BUILDING FOR HEALTH

THE NEXUS OF GREEN BUILDINGS, GLOBAL HEALTH, AND THE U.N. SUSTAINABLE DEVELOPMENT GOALS

HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH
Center for Health and the Global Environment

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BUILDING FOR HEALTH

EXECUTIVE SUMMARY

Winston Churchill famously once declared, "We shape our buildings; thereafter they shape us." We recognize today that Churchill was more right than he knew. Buildings are the places where we express our culture and create the spaces where we safely share our traditions, nurture our bodies and minds and bring solace to the outer stresses in our lives. Yet, the way we design, construct, operate and maintain our buildings determines if they will act as a constant assault on our health or if they will be a place that promotes health and wellbeing.

"We Shape our Buildings; Thereafter They Shape Us."

Winston Churchill

Buildings define our skylines, creating the bland and forgettable or the iconic and identity-forming. They can wall us off from nature or connect us to it. They can be prisons of isolation or they can engage us with our community. They are places where people find economic opportunity or misfortune. Buildings can waste energy, water, and materials on a grand scale, or they can be 'net zero' and laboratories for innovative technologies. They can raze the surrounding landscape for miles, or can be built in harmony with the natural landscape. Buildings can exacerbate the impacts of severe weather, or they can be places of refuge during heat waves, floods and storms. They can act as conduits for outdoor air pollution to be carried into our homes, offices and schools, or they can block or trap these pollutants at the building's edge. They can make us feel unsafe and threatened, or they can be secure and protective, providing comfort and ease of mind.

Today Churchill may have said, "We shape our buildings, thereafter they shape **PUBLIC HEALTH**."

Within the four walls, buildings influence the air we breathe, the water we drink, the light we see (or don't) and many other factors that determine **INDOOR HEALTH**.

As the global population continues to rise with more and more of us in urban centers, the demand for new buildings and cities increases accordingly, straining our natural systems and **RESOURCE HEALTH** as we strive to build for today without stealing from tomorrow.

And buildings are engines of economic growth and innovation, providing opportunity for work and advancing **ECONOMIC HEALTH**.

Last, buildings are a major consumer of energy globally, a production system that currently relies on fossil fuels. These fuel sources threaten our **ENVIRONMENTAL HEALTH** by polluting our air, water and food systems, and are the cause of global climate change, perhaps the largest public health threat we face today.

"The pathways to sustainable development will not be identified through a top-down approach, but through a highly energised era of networked problem solving that engages the world's universities, businesses, non-governmental organisations, governments, and especially young people, who should become the experts and leaders of a new and profoundly challenging era."

Jeffrey Sachs, Columbia University
The Lancet, 2012, From MDGs to SDGs

THE NEXUS OF GREEN BUILDINGS, GLOBAL HEALTH AND THE U.N. SUSTAINABLE DEVELOPMENT GOALS

To meet the challenges of rapid urbanization, natural resource constraints, and global climate change, as well as those posed by severe poverty and inequality around the world, the United Nations (UN) developed a framework, known as the Sustainable Development Goals (SDGs), to encourage sustainable, equitable, and environmentally-conscious development by governments, private sector, and society over the subsequent 15 years. In this report, *The Nexus of Green Buildings, Global Health and the U.N. Sustainable Development Goals,* we explore how green buildings intersect with 11 of the 17 goals.

BUILDING FOR HEALTH

We see green buildings, with their focus on Indoor Health, Resource Health, Economic Health and Environmental Health, as playing a critical role in advancing the Sustainable Development Goals and public health globally.

"Quite simply, buildings are at the epicenter of our sustainable urbanization efforts that will determine our current and future health."

Joseph G. Allen, Harvard University
Director, Healthy Buildings Program

INTRODUCTION: A CHANGING WORLD

Rapid Urbanization

For thousands of years we have organized societies around buildings. Groups of buildings became villages, villages became towns and, eventually, cities. A few years ago, for the first time ever, more people were living in cities than outside of them. As populations consolidated into cities, population growth skyrocketed. Fewer than 1.5 billion people lived on earth in 1800. A mere 200 years later, human population surpassed 7 billion people and may reach 9 billion halfway through this century with as many as two-thirds of all people living in cities (US Census Bureau, 2017; United Nations, 2017; United Nations, 2014)

Urban growth will impact cities large and small, but the fastest growth will be seen in mid-sized cities of about 1 million people (United Nations, 2014). Considering population growth together with rapid urbanization and that most people spend most of their time indoors (Klepeis, 2001) makes clear that buildings will have an outsized impact on health globally for decades to come.

"When you think of the urbanization that's going on around the world now, we will see a doubling of our built environment before our century is over. We better do it right, both energy-wise and materials-wise, to optimize the human condition in those places."

John D. Spengler, Harvard University,
Director, Center for Health and the Global Environment

Natural Resource Constraints

We use the equivalent of 1.5 Earths to maintain our current standard of living (Ewing et al., 2010). As our population and cities have expanded, many natural resources have been overly taxed to keep pace with this growth, creating unsustainable demands on the ecosystem. Urban development has endangered many species and habitats, and the proximity between natural resources and cities is decreasing over time (Mcdonald et al., 2008). Urban population growth may be the largest driver of deforestation, as it drives timber demand for building and construction materials (DeFries et al., 2010; Ramage et al., 2017). By 2050, 5 billion people are expected to live in water stressed areas (Schlosser et al., 2014). Oceans, too, have been overexploited largely at the behest of urbanites. Most ocean fisheries are harvested at or above sustainable yields and pollution from plastics, chemicals and sewage affects almost every corner of the world's oceans which mostly comes from coastal cities.

