the States
Environmental Defense Fund
Export-Import Bank of the United States
George Washington University
Global Environment Facility
Global Environmental Management Initiative
Greenberg Traurig, P.A.
Greenpeace USA
Hogan Lovells US, LLP
International Chamber of Commerce
Keep America Beautiful
Louis Berger, Inc.
Marstel-Day LLC
Maryland State Attorney General's Office
National Aeronautics & Space Administration
National Wildlife Refuge Association
Population Reference Bureau
Pure Strategies, Inc.
Smithfield Foods, Inc.
Soyka & Company
United Nations Foundation
U.S. Agency for International Development
U.S. Army Corps of Engineers
U.S. Council for International Business
U.S. Department of Commerce
- National Oceanic & Atmospheric Administration
- International Trade Administration

U.S. Department of Defense, Office of Assistant Secretary for Energy & Environment
U.S. Environmental Protection Agency
- Office of International and Tribal Affairs
- Chemistry, Economics, and Sustainable Strategies Division
- Office of Environmental Justice

U.S. Department of State
Washington Post
Waste Management, Inc.
White House Council on Environmental Quality, Office of Federal Sustainability Officer
World Bank
World Wildlife Fund

Field Studies – Local (Washington, D.C. area):
D.C.-Water Blue Plains Advanced Wastewater Treatment Facility
U.S. Green Building Council
Montgomery County (Maryland) Recycling Facility
Embassy of the Netherlands in Washington, D.C.

Field Studies – Domestic (Miami, Florida and surrounding area):
Bilzin Sumberg Law Firm
Covanta Dade Renewable Energy, LLC, Resources Recovery Facility
Everglades National Park
Fort Lauderdale U.S. Export Assistance Center, Department of Commerce
Lloyd's Register North America
Miami Beach Government, Environment & Sustainability Department
Miami-Dade County Government, Office of Resilience
National Hurricane Center, National Oceanic & Atmospheric Administration
Port Everglades
Royal Caribbean International
US Southern Command Headquarters, J45

Field Studies – International (Amsterdam/The Hague/Rotterdam, The Netherlands):
AkzoNobel N.V.
Amsterdam Canal Ring UNESCO World Heritage Site
City of Rotterdam, Office of Chief Resilience Officer
Confederation of Netherlands Industry and Employers (VNO-NCW)
Global Reporting Initiative
Heineken N.V.
Keukenhof Park
Netherlands National Commission for UNESCO
Netherlands Ministry of Infrastructure and Water Management
Netherlands Ministry of Foreign Affairs
Port of Rotterdam
Royal Dutch Shell plc
U.S. Embassy, The Hague

INTRODUCTION

In the early 1950s, farmers in a Colorado town reported "unexplained sickness among livestock" and damaged crops. In time, researchers linked these problems to an Army chemical arsenal near Denver that had manufactured war materials years earlier. Rachel Carson documented this incident, among many others, in *Silent Spring*, the "bible" for the American environmental movement. Military operations and environmental concerns thus were linked before an industry emerged to address the challenges and opportunities presented by the interaction between humanity and the earth around us.[1]

This report examines the Environment Industry, a thriving industry with growing influence in this country as a vital source of support for national security. The effects of the environment on human safety and prosperity are undeniable, and as sea levels and temperatures rise, the United States is best served by being aware of the environment and planning to meet and anticipate threats from environmental conditions. The industry represents a unique advantage in the strategic deployment of resources because environmental concerns can have potentially devastating effects on the nation's security, and these threats can be anticipated, prevented, mitigated, and adapted to using resources available from this industry.[2]

The seminar surveyed the business, security, and regulatory aspects of the Environment Industry through a broad series of discussions with environmental experts and onsite visits to examine environmental principles and practices in the field. Over 50 lecturers shared their perspectives on aspects of the field, from legal to defense, economic, business, and other applications.

Two complementary field studies – one domestic, one international – followed, designed to test classroom observations and assumptions. Miami wages a constant battle to merge a growing coastal metropolis with the Everglades, a natural resource that, when used properly, can balance the threat of water damage to human populations but is itself threatened by encroaching development. The Netherlands, where the lowest point is nearly 20 feet below sea level, is of necessity a leader in environmental management, since its very existence depends on how and how well it manages to coexist with surrounding seas. Armed with expert insights and first-hand observations, the seminar assessed the state of the industry in terms of its economic competitiveness and its support for the nation's strategic security interests.

Definition of Industry: The Environment Industry is defined here as the sum of operating activities and revenues generated through environmental protection, assessment, compliance with environmental regulations, pollution control, waste management, remediation and restoration, and provision and delivery of environmental resources for the purposes of risk mitigation, consequence management, "future-proofing" infrastructure, and the continued wellbeing and prosperity of society.

This definition builds on what is generally considered the most authoritative and widely accepted industry definition from Environment 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." (The EBI industry structure is at Appendix A.)

Yet another definition taken into account here was one the International Trade Administration uses for environmental technologies: "all industrial goods and services that: (a) foster environmental protection and physical resource efficiency in industrial settings; (b) generate compliance with environmental regulations; (c) prevent or mitigate pollution; (d) manage or reduce waste streams; (e) remediate contaminated sites; (f) design, develop and operate environmental infrastructure; and (g) afford the provision and delivery of environmental resources."

CURRENT CONDITIONS

The top 200 environmental firms, whose performance is a proxy for the health of the industry, registered a 2.1% increase in revenue in 2016, divided between a 2.2% rise in domestic earnings and a 1.6% increase in non-U.S. revenue.[3] The industry leaders earned $54.5 billion in 2016, $42.3 billion coming from domestic projects.[4] Anticipating Trump administration changes in U.S. environmental policy, the industry is cautious but still seeking expansion and opportunities where they lie. The leading environmental federal contractors are all too familiar to government procurement officials at all levels: e.g., Fluor, AECOM, CH2M Hill, Bechtel, Battelle, etc.[5]

Many segments of the Environment Industry generate trade surpluses favoring the United States. In 2013, the latest data available from Environmental Business International (EBI), U.S. environmental companies earned $345.1 billion in worldwide revenue. U.S. industry exports of $51.4 billion countered imports of $34.7 billion, resulting in a trade surplus of $16.7 billion.[6] Developments in recent years have affected both figures, but the industry should continue to show trade surpluses. Chinese reductions in waste imports, for example, assuredly will reduce U.S. resource recovery exports, but this will be offset by U.S. energy independence reducing clean-energy imports.

The Trump administration, elected on a pro-business platform, has leaned toward curtailing environmental (and other) regulations[7] that could constrain economic expansion in the United States. For now, EBI holds to its pre-Trump forecasts for industry growth of 2.5%-3.5% through 2020,[8] but notes the business advantages of best-case economic outcomes: booming economic growth at 3-4%, the freeing of U.S. capital for investment, stimulating activity through public and private investment in infrastructure. However, "climate change denial and threatened isolation from global cooperation on climate policy"[9] threaten international business opportunities. "[T]he dismantling of the EPA or at least its Clean Power Plan"[10] threatens America's heritage of environmental stewardship.

Until recently, the greatest expectations for new U.S. markets have lain with infrastructure, in light of indications that the federal government would invest in America's aging physical plant. However, the White House will look instead to state and local governments for most such infrastructure funding,[11] though municipal governments, waiting to test the waters before committing precious funding in an uncertain regulatory environment, dealt service providers a 1.1% decrease in revenues in 2016.[12] Disappointment over expected federal money for infrastructure programs could continue to slow earnings in related segments.

Waste management, the most mature industry segment, continued to lead the industry in 2016,[13] because "it will always be necessary to have trash removed from our homes and businesses and disposed of safely."[14] Waste Management, Inc. and Republic Services together accounted for 37% of segment revenues in 2014.[15] Recycling has provided an additional source of industry growth for waste management firms. Hazardous waste, by contrast, retreated as government hazardous material projects in the energy sector started to thin out. This accentuated the fact that the hazardous waste segment lacks competition – the top 10 firms claiming 95% of industry revenues.

In 2016, water continued to figure prominently in the industry posture. After waste management (25.3% of 2016 revenue among Top 200 firms) came the water supply (19.3%) and wastewater (16.6%) segments.[16] Income in the wastewater segment registered a 13.7% gain over 2015 revenues.[17] In an uncertain regulatory regime, a focus on water and its effects can support continued opportunities, without examining the science behind the changes. Corporate executives generally are confident that any infrastructure projects breaking ground will be in the water field. Leaders in that field, however, "worry about aggressive price competition."[18] One executive bemoaned challenges from "too many contractors who are willing to severely underbid the work and then underperform."[19] Another executive saw water supply approaching a dire situation calling for novel solutions and innovation: "There is a growing appreciation that water solutions will be different

from in the past. We are at a tipping point and need to challenge legacy issues with innovation. Water is too precious now."[20]

U.S. firms found numerous opportunities overseas in 2016: CH2M Hill ($1.569 billion in 2016 revenues earned abroad), Bechtel ($1.132 billion), Tetra Tech ($1.048 billion), AECOM ($712 million), and Golder Associates ($589 million) together accounted for $5.05 billion in exports of environmental goods and services.[21]

Environment Industry executives saw 2017 bring a resurgence of work from oil-based clients, after this sector's prospects had waned in previous years.[22] Midstream oil and gas clients registered the most promising growth potential in an EBI survey, with upstream and downstream clients ranking fourth and fifth, respectively. The petroleum sector returned to the favored status it last held in 2013, reversing a waning trend over the past five years, presumably due to reduced environmental protections on fuel extraction. The industry expected the federal government to give greater attention to oil and gas infrastructure in 2017 with the relaxation of environmental prohibitions on fracking and other extraction techniques now favored by the Trump administration.[23] Renewable energy, conversely, after five years in the top five growth-oriented clients, took a steep dive to the 28th most promising customer base, as petroleum fuels look to supplant earlier interest in renewables. The industry's outlook for federal clients remains dour, as the Department of Energy, the Environmental Protection Agency, and other clients claimed the bottom three rankings for growth potential.

