Safeguarding our Global Commons

A Systems Change Lab to Monitor, Learn from, and Advance Transformational Change

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INTRODUCTION

The world is failing to spur transformational systems change at the pace and scale needed to safeguard the global commons—the shared ecosystems and natural processes that stabilize life on Earth and underpin well-being.[1] Today, we face a slew of crises that threaten lives and livelihoods around the world, from unabated climate change and accelerating biodiversity losses to rising inequality and pervasive hunger. To avoid the worst climate impacts and build equitable and prosperous societies, we must ignite widespread change across all the global systems: how we grow food, build cities, power industry, and move around the world. We must fundamentally change our consumption patterns, financial systems, and economic policies, as well as how we govern, plan for the future, and measure progress. These transformational changes must also improve equity and social inclusion.

If we are to convince decision-makers that a massive global reset is both necessary and possible in this decade, we need to take a hard look at our collective approach to addressing these urgent issues. We need to understand which interventions and movements are working and which are not—and why. We will then need to rapidly deploy resources to those initiatives poised for success and revise efforts that are ineffective or insufficient.

Leading governments, businesses, coalitions, and other decision-makers require evidence that systems change is possible—and a roadmap to realize such change. We need a central space from which to monitor, learn from, and accelerate transformational change across all critical systems. Such a central space could act as a lighthouse for change agents looking to address the long-term structural issues causing our current social, political, economic, and environmental crises—progress on all of which has been upended by COVID-19. The Systems Change Lab, to be established as a component of the Global Commons Alliance, and with its partners will keep tabs on the scale and pace of our collective efforts and will seek to uncover more effective strategies to affect systems change in order to realize a much better future.

ABOUT THIS PAPER

This paper, which was developed with the tremendous support of the Global Environment Facility, begins with an analysis of the current situation and the need for fundamental shifts across the many ways we operate if we are to realize a sustainable future. It then examines the common ingredients of historical transformations. Next, it identifies the 11 sets of transformations needed to move human society to live within planetary boundaries. For example, a systems change in transportation must include the complete phasing-out of the internal combustion engine, transitions to zero-emissions mobility (such as bicycling), and new zero-carbon fuels for hard-to-abate sectors, such as aviation and maritime shipping. Each of these transformations will generally require engagement from governments, citizens, and companies, and entail technological progress, policy changes, new accountabilities, and shifts in norms and behaviors.

Many of these transformations are already widely understood, with well-established coalitions of experts and decision-makers seeking to advance the required shifts. But for others, this is not the case. Many of these transformations have expert communities engaged with them, and some have vibrant multi-stakeholder leadership driving change forward. But while there is information and activity in many areas, there is currently no focus on the overall picture. Which of these shifts are picking up momentum and accelerating, and what has enabled them to do so? What are the hallmarks of successful transformation? How can lessons of success be transmitted across sectors? Which are the lagging transformations that require new approaches, political pressure, and greater urgency?

There is no single place where these changes are tracked and totaled, where lessons can be learned and gaps identified. This paper concludes by offering a way forward to address this gap—a new Systems Change Lab. The lab will monitor the progress of required transformations around the world, distill our rapidly evolving understanding of what constitutes and promotes systems change, identify critical gaps, and mobilize support for coalitions as they push toward tipping points to realize a more sustainable future.

CHAPTER 1

Why We Need Systems Change

Action to date has failed to spur change at a pace and scale commensurate with the global crises we now face. Decision-makers and the public are increasingly aware that we have a narrow window of time in which to steer action in the right direction. More specifically, we must halve greenhouse gas (GHG) emissions in the next decade and reach net zero emissions by mid-century. We must also end the destruction of the natural world and become "nature positive"— with nature regenerated by human life; protect the ocean, for the sake of ocean-based livelihoods and its wealth of species; and reset the social contract between governments, citizens, and corporations. We must be disruptive enough to break through the power of current path dependencies, locked-in capital, and vested interests. We must go further still; we must flip path dependency on its head and harness change to secure a healthier, safer future. And we must do it quickly enough to leap through the closing window of opportunity.

Not only must we act quickly to catalyze much-needed transformational change, but we must also do so while grappling with a global pandemic and the deep economic recession it has triggered.[2] Yet the recovery from this difficult moment presents a rare, unexpected opportunity. Countries around the world will spend tens of trillions of dollars to rebuild their economies and societies from the effects of COVID-19. Some have already announced plans to invest these funds in green, resilient, and inclusive recoveries.

But absent a step change to safeguard the global commons, these stimulus packages could also lock in business-as-usual growth, compounding the current environmental, political, and socioeconomic challenges. That is not the world we would wish to pass on to the next generation.

Our Current Situation

The late 20th century's economic acceleration deepened societal and environmental crises, including:

UNABATED CLIMATE CHANGE: Rising GHG emissions have caused 1°C of global warming above preindustrial levels.[3] Already, vulnerable communities around the world are grappling with the fallout—melting glaciers, stronger storms, droughts, floods, and sea level rise.[4] These impacts will intensify as the global temperature continues to increase. At 1.5°C of warming, sea levels will rise 0.40 meters by 2100, the world will lose up to 90% of coral reefs, marine fisheries will decline by 1.5 million tonnes, and 14% of the global population will be exposed to severe heat once every five years. Another 0.5°C of warming will cause declines in the ocean's fish stocks to double and species losses to increase two- to threefold.[5] Yet even with full implementation of countries' commitments under the Paris Agreement, the world is heading toward 3.2°C of warming.[6] To avoid the worst climate impacts, countries must change course this decade, halving global GHG emissions by 2030 and reaching net zero by mid-century. Absent rapid, unprecedented systems change across all sectors, the climate crisis will continue unabated, with far-reaching effects across human and natural systems that will unravel sustainable development gains around the world.[7]

PERVASIVE FOOD INSECURITY: World hunger is on the rise after a steady, prolonged decline. Today, more than 2 billion people live without reliable access to adequate, nutritious, and safe food, and more than 820 million people—one in nine—suffer from hunger. Across most of Africa, that number jumps to nearly one in five.[8] Yet almost a quarter of the world's calories is lost somewhere along the supply chain, and global demand for food is growing. As the world's population swells to almost 10 billion and incomes rise across developing countries, food consumption will increase by more than 50% by 2050. Feeding human society will require 56% more crop calories than the world's farmers produced in 2010—a feat that will strain already stressed water resources, release an estimated 15 gigatons of carbon dioxide equivalent emissions annually, and convert an area nearly twice the size of India from other uses into agricultural land.[9] Not only will current trends increase global GHG emissions and degrade ecosystems, but without accelerated adaptation efforts, climate change impacts also threaten to reduce growth in yields by up to 30% by 2050.[10] A new agricultural system is urgently needed—one that increases productivity and incomes, builds resilience to climate impacts, sustainably manages lands, and enhances carbon sequestration. Shifting to healthier, more sustainable diets and halving food loss and waste this decade will also prove critical to feeding 10 billion people by mid-century.

DISAPPEARING FORESTS: Humans have already significantly altered three-quarters of Earth's land, and over the past two decades, deforestation has remained stubbornly high despite efforts to reduce global forest loss.[11] In 2019, for example, the planet lost 3.8 million hectares of primary tropical forest—equivalent to losing a football field every six seconds.[12] This land-use change not only releases large stocks of carbon into the atmosphere, but it also reduces forests' capacity to sequester and store carbon. The effects of converting these tropical ecosystems to agricultural land extend far beyond climate change to include biodiversity losses, disturbances to freshwater systems, and heightened exposure to natural disasters, such as landslides and floods.[13] Although some countries and companies have taken significant steps to curb forest loss, most will fail to meet their 2020 commitments to protect forests.[14] Reversing these trends will instead require urgent, transformational changes, from protecting 30% of forests by 2030 to reducing deforestation by 70% relative to 2019 over the next decade.[15]

ACCELERATING SPECIES LOSS: Globally, biodiversity is declining at a rate unprecedented in human history. Approximately 1 million animal and plant species will face extinction, many within decades, if business continues as usual. Since 1990, native species' average abundance across major terrestrial habitats has dropped by at least 20%, and scientists now classify more than a third of all marine mammals as threatened. Taken together, climate change, pollution, land-use change, direct exploitation of nature, and invasive, alien species are driving biodiversity losses, which will likely continue to accelerate.[16] As species and ecosystems disappear, so too will many of the services that sustain human society, from provisioning food and purifying water to regulating the climate and pollinating crops. Immediate action must be taken across terrestrial, marine, and freshwater systems to halt overexploitation of species, stop the spread of invasive species, and protect, restore, and sustainably manage ecosystems.

UNCHECKED CONSUMPTION: Worldwide, annual natural resource extraction has more than tripled since 1970, rising from 27 billion tons to 92 billion tons. The mining and processing of these raw materials now account for roughly half of global GHG emissions and more than 90% of biodiversity losses. Should these historical trends continue, annual natural resource extraction will reach 190 billion tons per year by 2060.[17] Yet many of these raw materials end up in goods that are thrown away after just one life cycle. For example, roughly 60% of all plastic—or approximately 5 billion tonnes—produced since the 1950s has ended up in landfills or the natural environment.[18] Marine plastic pollution alone has risen by a factor of 10 over the past four decades.[19] Safeguarding the global commons will require a decoupling of economic growth from resource consumption.

OCEAN UNDER THREAT: Stretching across more than 70% of Earth's surface, the ocean feeds more than 3 billion people, produces half of the planet's oxygen, and absorbs at least 20% of all carbon dioxide (CO_2) emissions.[20] Yet this life-supporting system faces an onslaught of anthropogenic pressures. Rising GHG emissions have doubled the rate of ocean warming over the past three decades, triggered more frequent and intense marine heat waves, acidified surface waters, and expanded oxygen-depleted zones around the world.[21] Pollution, along with overfishing, the spread of invasive species, and habitat loss, are compounding these climate impacts, leading to significant ocean productivity and biodiversity losses. Today, more than one-third of fish stocks suffer from overexploitation, almost a third of reef-forming corals face the threat of extinction, and two-thirds of marine habitats have been severely altered.[22] The ocean's ability to support human society, particularly along the coasts, will likely decline significantly if we fail to act now.[23] Key priorities this decade must include fully protecting 30% of the ocean, sustainably managing fisheries, and dramatically reducing pollution.

FRESHWATER SYSTEMS IN CRISIS: Aquatic systems are also facing formidable threats. Not only have global water withdrawals more than doubled since the 1960s, but agricultural expansion, urban development, and other land-use changes have significantly altered freshwater availability and quality.[24] Pollution, habitat destruction, invasive species, and flow modifications (e.g., building dams or moving water across watersheds) are also undercutting aquatic ecosystems' capacity to support life, while climate change is shifting the temporal and spatial distributions of water resources globally.[25] Water scarcity may soon become the new normal in some parts of the world, while others will encounter more extreme rainfall events and flooding.[26] Without urgent, transformational change, the number of people living in water-scarce areas could reach 5.7 billion by 2050, three times more people may face exposure to severe flooding by 2100, and unchecked pollution will constrain economic growth and harm human health.[27] Avoiding these impacts will require countries to adopt comprehensive water management approaches, radically improve in water efficiency, and protect freshwater ecosystems.

All of these challenges compound extreme poverty and rising inequality. Over the past three decades, the proportion of the global population living in extreme poverty has declined significantly, from 36% in 1990 to 9.2% in 2017. Yet despite this remarkable success, 689 million people still earn less than US$1.90 per day, and new forecasts predict that, for the first time in a generation, extreme poverty rates will increase. Inequality is also on the rise. Now, just 26 of the world's richest people own as many assets as 3.8 billion people,[28] the vast majority of whom earn less than $5.50 per day.[29] The bottom half holds less than 1% of global wealth, while the top decile owns more than 80%.[30] This persistent gap between the world's haves and have-nots jeopardizes economic growth and development, erodes trust, and creates fertile ground for social unrest.[31]

COVID-19 will push between 88 million and 115 million people into extreme poverty in 2020. Over the next decade, both conflict and climate change also threaten to undermine poverty eradication efforts. By 2030, global temperature rise could force between 68 million and 132 million people to live on less than $1.90 per day. These setbacks will disproportionately impact countries with high incidences of poverty, particularly in sub-Saharan Africa, where past gains have failed to keep pace with population growth and the total number of people living below the international poverty line is rising.[32] Without paradigm shift, the world will fail to end extreme poverty by 2030, and inequality will intensify.

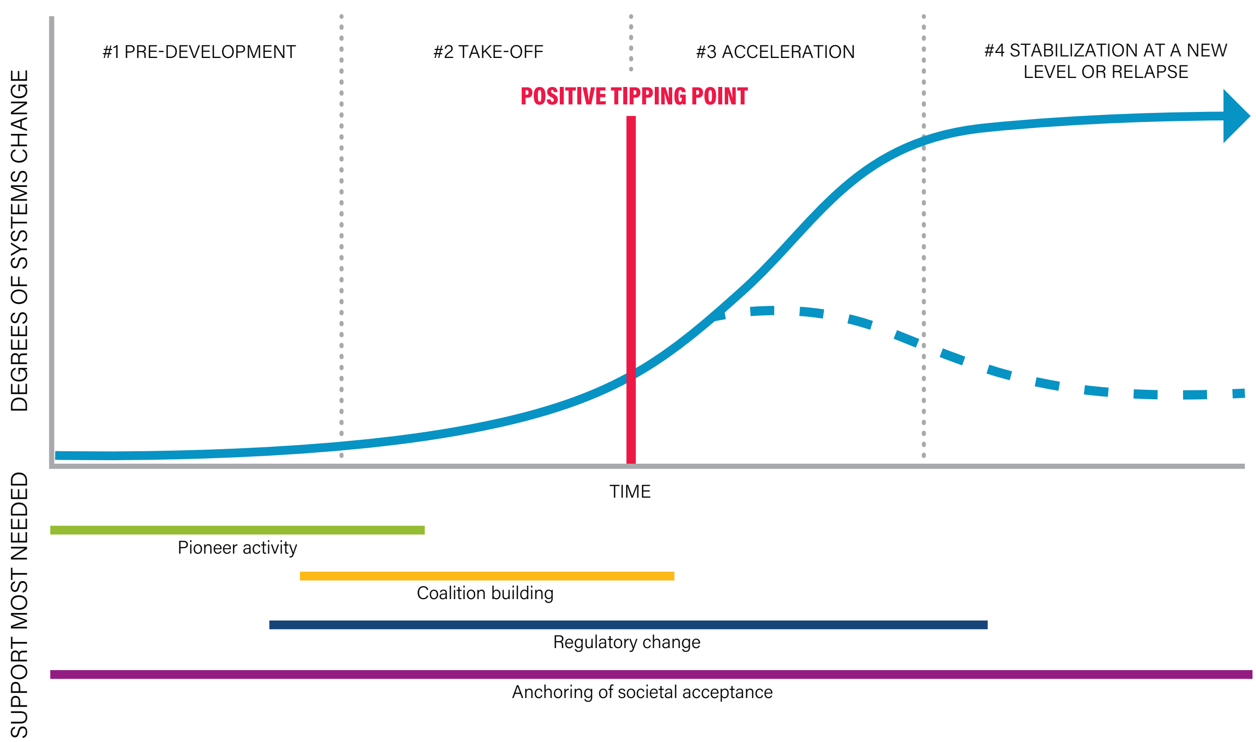
It is against this backdrop of crises that the pressure to catalyze rapid, unprecedented transformations is building. The generation now reaching adulthood demands a different approach. Young people are rightly frustrated. Enabled in part by digital tools, they are creating new movements around the world, demanding ambitious climate action, sustainable management of the global commons, fairer economies, and more equitable societies.

Realizing this future will require major systems change—a fundamental, sustained shift or a series of smaller changes that, taken together, will disrupt the status quo and lead to the formation of a new paradigm.[33] Steps toward systems change, if successful, will ratchet up ambition over time, become more durable and difficult to reverse, and expand to impact a greater proportion of the population.[34] Systems change will also address the root causes of today's challenges and radically alter the components, structures, and dynamics that underpin a system's current behavior.[35] Such profound change involves multiple actors at multiple levels to establish a new, lasting equilibrium at scale, especially given that systems typically overlap and small changes can have unforeseen effects, necessitating a systemic approach.

There are many different ways to define a system, but most simply, it is a configuration of various elements that work toward a particular outcome, for example, the production of food or energy.[36] Systems thinking can help explore the relationships between these elements in an effort to more deliberately realize more sustainable outcomes.

The process of systems change, especially for technological change, may follow the shape of an "S"—an irregular curve with change occurring at different rates during different stages (Figure 1). Changes that seem impossible at first can develop momentum, become more durable, and expand to the point where they become the new normal.[37] Yet the risk of relapse exists at any point along the curve; although the probability of reversal declines as the new system takes root.

Figure 1 | Phases of Systems Change



Source: Adapted from ICAT 2020.

CHAPTER 2

Ingredients of Systems Change

Historically, systems change has often emerged from the convergence and interaction of many enabling factors, rather than a single silver bullet. Although the precise ingredients of transformational, often nonlinear change vary across sectors and geographies, some elements appear to be common, including the following four sets of drivers: change agents, innovations, policies and institutions, and behavior change and social norms (Figure 2).