A Changing Climate

Climate change compounds the challenges of urbanization and natural resource depletion. Buildings account for about 40% of energy consumption globally, and most of the energy they consume comes from fossil fuels that produce planet-warming greenhouse gases when burned. Under the influence of human produced greenhouse gas emissions, global temperatures have increased by 0.85°C (1.53°F) (United Nations, 2015), and are expected to increase another 2-4C (3.6-5.4°F) by the end of the century, depending

upon global greenhouse gas emission in the near future (United Nations, 2015). Heatwaves have become more frequent and severe, with many cities facing 2-3 times as many heatwave days by 2100. From 1901-2010, sea levels rose 19cm (0.6ft), on average, and are expected to rise an additional 50cm-1.5m, and perhaps substantially more (0.8-2ft) by the end of the century, depending on geographic location (United Nations, 2015). According to a report from the National Academies of Science and the Institute of Medicine (2011) our heaviest rainfall events are producing 20% more precipitation than in the last century, increasing the likelihood of flooding events. However, some areas of the globe are projected to experience drier conditions, with droughts becoming more probable in the future. Because of their resource footprints, energy consumption, and land use for development, the buildings that we live and work in are contributing to climate change, and yet will also become increasingly compromised by these climate change impacts.

"A look at the forecasts in the U.S. government's National Climate Assessment for the year 2100 makes you realize how many lives could be saved, how many illnesses could be prevented, by doing what we already know how to do to mitigate climate change. Reducing greenhouse gases in the Earth's atmosphere may be the greatest public health intervention ever."

Aaron Bernstein, Harvard University; Boston Children's Hospital; Associate Director, Center for Health and the Global Environment

The United Nations Sustainable Development Goals

To meet these challenges, as well as those posed by severe poverty and inequality around the world, The United Nations (UN) developed the Sustainable Development Goals (SDGs) to encourage sustainable, equitable, and environmentally conscious development by governments, private sector, and society over the subsequent 15 years. Launched in 2015, the 17 SDGs promote innovative and collaborative actions from all countries, regardless of economic development, to end global poverty and protect environmental resources for future generations (United Nations, 2015). Unlike the past Millennium Development Goals, the SDGs directly and indirectly address the built environment and so provide a North Star for advancing public health through buildings while safeguarding the health of our planet or its inhabitants for generations to come.

"The bonds that tie the environment to human health transcend political and geographic boundaries. What we do now will determine our collective health for generations."

Environmentalist Papers No. 1

THE NEXUS OF GREEN BUILDINGS, PUBLIC HEALTH AND THE U.N. SDGS

1 BUILDING SDGS, GROUP 1
PUBLIC HEALTH AS THE FOUNDATION

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

Using the UN SDGs as the starting framework we posed a question:

> *What is the role of buildings in advancing the SDGs and addressing the challenges posed by rapid urbanization, natural resource constraints, and climate change?*

In short, buildings play a critical role in the challenges we face, but they can also play a role in helping us overcome these challenges in sustainable and equitable ways. And one class of buildings in particular, green buildings, represent a gateway into a truly sustainable future. In their first 25 years of existence, the green building movement has edified the entire building industry with best practices in the design, construction and operation of buildings, to the extent of substantially influencing our current building codes.