The booming U.S. economy should provide an increase in environmental equipment revenues.[24] However, the uncertain regulatory environment is unlikely to drive research and technology breakthroughs that spur advances in equipment.[25] Instead, EBI calls for the industry to seize the opportunity to make technological advances that "push the envelope. The more sophisticated the equipment, the higher the growth," highlighting opportunities in water: "recycling, point-source treatment, desalination and complete reuse water."[26] Indeed, in EBI's Snapshot Survey for 2017, executives consider the water sector the most promising growth segment.[27] Energy management/ efficiency ranked second, consistent with the renewed interest in oil and gas clientele.[28] Water also figures in sustained equipment segment growth. EBI concludes that water resource management offers "synergy between resource recovery [and] renewables, [unlike the] energy and equipment and service segments. . . . More importantly, water management promises to dwarf all other segments, even solid waste, in terms of revenue size."[29] Reflecting the U.S. administration's de-emphasis on climate change, executives dropped climate adaptation/resilience and climate/carbon mitigation to the bottom of expected growth rankings.[30]

CHALLENGES

In September 2015, the United Nations adopted 17 Sustainable Development Goals (SDGs) as part of its 2030 Agenda for Sustainable Development to address environment, poverty, sustainable development, and economic and social issues globally.[31] Market opportunities through 2030 could exceed $12 trillion for merely a subset of the SDGs. The overriding challenge ahead will be for business, governments, communities, and other stakeholders to mobilize and to harmonize their efforts to realize the economic potential represented by these global goals. (The SDGs are described in Appendix B.) What does and what could this mean for the Environment Industry?

SDG 6: Clean Water and Sanitation. Water is basic to human survival, so this goal seeks to ensure that the entire world has access to sustainable, safe drinking water and clean sanitation conditions. Today, 660 million people lack access to potable water,[32] and millions die each year from unsanitary water conditions.[33] Water development infrastructure must double in capacity in the next five years to avoid catastrophic effects with over 700 million people searching for clean drinking water.[34]

Water markets are mostly in least-developed countries, where almost one in three people lacks access to clean drinking water, one in two in sub-Saharan countries.[35] Typically, these markets will be more open in rural locations. Business opportunities include protection of aquifers and wetlands, reductions in water pollution, and better water management procedures. U.S. businesses can glean market ideas in this area from other countries: e.g., India has water harvesting structures to increase cropland productivity; China harvests 70 percent of the rainwater in cities; and Ukraine has installed artificial wetlands to filter water of pollutants and sediments.[36]

SDG 2: Zero Hunger. Food security – the availability of, access to, and utilization of food – reflects whether a population meets its basic dietary needs. Food insecurity, the opposite, can have multiple triggers: natural disasters, climate, war, or political instability,[37] and there is a direct link among food security, international trade, and market access.[38] Food insecurity is greatest in southwest Asia, where 281 million people face hunger, and in sub-Saharan Africa, where hunger afflicts more than 23 percent of the population.[39]

One of the greatest environmental stresses on earth is sustenance and commercial agriculture,[40] and the sustainability challenge of this goal is how to produce enough food for the world's population without destroying the earth's ability to generate that food.[41] Business opportunities to educate and invest in sustainable development, technology, and improvements on small farms support this SDG. Moreover, U.S. businesses can partner with target locales to establish meal programs in schools, fed by local farms.

SDG 13: Climate Action. Government and industry partnership face the challenge of controlling carbon dioxide emissions and ecosystem degradation that contribute to global climate change, and the UN recognizes the need for a well-coordinated international solution.[42] (Though scientific and international communities are accept that human activity causes harmful climate change, the U.S. administration is less committed to that view.[43]) Leading U.S. businesses have elected to address climate change. American Express, for one, has committed to sustainable steps to reduce its environmental footprint, running its headquarters and much of its operations on carbon-free electricity."[44] However, imposing greenhouse gas regulations too quickly can strain industry with high costs and immature technology, so governments may have to provide tax or other incentives to encourage firms to adopt responsive practices that counter climate change.[45]

SDG 7: Affordable and Clean Energy. This SDG calls for "affordable, reliable and sustainable energy for all."[46] The challenges are to provide clean, sustainable power while reducing greenhouse emissions and costs for energy-intensive processes. The low price of oil and natural gas discourages investments in cleaner energy systems, since infrastructure and business models are based on fossil fuels that, for the moment, are plentiful and affordable. Systems to store alternative energies are still maturing, limiting how enterprises can leverage technology to generate energy. With a growing global market for clean, affordable energy, U.S. industries are well placed in this market.

SDG 11: Sustainable Cities and Communities. Cities must evolve to host the 2.5 billion people who will live in urban areas by 2050. As societies become more industrialized, and service-oriented urban hubs of commerce develop, their resiliency and sustainability will be critical to economic growth and prosperity. This SDG focuses on affordable and inclusive housing, transportation, reducing environmental impacts while increase well-being, supporting resiliency, providing universal access to green spaces, protecting cultural and historical heritage, and supporting the least-developed regions in attaining these targets.

Such efforts can be accomplished by providing affordable housing that is durable, uses environmentally conscious building techniques, and is built around a circular economy.[47] Energy-efficient systems, resilient construction, office sharing, district heating and cooling systems, and microgrids provide similar advantages for commercial buildings.[48] To meet these challenges local and national governments, academe, and business must partner on new technologies to build resilient,

sustainable cities.[49] U.S. firms across the spectrum of business can counsel governmental and commercial entities on how best to shape the smart cities this goal contemplates.

SDG 12: Responsible Consumption and Production. Many businesses have found cost benefits after changing their supply chains by buying lower cost recycled products, using renewable energy, recycling materials and lowering disposal costs.[50]

Ultimately, firms are moving toward a circular economy that "aims to eradicate waste – not just from manufacturing processes, as lean management seeks to do, but systematically, throughout the life cycles of products and components."[51] For example, Levi Strauss accepts old clothes and shoes for repurposing or recycling, thereby reducing the 11 million tons of textiles that end up in landfills.[52] But responsible consumption and production have challenged the once-profitable recycling industry. Now, thousands of municipalities pay to dispose recyclables because of a confluence of factors such as a rising U.S. dollar, a weak Chinese economy, and falling oil prices.[53]

SDG 15: Life on Land. This goal aspires to "conserve and restore the use of terrestrial ecosystems such as forests, wetlands, drylands and mountains" by halting deforestation, combating desertification, and reducing the impact of invasive alien species.[54] This goal creates industry opportunities in the services sector, as environmental consultants and remediation services advise on how to rehabilitate lands, and monitor and prevent land degradation and contamination. Companies must follow government regulatory guidelines and preserve their reputations with stakeholders to prevent costly repercussions. As a result, environmental consulting is expected to double in growth from $29 billion to over $43 billion by 2025.[55]

SDG/Sector Linkage. The SDGs can provide a lifeline for individual businesses and the world economy as a whole. Creating a business strategy, incorporated in policies, and altering markets to line up with the SDGs can provide a "viable model for long-term growth, as long as businesses move towards them together. The goals [SDGs] are designed to interact, so progress on them all will have much more impact than achieving only some."[56]

Some companies may directly pursue action on SDGs for profit, while some companies indirectly seek dual benefits. Indirect pathways include boosting a company's reputation with customers, thereby promoting the corporate ethos and increasing sales, even though the company's market is not linked at all to their contribution. Such corporate philanthropy, likely involving partnering with an environmental firm to assist, is a primary way for SDGs to be achieved. Environmental companies, on their own, may not have the capital to succeed, so there is a need for large and small firms across all sectors to participate. The first peers to lead in a sector are subject to extreme risk, as they move forward without guarantees that other businesses will follow. However, first movers will also have the opportunity to gain a five to ten-year advantage on the market, which could bring great rewards. The ensuing symbiotic relationship can create strong partnerships; so, just as business needs the SDGs to grow and expand, the SDGs need business to fully achieve success.[57]

If the United States (like other countries) is unsuccessful in pursuing markets to achieve the SDGs, already terrible conditions may be exacerbated. More people living in poverty, hunger, and sickness, without access to clean water and sanitation, will only make the world more dangerous and insecure. Security threats and conflict thrive in locations where basic needs aren't met. Accordingly, if the United States isn't successful, through government and business, in effectively capitalizing on the sustainability opportunities represented by the SDGs, there is every reason to anticipate a continuation and expansion of such unwanted conditions as intra- and inter-state conflict, civil unrest, and the destabilization of governments and societies in the most fragile parts of the world.