CHANGE AGENTS

Sustained, engaged leadership from governments, businesses, and civil society can jump-start systems change. High-level leaders can envision a sustainable future for their governments, organizations, and companies, establishing new mandates, driving institutional change, and channeling the resources needed to achieve it. These champions can be found at the helm of governments, institutions, and companies, but they need not be. Scientists can provide critical knowledge and technical expertise. Civil society organizations can spark systems change through their direct involvement in communities. Entrepreneurs can design new technologies to spur transitions. Investors can channel much-needed resources into research and development, and companies can create new markets for successful innovations as well as adopt more sustainable business models. And now there is a new class of leaders—from Greta Thunberg to organizers of the Black Lives Matter movement—who do not sit at the top of governments, institutions, or companies, but who are now creating movements and unleashing change.

Multi-stakeholder coalitions can also be powerful forces, as they can align their work with needed systems change and advocate that their colleagues follow suit. Convening these champions of change within coalitions that cut across sectors and levels of decision-making can further accelerate and sustain transformational change. These forums enable knowledge sharing, allow organizations to pool resources, and help decision-makers avoid unintended consequences by creating a space for stakeholders from different systems to share their perspectives. Together, these actors can counterbalance those invested in business-as-usual growth and drive transformational shifts.[38]

Those who benefit from these transitions represent another critical, yet often overlooked, agent of change. These groups not only advocate for transformations over time, but they also tend to resist attempts to return to the old paradigm.[39] Wind turbine and solar panel producers, for example, will advocate for the continued expansion of renewable energy, while fishers who have benefited from territorial use rights, which enable them to co-manage fisheries and incentivize sustainable harvest levels, will likely refuse to relinquish those rights. These beneficiaries often ensure that systems change lasts, and policies that expand the number of those who gain from a transition can further deepen support for it.[40]

INNOVATIONS

From developing plant-based meat substitutes that help enable the switch to more sustainable diets to establishing pay-as-you-go solar lighting schemes that expand access to clean energy in underserved communities, new technologies often spur systems change.[41] In Fiji and the Philippines, for example, distributing post-disaster social payments by mobile money allowed the government to provide a much higher number of affected communities with the financial resources needed to recover and rebuild—funds that may ultimately increase their adaptive capacity.[42] These innovations, which broadly include new practices, approaches, and techniques, depend on a society's knowledge base and skill set. Investing in education, training, science, research, and development, as well as networks that facilitate collaboration among experts, can all create a strong foundation for innovation. Yet technologies' ability to catalyze transitions at scale also hinges on widespread adoption. Pilot studies, experimental trials, and demonstrations can enable early uptake of a new solution. During this initial testing stage, experts can evaluate innovations while increasing their understanding of the new technologies and building the skills needed to use them. Moving beyond early adopters to reach a critical mass of supporters, however, often requires additional policies that accelerate diffusion.[43]

POLICIES AND INSTITUTIONS

Taken together, laws, policies, and regulations establish the rules of the game, which can catalyze, stymie, or entrench systems change. For example, they can establish formal or informal institutions, regulations, and financial mechanisms that support (or mandate) shifts to low-carbon, resilient, and sustainable development. To identify potential trade-offs and avoid unintended consequences that may impede transformational shifts, policies must also be aligned across sectors and at all levels of decision-making.[44] And sometimes even small changes in policy design can unleash significant change. Canada's province of British Colombia, for example, adopted a revenue-neutral carbon tax that channeled all revenues raised to municipalities and school boards. This created a lasting coalition of schools, parents, and other community members who

do not want to lose this much-needed funding, as they would should the tax be rescinded. This seemingly small decision helped create a durable climate mitigation policy.[45]

However, policies that seek to create an enabling environment for systems change are not always implemented, particularly if they fail to influence those who have a vested interest in continuing business as usual. Strong institutions, however, can achieve policy objectives to catalyze systems change by upholding laws, monitoring compliance with regulations, holding those who break the rules to account, and developing and implementing plans that accelerate sustainable development.

In addition, demonstrating that new solutions are not only possible, but also attractive to businesses, consumers, and others that must adopt them, underpins successful transformations. Key to this effort is creating the right incentives. A wide range of economic instruments—feed-in tariffs for clean energy, tax rebates for energy-efficient appliances, and increased access to low-cost finance for sustainable agriculture technologies, for example—can help motivate businesses and communities to stay within planetary boundaries. Nonmonetary approaches can also be effective in supporting systems change. Retraining workers formerly employed in carbon-intensive sectors and providing new employment opportunities, for example, can ease disruptive transitions to low-emissions pathways and create advocates for sustained change. Additional noneconomic incentives include sustained institutional support for transitions, removing bureaucratic hurdles to change, and granting ownership of natural resources to local communities.[46] For instance, providing tenure security to smallholder farmers, local communities, and Indigenous Peoples enables these new landowners to restore and conserve their territories. In the Amazon basin, specifically, annual deforestation rates are two to three times lower inside tenure-secure Indigenous forestlands than in similar areas without tenure security.[47]

Deterring harmful technologies, behaviors, and norms can also spur transformational change. Carbon taxes, elimination of fossil fuel subsidies, import duties on high-emissions goods, and tariff structures that discourage investment in business-as-usual innovations can all send strong signals to consumers and firms. Ultimately, these disincentives can shift demand toward more sustainable products while also motivating companies to adopt business models that improve their bottom lines and better protect the global commons.[48]

Case Study 1

Restoring 5 Million Hectares of Farmland Across Southern Niger

An unprecedented, farmer-led restoration movement swept across southern Niger in the early 1980s, reversing desertification and transforming severely degraded farmlands into productive, resilient agroforestry systems.[49] After more than a decade of expensive, failed tree-planting initiatives funded by international development organizations, Nigerien farmers began either to grow native shrubs and trees across their fields or allow the woody perennials to sprout from remnant root systems—a local practice known as farmer-managed natural regeneration (FMNR).[50] Since the mid-1980s, more than a million rural households have added 200 million new trees to their croplands—a feat that has diversified livelihoods, increased farmers' income, and boosted annual cereal yields by 500,000 tons, or enough to feed another 2.5 million people.[51] FMNR now stretches across 5 million hectares, an area roughly the size of Costa Rica, and over the past two decades, these on-farm trees have sequestered an estimated 25 million tons of carbon.[52]

A perfect storm of enabling factors converged in southern Niger, prompting farmers to abandon land-clearing practices adopted during French colonial rule in favor of FMNR. Recurrent droughts, crop failures, and famine in the early 1970s left millions of rural households across the Sahel severely food insecure.[53] These exogenous forces likely motivated some farmers to seek new approaches, including regenerating native, nitrogen-fixing woody perennials. This innovative "technology" provided clear benefits to farmers at relatively low cost, from improving soil fertility and boosting water retention to protecting crops from wind storms and combating erosion. *Faidherbia albida*, or white acacia, has been a popular choice, because it does not compete for sunlight with crops during the rainy season.[54]

Several leaders, such as Guero Chaïbou at the International Fund for Agricultural Development and prominent Nigerien agroforesters Mahamane Larwanou and Abasse Tougiani, championed FMNR within high-level policymaking circles. However, it was early adopters of the practice who played a critical role in persuading other rural households to allow native trees to grow across their croplands.[55] Nongovernmental organizations also raised awareness across southern Niger, promoting FMNR on the radio, conducting training sessions, and hiring extension agents. Although these information campaigns helped farmers understand the benefits of FMNR, supportive national policies ultimately incentivized rural households to protect trees on their lands. Starting in 1993, the Nigerien government adopted a series of land reforms that strengthened tenure security, customary rights to forest resources, and local rights to manage and harvest on-farm trees.[56] Allowing farmers to own and benefit from trees that had previously belonged to the state empowered rural households to invest in more sustainable agroforestry practices.[57]

BEHAVIOR CHANGE AND SOCIAL NORMS

Clearly communicating the crises that society now faces represents a critical first step in raising awareness. Recognizing the urgency of these challenges, alongside the consequences of inaction, helps stakeholders understand why they must act, but they also need information highlighting the concrete steps that they can take to accelerate transitions required to protect the global commons. These messages must come from trusted, well-respected sources, who so powerfully articulate these calls to action that they stick with people long after an advocacy campaign or conversation ends. Like efforts to raise public awareness, behavioral change tactics, such as showing households how their water and energy use compares with their neighbors' use, or combining meat and vegetarian entrees within the same menu sections, can also guide consumers toward lifestyles that stay within planetary boundaries.[58] The COVID-19 pandemic reminds us all that even seemingly small changes in behavior, such as wearing a mask or washing one's hands, can significantly affect the fates of nations. Similarly modest lifestyle changes, from reducing household food waste to bicycling to work, can also add up to transformational shifts.

Figure 2 | Ingredients of Systems Change

Together, raising awareness, changing behaviors, and shifting social norms are key ingredients of durable systems change. As environmental sustainability first becomes culturally acceptable and then, in some cases, expected, citizens' collective values will likely shift as well. So too will the policies they support, the goods they demand, and their patterns of consumption.[59] In the United Kingdom, for example, a baseline study quantified household food loss and waste and its cost to families—an annual average of £680 per average family. A public awareness campaign, "Love Food Hate Waste," disseminated this knowledge widely and provided tips on how to reduce waste, while a major supermarket chain started to change dates on food labels from "sell by" to "use by"—efforts that enabled behavioral changes.[60] Once consumers recognized the financial benefits of reducing household waste, they developed an expectation that food retailers would help support their efforts, which, in turn, helped motivate suppliers to step up their efforts to curb food loss and waste.[61]

Triggering durable, self-reinforcing transitions, in which the costs of returning to the old paradigm and the benefits of moving to the new system both continue to rise, can entrench long-term acceptance of the shift. But these four drivers must also come together in ways that expand the benefits of systems change beyond its initial advocates to reach new populations (Case Studies 1 and 2). Doing so can establish positive feedback loops that cultivate lasting, widespread support for the new paradigm.[62]

It is also important to note the critical role that exogenous forces—unforeseen events and crises—play in systems change, creating windows of opportunity to transform our politics, policies, societies, and behaviors.[63] For example, after an accidental release of toxic gas from a Union Carbide pesticide plant killed thousands of people in Bhopal, India, the U.S. Congress passed legislation that mandated companies to report the amount of dangerous chemicals that they release into the environment every year, and the U.S. Environmental Protection Agency (EPA) compiled this information in the publicly available Toxic Release Inventory.[64] The 1988 launch of this database spurred an enormous amount of citizen action and numerous lawsuits. From 1988 to 2000, releases of the 650 chemicals listed on the inventory declined by 48%—a reduction of 1.55 billion pounds, which many experts attribute to increased public scrutiny.[65] Similarly, in Uruguay, a prolonged drought crippled hydroelectric generation, while rising oil prices, coupled with increasing energy demands, led to blackouts.[66] These external forces prompted the government to rethink its energy security strategy and invest in renewables. Now, a diverse mix of clean energy sources generates nearly 95% of the country's electricity.[67] Moving forward, we need to be better prepared for, and seize, these opportunities—much like the ones in front of us today.

Case Study 2

Phasing out the Internal Combustion Engine

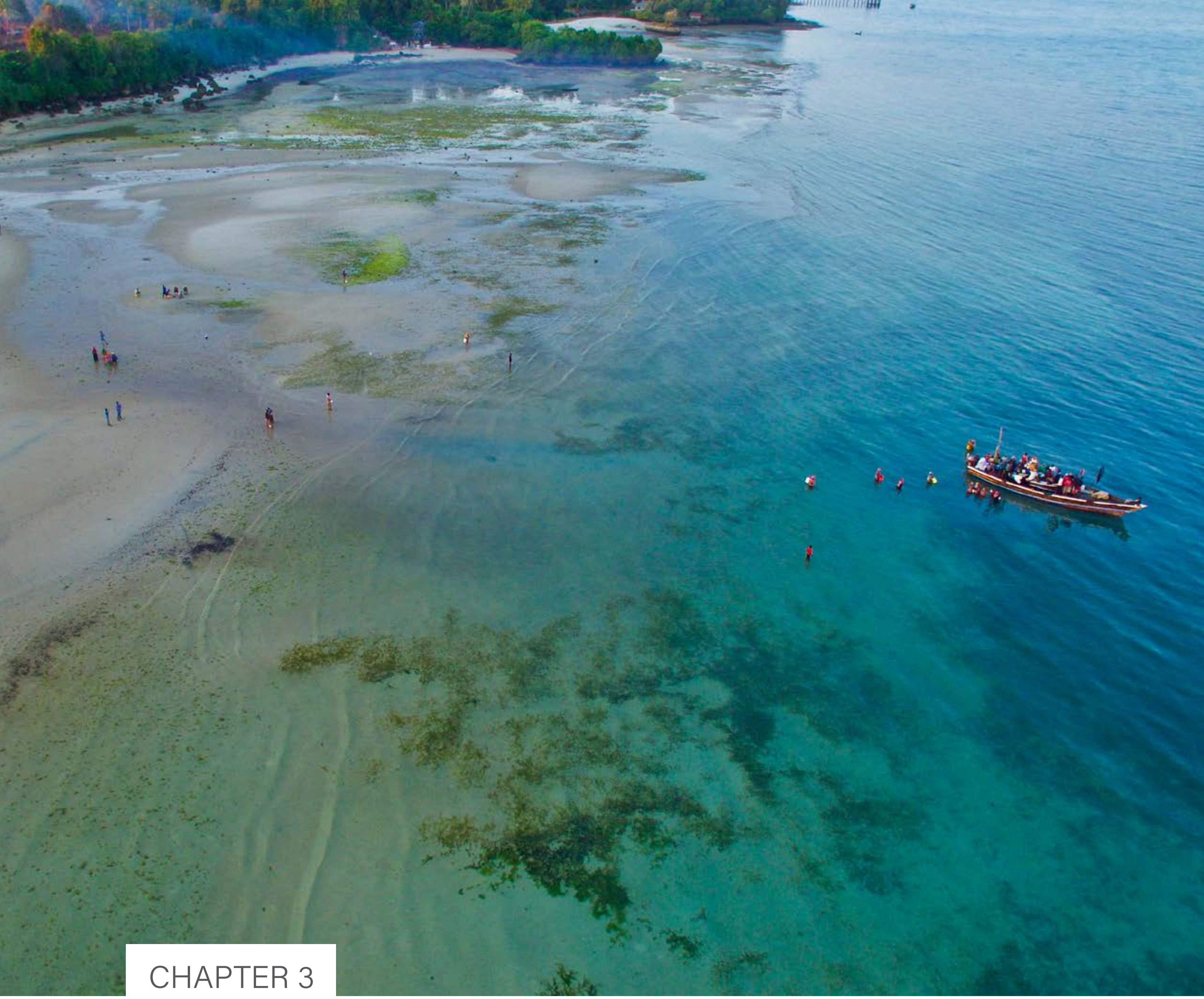
Efforts to phase out internal combustion engines, now responsible for approximately 10% of global GHG emissions, are gaining traction globally.[68] At least 66 countries and 48 companies, as well as 71 cities and regions, have announced plans to shift toward zero-emissions vehicles.[69] Many of the world's leading automobile companies, including Volkswagen, Ford, Toyota, Hyundai, and BMW, have also signaled an intention to move away from combustion engine vehicles over the next decade.[70]

Electric vehicle (EV) adoption is accelerating around the world. Global sales of electric cars, for example, grew 40% in a single year, totaling 2.1 million in 2019.[71] Some experts now predict that battery EVs, specifically, will reach a tipping point in 2022, achieving price parity with combustion engine cars, and their market share will rise to 10% in 2024.[72] By 2040, more than half of all passenger vehicles sold worldwide will be electric, and electrification of other methods of transportation, such as scooters, motorcycles, delivery vans, and buses, is also projected to expand rapidly this decade.[73] These shifts, along with efforts to increase electricity generation from renewable sources, will prove critical to decarbonizing the transportation sector, which currently accounts for 15% of total GHG emissions.[74]

Many drivers of systems change have come together to spark these early successes. Innovations in battery technologies, charging infrastructure, and electric motors, for example, have underpinned the automobile industry's ability to produce EVs at lower cost.[75] Clear signals from national and subnational governments, such as zero-emissions vehicle quotas, fuel economy and efficiency standards, and internal combustion engine bans, have motivated carmakers to scale up their investments in EV development, while supportive policies have aided deployment.[76] Requiring cities to increase the number of EVs within their fleets, channeling funding to research and development, and supporting the expansion of charging infrastructure have all aided the transition to zero-emissions transportation. But most policies that were prioritized have focused on offering consumers incentives to purchase electric cars. Tax credits, exemptions, and rebates are among the most popular tools for reducing the cost of EV ownership.