THE NEW ERA OF GREEN BUILDINGS

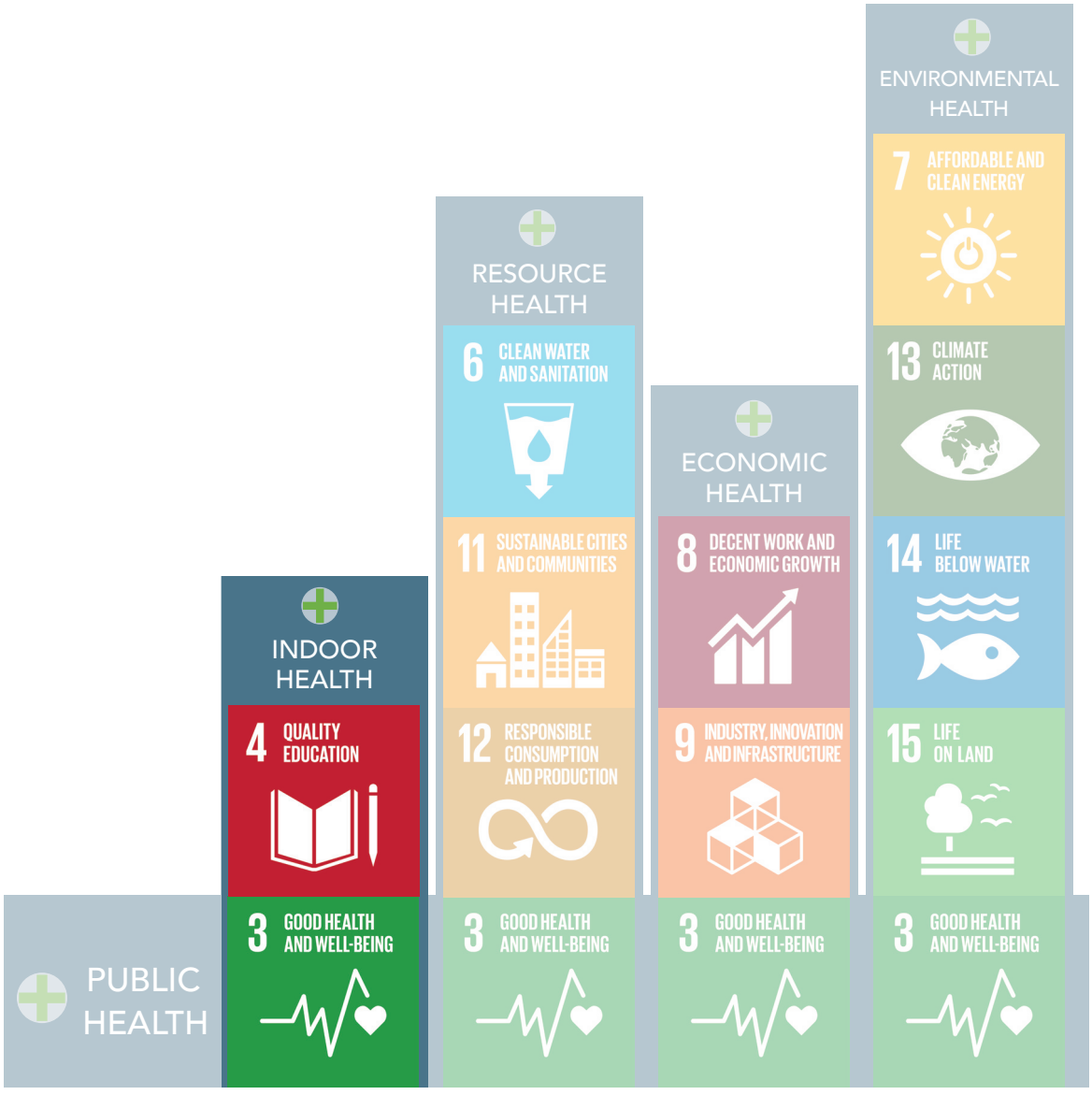
The potential for green buildings to be a truly transformational public health tool has not been fully realized. To date green buildings have been defined and valued by their focus on energy conservation. The future, however, is an enhanced definition of the green building movement that places health at the foundation of all buildings and ensures that green building principles reach everyone, not just those in developed countries.

This new era of green buildings, with goals of providing enhanced indoor environmental quality **(INDOOR HEALTH),** decreasing consumption of materials and water, and reducing waste **(RESOURCE HEALTH)** acting as platforms for technological innovation and employment **(ECONOMIC HEALTH)** and reducing energy consumption and concomitant pollution emissions **(ENVIRONMENTAL HEALTH),** is a key starting point for advancing sustainable solutions and **PUBLIC HEALTH** globally.

2 BUILDING SDGS, GROUP 2
INDOOR HEALTH

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

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



INDOOR HEALTH

The World Health Organization estimates that 25% of all diseases globally are attributable to the environment, resulting in more than 12 million deaths annually (World Health Organization, 2016b). Reducing the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination begins with reducing daily adverse exposures to these hazards. Nowhere is this more important than inside the four walls of the building for the simple reason that this is where we spend most our time. Currently, the average lifespan across the developed world is about 70 years (World Bank, 2017). By the time we reach this age, over 60 years of our life will be spent indoors.

A robust body of research produced over 40 years on the importance of the indoor environment has revealed what we call the 9 Foundations of a Healthy Building: ventilation, thermal health, air quality, moisture, dust and pests, safety and security, water quality, noise, and lighting and views (9 Foundations of a Healthy Building, 2016). For example, poor indoor air quality and ventilation are associated with increased sick building symptoms, altered infectious disease transmission, and reduced cognitive function (Daisey et al., 2003; Mendell, et al., 2008; Allen et al., 2015; Sundell et al., 2011; Glas et al., 2014; Song et al., 2016; Allen et al., 2017; Spengler et al., 2001). Unfavorable thermal conditions have been found to negatively impact eye and throat irritation, headaches, heart rate, respiratory symptoms, mood, and thinking and performing (Spengler et al., 2001; Bluyssen et al., 2015; Lan et al., 2011; Allen et al., 2017). The significance of indoor environmental quality extends beyond air quality and thermal health to well-known hazards like asbestos, to biological hazards like mold and *Legionella,* to chemical hazards like formaldehyde and benzene, to allergens from animals and pests, to water quality issues like lead and arsenic in drinking water, and even to radiological hazards like radon, a ubiquitous gas that enters our buildings from the ground below and the second leading cause of lung cancer globally (Spengler et al., 2001).