"Addressing these challenges will require concerted efforts from policymakers to set the right enabling conditions" for industry sectors not only to comply with regulatory guidance but to promote innovative solutions to facilitate environmental action in the most efficient and effective manner.[58] "Trade policy is one sphere of governance that can play a supportive role to ensure greater

environmental sustainability" and can have a profound international impact.[59] Government can reward industry by offering such incentives as tax deductions and relief, research grants, and interest-free loans to promote change and inspire the development of new technologies to support the creation of a more sustainable, survivable world. In enforcement regimes, governments must realize that when the cost of compliance is greater than the cost of non-compliance, regulations discourage, rather than encourage, sustainability.[60]

International financing organizations such as the Global Environment Facility can provide necessary funding to support sustainable investment by continuing to be an incremental funding mechanism for developing countries on high-risk projects early in development.[61]

OUTLOOK

U.S. environmental firms have a great opportunity to expand operations into global markets. The United States, the largest provider of environmental technologies and services, accounts for approximately one-third of the global market,[62] and its sophisticated and innovative products are highly valued. Each of the world's regions presents unique challenges reflecting its level of development, environmental regulatory scheme, geography, and demographics. EBI survey results reveal that corporate executives consider the biggest overseas growth potential for environmental firms to be China, with 56% of respondents calling for good growth potential over the next two years. Other leading markets are India, Southeast Asia, Australia/New Zealand, and Germany. In developing regions, while estimates are generally tame, some executives see prospects for very strong growth in South and Central America, Africa, and Russia. [63] It thus is useful to consider the outlook for the Environment Industry through a regional lens.

Asia-Pacific. Rising sea levels along the coastlines of the Asia-Pacific region, resulting from greenhouse gas emissions, combined with strained water resources, waste management, and shrinking biodiversity, are the region's largest environmental threat. An emphasis on environmental concerns creates an opportunity for business investments from the United States and other developed countries. China and India are the most populous nations in the world and, in all, eight Asian nations have more than 100 million residents, with Vietnam expected to join that club by 2030. [64] Surges in industrial capacity and urban density create new environmental concerns, including air quality, regional biodiversity, access to freshwater sources, chemical and waste disposal, and environmental governance. [65] China is the largest carbon dioxide contributor in the world, followed closely by India, Japan and South Korea.[66]

U.S. Pacific Command commander Admiral Samuel Locklear has cited climate change as Asia's greatest security threat.[67] The environment has sparked conflicts over rights to water from shrinking Himalayan glaciers, while disputes have arisen when Vietnamese fisherman have followed schools of fish migrating north into Chinese waters due to rising sea temperatures.[68] Rising sea levels also pose seismic shifts in Asian demographics. Waves of immigrants would be launched if island nations like the Maldives and Vanuatu were inundated by rising sea levels. The disappearance of these islands also threatens U.S. force projection in Asia as rising oceans swallow critical airfields and logistical staging areas in Asia.[69]

China remains the top market in water, air, and waste management, and is followed by India, Indonesia, South Korea, and Vietnam.[70] In China, the current five-year plans prioritizes innovation for environmental sustainability technologies, adding alternative energy and environmental technologies as one of the seven industrial sectors at the backbone of China's economy.[71] Air pollution remains China's greatest environmental problem despite strong governmental reforms.[72]

In 2015, U.S. exports of environmental technologies and services to Asia totaled $48 billion, and the export potential was approximately $710 billion.[73] While China, India, and the rest of Eastern Asia are potential markets, U.S. companies face barriers to get into these countries, including

corruption, weak protection of intellectual property, high tariffs, preferential treatment to domestic companies, and weak and inconsistent environmental regulations.[74]

Europe and Russia. Greater Europe is heavily urbanized (over 70% of Europeans live in cities), with dense populations, diverse geography, and well-established infrastructure. Most of Europe is fully developed, with mostly urban populations coupled with a larger percentage of land under cultivation than global averages.[75] Sea-level rise affects most European coastal areas. Finally, Europe has experienced widespread soil degradation, with large increases in soil-bound carbon in the Iberian Peninsula and Sicily, and desertification around the Black Sea.[76]

Climate change and greenhouse gas emissions are a universal concern in Europe and shape regulatory policy and action. All European countries are parties to the Paris Agreement.[77] Despite the advanced regulatory regime in most European countries, Europe's resource footprint is unsustainable.[78] Greenhouse gas emissions are rising in southeastern Europe, and stable or declining in the rest of Europe.[79] Over 95% of the population is exposed to air pollution levels that exceed World Health Organization guidelines.[80] The circular economy, where "durable goods would be designed so that they could be repaired rather than replaced and biological materials would be managed so that they could be returned to the biosphere without contamination," is a norm for European development, especially in Western/Central Europe.[81] Notably, European Union nations have separated economic growth from growth in greenhouse gas emissions; between 1990 and 2013, emissions declined by 21 percent, while gross domestic product increased by 45 percent.[82]

U.S. firms have limited penetration into the European environmental market, with $3.6 billion in annual revenue as of 2016, representing about 30% of U.S. environmental market exports.[83] Priorities in the EU portions of the region include low carbon resource efficiency, sustainable cities, improved health, and adaptation to climate change,[84] providing a lucrative market for U.S. environmental firms with cutting-edge technological applications. U.S. environmental firms that specialize in water treatment solutions, such as Tetra Tech, will find a lucrative growth market in Southeastern and Eastern Europe, especially the water and waste management sectors. The best in-road for U.S. firms in Western and Central Europe is in the form of comprehensive design and consulting, where U.S. firms are dominant global leaders.

Africa. Africa has abundant natural assets but as a continent faces grave environmental threats. "Africa's population reached 1 billion in 2009, with estimates that it will double by 2050."[85] This population boom will stress the "ecosystem by increasing demand for food, energy, medicines and water, while bringing distortions to land tenure arrangements, as well as accelerating environmental degradation through soil erosion, deforestation, and biodiversity loss."[86] The continent is warming at 3-4 degrees Celsius this century, faster than the global average.[87] The African Union has developed a strategic framework, Agenda 2063, for socioeconomic transformation of the continent that builds on and seeks to accelerate established initiatives for growth and sustainable development. Nations on the continent are striving to improve air quality, especially through expanded renewable energy measures.[88] "One of the major problems in urban centers nowadays is the collection, treatment, transportation, storage, and eventual disposal of waste. The prevailing increase in the level of urbanization in Africa is expected to continue in the future."[89]

Latin America. While the 32 nations of Latin America and the Caribbean are rich in natural resources, production and consumption in the region are unsustainable as persistent anthropogenic activities cause environmental degradation.[90] Environmental health is threatened by climate change, biodiversity loss, water and land mismanagement, natural disasters, coastal and marine management threaten the health of the region's environment.[91] Weak government institutions, inadequate enforcement, poor financial flows, and growing populations hamper attempts to redress these threats.[92] The region is biologically rich across its varied geography and ecology. Home to 23% of

the world's forests and 31% of the globe's freshwater resources,[93] Latin America and the Caribbean together have the second largest green water footprint in the world due to the rainfall held in the soil.[94]

Recently, Latin American and Caribbean leaders pledged to meet the UN Sustainable Development Goals, which would qualify their nations for UN financing. However, countries must first meet accreditation standards that demonstrate that they can effectively manage those funds.[95] Notably, the region lacks an environmental policy framework for adequate policies, institutions, and compliance enforcement to ensure effective governance. Many of the region's countries are the most indebted in the world, and the competition for funding from governments is intense. Moreover, environmental stewardship funds are often crowded out, limited, or eliminated in favor of higher priority needs such as basic health and human services. The global recession slowed international investment in the region. [96] While dedicated climate financing would mitigate the competition for public funds between environmental and other support or social projects,[97] the region faces two obstacles: access to loans and access to remittance money.

The U.S. Department of Commerce ranks Mexico as the Number 2 environmental market for opportunities for U.S. firms. Mexico has an environmental technology industry valued at over $15.5 billion and offers opportunities for U.S. exports in delivering safe potable water systems, wastewater, water reclamation, and water monitoring.[98] Furthermore, Mexico needs a modernized waste management system.[99] In Brazil, U.S. firms can skirt barriers to entry in the water market through by entering into public-private partnerships.[100]

Middle East. Governments and stakeholders in the Middle East are becoming more interested in the environment. The League of Arab States established a high-level council to address sustainability. The highly urbanized population in the Middle East is expected to increase by nearly 40% to 205 million between 2015 and 2030.[101] "These high rates of population growth and urbanization, coupled with current consumption patterns, compound the pressures on the region's limited land and water resources."[102] In developing countries like those in the Middle East, food, energy, and water scarcity can cause conflict and instability,[103] while adverse environmental conditions can trigger migration to Europe. [104] In the 30 years from 1979 and 2009, rainfall decreased and temperatures increased, changes that have altered animal habitats and migration patterns.[105] Additionally, greenhouse gas emissions are rising slightly higher than the global norm.[106]

Saudi Arabia presents environmental business opportunities in the region, ranked 5th by the Department of Commerce, with an environmental technology market valued at $9.4 billion in 2017.[107] SoftBank, an American company, and Saudi Arabia have agreed, for example, to build a 200GW solar farm for $200 billion.[108]

GOVERNMENT GOALS AND ROLE

The U.S. government can play a key role in shaping and nurturing the Environment Industry, and in the process furthering overarching U.S. security interests, by actively promoting economic prosperity, technology development and diffusion, and human capital enhancements.