In China, for instance, the national government not only set zero-emissions quotas for carmakers, but it also has provided subsidies—more than $8.4 billion in 2015 alone—to make EVs more affordable. Several provinces and municipalities have matched these national subsidies, and in some major Chinese cities, such as Beijing, officials have eased local automobile ownership restrictions for those with electric cars.[77] The government now plans to subsidize local efforts to expand charging infrastructure to alleviate consumers' range anxieties.[78] These policies have accelerated EV ownership throughout China, a country that now has nearly half of the world's electric cars and buses.[79]

Although China boasts the greatest number of EVs in the world, Norway leads the market by share, with the highest per capita ownership of EVs, which account for over half of new car sales.[80] Because the country generates nearly 100% of its electricity from renewable sources, Norway has focused its decarbonization efforts on other sectors, such as transportation, which emits more than a third of the nation's carbon dioxide.[81] Efforts to incentivize EVs charged on Norway's clean grid began in the early 1990s, but have ramped up in recent years, with the government recently announcing that all light vans and passenger cars sold in 2025 must be zero-emissions vehicles.[82] Like China, the Norwegian government has adopted a portfolio of policies to achieve this goal, including high taxes on combustion engine cars, tax exemptions for EV purchases, free parking and charging, toll fee waivers, access to bus lanes, and additional driving privileges.[83] Other European Union countries and American states are beginning to follow suit, and in doing so, these early leaders are showing policymakers around the world both what is possible and what is needed to phase out internal combustion engines. Continued efforts, however, will be required to ensure that these initial successes spur a lasting transition to zero-emissions mobility.



CHAPTER 3

The Transformations We Need

Tables 1 and 2 summarize the major transformations required to protect the global commons. For illustrative purposes and to encourage discussion, this paper identifies nearly 50 specific shifts, but different taxonomies are clearly possible. Some of these transformations are "sectoral" in nature, calling for fundamental shifts in how we power our economies, produce goods and services, manage our land, waterways, and the ocean, and run our financial systems (Table 1). Others are broader imperatives, such as the way we measure progress, deliver services, ensure equity, and govern our shared Earth system

Table 1 | Sectoral Transformations

ENERGY

- Double the rate of improvement in energy efficiency
- Electrify transport, industry, and heating
- Decarbonize power
- Drive down the cost of energy storage
- Develop new fuels (e.g., hydrogen) and solutions for hard-to-abate sectors
- Scale up carbon removal and carbon capture and storage

TRANSPORT

- Eliminate the internal combustion engine
- Transition to new zero- or low-emissions fuels for heavy transport, shipping, and aviation
- Shift from road to rail and shipping
- Shift to public and shared transport, and to biking and walking

LAND, FOOD, AND FOREST MANAGEMENT

- Protect 30% of forests and other land by 2030
- Restore degraded landscapes
- Manage land sustainably to increase yields 40% by 2050 without expanding agricultural land or degrading ecosystems
- Halve food loss and waste by 2030
- Shift diets and ensure equitable access to nutritious food to feed 10 billion people by 2050
- Ensure supply chains are sustainable, including localizing value chains where possible
- Avoid overexploitation of terrestrial species
- Stop invasive species

OCEAN MANAGEMENT

- Ensure 30% of the ocean is fully protected by 2030
- Sustainably manage fisheries and aquaculture and avoid overexploitation of marine species
- Sharply reduce marine litter and pollution
- Stop invasive species

CITIES AND THE BUILT ENVIRONMENT

- Adopt compact urban design and transit-oriented development
- Ensure all new buildings are net zero carbon by 2030 and all existing buildings are decarbonized by 2050
- Shift to transport modes that have zero emissions and zero road deaths
- Transition to zero waste cities
- Make cities resilient

SUSTAINABLE PRODUCTION AND CONSUMPTION

- Adopt circular product design, production systems, and supply chains
- Use pure, nontoxic, and regenerative materials (e.g., in products and systems)
- Shift to circular business models and a sharing economy
- Shift consumption patterns to reduce waste and overconsumption

FINANCIAL SYSTEMS

- Measure, disclose, and manage climate and other types of environmental risks
- Scale up public climate finance
- Unlock private investment in sustainable infrastructure
- Extend financial services to underserved groups
- Price GHG emissions and other environmental externalities
- Eliminate harmful subsidies

FRESHWATER MANAGEMENT

- Perform comprehensive water assessments and management
- Radically improve water efficiency
- Protect and restore freshwater systems
- Avoid overexploitation of freshwater species
- Stop invasive species

Table 2 | Cross-Cutting Transformations

MEASURING PROGRESS

- Leverage the digital revolution and improve data systems, including tracking equity of progress
- Advocate for and accept new measures of progress

INCLUSION, EQUITY, AND THE JUST TRANSITION

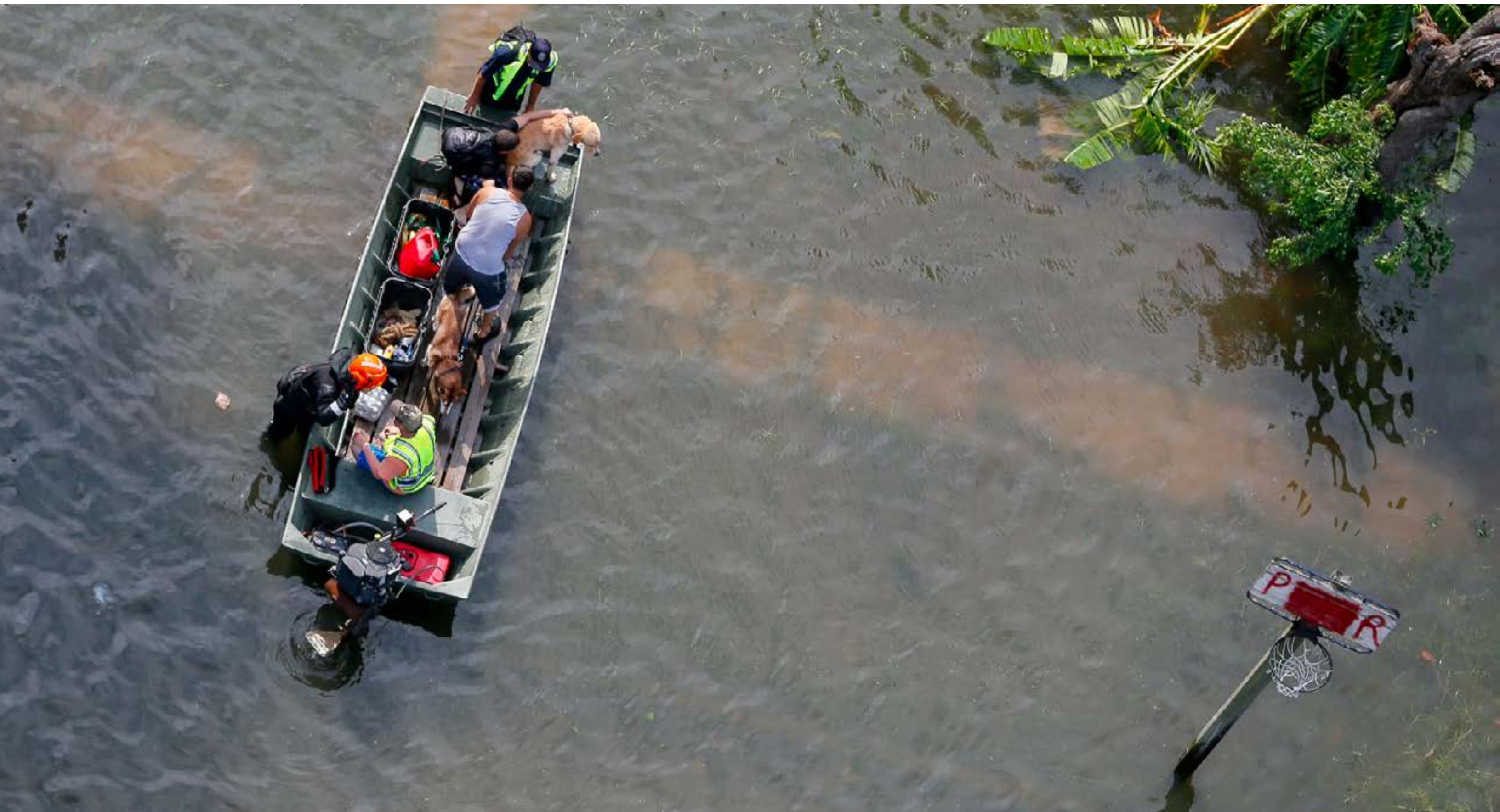
- Provide universal access to basic services and opportunities
- Shift to defining prosperity by inclusive well-being
- Shift to a new decision-making model, with more inclusive and community-driven leadership

GOVERNANCE FOR THE GLOBAL COMMONS

- Make the global architecture (e.g., the United Nations, international agreements, multilateral development banks, and the World Trade Organization) more fit-for-purpose to address challenges
- Reset the social contract between government, corporations, and citizens

(Table 2). This second group of transitions can both underpin the first set, as well as set conditions on how transformations must take place. Thus, for example, the radical shifts needed to protect nature must be undertaken in a manner that is just, inclusive, and enhances the well-being of vulnerable people. Put together, these shifts can transform the major key systems that define humanity's relationship with the natural world.

Chapters 4 and 5 contain a brief introduction to the key system under discussion and then describes the required transformations, providing a snapshot of where these stand, active efforts to achieve the needed changes, and institutions that are tracking their progress, performing critical analysis, and forging coalitions. These alliances, as well as individual organizations, may become key partners in the future work of the Systems Change Lab.



CHAPTER 4

The Sectoral Transformations We Need

Sectoral transformations will be required across energy, industry, transport, cities and the built environment, consumption and production systems, and the ways in which we manage land, freshwater, and the eocean.

ENERGY

Global energy consumption continues to rise, with the average rate of increase nearly doubling from 2010 to reach 2.3% in 2018. Fossil fuels—coal, oil, and natural gas—still supply most total primary energy use in the world (80% in 2019).[84] The world needs energy, particularly electricity, that is accessible, affordable, sustainable, and reliable. Although meeting these four objectives involves some trade-offs, the current model is unsustainable, negatively impacting the climate, air, water, biodiversity, and land. These harmful effects from energy production, conversion, and utilization have been exacerbated by the phenomenal rise in global energy consumption, industrial activity, and transportation. An increase in energy consumption, although needed in emerging economies, comes with its fair share of challenges, especially when the overall system remains heavily reliant on fossil fuels.

Emissions from the energy sector are the largest contributor to global GHG emissions—the sector is responsible for 73% of emissions worldwide.[85] Within this sector, heat and electricity generation accounts for most emissions (30% of total emissions), followed by transportation (15% of total emissions), and then manufacturing and construction (12% of total emissions).

In addition to GHG emissions, energy production and use is also predominantly responsible for emissions of sulfur dioxide (> 99%), nitrogen oxides (> 99%), and particulate matter (85%).[86] These emissions are significant contributors to air pollution, which is currently ranked as the world's largest environmental health threat; approximately 7 million deaths are attributed to poor air quality each year. Energy production and power generation are also responsible for roughly 10% of water withdrawals, and this percentage will rise with a growing population, urbanization, and increasing energy demand.[87]

The following transformations are required for providing zero carbon, accessible, sustainable, affordable, and reliable energy. These are needed in all sectors using energy—buildings, transportation, and industry—as well as in the power supply, and can be described as:[88]

- Optimize: Increase efficiency and reduce energy use
- Electrify: Shift energy demand to electricity and away from fossil fuels
- Decarbonize: Shift entirely to zero carbon technologies to generate electricity

This section discusses three additional transformations that will be required if we are to protect the global commons:

- Energy storage that will enable electrification and decarbonization
- Scaling carbon removal and carbon capture and storage
- New fuels and solutions for hard-to-abate sectors

Energy use in industry has been highlighted in the mentioned transformations, while buildings and transport are discussed under "Cities and the Built Environment" and "Transport," respectively.

Double the rate of improvement in energy efficiency

If countries around the world adopted the right mix of energy efficiency policies over the next two decades, in line with the energy efficiency target of the United Nations' Sustainable Development Goal (SDG) 7, they could deliver 40% of the GHG emissions cuts needed to achieve the Paris Agreement without any new technologies.[89] Yet progress has stalled. The annual energy intensity rate has been declining gradually since 2015. In 2018, for example, it decreased at a slower rate (1.2%) for the third consecutive year. Public policy measures have struggled to establish and implement mandatory energy efficiency policies to reduce final energy use. As of 2018, only 34.7% of all global energy use was covered under mandatory policies, which was only a slight increase from the 21.8% covered in 2010. Changing weather patterns that brought hotter summers and colder winters to some regions of the world, along with longer-term structural trends such as growing demand for bigger cars and larger buildings, have also raised energy usage. Similarly, industrial shifts, such as energy-intensive sectors increasing their share of production in several major economies, also drove up global demand for all primary energy fuels.[90]

With demand across transportation, buildings, and industry together accounting for more than 85% of final global energy consumption in 2017, efficiency measures across sectors are needed.[91] Past successes have shown that a mix of capacity-building initiatives, information programs, regulations (e.g., mandatory minimum energy performance standards), and financial incentives (or disincentives) are crucial for energy efficiency improvements in these sectors.[92]

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Tracking and accelerating action

Several international alliances, many of which involve public-private sector collaboration, have formed to accelerate global efforts to improve energy efficiency. The Three Percent Club, a coalition of 15 countries and more than a dozen businesses and institutions, focuses on deploying existing efficiency technologies, while the Energy Efficiency Global Alliance and the Global Commission for Urgent Action on Energy Efficiency present examples of multi-sectoral leadership initiatives. The Global Energy Efficiency Accelerator Platform of Sustainable Energy for All also seeks to scale up energy efficiency policies, actions, and investments.[93] Many organizations at the helm of these coalitions are monitoring the state of play on energy efficiency, with the International Energy Agency (IEA) and Sustainable Energy for All leading the charge. Other sectoral initiatives and national agencies are also providing critical data and analysis that feed into global efforts. Key players include United for Efficiency, the Global Fuel Economy Initiative, the Industrial Energy Accelerator, the Building Efficiency Accelerator, the District Energy Initiative, the Global Alliance for Building and Construction, and the Cool Coalition.

Electrify transport, industry, and heating

Electrification of the economy refers to replacing technologies in industry, in buildings, and in the transport sector that use primary energy sources (mostly fossil fuels) with technologies that use electricity.[94,95] When this electricity is sourced from low-carbon resources, it helps amplify the benefits of electrification, reduce its costs, and decarbonize the economy.

Industrial production typically involves thermal heating processes that utilize fossil fuels—either directly by generating heat through combustion or indirectly through steam or hot water from boilers.[96] Electrification in industry focuses on process heating and boilers, the primary industrial uses of fuel combustion.[97] Electrifying industrial heat applications allows high process temperatures to be reached more efficiently by utilizing other energy sources, such as waste heat.[98]

Cost is a key challenge to electrification in industry. For example, in the United States, electricity is more expensive than the average cost of thermal fuel per unit of energy.[99] Electrification of some processes can also be technologically challenging and cause complications, thus slowing industry uptake.[100] For example, changing one part of a highly integrated industrial process often requires changes in other parts of a given process, which can be challenging.[101]

The share of direct fuel combustion in global industrial energy use in 2016 was 73%, with electricity accounting for only 27%.[102] Emissions from industrial on-site fuel combustion and manufacturing processes accounted for almost one-fifth of GHG emissions globally in 2014, with about a dozen industries responsible for more than 90% of emissions.[103]

With currently available technologies, almost 50% of the fuel used for energy in industries could be replaced with electricity.[104] In the "the future is electric" scenario of the IEA, industry could potentially have 37% electrification globally in 2040—mainly from heat pumps—across a wide range of subsectors, from 13% in cement production to 60% in aluminum.[105] Research, development, and demonstration for industrial electricity-based technologies to lower capital costs and increase efficiency are required to realize the potential for electrification.[106] Further, lower electricity prices or a lower carbon price could make industrial electrification more financially attractive.[107]

Tracking and accelerating action

Progress across industries with their distinct emissions sources and different technological solutions to electrification is not regularly monitored. The industrial sector is difficult to electrify and initiatives championing electrification tend to be more focused on transport (such as the International Council on Clean Transportation) and buildings (such as the Building Electrification Initiative and the Rocky Mountain Institute's Building Electrification Program) than on industry, which presents relatively fewer opportunities to electrify given the wide variety of end uses and technologies and limited research.[108] Some concerted efforts toward electrification of industrial processes do exist; for example, the Global Sustainable Electricity Partnership promotes electrification across end-use sectors and calls for industry to aim for doubling the share of electricity to more than 50% by 2050 (from the 2018 average of 23%).[109]

Decarbonize power

Electricity supply is one of the biggest sources of CO_2 globally, accounting for approximately 40% of global energy-related CO_2 emissions. Deep decarbonization of the global power supply is needed to limit global warming to 1.5˚C, which would avoid the worst climate impacts. Achieving near-zero electricity sector emissions by mid-century is one of the strategies considered most necessary to remain in accordance with the Paris Agreement.