"Under the principle of accountability, all relevant organizations should establish explicit criteria for evaluating and assessing building air quality and its impact on the health of the population and on the environment"

World Health Organization
The Right to Healthy Indoor Air, 2000

The influence of buildings on health is grossly apparent in schools, a focus of Goal 4. There are many facets to a high-quality education, of course, but the one that often gets ignored is the role of the building. There is overwhelming scientific evidence shows that the school building influences student health, student thinking and student performance (Schools for Health, 2017). For example, student health is sensitive to thermal characteristics including humidity, which have been associated with the development and exacerbation of respiratory symptoms in adults and children in schools. Low absolute humidity has been associated with increased influenza virus survival and transmissibility and the onset of seasonal influenza outbreaks (Koep et al., 2013; Myatt et al. 2010). Many schools in the developed world are also chronically under ventilated, with a cost to student learning. As one example, researchers observed a 5% decrement in students' ability to concentrate in poorly ventilated classrooms, roughly equivalent to the impact that a student might feel from skipping breakfast (Coley et al., 2007). Other studies link low ventilation to greater fatigue, impaired attention span, and loss of concentration (Chatzidiakou et al., 2012); poorer performance on tests of concentration (Dorizas et al., 2015); and lower levels of focus among university students during lectures (Uzelac et al., 2015). Importantly, when we act we see an immediate impact; multiple studies

have shown that when steps to mitigate poor IEQ are taken, student performance improves (Basch, 2011; Centers for Disease Control and Prevention, 2009; La Salle and Sanetti, 2016; Michael et al., 2015). In one study, fifth-grade students in 54 U.S. classrooms reported evidence of an association between ventilation rates and pupils' performance on standardized mathematics tests (Shaughnessy et al., 2006). Similarly, in a study of 100 U.S. elementary classrooms, positive associations were observed between ventilation rates and performance on standardized tests in math and reading, with researchers estimating that even modest increases in ventilation rates (1 liter per second per person) was associated with an expected increase of 2.9% and 2.7% in math and reading scores, respectively (Haverinen-Shaughnessy et al., 2011).

Green Buildings and Indoor Health

Building for health begins with optimizing the indoor environment (Spengler and Sexton, 1983; Spengler and Chen, 2000; 9 Foundations of a Healthy Building, 2016), and all green building standards have a focus on enhancing indoor air quality. In one green-building standard, LEED Version 4, there are 13 credits related to indoor environmental quality included in the rating system. These include measures for filtering the air, radon-resistant construction, and ensuring adequate ventilation, with additional credits for enhanced systems and low-emitting products. In the BREEAM green-building standard, "Health & Well-Being" credits account for 15% of the weighting in BREEAM assessed buildings. The newest version of Greenmark, a rating system used in Singapore and other tropical climates, features an even greater emphasis on indoor air quality and human health. Early research suggests that this focus on IEQ has a positive impact on health. In a review of 17 studies of green buildings and health, in general green buildings had better indoor air quality and occupants in green buildings reported greater satisfaction with indoor environmental quality (Allen et al., 2015). As the green building movement advances, and green building principles extend to all areas of the world, an even greater emphasis on a wider range of indoor environmental quality factors is necessary.

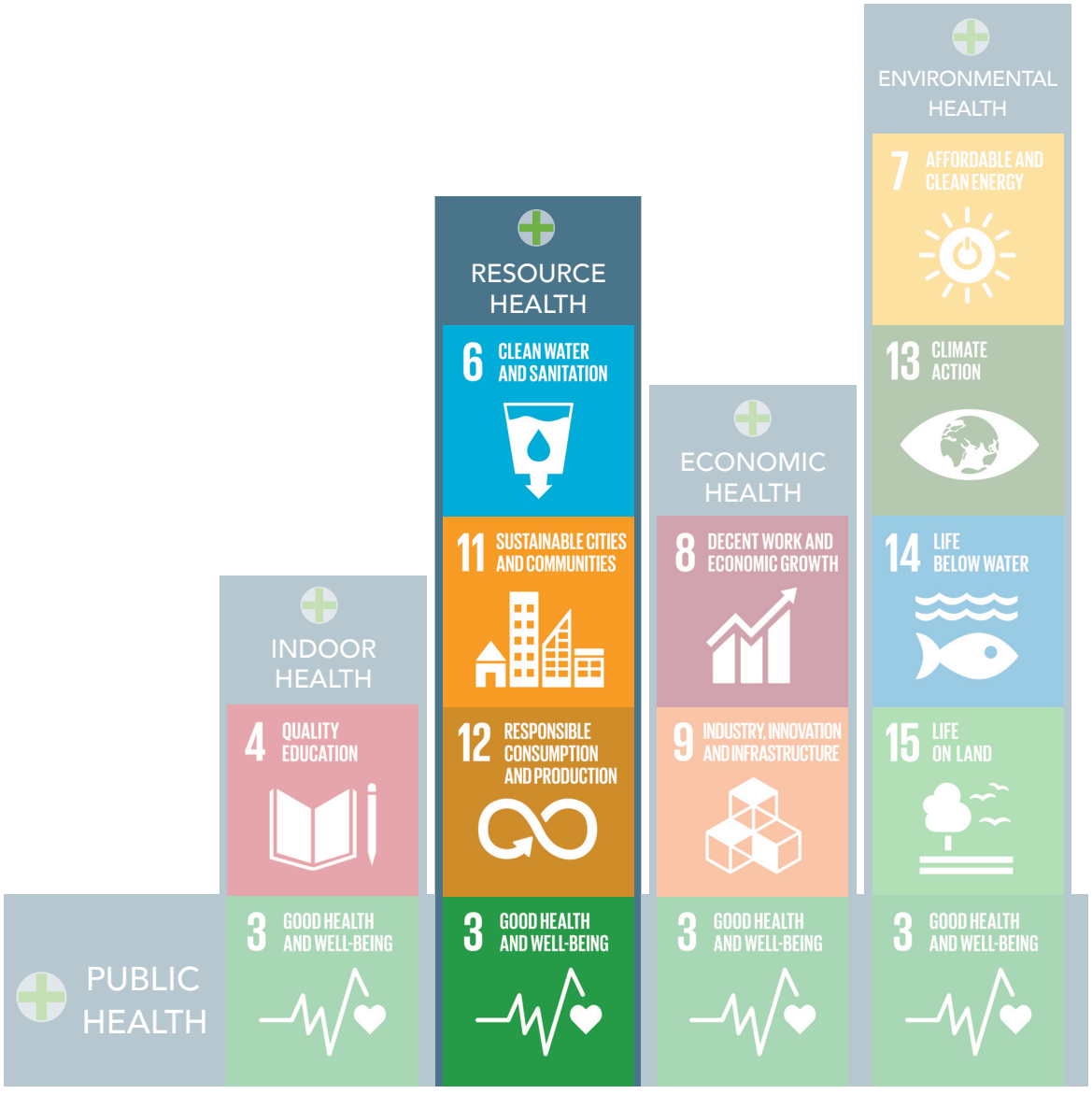
3 BUILDING SDGS, GROUP 3
RESOURCE HEALTH