Promoting Prosperity. The government should actively seek to bolster economic potential and competitive advantage among nations competing for the global sustainability market (integrating environmental, social, and economic activity). As importantly, government should reinforce economic potential and competitive advantage among U.S. firms competing for this global market. Regulations should be structured and enforced with an eye to enabling firms to develop capital and labor that facilitates American expansion in the field. Tax incentives, for example, could specifically reward firms for pursuing the sustainability market. Finally, government could, rather than levying tariffs, rectify trade imbalances by establishing sustainability preconditions for imports.

Government unreservedly should act to advance U.S. credibility and standing by reestablishing U.S. environmental leadership in global alliance relationships. UN proceedings on

climate change and sustainability reflect the global community's commitment to such matters. Global competitors, most notably China, eye the U.S. withdrawal from the Paris Agreement, for example, as an opportunity to acquire influence at U.S. expense. As such, the United States should stay engaged on scientific, technical, and political grounds to reaffirm common interests with allies and neutrals in various fora – those dedicated specifically to the environment and those concerned with national security matters more generally.

Building Human Capital. Aggressive government promotion of education and training to eradicate the human capital capabilities gap in the U.S. scientific, technical, engineering, and mathematics (STEM) labor market is absolutely essential. U.S. students are outnumbered by international students in STEM fields.[109] The benefits of more aggressive STEM support are twofold: environmental firms can operate in the United States with a steady source of qualified employees, while the wealth generated by their operations provides high-paying jobs for U.S. workers. Government outreach to and mentoring of STEM students and programs that reward STEM professors and teachers more significantly are crucial. The federal government also should encourage and even underwrite local and state government partnerships with private groups to build a more robust domestic STEM labor pool.

Incubating Technology Innovations. The United States would be immeasurably well served if government were to undertake a nationwide, Moonshot-like or Manhattan Project-like effort to research, develop, and affordably produce and field major innovations in environmental technologies. A federal research and development organization – centered perhaps in the White House Office of Science and Technology Policy, in concert with the established national laboratory system and the private sector (perhaps a collaborative consortium) – would promote and underwrite basic and applied research to advance such technologies, while inviting matching investment from various sources – governmental, inter-governmental, non-governmental, and philanthropic – at home and abroad

Linking Environment and Defense. The United States has direct defense interests in environmental affairs, which shape and affect U.S. military activities. For example, military installations that use hazardous chemicals incur massive government clean-up costs. With many chemicals, military units can't keep personnel safe from exposure to harmful contaminants because commanders can't predict the toxic effects of those substances. In forward deployments, U.S. bases can't manage waste with modern means; rather, open-pit burning exposes deployed combatants and host-country non-combatants alike to toxic airborne particles. Additionally, when local water sources are contaminated, forward deployments must transport large quantities of water.

In such ways do environmental factors affect military operations. The widespread use of the herbicide Agent Orange in Vietnam poisoned U.S. soldiers and local citizens, and damaged Vietnam's ecology for years. Enemy forces burned oil fields to impede advancing U.S. troops in Operations Desert Storm and Iraqi Freedom, exposing troops to toxic chemicals and requiring massive cleanup of attendant oil and fire damage. Even more fundamentally, environmental conditions can trigger food and water insecurity, which in turn can foment political and social instability when populations vie for limited essential resources. Such instability can implicate U.S. security interests, as in Syria, where water shortages exacerbated the 2016 civil war.[110]

The 2017 National Security Strategy establishes four pillars as the basis for defining, defending, and advancing vital U.S. interests: furthering economic prosperity, ensuring defense of the homeland, building a lethal fighting force, and advancing the American way of life. [111] Because the Environment Industry is engaged in a wide range of activities and represents a wide range of capabilities that support these strategic pillars, it should be part of comprehensive planning to advance U.S. national security interests.

Pillar	Environment Industry Contribution
Economic Prosperity	$13.1 billion trade surplus U.S. revenue from $12 trillion global sustainability potential
Lethal Fighting Force	Engagement on climatic conditions allows strategic response to global instability affecting U.S. interests Planning for, mitigating, and adapting to climate effects on military installations and operations[112]
U.S. Influence in Alliances	Assuming environmental leadership role and building commonality with allies on other strategic issues
Homeland Security	Preparedness before, resilience after natural disasters
National Defense Strategy	Assuming environmental leadership role and building commonality with allies on other strategic issues

ESSAYS ON MAJOR ISSUES

The following essays illustrate critical topics that underpin the Environment Industry. LTC Philip Forbes explains economic and financial sources of funding for environmental work. LTC Ralph Radka surveys cutting-edge environmental technologies. Dr. Gerald Garino highlights some of the key domestic and international legislation associated with the growth and maturation of the industry.

"ECONOMIC & FINANCIAL RELATIONSHIPS OF THE ENVIRONMENT INDUSTRY"
Lt Col Philip Forbes, USAF

The purpose of any firm is to produce a good or service for a consumer. Most production processes result in a desired good and byproducts such as unused material and pollution. A growing number of firms have become more involved in the reduction of waste in the design, production, delivery, and removal of the goods and services they provide. This attitude of environmental stewardship, coupled with the intent to create long-term shareholder value through the opportunities and risks associated with economic and social development broadly describes corporate sustainability (CS).[113] To many, it may not appear that such measures pave a direct path toward adding value in terms of increasing revenue or better distinguishing a firm from its competitors. It is true that a firm can be profitable without adopting CS strategies (CSSs) and firms will only adopt these strategies if they add value. However, firms are successfully implementing CS strategies because they are complementary to competitiveness and profitability.

Industry Interactions Through Economic and Financial Lenses. The universe of interactions involving a firm's inputs and outputs can be viewed in one of two ways: through the lenses of economics or finance. The Environment Industry's economic and financial constructs contain facets that are unique and not easily transferrable to other industries (e.g., advanced materials, robotics, etc.). Moreover, both realms are complementary to one another.

Environmental Economics

The relationship between behaviors and incentives at the firm or industry level provides a sound platform for surveying the Environment Industry. Incentives may take the form of policies, regulations, opportunities to differentiate from competitors, and institutional agreements (e.g., Paris Climate Agreement, Kyoto Protocol). They are often manifest in the relationships between a firm and its suppliers, customers, or peripheral stakeholders. The degree to which a firm is incentivized by its relationships with is suppliers is directly tied to how much influence one has over the other. Ten years into its own sustainability initiative, for instance, Walmart now ranks its suppliers on a Sustainability Index using over 700 categories.[114]

Customers represent the demand side of a firm's interactions and smaller firms, or those who operate in an environment with several substitutes, low barriers to entry, or low margins may not wield the same influence over suppliers that companies like Walmart do. However, certain suppliers

whose brand emphasizes sustainability may still appeal to core groups of customers. Grocery stores, whose 2016 industry-wide profit margin was 2.5%, fall into this category of low margins and numerous substitutes.[115] In light of this, the grocery chain Giant Food has released its own certified organic Nature's Promise brand of over 1,000 products to sate the demand for sustainably produced goods.[116]

A third relationship involves a firm's peripheral stakeholders. In the context of the environment industry, these tend to have a location-sensitive relationship which can range from as close as the firm's immediate property boundary to a population thousands of miles away. For instance, a particular town's drinking water may be affected by the local factory discharging waste into watershed areas. On a larger scale, China's industrial activity has been linked to air quality in the United States.[117]

Such byproducts represent a market failure known as a *negative externality* and in the face of these, firms run the risk of political backlash. Whereas a firm can pursue sustainable approaches on its own accord to strengthen its position among competitors through value creation, political backlash may sometimes result in regulation and policies that force a firm to act in a way it otherwise would not. An example of this was the passing of the National Environmental Policy Act (NEPA) in 1969 which begat the present-day Environmental Protection Agency in 1970 and the Clean Water Act in 1972.[118]

In other instances, the various components of the environment industry have elected to get in front of mandates and legislation on their own accord. Acting *sua sponte*, and with sufficient transparency, a firm may not only avoid unwanted regulation that may harm it operations but find ways to negate the very activities that would disturb stakeholders altogether. Such initiatives may take the form of financial instruments and their ability to move industry forward is the raison d'être of environmental finance.

Environmental Finance

Environmental finance refers to instruments that enable an organization to execute its CS strategy or to carry out projects which might negatively impact the environment.