Decarbonizing the electric power sector refers to using low-carbon resources for producing electricity. There are a number of viable technology options for this—for example, solar or wind energy—that can provide more flexibility, and significantly contribute to environmental co-benefits, such as improved human health. For example, expanding power generation from renewables could also produce $650 billion in business opportunities annually by 2030, as well as create millions of new jobs around the world.[110]

There has been a remarkable shift in electricity generation away from fossil fuels, especially coal, toward renewable sources—although, globally, we are far from having a large share of intermittent renewables power the grid. In 2018, solar energy accounted for 2.1% of global power generation, while wind energy accounted for 4.8%.[111] This has been driven by declining costs; coal-fired power is currently not competitive economically in many regions. According to Bloomberg New Energy Finance (BNEF), solar and wind energy now provide the cheapest power for 67% of the world. Solar projects in Chile, the Middle East, and China, and wind projects in Brazil, the United States, and India, are approaching figures below $30 per megawatt-hour, lower than the costs of building and producing power from plants that use coal or even the cheapest gas. However, although coal use is in decline, it still dominates emissions, making up more than 40% of current fossil fuel CO_2 emissions. Coal is being used to meet rising energy demand in some countries, including China and India.[112]

Tracking and accelerating action

There are several coalitions and organizations that are monitoring progress, either at the sector level or for individual technologies, and working to affect change in the power supply sector. Regarding monitoring this transformation, IEA and the International Renewable Energy Agency (IRENA) are at the forefront with global and national data on supply related indicators. There are also several country-specific data sources (e.g., the U.S. Department of Energy's Energy Information Administration) as well as other organizations monitoring progress and conducting related analysis, such as the Rocky Mountain Institute, the Overseas Development Institute, Climate Analytics, and Power Watch. A number of coalitions are working to decarbonize the power sector, including the Energy Transition Commission, the Deep Decarbonization Pathways Project, RE100, the Powering Past Coal Alliance, the Just Transition Centre of the International Trade Union Confederation, the Platform for Coal Regions in Transition, and more at regional and national levels.

Drive down the cost of energy storage for electricity

Electric energy storage is crucial to the energy transition; it can boost solar and wind power generation and help decarbonize end-use sectors. Renewable energy provides a variable energy supply that may not align with energy demand, and it is less predictable in terms of electricity generation. In 2018, the average annual capacity factor for solar energy and on-shore wind energy ranged between 10% to 21% and 23% to 44%, respectively.[113] Although renewable energy-related costs have declined and renewable energy's share in meeting demand has increased, advancements in storage

technologies are needed to allow greater system flexibility to accommodate an increasing share of variable renewable energy.[114] Accordingly, energy storage can make power generation more cost-effective; it makes it possible to make better use of periods of time when the cost of generating power is significantly lower than at others.[115] In addition to grid balancing and renewable energy integration, energy storage also makes possible a smoother flow of power and better reliability in backup electricity systems.[116] Nonetheless, energy storage technologies inherently use more electricity than they provide, as technologies such as pumped-storage hydropower use more electricity to pump water through different reservoirs than they produce, and non-pumped-storage hydropower systems face energy conversion and storage losses.

In 2017, a total of 4.67 terawatt hours (TWh) of electricity storage capacity, or 176 gigawatts (GW) of storage power capacity, was installed globally; 96% of this was pumped-storage hydropower. During high renewable generation periods, pumped-storage hydropower storage facilities store electricity by pumping water from a reservoir at a lower elevation to one at a higher elevation. When electricity is needed, this water is then released back to the lower reservoir, generating power through turbines. Other technologies included thermal storage (1.9%), batteries (1.1%) and other mechanical storage (0.9%).

Although pumped-storage hydropower storage is commercially mature, with almost half of the global energy storage capacity in China, Japan, and the United States, the batteries market is growing rapidly, with lithium ion batteries enjoying the largest share (59%) of installed capacity in 2017. Different storage technologies are suited for different service needs. For example, pumped-storage hydropower is better for longer storage durations; in other circumstances, technologies with higher electricity storage density, such as sodium sulfur batteries, may be favored in places such as city buildings, which have space constraints.[117]

Battery storage costs have declined dramatically over the past decade, a trend that is likely to continue.[118] Falling costs of energy storage are making renewable energy more competitive. It is estimated that 70% of installed capacity will be in eight countries—the United States, China, Japan, India, Germany, the United Kingdom, Australia, and South Korea—that will lead the energy storage market.[119] Total deployment levels of EVs and stationary storage, coupled with manufacturing experience, will together influence the future cost of lithium ion batteries.[120]

Advancing a range of energy storage technologies to improve performance and lower costs will require investment in research, development, and deployment at a large scale.[121] Energy storage is an early-stage technology existing in a few markets and requires significant policy support. In 2019, 2.9 GW of energy storage was added to electricity systems, which is almost 30% less than in the previous year (in part because of concerns over several fires at grid-scale storage plants in South Korea).[122] This was the first decline in nearly a decade. However, there are positive developments at smaller scales; for example, India now explicitly incentivizes the co-location of renewable electricity and storage, and Europe is launching pilot projects for new applications and markets and providing long-term support through the European Clean Energy Package.[123]

For batteries in particular there is a need to scale up end-of-life recycling, reuse, and disposal in the 2020s.[124] Today, the recycling of batteries is almost nonexistent—in the European Union and the United States, for example, only approximately 5% of all lithium ion batteries are recycled. Further, if not done correctly, battery recycling can be hazardous and produce toxic by-products in accidental battery fires or explosions, endangering those handling these processes. Materials availability is unlikely to be a limiting factor in the growth of battery electricity storage technologies until at least 2025.[125] Reusing batteries in energy storage applications at the end of their life in EVs will help reduce costs.[126]

In addition to storage technologies, other solutions to match intermittent and distributed energy sources with demand (such as dispatchable clean energy generation, automated load shifting, price signals with time of use rates, and transmission infrastructure for a centralized renewable system that moves energy from excess renewables capacity areas) are needed to reduce the need for storage.

Tracking and accelerating action

Information related to the number of energy storage facilities, geographical distribution, energy storage capacities, and costs is found in disparate sources of scientific or institutional publications and consultancy reports published by organizations such as BNEF and Navigant.[127] Some of these include country- or region-specific information, especially for the most important national markets. The open-access U.S. Department of Energy database on battery storage is used in many analyses, and there are a few global fee-based databases, such as IHS Markit. However, the Department of Energy database includes information registered by operators of storage systems on a voluntary basis, and it has not been systematically compiled, leading to gaps in country-specific information.

A few coalitions have been announced in recent years, such as the World Bank's Energy Storage Partnership in 2019, which is focused on accelerating the deployment of energy storage in developing countries, and the International Coalition for Energy Storage and Innovation to scale up the availability of energy storage facilities. At the national level, there are examples such as the India Energy Storage Alliance with more than 90 members, including energy storage manufacturers, research institutes, renewable energy, power electronics, and companies that manufacture EVs.[128]

Develop new fuels and solutions for hard-to-abate sectors

So-called hard-to-abate sectors include heavy-duty transport (shipping, aviation, and heavy-duty road transport) and heavy industry (steel, chemicals, cement, and others).[129] Across the sectors, companies rely on high-temperature heat or high energy density to power their operations—energy needs that electricity cannot easily replace; hence the term hard-to-abate. Together, these account for almost a third of global annual CO_2 emissions and are expected to grow from 10 gigatonnes (Gt) in 2019 to 16 Gt by 2050 if current trends continue.[130] Direct electrification plays a limited role in decarbonizing these sectors and other solutions, such as zero carbon electricity-based fuels and low-carbon fuels along with carbon capture and storage, are needed.[131]

Hydrogen made using renewable electricity and low-carbon fuels can deliver low-carbon to zero-carbon energy in industrial process in sectors such as steel and cement. Currently, more than 95% of hydrogen is produced using fossil fuels. Using carbon capture or electrolysis can provide zero carbon hydrogen but both are significantly more expensive than using fossil fuels. Falling costs of renewable electricity coupled with the expected decline of electrolysis equipment is expected to help bring the cost down for zero carbon hydrogen. Parallel investment in associated technologies, such as hydrogen storage, will also facilitate scaling up capacity.[132]

Encouraging research and development efforts, demonstration of industrial-scale projects, infrastructure investment, and early market and policy support are needed to realize this transition.[133] These can be complemented with a boost in consumer or institutional demand for greener materials (e.g., so-called green steel or green cement) through information campaigns or government procurement policies. For example, a pilot is underway in Sweden to use renewable hydrogen to produce steel with a goal of producing produce fossil-free steel by 2035 at a cost that is competitive with traditional steel. It can potentially reduce Sweden's emissions by 10%.[134] Many more such examples will be needed to truly bring down costs. The European Union's hydrogen strategy aims to increase clean hydrogen capacity sixfold to 6 GW by 2024 and 40 GW by 2030 through the newly launched public-private European Clean Hydrogen Alliance.[135] A similar initiative for batteries launched in 2017 has mobilized billions of dollars in public and private investment. It is hoped that this will reduce the cost for producing green hydrogen (hydrogen from renewables) from $6 to $2 per kilogram by 2030, compared with the cost of "gray hydrogen," produced industrially from natural gas, at around $1.79 per kilogram.[136]

Tracking and accelerating action

The Energy Transitions Commission is a key group that has done research on these sectors; for example, see the findings published in its *Mission Possible* report. In addition, the European Clean Hydrogen Alliance and coalitions such as the Clean Cement and Concrete Coalition, the Net-Zero Steel Initiative, and the Collaborative Innovation for Low-Carbon Emitting Technologies in Chemicals are working to lower emissions in hard-to-abate sectors.

Scale up carbon removal and carbon capture and storage

To prevent the worst climate change impacts, the world must not only rapidly reduce GHG emissions, but also remove and store carbon from the atmosphere. All mitigation pathways that limit global temperature rise to 1.5°C above preindustrial levels, for example, require the removal of billions of tonnes of CO_2 annually by 2050 in addition to deep emissions cuts across all sectors. Yet most technological carbon removal strategies tend to be energy intensive, and scientists are only just beginning to assess the costs, environmental impacts, and feasibility of large-scale deployment.[137]

Many natural approaches, which rely on biochemical processes to remove atmospheric carbon, are ready for deployment now, cost less than technological strategies, and generate co-benefits, from improving water quality to safeguarding biodiversity.[138] These include afforestation and reforestation, land management strategies that increase soil carbon, and the restoration of carbon-dense ecosystems such as wetlands. Some of these practices are already well established, but current adoption rates do not yet match estimated need or potential. If mobilized at scale, these natural solutions could remove approximately 5.6 Gt of carbon dioxide equivalent annually—equivalent to the agricultural sector's total global emissions in 2014—for less than $100 per tonne of carbon by 2030.[139] However, carbon sequestered in these ecosystems is vulnerable to reversal (e.g., a forest fire can release stored carbon back into the atmosphere), and significant uncertainties, such as impacts on agricultural production, evapotranspiration, and planetary albedo, must be addressed before widespread deployment. Furthermore, they cannot alone meet the scale of carbon removal that the models suggest is necessary to meet the Paris Agreement's goals.[140]

Technological strategies, which remove carbon directly from the air or accelerate carbon storage by manipulating natural processes, are nascent but gaining traction. These include direct air capture (DAC), direct air capture and storage (DACS), carbon mineralization, and bioenergy with carbon capture and storage (BECCS). Already, a handful of start-ups are experimenting with carbon mineralization; a number of commercial DAC systems exist in Canada, the United States, and Europe; and BECCS has entered the demonstration phase, with half a dozen operational projects. Many of these solutions show early promise—direct air capture and storage, for example, could feasibly remove 1.4 Gt of CO_2 annually in the United States by 2050.[141] Yet technological carbon removal approaches can be often energy intensive, expensive, require large tracts of land, and may also come with considerable risks.[142] For BECCS in particular, there is limited potential when accounting errors are kept in check, and double counting of biomass and land already being used is avoided.[143] Minimizing these downsides will require incentives, policy safeguards, effective governance, and accounting procedures, while scaling promising technologies will depend on significant investments in research, development, and deployment, as well as enabling infrastructure such as CO_2 pipelines and storage networks, designated geological sites, and power from renewable sources.[144] Ultimately, advancing a portfolio of natural and technological solutions can help lower aggregate costs, boost cumulative removals through mid-century, and minimize the risk that some strategies will fail to scale up.[145]

Distinct from carbon removal, but required for some carbon removal approaches, carbon capture and storage (CCS) technologies reduce anthropogenic emissions by separating CO_2 from energy and industrial sources and storing the GHG, usually underground. Although fossil fuel use must decline steeply, many global decarbonization pathways rely on CCS in the interim. CCS can capture more than 90% of CO_2 emissions from power plants and industrial facilities.[146] Today, two large-scale CCS projects in commercial power plants capture 2.5 metric tons of CO_2 ($MtCO_2$)

per year, while 19 CCS projects operate in industrial facilities, with a potential annual capture capacity of 34 $MtCO_2$.[147] But the technology does come with several drawbacks. For example, the additional electricity and heat needed to operate the CCS unit either reduces the plant's rated power output or increases the amount of fuel consumed to produce the same electricity output as a plant without CCS.[148] Also, while higher capture rates are technically possible in power plants, in some industries such as iron, steel, and cement, more dilute CO_2 streams and multiple capture points make it economically and technically challenging to capture the emissions.[149] Developing cluster facilities for several plants, however, can help scale up efficiencies and reduce costs. Still, expanded deployment of CCS will require continued research and development, additional technological innovations, and greater investment in CO_2 transport and storage infrastructure. Targeted policy measures, including tax credits, feed-in tariffs, public procurement, grant funding, and low-carbon product incentives, can help boost investments.

Tracking and accelerating action

The Global Carbon Capture and Storage Institute, the Carbon Management Research Initiative at Columbia University, the Center for Climate and Energy Solutions, and IEA are all, to some extent, monitoring and analyzing the uptake of CCS technologies.

The carbon removal landscape, however, appears more fragmented, with a number of environmental institutions, such as Conservation International and The Nature Conservancy, advancing natural solutions, while others, such as the Rhodium Group, are focusing on the potential of technological innovations. World Resources Institute (WRI) is one of the few organizations conducting research on both approaches, although its current focus is limited to the United States. Recent reports from the Intergovernmental Panel on Climate Change (IPCC) and the National Academies of Sciences, Engineering, and Medicine have also assessed scientific progress on carbon removal.

Several coalitions dedicated to scaling up CCS and carbon removal have formed in recent years. These include such groups as Carbon 180 and the Carbon Capture Coalition, which brings together more than 80 businesses and organizations to advocate for U.S. federal policy support for deployment of carbon capture, transport, use, removal, and storage.

> If mobilized at scale, natural carbon removal solutions could remove approximately 5.6 Gt of carbon dioxide equivalent annually—equivalent to the agricultural sector's total global emissions in 2014—for less than $100 per tonne of carbon by 2030.

TRANSPORT

Transport generates almost a quarter of CO_2 emissions from fuel combustion, and nearly three-quarters of these releases come from road vehicles, including cars, trucks, buses, and two- and three-wheelers.[150] A significant increase in mobility, freight, aviation, and shipping stemming from urbanization and economic growth has led to pollution, emissions, and other environmental damage from the sector. By 2030, annual passenger traffic is set to increase by 50% and global freight volumes will rise by 70% from the 2015 measurements.[151] The transport sector is currently on track to generate GHG emissions (by 2050) that are three to six times greater than the amount of GHG emissions consistent with achieving the goals of the Paris Agreement.[152] Although the COVID-19 pandemic caused a drastic decline in transportation emissions in 2020, this trend is not likely to continue without interventions. To ensure that this sector decarbonizes by 2050, governments, private companies, and nongovernmental organizations will need to invest in technological transformations to eliminate unsustainable fuels and plan transformations to drastically reduce vehicle kilometers traveled (VKT).

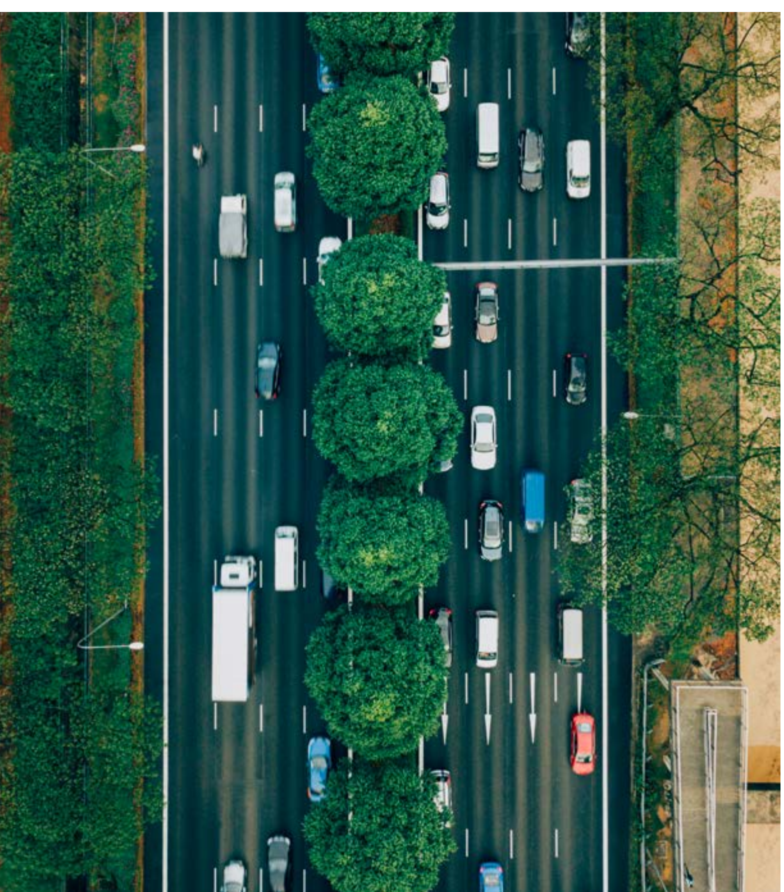
Eliminate the internal combustion engine

Internal combustion engines account for about 10% of GHG emissions globally and lead to air and noise pollution with significant health impacts.[153] Reducing dependence on conventional vehicles and shifting to EV is a prominent solution in 2050 scenarios. Although some countries have made commitments to phase out conventional cars, the automobile market has not made the dramatic shift necessary to see substantial change.