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

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

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

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



Buildings are the largest, most resource intensive product on the planet, and as such the construction of new buildings come at the expense of our natural systems. The land needed for our cities, the materials and water needed for our buildings, and the waste generated by our buildings are putting a strain on global resource health. Of all raw materials extracted from the surface of Earth, almost 25% are attributed to buildings and their construction (Bribian et al., 2011). Harvesting timber for building materials and construction contributes to deforestation and is water and energy intensive (Ramage et al., 2017). The steel, cement, minerals, and other natural resources used in building construction require energy and water for extraction, processing, transportation, and disposal, and contribute to global warming (Bribian et al., 2011)

Buildings account for 12% of total water use in the US (US Green Building Council, 2014), as they utilize water for restrooms, kitchens, laundry, heat and cooling, and landscape irrigation. The water use intensity can vary by sector and the type of building, with increasing water use reported with greater frequency of use of the building (US Environmental Protection Agency, 2012). For example, hospitals use an average of 315 gallons of water per bed per day, commercial office spaces use 13 gallons of water per person per day, on average, and hotels use an average of 102 gallons per room per day (US Environmental Protection Agency, 2012).

Waste generation is growing rapidly around the world, with 11 million tons expected to be produced per day by 2100, three times today's amount (Hoornweg et al., 2013). In 2014, the building construction and demolition industry generated more than 165 million tons of debris in the United States alone, consisting of concrete, wood, asphalt, metals, bricks, glass, and plastics from residential and commercial demolition and construction (US Environmental Protection Agency, 2016). Most waste ends up in landfills, and becomes a potential groundwater pollutant, source of methane release, and other adverse impacts.

"Clean water and proper sanitation are the foundations of healthy and prosperous communities. When women and children don't have to spend hours gathering water, or suffer from waterborne diseases, or be in physical danger while using a toilet, they are able to go to school, work, or start their own businesses — all of which bring economic growth and dignity. It is difficult to imagine how other SDGs can be achieved without added focus on water, sanitation, and hygiene."

Laura Kohler, Senior VP, Human Resources & Stewardship
Kohler Co.

Goal 12 calls for environmentally sound management of chemicals. To date, we have done the opposite. We have produced millions of pounds of 'persistent organic pollutants' for materials commonly used in buildings, from couches and chairs to insulation and carpeting. Many of these chemicals migrate out of these building products into our homes, offices, schools, and into air and dust that act as the pathway for these chemicals to enter our bodies. The chemicals also migrate into the outdoor environment and can stay there for decades or centuries (Jones and de Voogt, 1999; Hu et al., 2016). We now find many of these chemicals in all corners of the globe, even in areas with no nearby sources of these chemicals, from polar bears in the Arctic to sea animals in the middle of oceans (Yeung et al., 2017; Sunderland, 2013; Yamashita et al., 2008). Although many of these chemicals are harmful to humans and other species (Allen et al., 2016; Birnbaum and Staskal, 2004), preventing their release into the environment has been difficult. Even though

some chemicals are, for example, banned in a few countries (The Stockholm Convention, 2001), their production and use is often shifted to a different country – usually less economically developed – essentially outsourcing the hazard. In other cases, what has come to be known as 'regrettable substitution' occurs in which a harmful chemical gets taken off the market, only to be replaced by a similar chemical that is as harmful as the banned chemical (Allen, 2016).