Mitigation credits refer to an agreed-upon unit of measure designed to compensate for the conversion of a wetland or habitat for economic purposes. These are not forms of currency in the monetary sense, however: firms use cash to purchase mitigation credits from mitigation banks. The EPA defines mitigation banks as "a wetland, stream, or other aquatic resource area that has been restored, established, enhanced, or . . . preserved for the purpose of providing compensation for unavoidable impacts to aquatic resources."[119] Such banks may be established by governments, corporations, or non-profit organizations.[120] When a bank sells a credit to a developer, the bank becomes a third party in the development process who bears responsibility for compensatory environmental mitigation.[121]

Carbon credits permit the holder to emit carbon dioxide (or equivalent greenhouse gas) into the atmosphere.[122] Like mitigation credits, carbon credits are created when a firm demonstrably reduces its emission of greenhouse gasses using guidelines of the Clean Development Mechanism (CDM) of the Kyoto Protocol. Collectively, these are traded in emission markets (also known as climate exchanges). Of note, in 2016 the total value of the world's carbon markets exceeded $74 billion.[123]

Green bonds (short for green building and sustainable design project bonds) are a third major category of environment finance instruments. These bonds are directed toward projects that promote energy efficiency, sustainability in agriculture, fishing, forestry, water management, and the development of environmentally friendly technologies.[124] The attractiveness of this category of bonds is that they are tax-exempt. Projects funded through green bonds must meet certain criteria which

may include certification by the U.S. Green Building Council.[125] Issuance of green bonds has grown from $2.6 billion in 2012 to $93.4 billion in 2016.[126]

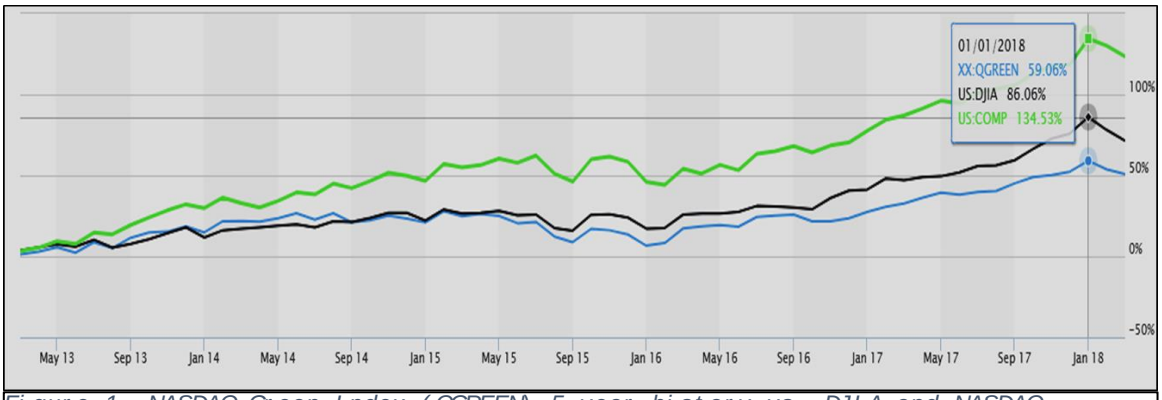

Figure 1. NASDAQ Green Index (QGREEN) 5-year history vs. DJIA and NASDAQ (Source: MarketWatch)

Investors may find and analyze investment opportunities in instruments like green bonds on a number of different indices. One such index is the NASDAQ Green family of indices which includes several sub-indices weighted toward companies that are associated with clean energy, fuel cells, green buildings, and pollution management, to name a few. As a composite index of several companies including Cisco Systems, Air Liquide, and the Simon Property Group, it has mirrored the movements of other major indices such as the Dow Jones Industrial Average and the NASDAQ Composite.[127]

Corporate Sustainability Strategies: Operationalizing Economics and Finance. Firms apply the principles of economics and the instruments of finance to develop and bring their corporate sustainability strategies to life. This section illuminates a number of shaping mechanisms that firms use to develop and guide their CSSs as well as a means to validate the alignment of their activities against industry norms.

A central concept that many companies apply to unify these fields is the triple bottom line (TBL). The TBL is a concept which was first brought into use in 1994 and tempers the traditional focus of a company–revenues vs. losses–with the degree to which a firm exercises social and environmental stewardship.[128] This does not always imply that social and environmental sustainability outcomes are on equal footing with concerns over profits and losses since companies are unlikely to pursue CSSs if doing so requires operating at a net loss. Instead, a firm's CS strategy must always seek to reduce cost or waste, or to add value.

CS strategies vary in scale and scope. In some cases, a firm's CSS may center on a small number of activities such as reducing emissions and waste. Grocery store chain Wegmans donates its unsalable food (e.g., day-old bread and imperfect produce) to local foodbanks. In 2017, the privately-held grocery chain donated 16.5 million pounds of food in this manner. The direct effect on the social fabric of the local area seems obvious as does the reduced impact on landfills.[129]

Alternatively, larger firms like Ford Motor Company have a broad portfolio of sustainability initiatives ranging from addressing human rights and working conditions in its worldwide operating locations to reducing end-of-life impacts of its automobiles.[130] Ford proclaims in its 60-page sustainability report, "[W]e're trusted by investors and other stakeholders to operate responsibly and transparently, living our promise to Go Further, The Right Way."[131] The ever-present investor and stakeholder interests in a firm (or in the case of a municipality, the taxpayer) demand that the entity seriously consider not only *what* activities it pursues as part of a CS, but *why* it is doing them at all.

Risk management is another prominent reason for implementing CS strategies. Reasons such as regulatory management and management of operational risks related to climate change were among the top drivers for pursuing CSSs in the McKinsey study.[132] For companies that work along these

lines, measurable progress toward environmental management may be difficult to quantify when reporting to regulators, stakeholders, and potential investors. Moreover, firms whose CSSs are in their nascence may benefit from proven and repeatable processes. For this reason, firms may wish to become ISO 14001 certified.

The International Organization for Standardization (ISO) developed the 14000-series of standards to address environmental responsibilities and the 14001 certification applies to those companies who wish to undertake a long-term approach to protecting the environment in balance with socio-economic needs.[133] These are voluntary standards which often exceed many regulatory mandates and may also serve to align a firm's operating culture with goals oriented toward the TBL. Through adherence to these standards, and with transparent reporting on progress, investors may look at ISO certification—and a firm's CSS, in general—as a value-added hedge against certain risks over the long run.

On Time Horizons and Value Creation. A tension exists between investors and the governing organs of a firm in which the investors often demand performance (e.g., profits or growth) over a short time period. A firm's CEO, cognizant of the demands of investors, must also steer the firm in a direction that will maintain its competitiveness and viability over the long-term. As a result, firms may be hesitant to pursue ambitious CSSs that require significant investment or borrowing and might take years to mature and realize value. For instance, in an effort to reduce emissions and energy consumption a major distributor may hold off converting its entire fleet from diesel to autonomous electric vehicles given the required investment to do so. However, through clearly stated and realistic goals whose progress are reported quarterly, the distributor may elect to phase in the use of wind or solar implements to power its facilities before pursuing more sweeping changes.

An example of where an incremental, time-phased approach has been successful is with sporting goods giant Adidas Group. As early as 1989 the company began eliminating the use of chlorofluorocarbons (CFC) in their products.[134] In the late 90s, the company turned it focus on its suppliers as it implemented what it now calls Workplace Standards which are contractual obligations between Adidas and its suppliers to apply guidelines based on international human rights conventions.[135] Almost every year since 2000, Adidas has added another element to enhance its TBL with its last major installment taking place in April 2016 where it went plastic-free in its stores.[136]

Toward the realization of CSS goals, companies may find opportunities to innovate. For instance, Waste Management has partnered with Canadian firm Enerkem Alberta Biofuels to convert non-recyclable solid waste into clean fuel and renewable chemicals.[137] Pursuing sustainability strategies may also reveal new business opportunities altogether. Established in 1996, HarborRock began operating in the aggregate business, specifically the disposal of dredged materials.[138] Prior to its entry into the market, dredged sediments were stored on large plots of land with few applications for follow-on use. However, HarborRock developed a means of converting the sediment into lightweight aggregate (LWA) using a cost-effective process. LWA is highly marketable and used worldwide in products like masonry blocks and structural grade concrete. The production of LWA also creates a permanent disposal solution for dredged materials.[139]

Whether companies in a given market compete on price (driven by operating costs), reputation, or differentiation, pursuing corporate sustainability strategies is a viable means to reduce waste and build value into a given brand or product. Anything that gives one firm an edge over a competitor is a positive thing. CSSs can help companies reduce the risks associated with climate change or regulations designed to protect the environment or group of people; however, the governing body of the firm must balance the implementation timeframe against cost, benefit, and investor expectations. Nevertheless, when adequately conceived, and properly executed, CSSs are a viable means toward value creation and can improve the overall competitiveness of a brand.

Conclusion. With the exception of Giant and Wegmans, the firms exemplified in this inquiry do not compete with one another. Yet they are all implementing, in their own way, measures that incorporate environmentally and socially-conscious outcomes to their business processes. Moreover, most of these companies have been doing so for several years and have remained key players in their industries. Each one – and thousands more firms like them throughout the world – is responding to the cross-cutting forces of investor expectations, mandates imposed by governments and international agreements, and an ever-growing base of customers who demand sustainably produced goods and services. What these firms are finding along the way is that CS strategies are not only a way to reduce costs, risks, and boost innovation, but a potential means of differentiation as their peers execute similar strategies. In short: corporate sustainability is becoming a means of survival unto itself.