Future mobility options are likely to include a combination of vehicles—battery electric, hybrid electric, fuel cell electric, and conventional—that are significantly more efficient. This transition will require research and investment in EV batteries; charging infrastructure that promotes vehicle-to-grid integration where EV batteries are responsive to the grid's needs; a clean electric grid; infrastructure to deploy electric buses; battery recycling programs; modifying building codes to require the necessary infrastructure for charging options in public areas, workplaces, and multifamily housing units; and efforts geared to increasing consumer acceptance of EVs. Although EVs will likely dominate the future of transportation, fuel cell EVs will also require further research and investment, especially when it comes to long-haul, heavy-duty applications.

Between 2014 and 2019, the average annual growth of the EV market was 60% (and battery price has decreased by 85% since 2010).[154] To help generate this market growth, a significant number of entities—at least 66 countries, 71 cities or regions, and 48 companies—made announcements and adopted plans for phasing out internal combustion engines and shifting to zero-emissions vehicles.[155] Companies have banded together in groups, such as the Corporate Electric Vehicle Alliance and EV100, to make EVs more competitive in the market in terms of both cost and variety of models.[156] Organizations such as the International Council on Clean Transportation are providing grassroots organizing, research, and policy support for the elimination of internal combustion engines. As of 2019, 23 automobile manufacturers had introduced electric car models and set EV sales targets that were largely motivated by governments' strong policy signals (e.g., in China and Norway).[157] Despite strong signals, annual EV sales decreased in 2019 and are projected to decrease in 2020, partly because China briefly phased out EV subsidies, but largely due to the COVID-19 pandemic.[158] This decline should be temporary, as countries are maintaining, strengthening, or reinstating their EV subsidies.

Although there has been significant progress in countries and companies making commitments to scale up EV production across vehicle classes, the most effective EV deployment requires advances in smart charging programs. Maximizing the emissions reductions associated with eliminating internal combustion engines will require charging infrastructure



that considers how vehicle-to-grid integration can offer drivers incentives to use EVs more sustainably and can help grid operators increase their storage capacity, which will increase their ability to integrate renewable energy sources. These co-benefits make battery EVs more compatible with other sustainable mobility and sustainable energy projects than other EVs.

Tracking and accelerating action

Although research is being done on these applications by groups such as the National Renewable Energy Laboratory and IRENA, real-world applications remain in the pilot stages. EV adoption and the accompanying infrastructure are being tracked at a global level by organizations such as the IEA and BNEF, the Rocky Mountain Institute, and the International Council on Clean Transportation.

The EV100 coalition brings together companies that are committed to transitioning to EVs by 2030. A few regional coalitions that advocate for change also exist, such as the Corporate Electric Vehicle Alliance in the United States.

Transition to new zero- or low-emissions fuels for heavy transport, shipping, and aviation

Heavy-duty transportation—freight trucking, shipping, and aviation—contributes approximately 43% of global GHG emissions.[159] In business-as-usual scenarios, emissions from shipping alone could increase by 50% to 250% by 2050.[160] Reducing these emissions requires finding low- and zero-emissions alternatives to the liquid fossil fuels that dominate this sector, but long-haul aviation, shipping, and freight are likely to continue to use liquid fossil fuels in the medium to long term because of limitations in electrical energy storage. Without breakthroughs in battery technology and fast-charging batteries with higher energy densities, this sector will require biofuels, hydrogen fuel cells, or synthetically made fuels. A number of new fuels could feasibly power future zero-emissions shipping vessels: hydrogen or ammonia used in combustion engines, electric batteries, or hydrogen fuel cells. To maximize environmental benefits, the production of these new fuels should rely on renewable sources such as solar power or wind power, given that, today, processes to create both hydrogen and ammonia are energy intensive.

On the basis of today's technology, hydrogen fuel cells appear to be the best option for zero-emissions vehicles in sectors that are hard to electrify, including heavy-duty freight, transit between cities, shipping, and aviation. Fuel cell vehicles' lighter batteries and fuel storage tanks allow them to carry heavier payloads and travel longer distances than their electric battery counterparts.[161] Regional groups, such as Europe's Fuel Cells and Hydrogen Joint Undertaking, seek to further hydrogen fuel cell adoption. However, fuel cell EVs are still nascent technology and make up only about 0.5% of total zero-emission vehicle sales.[162]

Tracking and accelerating action

Although coalitions are working to reduce emissions in these heavy-duty, long-haul sectors, there is still work to be done. The Getting to Zero Coalition, which includes more than 90 maritime companies, envisions building and deploying the first commercially viable, zero-emissions deep-sea ships over the next decade and pledges to halve the industry's GHG emissions by 2050.[163] In 2018, the International Maritime Organization adopted an initial strategy that committed to cutting emissions from global ocean shipping to 50% of the 2008 level by mid-century.[164] This agreement is particularly promising given the regulatory power of the International Maritime Organization; however, efforts to transition to zero-emissions fuels are still nascent.

As for aviation, the International Civil Aviation Organization's Carbon Offsetting and Reduction Scheme for International Aviation has 85 country signatories. The organization has developed a CO_2 Estimation and Reporting Tool to track progress in the sector.[165]

In the freight sector, the Climate and Clean Air Coalition and the EPA sponsor the Global Green Freight Action Plan. This effort facilitates collaboration between the public and private sectors to enact actionable plans that reduce freight emissions.[166]

Shift from road to rail and shipping

A combination of modal shifts and better logistics could deliver CO_2 reductions of 20% in heavy-duty, long-haul vehicles.[167] Shifting to cleaner forms of transport—from trucks to railroads and ships—can help cut freight transport emissions. Railroads are approximately four times more fuel efficient than trucks; using rail for freight can reduce GHG emissions by 75%, compared with using trucks.[168] A 10% diversion of freight from truck to rail can give a 9% energy savings.[169] Likely candidates for shifting to rail or ships include commodities for long hauls that are not time sensitive (as opposed to, e.g., overnight mail).[170] The transition from high- to low-energy-intensity modes will require substantial investments in additional rail infrastructure and rolling stock. Similarly, diverting shipments from truck and rail to inland or coastal waterway systems requires an infrastructure that can handle large volumes of short-distance sea traffic, greater frequency of service, a reduction in associated costs with short-distance sea shipping, and a clear communication of why shippers should switch modes and operations.[171]

When shifting to rail or inland waterways is not an option, better planning and logistics can reduce the number of VKT by freight vehicles, which will have a substantial effect on emissions in cities. A number of planning changes can reduce emissions from freight in urban settings, including implementing urban consolidation centers as strategic hubs to move long-haul freight from trucks to smaller vehicles, creating vicinity unloading zones that ensure consolidated parking locations for trucks that serve businesses and neighborhoods; or implementing off-peak deliveries. For example, pilot projects for off-peak delivery hours show that delivering goods between 7:00 p.m. and 6:00 a.m. can reduce emissions by 45% to 67%.[172] Although these reductions are not as substantial as shifting from road to rail, they will still be key to lowering this sector's emissions.

Tracking and accelerating action

Several organizations are working to implement these transitions. Acting as a think tank, the International Transport Forum, an intergovernmental organization with 62 member countries, promotes more efficient transport policy, including a focus on freight shipping.[173] The Global Logistics Emissions Council works with more than 70 multinational companies to reduce transport-related emissions.[174] EcoLogistics and Center of Excellence for Sustainable Urban Freight Systems both partner with cities around the world to reduce freight emissions.

In the maritime sector, corporations are forming shipping alliances to increase cooperation on shipping routes to limit the amount of shipping overlap. Some of these include the Transport High Efficiency Alliance, the Global Maritime Forum, the Ocean Alliance, and the 2M Alliance.[175] In addition, new international shipping routes, the Northwest and Northeast Passages, are being established through the Arctic; ironically, these passages are opening up because of climate change, but if used, they would drastically reduce route distances.[176]

Shift to public and shared transport, and to biking and walking

Roughly 45% of transport emissions comes from light-duty road vehicles. A shift from private modes to public and shared modes of transport, along with better mobility and accessibility options that promote walking and biking, is key to tackling emissions in this sector.[177] Ultimately, VKT per person will have to be reduced, and this will involve a mix of transport and land-use adaptations. In the short term, transport demand management can shift commuters to more sustainable transit modes through a combination of incentives and disincentives.[178] Road-use pricing, driving and parking restrictions, and low-emissions zones discourage the use of private cars. At the same time, investing in bicycle lanes, sidewalks, micromobility, and mass transit options that are appealing, convenient, efficient, and affordable will convince citizens to move more sustainably. In the longer run, smart land-use planning can create a bigger shift in modes by investing in walkable, mixed-use developments near public transit.[179] Prioritizing these short-term and long-term changes will allow people to make sustainable travel choices that reduce transportation emissions.

Cities that have successfully implemented smart land-use planning show promising results. Cities such as Hong Kong and Copenhagen have seen decreases in emissions coupled with economic growth and fewer traffic deaths.[180] If shared mobility, autonomous vehicles, and restrictions on private cars are widely adopted, CO_2 emissions related to VKT can drop by up to 73% by 2050.[181]

Tracking and accelerating action

Coalitions such as C40 Cities, Local Governments for Sustainability, the International Association of Public Transport, the Sustainable Low Carbon Transport Partnership, and the Institute for Transportation Development Policy are helping cities to rethink urban design to move away from car dependency.

The Global New Mobility Coalition is working to address the increasing demand for transport by advocating for this total shift to shared, electric, and autonomous transport by 2050.[182] Furthering the work of these coalitions and making the most of growing mobility data will help cities scale up their initiatives.

CITIES AND THE BUILT ENVIRONMENT

Sustainable, resilient cities of the future must maintain a near-zero carbon footprint, eliminate fossil fuel use, and manage weather extremes, from heat waves to coastal storms.[183] But trends point the other way. Cities are becoming more populous and more resource intensive. The urban population is set to rise from 54% in 2015 to 66% in 2050, adding 2.4 billion people to cities, mostly in lower-income countries, particularly in China, India, and Nigeria.[184] At the same time, global urban material consumption will likely reach 90 billion tons by mid-century, rising faster than worldwide urban population growth.[185]

Driving this is a continuing pattern of spatial de-densification over the past century, which is having critical consequences for available arable land and food production, as well as cities' abilities to service their populations efficiently.[186] The results are rising levels of GHG emissions, air pollution, biodiversity loss, and water stress and contamination.[187]

A key challenge is that current and future urbanization is occurring in countries where incomes are not growing as they have during past waves of urbanization, when advances in transportation and agricultural surpluses supported urban growth, as during the industrial revolution. Growing cities, in which a larger share of poor people live, will exacerbate pressures on the natural environment. When urban residents cannot access basic services such as energy, water, housing, and waste, they self-provision in often illegal, informal, or unregulated ways. Intensive self-provisioning and unsustainable urbanization patterns result in widespread ecosystem degradation, unsustainable resource use, lower incomes and productivity, and danger to lives, as in the case of illegal settlements on unsafe territory.[188] Without urbanization that stays within planetary guardrails, we can expect high costs on individuals, households, society, the environment, and the economy.

Adopt compact urban design and transit-oriented development

Cities are currently growing outward, not upward, with the built environment expanding 66% from 2000 to 2012.[189] Driven by peripheral expansion and urban land markets, urban land cover is set to triple between 2000 and 2030, increasing by 1.2 million square kilometers.[190] Low and declining population densities pose problems for cities everywhere. In developing cities, these patterns result in unsustainable patterns of growth and expansion as local governments face the high costs of new infrastructure, leaving them unable to provide their populations with basic services. In many developed countries, it may be already too late—past decisions affecting land use, infrastructure, and the built environment have locked in sprawling urban development, which these citie are now struggling to reverse.[191]

> Cities are becoming more populous and more resource intensive. The urban population is set to rise from 54% in 2015 to 66% in 2050, adding 2.4 billion people to cities, mostly in lower-income countries, particularly in China, India, and Nigeria. At the same time, global urban material consumption will likely reach 90 billion tons by mid-century, rising faster than worldwide urban population growth.

Because of this urban expansion and the accompanying fuel and energy consumption, cities now generate nearly three-quarters of CO_2 emissions globally.[192] Electricity use is also rising rapidly—in many cities, faster than population growth.[193] In low-income cities around the world, both motorization and energy consumption release increasingly high levels of toxic pollution into the air, causing serious respiratory health disorders that lead to more than 1.3 million premature deaths worldwide each year.[194] Urbanization and its associated land-use changes impact both nearby and distant ecosystems directly and indirectly. Similarly, converted natural areas rich in biodiversity will likely experience significant damage and, in some cases, will be permanently lost.[195]

Cities can be designed more sustainably by changing where people live and work, and how they consume energy and other services. There is a growing consensus that urban density must be approached strategically and deliberately through urban development policies and design encouraging transit-oriented development (TOD)—the creation of compact neighborhoods where housing, jobs, and amenities are connected by efficient and affordable mobility options dominated by public transport between nodes and active mobility within nodes.[196]

There are many positive examples of progress toward the implementation of transit-oriented cities; however, to date inclusive urbanization remains an elusive goal. Change on a much larger scale is needed to ensure urban development is compact, connected, and affordable. Pioneering countries that have practiced TOD for several decades, such as Japan,[197] are being joined by others, such as China, South Africa, and India, in instituting national or regional TOD policies involving mass transit solutions, such as the bus rapid transit systems in Mexico City and Johannesburg and the Delhi metro.[198] More recently, several high-income cities have begun piloting concepts inspired by traditional TOD, such as Paris' "15-minute city,"[199] Melbourne's "20-minute neighborhoods,"[200] and major cycling and pedestrian infrastructure investments in London and Milan.

Tracking and accelerating action

International supporters of TOD and compact urban development include multilateral organizations such as the World Bank Group, the Global Environment Facility (through its flagship Sustainable Cities Implementation Program), and nongovernmental organizations such as the Institute for Transportation and Development Policy (which developed the TOD standard to guide practitioners),[201] C40 (a city network), and WRI, among others.

Ensure all new buildings are net zero carbon by 2030 and all existing buildings are decarbonized by 2050

Cities as a whole must decarbonize to achieve the goals outlined in the Paris Agreement. For this, major changes have to take place in the building sector, which accounts for around one-third of urban energy consumption,[202] and where emissions are set to double by mid-century.[203] To reduce emissions from the projected level of between 17.3 billion tonnes of carbon dioxide equivalent and 1.8 billion tonnes of carbon dioxide equivalent in 2050, all buildings would need to be net zero carbon by 2050.[204]

Net zero carbon buildings are energy efficient and reach a net balance between the carbon emissions from annual energy supply and demand. This equilibrium could be achieved through basic and advanced energy efficiency interventions, with on-site and off-site renewables, and can be situated across a portfolio of districts or buildings.[205] Today, less than 1% of existing stock is considered net zero carbon.[206] In most markets, even high-performance buildings (a lower benchmark than net zero carbon) represent less than 5% of construction.[207] In 2017, there was a total of 2,500 net zero energy buildings, with the majority of them being housing units mostly located in the European Union and North America.[208] Net zero buildings are still seen as one-time pilot projects, given their small number globally. There is also a perception that they are the preserve of wealthy cities, and are not economically feasible in lower-income cities.