Green Buildings and Resource Health

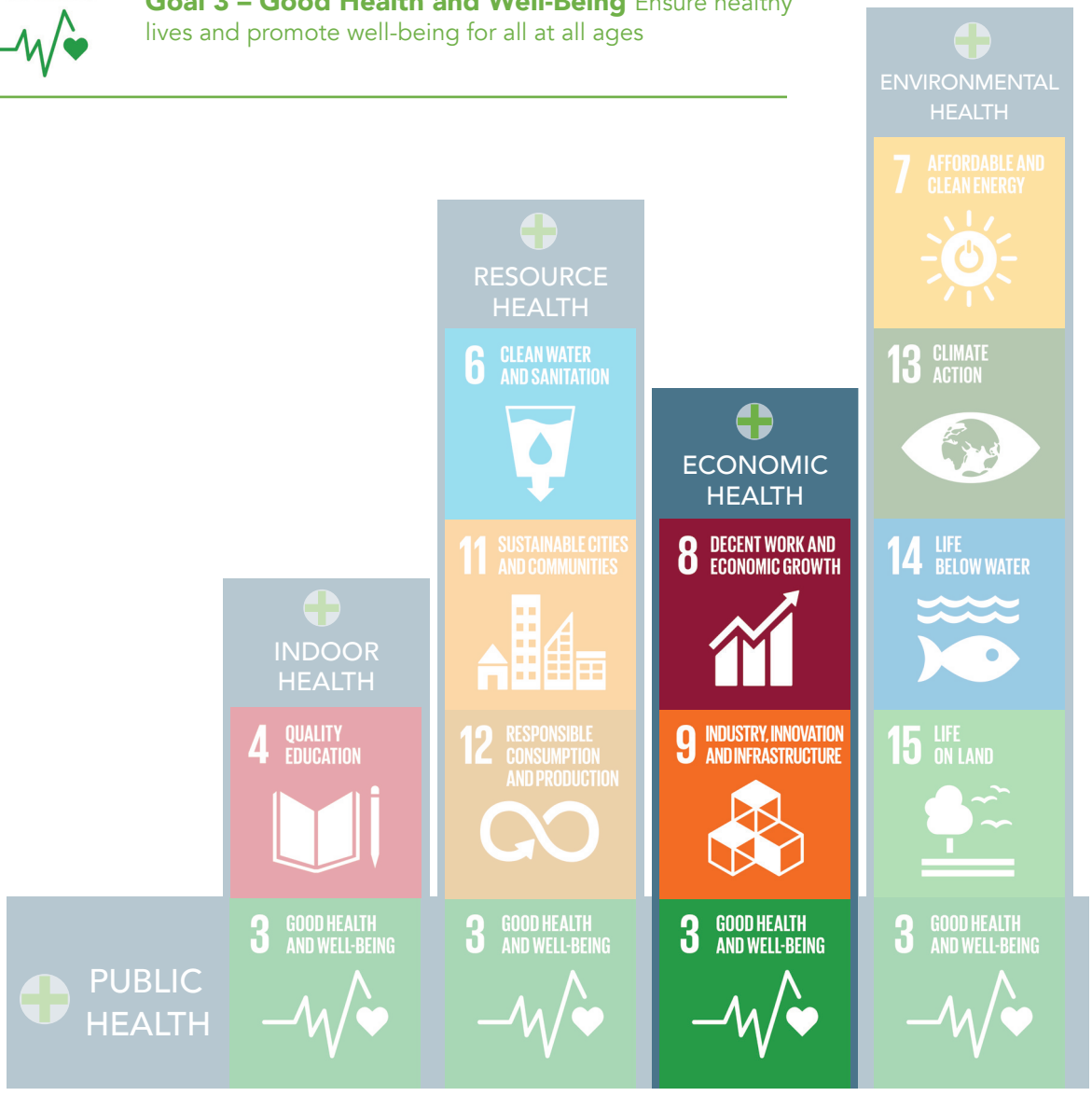
Green building strategies, net-zero approaches, and green chemistry principles hold promise to minimize the adverse impact of buildings on our natural systems and resources. Though what traditionally defines a green building varies, they all aim to conserve resources such as water and energy, preferentially use more sustainably sourced building materials, and focus on reused and recycled materials. They also aim to implement better land management practices and reduce waste. The evidence suggests these strategies are having an important impact. Efficient fixtures and reuse strategies can reduce the amount of water that is wasted by more than 10% compared to conventional buildings (Fowler et al., 2011). Since their development in the United States, green buildings have diverted 80 million tons of waste from going to landfills through recycling programs and reduced consumption, and this is expected to grow to 540 million tons by 2030 (US Green Building Council, 2017). Green building programs incentivize building footprints that protect natural habitats and resources. Newer iterations of green building standards are placing greater evidence on materials and chemicals of concern, and need to advance this further by promoting green chemistry principles like designing for degradation (Anastas and Warner, 1998).

4 BUILDING SDGS, GROUP 4
ECONOMIC HEALTH

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

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

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



Buildings are economic engines. In 2010, the global construction market was worth more than $7 trillion dollars (U.S.) and is expected to grow to $10 trillion (U.S.) by 2020 (Global Construction Outlook, 2016). About 15-18% of the U.S. national gross domestic product (GDP) is attributed to residential properties and housing services (National Association of Home Builders, 2017); Commercial real estate alone supports more than 6 million jobs and contributes almost $9 billion to the US GDP (Fuller, 2017). The construction industry, considering both residential and commercial properties, may grow as much as 85% by 2030, mostly in China, the US, and India (Pricewater Coopers).

"Green buildings provide value to all key stakeholders – investors, owners and tenants. This 'green building value trifecta' proves we can achieve sustainable urbanization by doing better for people and the planet while also providing value to shareholders. Buildings consume 40% of the world's energy today, so the future of buildings and the future of sustainability clearly go hand in hand."