"ENVIRONMENTAL TECHNOLOGIES"
LTC Ralph Radka, USA

The growth of the global community continues to place an increasing strain on the environment. Environmental science and technologies clean water, reduce air pollution, manage waste, and handle and dispose of toxic chemicals. More recently the industry has adapted to find new and better ways to reduce the amount of pollution or use less toxic chemicals during processing. Partners across the spectrum of society, industry, and government continue to work together to solve today's challenges and preserve our environment for the future.

C**lean Water.** Growing populations, agriculture needs, and industries continue to place an increasing demand on water. Recently, areas in the western United States under drought cut back agriculture and domestic availability. Around the world, North Africa, the Middle East, India, and China all deal with water shortage, toxicity, or cleanliness problems for their growing populations and industry.

Desalinization through reverse osmosis (RO) is a viable technology that has gained in popularity as improvements in membrane technology have reduced power needs and costs. Research continues to improve technology and reduce costs so that more regions can use RO and ultra-filtration systems to clean contaminated groundwater systems.

New technologies integrate nano-carbon technology into filter and RO-based membrane systems. Nano-filtration technology explores using one-atom-thick carbon sheets of graphene in filters and membranes, a technique that improves filter performance with ideal pore sizes when integrated into a filter matrix. One prototype of this technology can filter saltwater,[140] and other innovators seek similar solution through filter technology. Scientists at MIT have shown that a single-atom layer of carbon can comprise an entire filter membrane.[141] These advances in using graphene in water filters and membranes will improve performance and potentially lower costs, making them more versatile to treat a wide range of contaminants in water.

Cleaning contaminated groundwater aquifers has always been challenging and costly, and research focuses on decontamination underground (*in situ*). For years, anaerobic and aerobic underground biological treatment have also been used with pumps and barriers to control and degrade contaminates in the groundwater flow. Researchers have developed ways to inject liquid activated carbon into the ground to help adsorb chemicals such as polychlorinated or fluoridated hydrocarbons[142] and reduce contaminate concentrations before the groundwater is pumped to the surface for final treatment. Activated carbon has been used for years in above-ground systems, and this advance helps ensure our drinking water remains contaminant-free.

While the materials are plentiful, and the technologies are promising, filters and membranes need to be durable and cost-effective if the RO and ultra-filtration systems that use them will have costs, including energy and maintenance, comparable to traditional systems.

Waste Management. Waste management technologies are fairly mature within the United States and western world, and research focuses on taking recyclable elements out of the waste stream and landfilling the rest to protect groundwater and manage landfill gas and leachate.[143] Growing discontent with landfills as a waste solution and opportunities for profit will drive firms to seek innovative technology, with government support.

For example, the EPA is working with companies to improve technologies to degrade materials in landfills. These landfills optimize aerobic, anaerobic, and hybrid aerobic-anaerobic processes within the landfills to gain a number of enhancements. These enhancements include reducing post-closure care costs, rapidly enhancing land reduction stabilization, reducing leachate disposal costs, increasing landfill space use, and generate significantly more landfill gas. This enhanced gas production could then be used to create energy or converted to liquid natural gas for use in vehicles.[144]

Firms also seek technology to recycle plastics more economically. Paper and metal recycling is well developed and profitable, but plastics are more challenging because of the diversity of plastics in the waste stream. Polyethylene terephthalate (PET), used in plastic bottles and textiles, is one of the most common forms. Companies are currently testing technologies to break PET down to its base elements through biochemical depolymerization, so they could be re-created into new plastics. For example, bio-recycling uses enzymes to break down PET; researchers modified enzymes to increase their effectiveness, a step that makes this approach more viable for industrial application. [145] In another approach, heatless, pressureless technology breaks down PET into its monomers. Both technologies allow for the upcycling of the plastic into new bottles and other products.[146]

Clean Energy. Renewable and clean energy sources continue to grow both in the U.S. and globally. The widespread adoption has forced prices on wind and solar down consistent with traditional energy levels. Nations will continue to diversify their energy resources due to security concerns and the desire for clean and renewable sources. These concerns drive technology toward finding cheaper renewable energy alternatives, energy storage technologies to augment wind and solar, and carbon reduction technologies for existing traditional energy sources.

Silicon-based solar panels continue to expand across energy markets. While costs have dropped, they are still relatively expensive and only affordable with tax benefits. They are still fragile and the intricate process to produce them uses a great deal of energy. Now, researchers are looking at perovskite mineral based solar panels. Developments over the last five years resulted in energy transfer efficiencies of 20%. U.S. researchers are exploring ways to increase these efficiencies and to find cheaper manufacturing processes, advances that will expand the solar market into new areas and applications.[147]

The energy storage market is also growing in two different directions. The first looks to improve the current capabilities of lithium ion batteries with graphene, which increases the capacity, quickens recharge time, and reduces cell fatigue. In using graphene, researchers at the University of Warwick, England, found a new graphene anode could be "manufactured on an industrial scale and without the need to resort to the nano-sizing of silicon and its associated problems."[148] Alternatively, "blue batteries" use common, non-toxic, highly available, and sustainable materials to create large scale battery storage sites and limiting the availability of lithium may drive large scale storage solutions to use "blue battery" technologies due to the low cost and availability of materials. The Department of Energy's labs play a key role in improving energy storage technologies. In 2018 the DOE's Pacific Northwest National Laboratory (PNNL) discovered increasing the lithium-based salt in the battery electrolyte solution enables the battery to re-charge about seven times faster than traditional batteries.[149]

The viability of solar and energy storage has created a new industry: Microgrids. Advances in other technologies, such as the internet, enable the energy management of these grids and their tie-

ins with base utility grids, allowing the systems to adapt to renewable energy sources that fluctuate with the weather. The management systems can balance those elements against the varying costs of the base energy source and ability to contribute power back into the base grid. Microgrids can empower local users and communities with greater control over energy pricing and the "bureaucratic maze" of a power utility, "creating new cost-saving opportunities."[150]

Traditional coal, oil, and gas facilities will continue to operate for some time to meet the bulk of our energy needs. While technologies exist to clean emissions in order to meet current air quality standards, these facilities still contribute CO_2 to climate change. Some carbon-capture technologies are in development and in 2018 the Department of Energy selected seven projects to research and develop carbon capture technologies on current production plants. The projects will target both solvent or membrane-based CO_2 capture technologies or projects designing a commercial style post-combustion CO_2 capture system for use at an existing coal electrical plant. The Department of Energy has also been researching similar carbon transformation technologies out of its Oak Ridge Laboratory. Using a "nanotechnology-based catalyst which contains multiple reaction sites" the researchers turned 63% of the CO_2 dissolved in water into ethanol. [151]

Conclusion. Researchers within the industry, private firms, universities, funded by investments and sponsorship from state and local governments, work aggressively and cooperatively on evolving environmental technologies. As the population of the world and global industries grow, the strain they will place on the environment will only increase, making the science and technology limiting those impacts more important to every community and business.

"ENVIRONMENTAL LAW"
Dr. Gerard Garino, U.S. Department of Energy

The body of law that governs environmental regulation in the United States is controversial. Proponents see environmental regulation not only as a way to preserve nature, but also as a way to gain economic, scientific, health, and ecosystem service benefits. Opponents see regulation as an overreach of government authority and as unnecessary, inefficient, and costly. This inquiry surveys key U.S. statutes and the primary UN agreement on environmental affairs.

Clean Air Act. The first federal law regarding air pollution was the Air Pollution Control Act of 1955, which funded research on the problem. The Clean Air Act of 1963 first authorized control of air pollution, and as amended the Clean Air Act (CAA) of 1970, administered by the EPA, extended federal authority to regulate air pollution. The CAA is "a major environmental law milestone that became the model, in whole or part, for virtually every subsequent federal environmental statute."[152] The EPA has "comprehensive authority" to regulate and control the six "criteria pollutants": ground-level ozone, particulates, sulfur dioxide, nitrogen dioxide, carbon monoxide and lead.[153] The EPA sets National Ambient Air Quality Standards, or NAAQS, for the criteria pollutants. The states then submit to the EPA implementation plans to attain those standards. In regions where a state fails to attain a NAAQS ("non-attainment areas"), the state must limit impose emission limitations on new and existing sources to bring about attainment. The EPA regulates emissions from stationary sources in any category that the EPA determines to cause or contribute significantly to air pollution, and this has ramifications for carbon dioxide emitters. The CAA also authorized the EPA to set emission standards for mobile sources and determine automobile fuel standards.

In the 2007 landmark case *Massachusetts v. EPA* the Supreme Court sustained the EPA's authority to regulate greenhouse gas (GHG) emissions, and in so doing ratified the science of climate change.[154] The EPA issued its Clean Power Plan (CPP) to regulate GHG emissions from existing power plants.[155] The CPP is very controversial because it would affect mostly coal fired plants, which have higher GHG emission rates than natural gas plants. The EPA received over 4 million comments

on this rule, the most ever.[156] The CPP is pending review in federal appellate court, and it likely will go to the Supreme Court.

The CAA "has clearly reduced emissions and improved air quality."[157] The economic benefits are estimated to be 40 times the estimated costs of pollution reduction programs it requires.[158] Mortality and morbidity are lower, with less spent on medical bills, and cleaner air improves visibility and reduced grime on buildings. Despite the great benefits of the act, air pollution remains a significant problem and society still grapples to control greenhouse gases.