At the same time, continued focus on achieving greater efficiency in existing building stock and requiring higher levels of efficiency for new buildings is critical. These gains in efficiency could also generate significant economic benefits. For example, improvements in heating and cooling performance, coupled with investments in more efficient electronics, appliances, and lighting, could generate $825 billion in annual cost savings by 2030.[209] According to the IEA's *Global Status Report 2017*, a combination of regulatory solutions (such as building energy codes and appliance standards), incentives and financing instruments, successful models to attract private sector investment, information and capacity building, and changes in behavior are needed to reduce global energy use per square meter in buildings.[210]

Tracking and accelerating action

Interest around net zero carbon buildings and districts has rapidly grown in recent years, as illustrated by the growing commitment to declarations such as the World Green Building Council's Net Zero Carbon Building Commitment,[211] which has almost 100 signatories from cities, regions, and businesses, and C40 Cities' Net Zero Carbon Buildings Declaration.[212] These and other such documents have put net zero carbon buildings firmly on the agenda at international meetings between energy ministers and high-level decision-makers from around the globe, such as the Clean Energy Ministerial and the 2019 United Nations Climate Action Summit. The latter launched the Zero Carbon Buildings for All Initiative, a multi-partner global initiative that the Secretary-General of the United Nations has endorsed. The initiative secures commitments from national and local leaders to decarbonize new buildings by 2030, and all existing buildings by 2050; and from financial and industry partners to provide $1 trillion of investment by 2030.[213]

The growing momentum on zero carbon buildings is underpinned by initiatives led by nongovernmental organizations such as the Amplify program of the World Business Council for Sustainable Development (WBCSD),[214] the Building Efficiency Accelerator, a public-private collaboration supporting the implementation of building efficiency policies and programs (hosted by WRI since 2015), and the Global Alliance for Buildings and Construction,[215] a network that provides policy research, data, and analysis, including the annual *Global Status Report on Buildings and Construction.*

Shift to transport modes that have zero emissions and zero road deaths

Growing city footprints and motorization have gone hand in hand with urbanization, resulting in environmental degradation and declining health outcomes.[216] According to the World Health Organization, 98% of cities with more than 100,000 residents in low- and middle-income countries fail to meet the organization's air quality guidelines; air pollution linked to motorization in cities causes serious respiratory health disorders and is linked to 1.3 million premature deaths each year worldwide.[217] Globally, urban transport is one of the sectors with the largest emission reduction potential in cities.[218] By far the largest future emissions increases (about 90%) in urban transport are expected to come from developing cities.[219] As traffic volumes increase, congestion eventually worsens as motorization rates catch up with capacity and residents spend increasing amounts of time and money on travel. It has been estimated that time lost because of congestion costs is between 2% and 5% of gross domestic product (GDP) in Asia and approximately 10% in a megacity such as Beijing.[220] The human cost is staggering—traffic accidents, which disproportionately affect vulnerable road users such as pedestrians, bicyclists, and children, already kill more than 1.2 million people globally every year and could become the fifth largest cause of death by 2030.[221] There is growing evidence that personal security and the fear of being victimized decreases women's mobility in some countries and therefore their access to economic opportunities and health services.[222]

To reverse the rising tide of vehicle fleets and unsafe street design, urban transportation must become "triple zero," with zero emissions, zero road deaths, and zero exclusion from the education, health, food, and economic services that make cities livable and equitable for all.[223] This transition to more efficient, seamless, and accessible urban transport systems requires building an integrated offering of mobility services from a patchwork of coexisting public, informal, and private modes.[224] Mass transit that moves more people more efficiently than private vehicles should be strengthened, rather than allocating budgets to expand road capacity for private cars.[225] Electrification of bus fleets and urban freight is also an important piece of the puzzle, as buses are a dominant mode of transport in many developing cities and can reduce emissions by up to 75% compared with diesel buses;[226] electric buses also make journeys more pleasant through reduced vibrations, smoother operation, and lower noise levels.[227] Nonmotorized modes and "last mile" connections through safe street networks are essential to link residents with their destinations and avoid having them invest in private cars and two-wheeled vehicles.[228] In many places, urban transport systems have to be planned from scratch or heavily upgraded.[229]

Tracking and accelerating action

There is a large community of sustainable transport planners, practitioners, researchers, and public and nongovernmental champions actively working on a range of topics related to triple zero urban transportation. There is a rich history of innovation for sustainable mobility reaching back many decades. Local governments have been pioneers in implementing approaches to foster decarbonization, road safety, accessibility, congestion reduction, and many other

Local governments have been pioneers in implementing approaches to foster decarbonization, road safety, accessibility, congestion reduction, and many other sustainable solutions. Yet efforts to track progress are patchy and limited at a global scale.

sustainable solutions. Knowledge circulates globally, thanks to nongovernmental knowledge actors such as the Sustainable Low Carbon Transport Partnership, the Institute for Transportation and Development Policy, the New Urban Mobility Alliance, professional networks such as the International Association of Public Transport and the National Association of City Transportation Officials in the United States, and intercity networks such as C40 Cities and Local Governments for Sustainability.

Yet efforts to track progress are patchy and limited at a global scale. The Sustainable Urban Mobility for All coalition, established in 2017, brings some coherence to this disparate community by aligning more than 50 influential public and private actors from across the transportation space to advocate, act, and finance the sustainable mobility future. Its first flagship publication (the *Global Mobility Report*), a first-ever assessment of the global transport sector and the progress made toward achieving sustainable mobility, finds a large gap between reality and ambition that defies quantification for lack of common definitions, agreed methodologies, and data availability.[230]

Transition to zero waste cities

Globally, around 7 billion to 9 billion tons of waste are produced annually, of which 2 billion tons is municipal solid waste (MSW) that local governments must manage.[231] It is estimated that cities dump or send 70% of MSW to landfills, recycle or compost 19% to recover materials, and rely on modern incineration to treat the remaining 11%.[232] In many low-income cities, waste collection and processing are carried out by informal workers whose livelihoods depend on waste-derived revenues.[233] In these lower-income countries—principally those in sub-Saharan Africa, South Asia, and the North Africa—it is thought that MSW could double or even triple in the next 15 to 20 years.[234] This will put considerable strain on local governments, which spend about 19% of their budgets on waste management.[235]

Global MSW, which includes a range of organic and inorganic waste streams from households, businesses, and public organizations, has multiple environmental, social, and economic consequences. The generation of waste and its ineffective management through dumps and landfills accounts for about 5% of global GHG emissions.[236] MSW is also linked to the accumulation of plastic in the ocean, disease, nutrient imbalances in nearby water bodies from leached nitrogen, and adverse public health outcomes from the dumping and open burning of wastes.[237] In addition, in lower-income countries the health and livelihoods of informal workers whose labor underpins waste systems are often at risk from lack of formal recognition of their contribution, of access to social protection, and of secure revenue sources.[238]

Over the past decade or so, many cities around the globe have started working toward being "zero waste." What counts as zero waste varies considerably across cities and countries; however, there is a common understanding that it involves diverting waste from landfills, dumping, and incineration to other uses. Across the spectrum of national and local responses, zero waste may include a range of measures, including reducing waste generation, reusing and recycling waste, treating waste (by composting, anaerobic digestion, incineration, use of sanitary landfills, and other methods), and converting waste into resources (recovery) such as electricity, heat, compost, and fuel.[239] Composting of wet waste, in particular food waste, has become popular in high- as well as low-income cities.[240]

However defined, and whatever strategies are employed, most cities are far from achieving a 100% diversion rate. In the United States, for instance, the national average recycling and composting rate was around 35% in 2017.[241] There are many challenges with recovering waste streams, such as plastics and electronics, at a time when global recycling supply chains are under strain because traditional waste importers (China, Malaysia, India, and others) have stopped accepting such recyclable waste.[242]

Tracking and accelerating action

The most globally comprehensive effort leading the way toward zero waste cities is the "Global Waste Management Goals," the product of a multi-stakeholder process and coalition led by the United Nations Environment Programme (UNEP) and the International Solid Waste Association. These goals include, among others, universal access to adequate, affordable, and safe solid waste collection services, halting uncontrolled dumping and open burning, and building sustainable livelihoods for informal waste workers in the poorest cities.[243] Some of them are also reflected in the SDGs (especially Targets 11.6, 12.3, 12.4, and 12.5).

Other international efforts include a declaration put out by more than 20 large cities that are part of the C40 Cities' network.[244] These cities aim to reduce MSW waste generation (by 15% per capita), reduce landfilling and incineration (by 50%), and increase diversion from landfill and incineration (by 70%), all by 2030. Coalitions such as the Climate and Clean Air Coalition are supporting cities in waste assessments, management plans, and feasibility studies. United Nations Human Settlement Programme launched a Joint Programme on Waste SDG Indicator Monitoring and Capacity Development.[245] The European Union's Zero Waste Cities knowledge platform is one of the few that have adopted the only internationally accepted definition put forward by the Zero Waste International Alliance.[246]

Make cities resilient

As cities have grown in complexity over the past decades and climate change impacts intensify, so too has their vulnerability to risks of a range of adverse potential (and some actual) outcomes. For example, about 90% of cities are coastal, with many now grappling with rising sea levels and more extreme storm surges that could cost these urban areas more than $1 trillion annually by 2050.[247] By 2050, almost 1.1 billion urban residents will live in cities wrestling with recurrent water shortages as surface and groundwater flows will likely fail to keep pace with urban population growth and climate change.[248] Water quality is also a challenge for many city dwellers, with an estimated 80% of all wastewater globally released untreated into rivers, lakes, or the ocean.[249] This pollution, particularly when coupled with unsustainable water withdrawals and inefficient, aging pipes, leads to saltwater intrusion in coastal cities, contaminates freshwater supplies, degrades ecosystems, and causes serious, potentially life-threatening illnesses.[250] Shifts in precipitation patterns associated with climate change will exacerbate these challenges, complicating flood management efforts and intensifying competition over freshwater resources between cities and other regional users.[251]

Urban resilience has received recent attention in the context of climate change;[252] however, it encompasses a broader range of environmental, economic, and social risks,[253] such as terrorism and cyberattacks, infectious diseases, natural disasters, as well as economic and supply chain disruptions. As complex systems, undergoing constant changes in often unforeseeable directions, cities need resilience so they can bounce back and adapt to adverse acute shocks and chronic stresses.[254] Strategies for doing so include harnessing nature-based solutions for water and heat management,[255] building earthquake-resistant infrastructure, integrating projected climate impacts into urban planning (e.g., shifting floodplains and sea level rise), and developing contingency plans for emergencies, such as early warning systems and safety nets. Putting these strategies in place is especially important because climate change does not have equal effects on urban residents. The poor and the marginalized often shoulder the heaviest burdens and have fewest resources with which to respond.

Tracking and accelerating action

A growing number of actors are helping strengthen urban resilience across the globe. Public actors such as national and local governments are playing perhaps the most important role in putting risk reduction strategies in place, including financial safety nets for emergency situations.[256] Almost 75,000 local authorities worldwide have adopted plans aligned with national disaster risk reduction strategies and the Sendai Framework for Disaster Risk Reduction 2015–2030.[257] Bilateral and multilateral donors have also been critical in channeling climate adaptation funds, often through trust funds, to developing countries to help develop local response capacity. In addition, research organizations are generating increasingly sophisticated data products to track various indicators of resilience, including water risk (Aqueduct) and vegetated surfaces (the European Union's Joint Research Centre). Voluntary disclosures by corporations and local governments of relevant indicators and actions are being tracked by CDP (formerly the Carbon Disclosure Project). Coalitions working on strengthening urban resilience range from international research and advocacy groups, such as the Global Commission on Adaptation,[258] to grassroots advocates focused on specific localities and topics, such as Slum Dwellers International, which focuses on the urban poor, and infrastructure-focused initiatives such as Resilience Shift and the Standard for Sustainable and Resilience Infrastructure (SuRe®).[259] Experience gained from initiatives such as the 100 Resilient Cities network (now the Resilient Cities Catalyst and the Global Resilient Cities Network) shows that building urban resilience is a long-term journey in which results often become apparent only when disaster strikes.

SUSTAINABLE PRODUCTION AND CONSUMPTION

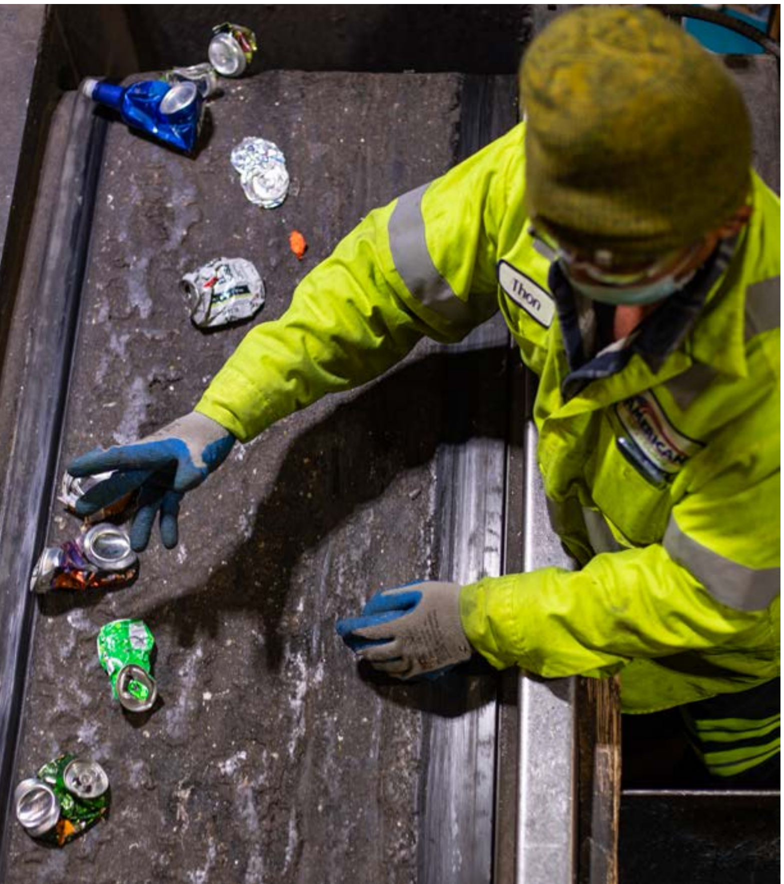
Today's unsustainable levels of production and consumption place enormous pressure on the global commons, driving biodiversity losses, stressing freshwater resources, and releasing billions of tonnes of GHGs into the atmosphere each year.[260] Reducing material use among the world's most affluent households and abandoning this linear, take–make–waste model for a circular economy—one that designs out pollution and waste, keeps materials in use for as long as possible, and regenerates natural systems—will prove critical to staying within planetary boundaries. Shifting to this new economy across all sectors, for example, could lower natural resource consumption by a third, nearly halve carbon emissions, and recoup trillions of dollars wasted by 2030. Doing so could also create 30 million new jobs over the next 10 years.[261]

But despite these potential gains, progress in transitioning to a circular economy remains slow and uneven. Although some companies, cities, and countries have made significant strides forward in closing material loops, just 8.6% of the global economy is circular.[262] Rather than cycling existing materials, we are continuing to deplete natural resources, with annual extraction rates more than tripling over the past five decades to reach 92 billion tons in 2017.[263] Our consumption of these virgin materials, which remains concentrated among high-income households, now outpaces improvements in end-use recovery by a factor of two to three, and should business continue as usual, natural resource extraction will more than double by 2060.[264] At this rate, we will exhaust the known reserves of nearly two dozen commonly used resources in the next five decades.[265] This trend not only threatens severe environmental degradation in the coming decades, but it also endangers future human well-being, particularly for the world's poorest communities, whose development, in part, depends on increased material use. Reversing course will require radical transformations to decouple resource consumption from economic prosperity.

Adopt circular product design, production systems, and supply chains

Transitioning to this new economy must begin with circular design, the stage at which manufacturers lock in 80% of a good's environmental impacts.[266] Today's overflowing landfills, marine garbage patches, and debris-filled waterways stem, in part, from design choices that give little thought to material life cycles. Nearly half of all plastic waste, for example, is from products created to be thrown away after a single use.[267] Achieving greater circularity will require a fundamental shift in these prevailing design conventions. Most important will be a rejection that waste exists—what is currently deemed waste today, for example, simply becomes an input into another good. Designers must create products from technical, inorganic materials that will continually cycle through the economy or from biological inputs that will regenerate, rather than degrade, ecosystems when they flow back into the environment.[268] Key strategies for achieving these new objectives include designing with a life cycle perspective, a method that considers durability, repairability, reuse, repurposing, and recycling; moving toward modularization to enable remanufacturing and component reuse; and focusing on dematerialization, which either directly reduces the volume of materials included in products or replaces physical goods with digital ones, such as storing files on network servers rather than maintaining paper records.

Designing out waste can spark a shift toward more sustainable consumption, but a truly circular economy will need additional changes across production systems and supply chains. In today's take–make–waste economy, materials generally flow from resource-rich countries to manufacturing powerhouses and then on to consumers in wealthy nations, where they end up in landfills. Just five countries in Asia, for example, manufacture 75% of the world's garments, which consumers concentrated in the United States, Europe, and Japan purchase. Ultimately, 80% of these clothes becomes waste. Supply chains for other fast-moving goods are similarly unsustainable, retaining just 20% of the materials' value. To close these open-looped systems and minimize resource loss, many companies must overcome three key barriers in their supply chains: geographic dispersion, material complexity, and linear lock-in. Case studies show that establishing reverse logistics systems that minimize distances between manufacturers and consumers can help reduce material leakage and enable material reuse. For many businesses, shorter distances to consumers also lower transportation costs, energy consumption, and GHG emissions. Manufacturing products with fewer, higher-quality materials can also decrease resource losses, while investing in material tracking systems enables



companies to monitor flows, prevent contamination, and improve recovery rates. But for some businesses, misaligned incentives along the supply chain may undercut these efforts to improve circularity. Companies facing this challenge will need to reconfigure these pathways to distribute the benefits (and costs) of improving circularity more equitably.[269]

Although a handful of companies now recognize the benefits of closing material loops, the widespread adoption of circular designs, production systems, and supply chains has yet to occur. Supportive policies—national circular economy strategies, sectoral targets, taxes on virgin natural resources, financial incentives for material reuse and recycling, circular design mandates, and extended producer responsibility laws—will be needed to push businesses to close their production, consumption, and waste generation loops.[270] Governments must also carefully measure the actual and anticipated impacts of these policies to avoid unintentional consequences, from displacing jobs to generating efficiency rebound effects that spur greater material production.[271]

Tracking and accelerating action

Several international coalitions have emerged to help decision-makers manage these challenges and accelerate the transition to a circular economy. The Platform for Accelerating the Circular Economy, a community of 75 public, private, and civic executive leaders, is at the forefront of this global effort. Sectoral initiatives, including the Circular Electronics Partnership, the Global Plastics Action Partnership, and the Global Battery Alliance, have also formed in recent years, as have national and regional alliances such as Canada's Circular Economy Leadership Coalition, the European Resource Efficiency Platform, and the China Association of Circular Economy. Many of the organizations spearheading these coalitions are monitoring progress toward a circular economy, including the Ellen MacArthur Foundation, the World Economic Forum, McKinsey & Company, WBCSD, the Circle Economy, and WRI. Most of this research, however, focuses on building the case for material cycling, identifying best practices, and providing tools that decision-makers can use to measure circularity within their businesses. Data measuring the uptake and impact of circular designs, production systems, and supply chains are both limited and not readily available, but will be needed to assess this transition.