John Mandyck, Chief Sustainability Officer
United Technologies Corporation

Buildings also influence the productivity of their occupants. Improving indoor environmental quality in current U.S. office spaces would yield economic benefits of $20 billion (U.S.) annually (Fisk et al., 2011). These benefits are derived from improved productivity, lower absenteeism, and reduced sick building symptoms. On an individual building level, improvements to indoor environmental quality result in increased worker satisfaction, attendance, cognitive function and productivity as well as fewer reports of 'sick building syndrome' symptoms (Singh et al., 2010, Pei et al., 2015; MacNaughton et al., 2016; Allen et al., 2015; MacNaughton et al., 2017). As an example of the potential economic benefit to improving the indoor environment, a recent study found that doing just one intervention (increased ventilation rate) was estimated to yield benefits that outweighed costs by $100 to $1 (MacNaughton et al., 2015).

Green Buildings and Economic Health

Many presume that economic growth must come at the cost of environmental and public health. Nothing could be further from the truth, as green buildings attest. Green building principles and ideologies minimize environmental impact, support construction jobs, higher property values and conditions for higher worker productivity. For owners and developers, green buildings result in 3% higher rent premiums and 7% higher cash flow as well as higher occupancy rates and transaction prices (Kok and Jennen, 2012). For tenants, employees in green buildings regularly report greater indoor air quality and fewer 'sick building symptoms' in green buildings (Allen et al., 2015). For workers, by 2018 green construction will support 1.1 million jobs and $75.6 billion globally (Booz Allen Hamilton, 2015). And the market is poised to grow. In the coming decades, China has mandated that 50% of new construction has to be green buildings (Yu et al., 2014). In Singapore a goal has been set to reach 80% green building adoption by 2030 (Building and Construction Authority, 2014).

5 BUILDING SDGS, GROUP 5
ENVIRONMENTAL HEALTH

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

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

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

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

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

Over 80% of energy worldwide comes from burning fossil fuels that emit a host of toxic substances to land, air and water. Buildings account for 40% of global energy use and as such account for a vast share of this pollution that kills millions of people worldwide each year. (Ürge-Vorsatz, et al., 2015; World Health Organization, 2016). Our current reliance on dirty energy sources has caused a cascade of detrimental impacts to Life Below Water (Goal 14) and Life on Land (Goal 15), and highlighted the need for urgent Climate Action (Goal 13) and a shift to Clean Energy sources (Goal 7).

Buildings are responsible for 30% of global greenhouse gas emissions that warm the planet. While climate change may harm anyone on the planet, those least able to prepare for it, and adapt to it, will be burdened disproportionately (Wright et al., 2015). Damages from climate change are anticipated to grow as more buildings and infrastructure are built in climate-vulnerable areas (Congressional Budget Office, 2016) and as extreme weather events, such as heatwaves and floods, become more common and sea levels rise. (US Global Change Research Program, 2016, Intergovernmental Panel on Climate Change, 2014). A worldwide investment in infrastructure of $90 trillion USD will be required over the next 15 years to reach net zero greenhouse gas emissions (New Climate Economy, 2016),

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"At its core, the issue of a clean environment is a matter of public health."

Gina McCarthy
Administrator, US Environmental Protection Agency, 2013-2017

Immediate adverse impacts to human health are the result emissions of health harmful air pollutants associated with fossil fuels. Pollutants, like particulate matter, sulfur dioxide, nitrogen oxides, and black carbon, are associated with numerous health outcomes, including cardiovascular, cerebrovascular, and respiratory diseases, development disorders, and mortality, (Dockery et al., 1993; Pope et al., 2008; Samet et al., 2000; Laden et al., 2006; World Health Organization, 2016; Raz et al., 2015) even at levels below current national standards (Di et al., 2017). In 2012 alone, approximately 3.7 million premature deaths were attributable to outdoor air pollution (World Health Organization, 2014).

Pollutants, including greenhouse gases via their effects on climate, also damage marine, freshwater, and terrestrial ecosystems. Over 3 billion people depend on marine based ecosystems for their livelihood, but our oceans are negatively impacted by humans via pollution, depletion of ecosystems, and the destruction of fisheries (United Nations, 2015; Wright et al., 2015). The oceans are absorbing large amounts of carbon dioxide from the atmosphere, acidifying aquatic environments to dangerous levels, threatening the shell and exoskeleton formation of oysters, clams, urchins, corals, and plankton, impacting entire ecosystems and food webs (National Oceanic and Atmospheric Administration; Wright et al., 2015). Energy consumption also impacts our waters during its production; chemicals used in coal and oil extraction, many of which are carcinogens, pollute local freshwater sources, contaminating drinking water located (Berrill et al., 2016; Epstein et al., 2011).