United Nations Framework Convention on Climate Change. Perhaps the most significant environmental issue of our time is global climate change caused by increased levels anthropogenic carbon dioxide (CO_2) in the atmosphere, leading to a warming of the planet.[159] The United Nations Framework Convention on Climate Change (UNFCCC) is a treaty the purpose of which is "to achieve . . . stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[160] The UNFCCC is a framework treaty to facilitate future cooperation among nations. The US ratified the convention in 1992. In 1997, the UNFCCC's Conference of Parties (COP) convened and adopted the Kyoto Protocol, establishing legally binding GHG emission targets to be met by 2012 for some, but not all, countries. This bifurcation of countries into developed and undeveloped categories was controversial and because of this and domestic US politics, the United States singed the Kyoto Protocol but never submitted it to the Senate for ratification.

Dissatisfaction with the Kyoto Protocol led to the Paris Agreement at the COP meeting in 2015. This Agreement did not set legally binding GHG emission targets, but instead required countries to individually define Nationally Determined Contributions (NDC) towards reducing global GHG emissions. NDCs should be ambitious given a county's situation and are to be revised every five years and become progressively more ambitious. There is no bifurcation between developed and other countries, though the Agreement recognized "common but differentiated responsibilities and respective capabilities, in the light of different national circumstances."[161] The Paris Agreement also explicitly recognized "the importance of the engagements of all levels of government and various actors."[162]

The U.S. signed the Paris Agreement, but the Obama administration determined that it did not need to be ratified by the Senate.[163] However, in June 2017 President Trump announced that the U.S. would withdraw from the Paris Agreement[164] but some states, cities, and companies continue to pledge GHG reductions.[165]

There are several factors to consider in determining the success and effectiveness of the Paris Agreement, including what the parties are pledging, whether they will meet their pledge goals, and whether the pledge goals go far enough. The two largest emitters of GHG are the United States and China. Emissions of GHG in the U.S. have generally been declining in recent years, due the Great Recession in 2007 and the increased use of natural gas for electricity generation.[166] EPA data show that the U.S. GHG emissions per capita and per dollar of real gross domestic product are below 1990 levels.[167] However, the Trump administration withdrew the Clean Power Plan, ordered review of new automobile fuel efficiency standards, and ended a methane rule for oil and gas wells.[168] Without strong federal leadership in this area, it is unlikely that the U.S. will be able to meet its targets, which are supposed to be ambitious in the first place. China, the second largest emitter of GHG, has pledged to peak carbon dioxide emissions by 2030, meaning they will continue to increase until then. They also pledge to increase the share of non-fossil fuels to 20% of energy consumption, and to increase forest volume above the 2005 level.[169]

Clean Water Act. Today's Clean Water Act is the result of 1972 amendments to the Federal Water Pollution Control Act. The Act controls pollution at the source by making it illegal to discharge any pollutant without a permit. The EPA sets the requirements and the states implement them. The

1972 act addressed point sources of pollution. The 1987 amendments required states to begin developing plans for controlling nonpoint-source pollution, such as runoff from agricultural and urban areas.

The CWA provides for federal funding to water treatment plants and regulates industrial and municipal wastewater discharges into waterways. The CWA requires that the best technology be used to remove pollutants from the water to be discharged. For sewage, the act requires secondary treatment, which is the removal of not only suspended solids but also biodegradable organic materials. The act also requires states to set overall water quality standards. For each of the waters where the water quality standards are not met, the state sets a Total Maximum Daily Load (TMDL) of pollutants. The EPA estimates that more than 40,000 waters do not meet water quality standards and require TMDLs.[170]

In contrast to the Clean Air Act, which has clearly been effective, the levels of pollutants in waters have decreased since the CWA, but it is unclear if the CWA is responsible for this. And the CWA comes at tremendous cost. Since 1972, $1 trillion has been spent to abate water pollution,[171] and an EPA report shows that the quantified benefits of the CWA may be less than the costs.[172]

National Environmental Policy Act. The National Environmental Policy Act (NEPA) was enacted in 1969. NEPA is the first national law of its kind, and since 1969 has been widely emulated throughout the world.[173] Indeed, one of the main criticisms of NEPA is that it is overly concerned with generating paper for paper's sake. The Council on Environmental Quality, which itself was created by the NEPA legislation, oversees the law's implementation.

NEPA requires that before a federal agency can undertake a new project, it must do an Environmental Assessment (EA) to assess the project's impacts on the environment. If potentially significant impacts are discovered, then an Environmental Impact Statement (EIS) is required. An agency may define Categorical Exclusions (CE) for which an environmental assessment is not needed because there is no potential for significant environmental impact. NEPA applies to federal agencies, but private firms may become involved if, for instance, a proposed private project uses federal land. The EPA also reviews EISs and maintains an EIS national filing system. However, there is no single agency tasked with NEPA enforcement. Because of this, disputes over EIS often end up in court.

The benefits of the law are even more difficult to assess because they are qualitative and anecdotal. The main benefit is that the NEPA process allows the public to comment. A report by the Environmental Law Institute cites examples where the NEPA process led to impact mitigation, creation of collaborative partnerships, and consensus, creative and alternative solutions.[174]

Endangered Species Act. The modern Endangered Species Act (ESA) was signed into law by President Nixon in 1973. The law seeks to conserve and protect endangered and threatened species, the habitats on which they depend, and to achieve the purposes of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and other relevant treaties.[175] These laws are significant because they seek to preserve non-human life, including plant life, and its habitats. This and other environmental laws are controversial because they can be surrogates for battles over diminishing resources.[176] For instance, for construction of the Tellico Dam, more land was condemned than needed to allow waterfront development, and Cherokee Indian artifacts and a river used for recreation would be lost.[177] After other legal means failed to stop the dam, the endangered snail darter was discovered and listed as an endangered species. In the seminal ESA case, the Supreme Court decided in *TVA v. Hill* that construction of a dam, on a site that threatened Cherokee artifacts and recreation sites, could not proceed because the ESA protected the endangered snail darter.[178]

The law can also be problematic for the military. The Department of Defense (DOD) defines encroachment as factors "that constrain or have the potential to inhibit the full access or operational use of the live training and test domain"[179] and endangered species and their habitats are one such

factor. DOD faces increasing challenges from encroachment.[180] One of the reasons is that military bases have become islands of species diversity in seas of development.[181] Thus, a large number of endangered species are found on military installations. This problem will likely only become worse as other habitat is lost to development. DOD manages its lands to prevent species at risk from being listed as endangered, at which point they become more difficult and more expensive to manage.[182]

Conclusion. During the Olympics in Beijing, nearby factories were ordered to suspend some operations to improve air quality for the Games.[183] Without the Clean Air Act, the air over many cities in the United States would be dense with smog like the air over cities in China. These laws aim, as the National Environmental Policy Act says, to fulfill the requirements not only of this generation, but future generations as well.

CONCLUSION

At one level, it is almost impossible to improve on the seemingly incontrovertible conclusions contained in Environmental Business International's most recent annual overview of the Environment Industry:

First, "Future opportunities for environmental companies lie in effective resource management and not environmental management. In the 21th century, society faces the tremendous challenge of reconciling environmental and economic concerns. . . . The underlying quest is to internalize the economic externalities of pollution, environmental degradation and wasted resources into an economic system that values the environment rather than freely permitting its exploitation. What does this mean for the future of the environmental industry? . . . Environmental providers must become resource managers as well as environmental managers if they are to fully integrate themselves with their industrial and government clients. . . . Future competitiveness of all industries and nations will increasingly depend on the efficient allocation, management and reuse of resources."[184]

Second, "Outside the developed nations of North America, Western Europe and Japan, a different but complementary approach must be taken to environmental business development. As developing and emerging nations attempt to catch up to the developed world in terms of standard of living and environmental quality, inestimable investments will need to be made in water, energy and waste infrastructures and resource management systems. . . . If it was the challenge of the past 20 years to reverse the pace of environmental degradation, the challenge of the next 20 years is to consolidate the transition into sustainable economy. . . . The world will not be governed by centrally planned economies; it will be ruled by the free market."[185]

At an even more elevated level, such observations command attention to the business implications of the UN Sustainable Development Goals now playing such a key national planning role in countries all over the world. The more than 35 CEOs and civil society leaders of the Business & Sustainable Development Commission have concluded that new sustainable business models could open economic opportunities worth up to $12 trillion and increase employment by up to 380 million jobs by 2030. Putting the SDGs at the heart of the world's economic strategy, they contend, could unleash a step-change in growth and productivity, with an investment boom in sustainable infrastructure as a critical driver. Business needs the SDGs, which offer a compelling growth strategy for individual businesses, business more generally, and the world economy; and the SDGs in turn need business, which necessarily must seize the market opportunities they open up if the abundance they promise is to be realized.[186]

This, then, defines the future playing field for a U.S. Environment Industry that, faced with a growing array of challenges and opportunities, remains a vibrant, still growing leader in the field, whose continued success calls out for national-level commitment.