Use pure, nontoxic, and regenerative materials

Pure, nontoxic, and high-quality materials—those that can be safely reused, recycled, or returned to the environment—are a prerequisite for circularity.[272] These

> Shifting to this new economy across all sectors, for example, could lower natural resource consumption by a third, nearly halve carbon emissions, and recoup trillions of dollars wasted by 2030. Doing so could also create 30 million new jobs over the next 10 years.

inputs must also be regenerative, either biologically, as renewable resources such as solar energy, or technologically, by there being predictable, well-managed stocks that, although currently locked up in existing products, will eventually return to supply chains. But the proliferation of chemical use within thousands of everyday products serves as a major impediment to these restorative material flows. Since 2000, global chemical production capacity has nearly doubled, from 1.2 billion to 2.3 tonnes, and commonly used goods now contain hundreds of these manufactured, often hazardous compounds. Not only do many of these chemicals harm human health and contaminate ecosystems when disposed, but they also create significant obstacles to extending product life cycles. Recycled materials sometimes contain chemicals that, although not dangerous when in the original products, pose health risks to consumers in their new forms. Flame retardants from recycled plastics, for example, have been found in children's toys, kitchen utensils, and thermos cups, while high concentrations of hazardous substances have appeared in rubber playground equipment built from recycled tires.[273] In other materials, particularly plastics, gradual chemical changes and the accumulation of contaminated substances pose additional challenges for reuse and recycling.[274]

Manufacturers also rely on chemicals to bind materials together, enabling designers to integrate products with different functions into a single good such as a smartphone, which allows users to make calls, send emails, take photographs, browse the internet, and watch television. But this increasing complexity limits resource recovery and reuse. Some electronic devices, for instance, rely on batteries that cannot be removed, while others include toxic chemicals, such as beryllium, that cannot be easily separated from their surrounding materials; in both instances, these design choices force recycling facilities to classify the entire product as hazardous waste. Nonhazardous mixed-material products are also difficult, if not impossible, to recycle. Food packaging that has chemical additives to improve shelf life, foil made from laminated films of plastic and aluminum, and disposable coffee cups lined with plastic are all examples of common products that existing systems cannot easily break down.[275]

Many countries have passed legislation to limit the use of hazardous substances in consumer products, with the European Union adopting some of the world's strongest restrictions. But even these policies do not sufficiently regulate chemical content in recycled feedstock, and biomonitoring data show that Europeans continue to face exposure to a complex chemical mix.[276] Switching to a smaller palette of benign chemicals will require countries around the world to adopt additional, stronger policies, such as those that mandate manufacturers to proactively disclose all substances included in their products, ban chemicals that limit reuse or recycling, and restrict harmful compounds in secondary feedstocks.

Tracking and accelerating action

Several organizations are tracking some, but not all, of the data needed to monitor this transition. The Circle Economy estimates global rates of material cycling, while the European Commission evaluates recycled resource use in production systems across its member states. The Ellen MacArthur Foundation and WBCSD both offer tools that help companies analyze their material flows, but they do not share businesses' scorecards publicly. High levels of circularity may suggest that companies are using pure, nonhazardous inputs, but existing metrics do not directly measure changes in the toxicity, complexity, and regenerative nature of materials. Similarly, UNEP's *Global Chemicals Outlook* synthesis reports assess global efforts to minimize the adverse impacts of global chemical production, use, and waste, but its latest publication highlights data gaps that prevent scientists from analyzing chemical flows throughout product life cycles.[277] Although many circular economy coalitions call on manufacturers to use nontoxic, pure, and regenerative materials, few alliances dedicated solely to addressing this particular challenge exist.

Shift to circular business models and a sharing economy

The predominantly linear business models of today's take–make–waste system provide little incentive to retain resources within the economy. To shift this paradigm, companies must not only rethink product designs, materials, production systems, and supply chains, but also transform their core strategies and value propositions. Business models that broadly support this transition to a more circular economy include circular supply models, which rely on renewable or recovered inputs rather than virgin raw materials; resource recovery models that retain materials' value by channeling them back to manufacturers or retailers for reuse or recycling; product life extension models that lengthen the use of existing goods; sharing models that increase the utilization of existing, often privately owned goods; and product service models, in which companies retain ownership of a good and instead sell its service, performance, or value.[278] These corporate schemes not only improve material cycling throughout the economy, but they also strive to serve the needs of a fast-growing, increasingly wealthy global population with a smaller absolute amount of materials. Although some of these approaches are fairly mature, such as waste recycling or product reuse and repair, circular business models' market penetration in most sectors stands at just 5% to 10%.[279]

Relatively new circular business models, however, are rapidly emerging, fueled by technological innovations, urbanization, and shifting consumer preferences that value access over ownership. Product service models, particularly mobility-as-a-service schemes, have become increasingly popular over the past decade, with bicycle, scooter, and car-sharing arrangements appearing in cities around the world from Vietnam to Kenya to Brazil.[280] Global membership of urban car-sharing schemes is increasing at an annual rate of 65%; in Western Europe, specifically, many businesses have diversified these product service models to include home lighting, washing machines, and clothing. Sharing business models, which allow owners of underutilized assets to charge consumers to use products that would otherwise remain idle, are also gaining ground, with AirBnB becoming the largest single supplier of short-term accommodation in just 10 years and Uber expanding to 250 cities in just five years.[281]

The rise of these two circular business schemes also underpins the expansion of the sharing economy, a spectrum of economic models in which swapping, sharing, trading, or renting assets broadly replaces conventional ownership of goods. Transactions across this continuum can occur between individuals, companies, or consumers and businesses.[282] Already emerging quickly in dense urban centers around the world, several sharing economy sectors, including travel, finance, car sharing, staffing, as well as video and music streaming, will grow significantly over the next five years. By 2025, global revenues in these five markets may reach $335 billion, up from $15 billion in 2015.[283] However, the sharing economy does not always lead to improved efficiency. Ridesharing, for example, can include someone renting a car that they did not previously own to drive for Uber, and taking people on rides they otherwise would not have made. Concerted efforts from both businesses and policymakers will be needed to steer the sharing economy toward greater sustainability.[284]

Widespread adoption of all circular business models will depend on governments' willingness to address market failures, misaligned policies, and perverse incentives. Policies that prioritize circularity include those that accurately price externalities (e.g., taxes on virgin resources), hold producers accountable for their goods' end-of-life management (e.g., extended producer responsibility laws), deliver subsidies to companies that invest in material cycling or integrate recycled inputs into their products (e.g., differentiated value added tax rates), and incentivize greater sharing of products (e.g., congestion pricing). Research and development investments, consumer educational programs, and green public procurement initiatives can also encourage companies to adopt circular business models.[285]

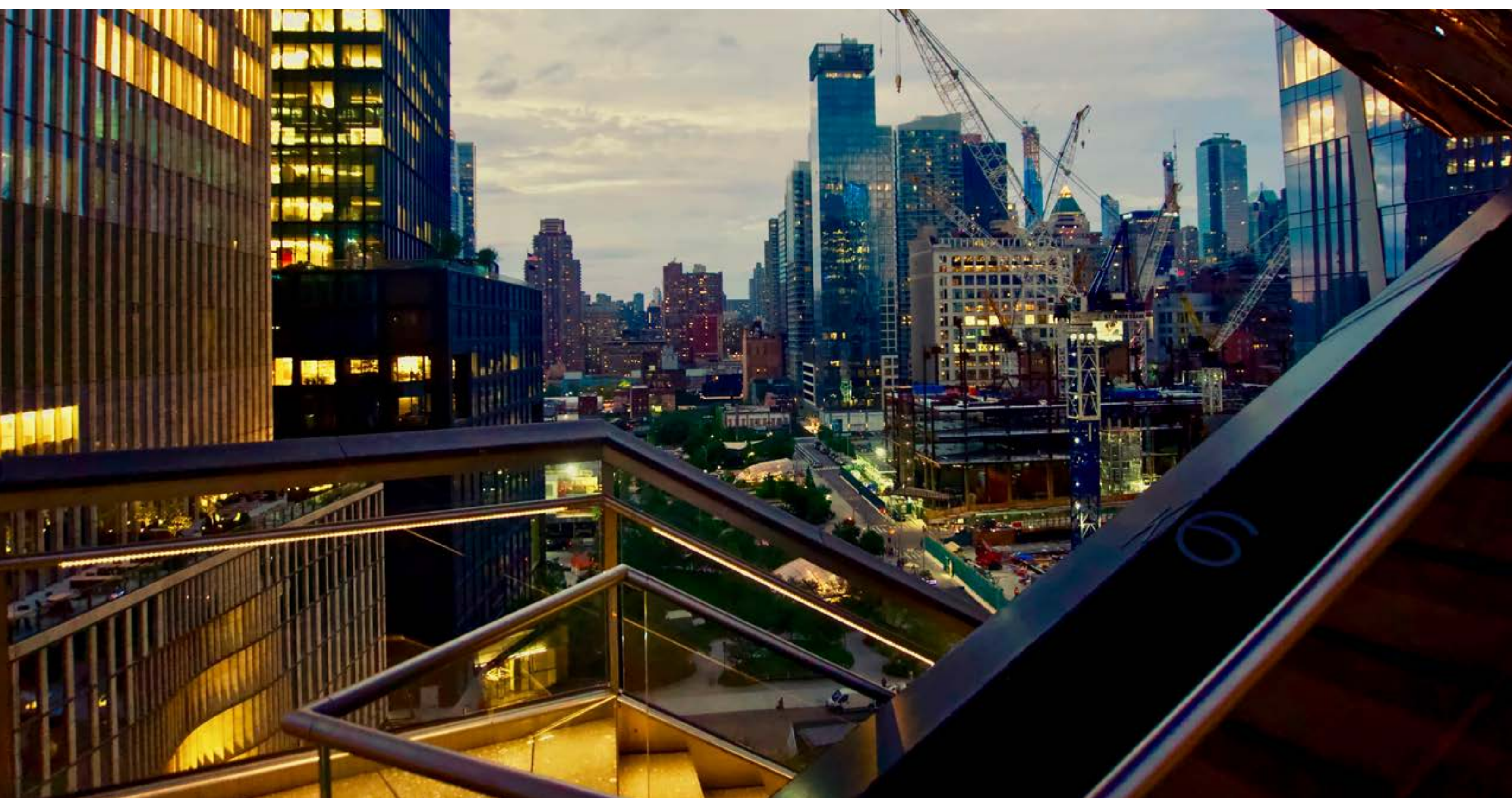
Tracking and accelerating action

Indicators from the Ellen MacArthur Foundation enable companies to assess circularity within their businesses, while those from WBCSD indirectly measure companies' uptake of circular business models. This information, however, tracks circularity only at the company level, and it is not publicly available. Data and data protocols needed to monitor the uptake of circular economy business models, including those that contribute to the sharing economy, are not readily available.

Shift consumption patterns to reduce waste and overconsumption

Improving circularity within material flows underpins this transformation, but it represents only one side of the equation. Even as companies close resource loops, global material use will likely grow if the world's most affluent citizens' consumption patterns continue unabated.[286] Since 1990, the global material footprint, a consumption-based indicator of resource use, has increased by 113%. Living standards across the world's wealthiest countries account for much of this rise and its related environmental impacts. High-income nations, for example, have maintained an average material footprint of about 27 tons per person over the past three decades—at least 60% higher than that of upper-middle-income nations and more than 13 times greater than that of low-income countries. In 2017, this material footprint caused environmental impacts, such as rising GHG emissions and biodiversity losses, that were three to six times higher per capita than those arising from the average material footprint in low-income nations.[287] These international analyses, however, often obscure deeper inequalities that are widening within countries.[288] Fueled primarily by income inequality, the top decile of income earners' consumption patterns account for 25% to 43% of environmental impacts globally, compared with just 3% to 5% of ecological harm caused by the consumption patterns of the world's lowest decile of income earners.[289]

Not only do current consumption trends of the world's wealthiest citizens threaten the global commons, but many less affluent households are increasing their material footprints every year, particularly within upper-middle-income countries.[290] If every person on Earth consumed as much as the average citizen in high-income countries, human society's material footprint would surpass the planet's biocapacity by a factor of nearly four.[291] Equitable, sustainable consumption —that which enables everyone to meet their basic human needs and live a dignified life—will instead require both "contraction and convergence."[292] Needed changes may be disruptive, such as shifting from high- to low-tech options (e.g., air-drying clothes instead of using a dryer), establishing minimum and maximum consumption limits, and rethinking definitions of economic prosperity. Technological gains that boost efficiency can contribute to this transition, but these innovations alone cannot keep the global population within planetary boundaries while also improving the well-being of those living in poverty. A growing number of studies, for instance, find that rising consumption levels have dampened—and in some cases canceled—the effect of new technologies designed to minimize goods' environmental impact.[293]



Tracking and accelerating action

Efforts to increase circularity within production systems have often garnered more attention than those focused on sustainable consumption.[294] However, a growing number of experts are calling for a new economic model to address current and projected ecological degradation arising from unsustainable resource use. Kate Raworth's doughnut economics, for instance, visualizes a safe operating space for humanity, where consumption needed for human well-being exists within planetary boundaries, as an alternative to those that focus primarily on GDP.[295] Similarly, the Capital Institute's vision of regenerative capitalism calls for the deceleration of consumption across the developed world to allow developing countries to attain equitable, sustainable material prosperity.[296] Many organizations leading the transition to a circular economy, such as the Ellen MacArthur Foundation and the World Economic Forum, also advocate for more sustainable consumption patterns and dematerialization, noting that reducing demand for materials sits atop the circularity hierarchy. But few are explicitly calling for the world's most affluent individuals to reduce their overconsumption and addressing the forces that drive these unsustainable lifestyles.

UNEP and the International Resource Panel track data on consumption-based material flows, providing information on total use, per capita use, and use per U.S. dollar. In their latest report, *Global Resources Outlook 2019,* they estimate global and per capita material footprints since 1990 and some of the drivers, while the Global Footprint Network tracks global and country-level ecological footprints. The United Nations Statistics Division also tracks material footprint as an indicator for SDG 12. Data that focus on the drivers of consumption, such as population growth, income (a proxy indicator for affluence), and technological innovation, exist but are often dispersed.