Green Buildings and Environmental Health

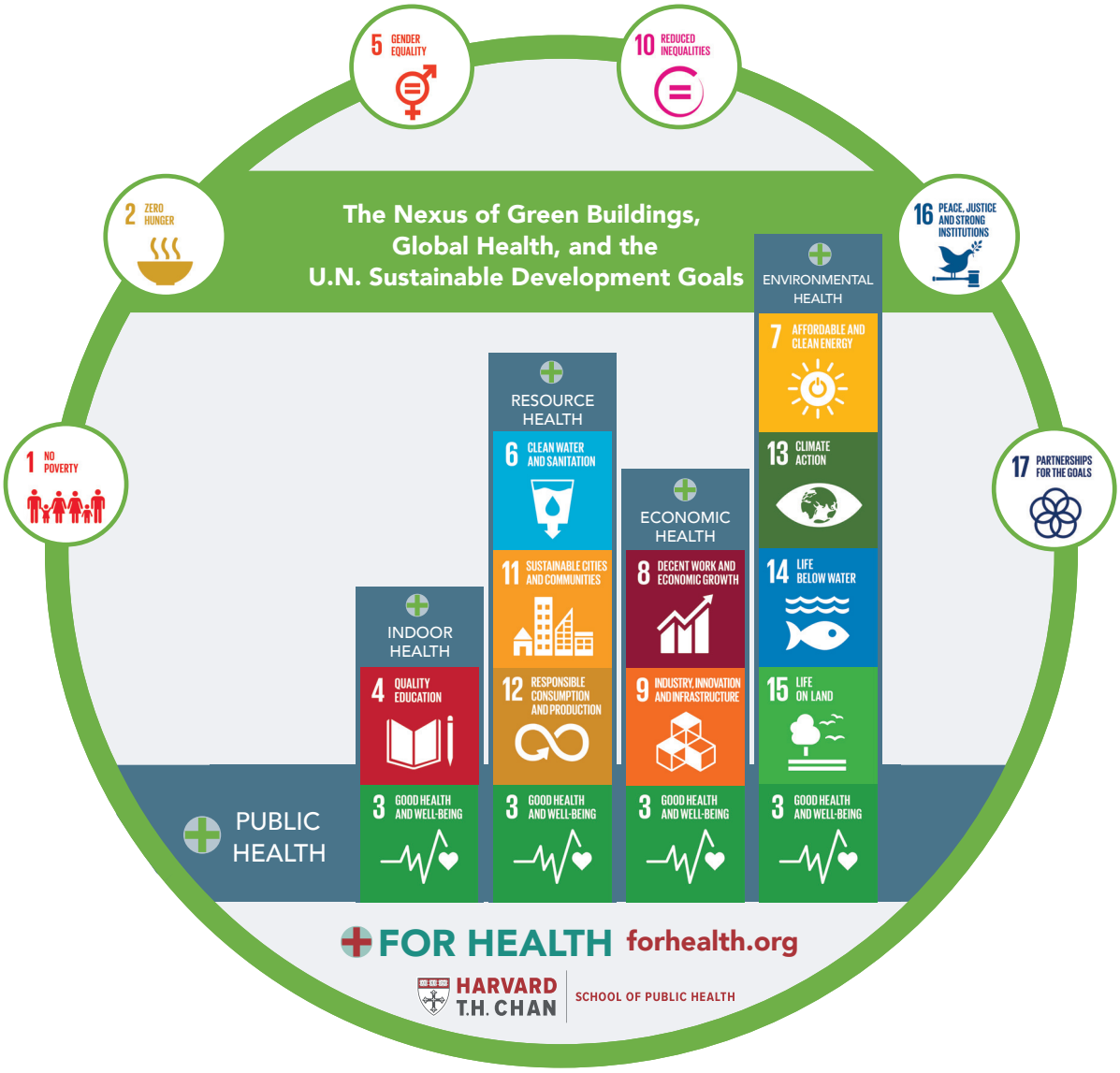
Solutions to the cascade of adverse environmental health effects associated with dirty energy come at three scales: regional, building and consumer. On a regional scale, it is imperative that we move to clean energy sourced by renewables, like wind or solar, that provide stable electricity supplies, emit few-to-no greenhouse gases, and significantly reduce health harmful air pollutants. At the consumer level, people can reduce their energy consumption and increase their use of energy efficient products, fixtures,

and technology in their homes and office spaces. But one of the biggest opportunities to improve environmental health needs to come from the building sector. Here, green buildings present an important opportunity to achieve reductions in energy use because of their focus on designing for, and certifying, energy performance. Energy use intensity of green buildings is typically 20-40% lower than a typically constructed building. In addition, the energy that green buildings save comes with a health co-benefit. Reducing energy consumption results in fewer health harmful air pollutants and greenhouse gases emitted to the atmosphere. Through these reductions green buildings provide a societal co-benefit: improved public health. These indirect, population-level health co-benefits of the green building movement have not been fully accounted for when exploring the benefits of better buildings.

CONCLUSION: BUILDING FOR HEALTH

Although the challenges related to rapid urbanization, natural resource constraints and climate change are daunting, they also provide an opportunity to mobilize solutions on a global scale. We now have a framework, the U.N. Sustainable Development Goals, that recognizes the central role that buildings will play in advancing health globally. Currently, 75% of the infrastructure needed by 2050 has not yet been built (Wiener, 2014). This presents the potential for one of the greatest public health interventions ever.

Green buildings and their Building for Health principles – Indoor, Resource, Economic and Environmental Health – will be part of the solution. As these concepts expand around the world, the concept of sustainable urbanization also needs to be a conversation that empowers all. Creating more equitable access to green building values, healthy buildings, and sustainable development is a global imperative.



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