APPENDIX A: Environmental Business International Environmental Industry Structure

Exhibit 1-2 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, C&E, Hazardous waste and remediation contractors
Wastewater Treatment Works	Collection and treatment of residential, commercial and industrial wastewaters. Facilities are commonly known as POTWs or publicly owned treatment works.	Municipalities, Commercial Establishments & All industries
Water Utilities	Selling water to end users: Municipal entities and private companies	Consumers, Commercial, All industries, Institutions
Solid Waste Management	Collection, processing and disposal of solid waste & commercial collection of recyclables	Municipalities & All industries
Hazardous Waste Management	Collection, processing and disposal of hazardous, medical waste, nuclear waste	Chemical, Petroleum, Mfgrs Government agencies
Remediation and Industrial Services	Cleanup of contaminated sites, buildings and environmental cleaning of operating facilities	Government agencies Property owners, Developers 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	Technology for in-process pollution prevention and waste 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	Solar, wind, biomass, fuel cell, geothermal, and wave & tidal: Systems sales and Power value	Utilities All industries and consumers

Source: Environmental Business International Inc. (San Diego, Calif.)

APPENDIX B: United Nations Sustainable Development Goals (SDGs)

Goal 1 End poverty in all its forms everywhere.
Goal 2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
Goal 3 Ensure healthy lives and promote well-being for all at all ages.
Goal 4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
Goal 5 Achieve gender equality and empower all women and girls.
Goal 6 Ensure availability and sustainable management of water and sanitation for all.
Goal 7 Ensure access to affordable, reliable, sustainable and modern energy for all.
Goal 8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
Goal 9 Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
Goal 10 Reduce inequality within and among countries.
Goal 11 Make cities and human settlements inclusive, safe, resilient and sustainable.
Goal 12 Ensure sustainable consumption and production patterns.
Goal 13 Take urgent action to combat climate change and its impacts.
Goal 14 Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
Goal 15 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 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 Strengthen the means of implementation and revitalize the global partnership for sustainable development.

APPENDIX C: Yale/Columbia Environmental Performance Index

The Environmental Performance Index ranks 180 countries on 24 performance indicators across 10 issue categories covering environmental health and ecosystem vitality. These metrics provide a general gauge of the environmental performance of individual countries.

2018 EPI RANKINGS

RANK	COUNTRY	SCORE	REG
1	Switzerland	87.42	1
2	France	83.95	2
3	Denmark	81.60	3
4	Malta	80.90	4
5	Sweden	80.51	5
6	United Kingdom	79.89	6
7	Luxembourg	79.12	7
8	Austria	78.97	8
9	Ireland	78.77	9
10	Finland	78.64	10
11	Iceland	78.57	11
12	Spain	78.39	12
13	Germany	78.37	13
14	Norway	77.49	14
15	Belgium	77.38	15
16	Italy	76.96	16
17	New Zealand	75.96	1
18	Netherlands	75.46	17
19	Israel	75.01	1
20	Japan	74.69	1
21	Australia	74.12	2
22	Greece	73.60	18
23	Taiwan	72.84	2
24	Cyprus	72.60	19
25	Canada	72.18	20
26	Portugal	71.91	21
27	United States of America	71.19	22
28	Slovakia	70.60	1
29	Lithuania	69.33	2
30	Bulgaria	67.85	3
30	Costa Rica	67.85	1
32	Qatar	67.80	2
33	Czech Republic	67.68	4
34	Slovenia	67.57	5
35	Trinidad and Tobago	67.36	1
36	St. Vincent & Grenadines	66.48	2
37	Latvia	66.12	6
38	Turkmenistan	66.10	7
39	Seychelles	66.02	1
40	Albania	65.46	8
41	Croatia	65.45	9
42	Colombia	65.22	2
43	Hungary	65.01	10
44	Belarus	64.98	11
45	Romania	64.78	12
46	Dominican Republic	64.71	3
47	Uruguay	64.65	3
48	Estonia	64.31	13
49	Singapore	64.23	3
50	Poland	64.11	14
51	Venezuela	63.89	4
52	Russia	63.79	15
53	Brunei Darussalam	63.57	4
54	Morocco	63.47	3
55	Cuba	63.42	4
56	Panama	62.71	5
57	Tonga	62.49	3
58	Tunisia	62.35	4
59	Azerbaijan	62.33	16
60	South Korea	62.30	5
61	Kuwait	62.28	5
62	Jordan	62.20	6
63	Armenia	62.07	17
64	Peru	61.92	6
65	Montenegro	61.33	18
66	Egypt	61.21	7
67	Lebanon	61.08	8
68	Macedonia	61.06	19
69	Brazil	60.70	7
70	Sri Lanka	60.61	6
71	Equatorial Guinea	60.40	2
72	Mexico	59.69	8
73	Dominica	59.38	5
74	Argentina	59.30	9
75	Malaysia	59.22	7
76	Antigua and Barbuda	59.18	6
77	United Arab Emirates	58.90	9
78	Jamaica	58.58	7
79	Namibia	58.46	3
80	Iran	58.16	10
81	Belize	57.79	10
82	Philippines	57.65	8
83	Mongolia	57.51	9
84	Serbia	57.49	20
84	Chile	57.49	11
86	Saudi Arabia	57.47	11
87	Ecuador	57.42	12
88	Algeria	57.18	12
89	Cabo Verde	56.94	4
90	Mauritius	56.63	5
91	Saint Lucia	56.18	8
92	Bolivia	55.98	13
93	Barbados	55.76	9
94	Georgia	55.69	21
95	Kiribati	55.26	4
96	Bahrain	55.15	13
97	Nicaragua	55.04	14
98	Bahamas	54.99	10
99	Kyrgyzstan	54.86	22
100	Nigeria	54.76	6
101	Kazakhstan	54.56	23
102	Samoa	54.50	5
103	Suriname	54.20	15
104	São Tomé and Príncipe	54.01	7
105	Paraguay	53.93	16
106	El Salvador	53.91	17
107	Fiji	53.09	6
108	Turkey	52.96	24
109	Ukraine	52.87	25
110	Guatemala	52.33	18
111	Maldives	52.14	10
112	Moldova	51.97	26
113	Botswana	51.70	8
114	Honduras	51.51	19
115	Sudan	51.49	14
116	Oman	51.32	15
117	Zambia	50.97	9
118	Grenada	50.93	11
119	Tanzania	50.83	10
120	China	50.74	11
121	Thailand	49.88	12
122	Micronesia	49.80	13
123	Libya	49.79	16
124	Ghana	49.66	11
125	Timor-Leste	49.54	14
126	Senegal	49.52	12
127	Malawi	49.21	13
128	Guyana	47.93	20
129	Tajikistan	47.85	27
130	Kenya	47.25	14
131	Bhutan	47.22	15
132	Viet Nam	46.96	16
133	Indonesia	46.92	17
134	Guinea	46.62	15
135	Mozambique	46.37	16
136	Uzbekistan	45.88	28
137	Chad	45.34	17
138	Myanmar	45.32	18
139	Côte d'Ivoire	45.25	18
140	Gabon	45.05	19
141	Ethiopia	44.78	20
142	South Africa	44.73	21
143	Guinea-Bissau	44.67	22
144	Vanuatu	44.55	7
145	Uganda	44.28	23
146	Comoros	44.24	24
147	Mali	43.71	25
148	Rwanda	43.68	26
149	Zimbabwe	43.41	27
150	Cambodia	43.23	19
151	Solomon Islands	43.22	8
152	Iraq	43.20	17
153	Laos	42.94	20
154	Burkina Faso	42.83	28
155	Sierra Leone	42.54	29
156	Gambia	42.42	30
157	Republic of Congo	42.39	31
158	Bosnia and Herzegovina	41.84	29
159	Togo	41.78	32
160	Liberia	41.62	33
161	Cameroon	40.81	34
162	Swaziland	40.32	35
163	Djibouti	40.04	36
164	Papua New Guinea	39.35	21
165	Eritrea	39.34	37
166	Mauritania	39.24	38
167	Benin	38.17	39
168	Afghanistan	37.74	22
169	Pakistan	37.50	23
170	Angola	37.44	40
171	Central African Republic	36.42	41
172	Niger	35.74	42
173	Lesotho	33.78	43
174	Haiti	33.74	12
175	Madagascar	33.73	44
176	Nepal	31.44	24
177	India	30.57	25
178	Dem. Rep. Congo	30.41	45
179	Bangladesh	29.56	26
180	Burundi	27.43	46

Rank, EPI Score, and Regional Standing (REG, shown in color) for 180 countries.

Asia
Latin America
Caribbean
Mid East & N.Africa
E.Europe & Eurasia
Pacific
Europe & N.America
Sub-Saharan Africa

ENDNOTES

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[22] "Ranking of Environmental Markets by Client: 2017-2018 [Exhibit 1-209]", *EBI (Report 2020-B),* 1-262.

[23] "Exhibit 1-200 - Rate what you believe the impact of the federal government will be on the following areas as they affect environmental markets or the economy in 2017-2018," Exhibit 1-200, *EBI (Report 2020-B)*, 1-258.

[24] *EBI (Report 2020-B)*, 1-188.

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[27] "Exhibit 1-211 Ranking of Environmental Markets by Media," *EBI (Report 2020-B)*, 1-264.

[28] Ibid.

[29] *EBI (Report 2020-B)*, p. 1-214.

[30] "Exhibit 1-211 Ranking of Environmental Markets by Media," *EBI (Report 2020-B)*, 1-264.

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