FINANCIAL SYSTEMS

Financial systems underpin growth and development. They encompass "institutional units and markets that interact, typically in a complex manner, for the purpose of mobilizing funds for investment, and providing facilities, including payment systems, for the financing of commercial activity."[297] The principal threat that the world's current financial system poses to the global commons is that the rules governing financial decision-making fail to account for environmental, social, and governance risks and opportunities. As a result, the world's "$80 trillion annual economy creates environmental externalities valued at over $7 trillion annually, and at current patterns of economic growth are set to further erode global natural wealth by over 10% by 2030."[298]

According to UNEP's 2015 Inquiry, the largest, most recent international effort to analyze and shift global finance, a "quiet revolution" has begun to unfold in financial systems—a revolution that is moving them toward the internalization of sustainable development into financial decision-making. A working definition for a sustainable financial system has been put forward: "one that creates, values and transacts financial assets in ways that shape real wealth to serve the long-term needs of an inclusive, environmentally sustainable economy."[299] This definition represents a shift from conceiving a "sustainable" financial system as one that can weather financial crises to a broader definition that seeks to align capital allocation with wider environmental, social, and economic goals to serve the transition to sustainable development.[300]

Measure, disclose, and manage climate and other types of environmental risks

Until relatively recently, decision-making about long-term strategies for the efficient allocation of investment capital did not routinely account for climate change risks. However, as losses from natural catastrophes have intensified in recent years, amounting to $640 billion in 2017–2019, investors are now seriously considering the risk of unanticipated financial losses associated with climate change. These losses may come from extreme events (e.g., storms, droughts, and wildfires), changing weather patterns over time (e.g., the effect of rising sea level on credit secured by coastal real estate), or rapid losses in the value of assets caused by changing policies or consumer preferences.[301]

Climate-risk disclosure has made important advances in recent years. Both investors and financial regulators are demanding internationally consistent climate and environment-related disclosures relating to the potential financial impact of climate risks. Investors see the absence of such information as a possible threat to their investments, while regulators see it as a threat to the functioning of financial markets.[302]

However, most countries do not yet mandate climate-risk disclosure. The notable exception is France, whose Article 173 constitutes the world's first climate change financial disclosure law since 2016.[303] Other countries, such as the United Kingdom, have committed to exploring mandatory disclosure, but in the meantime, few companies disclose—or manage—climate risks systematically. Voluntary disclosure has progressed thanks to initiatives such as the Task Force on Climate-Related Financial Disclosures (TCFD) and the Sustainability Accounting Standards Board. One important response has come from within the financial community in the form of a call for better information and greater transparency about how companies that issue public debt or equity across a wide range of sectors are exposed to these risks and are preparing to mitigate them.[304]

Disclosure is an important element needed for managing and pricing the physical risks from climate change. The International Monetary Fund's (IMF's) latest Global Financial Stability Report finds that equity valuations across many countries in 2019 did not reflect commonly discussed climate scenarios and physical climate risks, such as loss of life and property, or disruptions to economic activity caused by floods, heat waves, and droughts. Pricing these is a difficult exercise for investors, as it requires evaluating long-term firm-level implications of climate scenarios and expected mitigation and adaptation actions. Yet, the study finds that neglecting physical risks could present a significant source of market risk and that firm-specific disclosures on exposures (current and future) could help better price risks in the future.[305]

The TCFD provides an annual tracking of the implementation of TCFD recommendations for disclosing climate risks (full, partial, or none) and their incorporation into decision-making. The TCFD's recommendations are supported by corporations and investors (the latter with more than $135 trillion in assets under management collectively) and more than 1,000 organizations. However, the tracking covers only companies and does not include other financial actors, such as public finance institutions. Similar to the TCFD but more recent is the Task Force for Nature-Related Financial Disclosures launched by the governments of the United Kingdom and Switzerland, the World Wildlife Fund (WWF), and Global Canopy. Aiming to publish a reporting framework in 2021, the task force will follow a format similar to that of the TCFD and focus on the overexploitation of natural resources.

Scale up public climate finance

"Climate finance" represents the financial resources that cover the costs of transitioning to a low-carbon global economy and of building resilience to current and future climate change impacts.[306] In 2009, developed countries committed to jointly mobilizing $100 billion per year from public and private sources by 2020 to support climate action in developing countries.[307] The 2015 Paris Agreement aims to make these finance flows consistent with the objective of limiting the increase in global average temperature to 1.5°C above preindustrial levels and to achieve a balance between funding for mitigation and adaptation actions.[308] Commitments such as these send a strong signal to financial actors that a rapid and deep shift away from high-emission investments is needed.[309]

The global public climate finance landscape is a patchwork of countries, bilateral institutions, multilateral institutions, and regional organizations that are all involved in raising, channeling, and deploying finance for climate-related activities. These commitments have a critical role to play in terms of meeting the global costs of climate change mitigation and adaptation, helping to create new markets (such as those for renewable energy and energy efficiency), fostering innovation, reducing risk, leveraging private investment, and providing funding for goods and services that commercial markets do not support, such as improved disaster warning systems, capacity building, and community participation.[310] Using public funds in a catalytic manner requires finding the right approaches, resources, and space for experimentation, as it involves accounting for different needs across sectors and countries, depending on their financial readiness, the investment profiles of projects, and national and sectoral investment environments.

Climate finance flows reached a record high of $579 billion in 2017–2018 across all types of investors, with domestic, bilateral, and multilateral development finance institutions accounting for the majority of public finance.[311] However, a key barrier to scaling up the levels of public finance is mobilizing ambition among international actors and then translating these commitments into actual sources of finance that can be counted and tracked.[312] Other obstacles include fragmented responsibilities, poor institutional cooperation, limited resources, and programming and implementation costs.[313]

The United Nations Global Climate Action portal notes that more than 2,500 cities and 2,000 companies have registered their commitments to act on climate change. The United Nations Framework Convention on Climate Change (UNFCCC) Standing Committee on Finance tracks global climate flows on a biannual basis and the Climate Policy Initiative publishes a flagship report, which features a broad range of disaggregated data by geography and type.[314] These are fairly comprehensive exercises, but they do not include subnational tracking, making it difficult to understand how effectively global flows are in reaching the local level where climate projects are implemented.[315] There are many actors seeking to boost public climate finance commitments, disbursements, and effectiveness, including bilateral and multilateral institutional actors and nongovernmental organizations. Since 2019, finance ministers from 20 countries have formed the Coalition of Finance Ministers for Climate Action,[316] which endorses a set of principles to boost climate action through fiscal policy, public finance, and partnerships with key institutional actors such as the IMF, Organisation for Economic Co-operation and Development (OECD), UNFCCC, the United Nations Development Programme, and the NDC Partnership, among others.

Unlock private investment in sustainable infrastructure

Mobilizing private capital is seen as essential to achieving the required investment levels for low-carbon and resilient infrastructure. These investment needs for global infrastructure from 2015 to 2030 have been estimated at $90 trillion (or $6 trillion per year); another $270 billion per year would be required to make investments in energy, transport, cities, and other low-carbon areas.[317] Demand stems from both aging infrastructure in advanced economies and rapid urbanization in developing countries. The challenge is enormous—the amounts required are more than the entire existing infrastructure stock today, and approximately two-thirds is needed in the global South, where investment conditions are more challenging.[318]

The transformation needed is twofold: meeting the incremental cost of low-emissions, climate-resilient investments, as well as mobilizing and reorienting the large amount of business-as-usual investment in the first place.[319] Private capital is still largely untapped for sustainable investments, in particular the long-term debt finance in capital markets and the large pools of institutional investor capital.[320]

The challenge is enormous—the amounts required are more than the entire existing infrastructure stock today, and approximately two-thirds is needed in the global South, where investment conditions are more challenging.

Tracked private finance reached an annual average of $326 billion in 2017–2018, primarily going to renewable energy (85%) and low-carbon transport (14%), consistent with the greater commercial viability of these investments.[321] These numbers are still far from the estimates of what is needed for a sustainable infrastructure transition. The lack of transparent and bankable project pipelines reflects significant transaction costs involved in getting nontraditional, low-carbon, and resilient investments off the ground. Matching supply- and demand-side actors through project preparation activities can amount to 2.5%–5% of total investment cost—for energy sector projects, this could amount to $1–2 trillion, and $0.7–1.3 trillion for transportation.[322]

Several efforts are underway to boost private investment in sustainable and resilient infrastructure. These are taking place at global, regional, national, and project-level scales, and—given the geographically specific nature of investment conditions—across different geographies. There is a growing number of "project preparation facilities" that aim to match infrastructure projects with investors, helping to prepare transactions, business models, revenue sources, and often regulatory aspects, through technical assistance and stakeholder engagement, as well as enabling environment support. Many of these are bilateral and multilateral undertakings, such as the World Bank-hosted Public-Private Infrastructure Advisory Facility and the Group of Twenty's initiatives (e.g., the Global Infrastructure Facility and the Global Infrastructure Hub). Others are specific to an implementation level or a geography, such as the Cities Climate Finance Leadership Alliance and the Cities and Climate in Africa facility funded by the European Union, Switzerland's State Secretariat for Economic Affairs, and the Agence Française de Développement, which targets investment in African cities. Globally, there has been a movement to establish standards on sustainable and resilient infrastructure in order to distinguish it from conventional infrastructure, broaden its appeal among different investor groups, streamline regulations, and pave the way for innovative financial instruments to help accelerate investments, lower transaction costs, and reduce investment risks.[323]

Extend financial services to underserved groups

Financial inclusion is one of the best ways to build individual and collective resilience and enable people to buy low-carbon technologies.[324] Globally, about 1.7 billion adults remain "unbanked," living without an account at a financial institution or through a mobile money provider. Women account for more than half of the unbanked population, nearly half of whom live in just seven developing countries: Bangladesh, China, India, Indonesia, Mexico, Nigeria, and Pakistan.[325]

Increasing financial inclusion helps low-income populations better manage climate risks. The full range of financial services is relevant when building individuals' and small businesses' climate resilience—savings, credit, insurance, and easy money transfer options, including digital channels—as they can provide a buffer against climate events as well as help include those at the bottom of the economic pyramid throughout the transition to low-carbon economies. Extending financial services to underserved groups could strengthen their resilience while boosting investments in low-carbon technologies.[326] On the supply side, offering financial services to lower-income and poor populations is still lagging behind services offered to wealthier groups, especially in countries where the financial system as a whole is less mature. The principal reasons for not having an account, according to the 2017 Global Findex survey, are having too little money to use an account, the cost of and distance to a financial institution, because a family member already has one, lack of documentation, distrust in the financial system, and religious reasons.[327]

The World Bank provides the well-respected Global Findex Database, which tracks financial inclusion across more than 140 countries and includes a range of indicators and type of financial services. There are a number of existing partnerships and national initiatives that aim to foster financial inclusion. The Alliance for Financial Inclusion is a member-owned network that works on policy and regulation at a global level, in close partnership with and support of its members—central banks and other financial regulatory institutions from emerging and developing countries. There are also numerous national initiatives that focus on boosting financial inclusion in specific geographies, such as the national financial inclusion strategies of Indonesia, Mexico, and Pakistan.

Price GHG emissions and other environmental externalities

Externalities are a result of mispricing natural capital assets and economic activities. Natural capital assets include those that can be traded (e.g., fossil fuels and mineral commodities) and those for which no price exists, including public goods, such as clean air, safe drinking water, and biodiversity. It has been estimated[328] that unpriced natural capital costs arising—for example, from climate change, water use, land use, air and other types of pollution, and hazardous waste—was about 13% of global economic output in 2009. These price distortions have significant harmful effects on efforts to align the financial system with sustainable development. They are thought to introduce economic inefficiencies, divert resources from better uses within the economy, benefit the rich rather than the poor, decrease the competitiveness of low-carbon businesses by discouraging investment and negating carbon price signals, and damage public health by supporting polluting activities.[329]

Pricing externalities is designed to shift the burden for the damage back to those who are responsible for it. In 2018, almost 60 jurisdictions worldwide had implemented some form of carbon pricing, either through taxation or emission trading schemes (many of these in the Americas and Canada).[330] These efforts generated roughly $44 billion in carbon pricing revenues in 2018. However, current prices are not consistent with achieving the Paris Agreement, and carbon pricing schemes cover just 20% of global GHG emissions.

Theoretically, governments can then use these carbon revenues to generate revenues that can be reinvested.[331] The challenge of introducing carbon pricing (in the form of a cap-and-trade program or a carbon tax) requires designing, developing and executing the carbon pricing system itself, which is a major undertaking requiring technical expertise, political buy-in, and long-term implementation capacity.[332]

The World Bank provides an up-to-date, annual overview of existing and emerging carbon pricing instruments through its *State and Trends of Carbon Pricing* publication. The World Bank also hosts the Secretariat of the Carbon Pricing Leadership Coalition, a voluntary initiative that brings together government, business, and civil society to support the implementation of carbon pricing around the world and share implementation experiences. There are also various national and regional pressure groups and champions that promote different forms of carbon pricing in their own geographies, such as the Carbon Tax Center in the United States.

Eliminate harmful subsidies

The mispricing of externalities also includes monetary incentives for activities that are the source of environmental degradation. In OECD countries and major economies, it is estimated that government tax breaks and spending programs support fossil fuels at a level of $160–200 billion annually, accounting for an estimated 70% of all energy subsidies and contributing to considerable adverse effects on the global commons.[333] According to IMF estimates, subsidies were valued at $4.7 trillion (6.3% of global GDP) in 2015, with China, the United States, Russia, European Union, and India being the largest subsidizers. Coal and petroleum accounted for 85% of global subsidies. Reductions in these subsidies could have lowered global carbon emissions by 28%, reduced fossil fuel air pollution deaths by 46%, and increased government revenue by 3.8% of GDP.[334] Removing fossil fuel subsidies could also significantly reduce the average payback periods for a range of efficient appliances.

However, in most countries, subsidy reform is a politically contentious agenda. On the one hand, taxpayers are frequently unaware of how much public money is spent on subsidies in the first place, and are likely to see some prices go up as a result of reform. On the other hand, there is a lack of transparency on the production side with regard to how much energy producers (whether state-owned or not) receive from government, and subsidies may take many different forms, which are often not clearly identified in government budget documents. Special interests exerting political influence and weak institutions—limited government capacity and mechanisms for coordinating reform—add to inertia affecting fossil fuel reform. Still, some nations are making progress. The IEA classified 12 countries' experiences as successful, leading to permanent and sustained reduction of subsidies.[335] A review of carbon pricing initiatives found 57 national and subnational initiatives in implementation or scheduled to be implemented in 2019.[336]

Several global efforts aim at tracking and dismantling harmful fossil fuel subsidies. The IMF tracks global and regional energy subsidies for 191 countries on a regular (but not annual) basis. The Global Subsidy Initiative, led by the International Institute for Sustainable Development, is actively working to remove harmful subsidies through a range of research projects and capacity support, raising awareness about subsidies' harmful impacts and the possibilities for phasing out them in different countries. Campaigns and more activist approaches also exist, including notably Oil Change International's #StopFundingFossils campaign, which seeks to mobilize citizens to put pressure on their governments.

LAND, FOOD, AND FOREST MANAGEMENT

To stay within Earth's planetary boundaries, reduce GHG emissions to safe levels, and maintain critical ecosystem services, we will have to dramatically change the way we manage land. We have to reduce forest loss and degradation, accelerate forest restoration, and decouple increases in agricultural yields from the expansion of crop- and pastureland.

Terrestrial ecosystems sequester almost a third of all anthropogenic CO_2 emissions, making it impossible to limit global temperature rise to 1.5°C absent a paradigm shift in how we manage land. A change in land use—clear-cutting forests to make way for livestock pastures or farms—drives the agricultural sector's GHG emissions. Agriculture, peatland destruction, and other land-based sources, for example, account for nearly 45% of recent human-driven emissions of methane, a highly potent GHG. At the same time, despite increased deforestation and other land-use changes, the world's lands continue to remove more GHGs than they generate. From 2007 to 2016, for instance, land sequestered a net 6 Gt of CO_2 each year, equivalent to the United States' annual GHG emissions. Continued deforestation and land degradation, however, increasingly limit this carbon sink's ability to store GHGs.[337]

The food system currently operates as a major carbon source and threatens our collective ability to remain within the 1.5°C boundary.[338] Current practices are too resource intensive and could risk destabilizing essential regulatory functions of the ecosystems we depend upon. This risk becomes ever more pertinent as the global population grows and, on average, becomes wealthier. These socioeconomic and demographic changes consequently increase pressures on our food system, threatening to disrupt the safe operating space for GHG emissions, land and water use, and nitrogen and phosphorus application if no systemic change is undertaken.[339]

Protect 30% of forests and other land by 2030

Forests and other lands provide critical ecosystem services, from housing biodiversity, to providing food and fiber, to safeguarding communities from floods and droughts. They also protect us from much greater climate impacts, given the role they play as a carbon sink. Curbing deforestation and forest degradation offers the largest potential for lowering land sector emissions.[340]

This transformation entails protecting new land and strengthening the conservation of existing protected land to maintain critical ecosystem services, biodiversity, and carbon pools, as well as to reduce the conversion of forests, peatlands, wetlands, and grasslands. The New York Declaration on Forests called for halving tropical deforestation this year, by 2020, and ending it altogether by 2030. However, tropical forest loss continues unabated, with an annual loss of tree cover over an area the size of the United Kingdom taking place between 2014 and 2018. Primary forest loss has accelerated, with primary forest loss in the humid tropics accelerating by 44% from 2001–2014 to 2014–2018. The largest driver of forest loss is agricultural commodities, and if current trends continue unabated, the world will lose 289 million hectares of tropical forest—an area roughly the size of India—by 2050.[341]

In addition to halting deforestation, we must also prioritize preventing it, particularly in forests. High forest cover and low deforestation (HFLD) countries—those with forests that stretch across more than 50% of national lands and deforestation rates below 0.22%—contain nearly a quarter of the world's forests, much of the planet's intact, unfragmented tropical forests, and 10.5% of carbon stored in these equatorial ecosystems.[342] Yet these nations have received less than $2 billion in climate finance since 2007. Funding for reducing emissions from deforestation and forest degradation, plus sustainable management of forests and the conservation and enhancement of forest carbon stocks (REDD+), is strongly correlated to countries' loss of tree cover and emissions from deforestation

rather than to nations' total forest cover. These findings suggest that many donors are channeling REDD+ finance to regions grappling with acute deforestation pressures—but without financial support, economic development could sharply increase forest loss in HFLD nations over the coming decades.[343] Adopted in 2019, the Krutu of Paramaribo Joint Declaration on HFLD Climate Finance Mobilization calls on the international community, including the Green Climate Fund, to align financial frameworks and mechanisms with HFLD nations' sustainable forest management needs, representing an important step forward for those nations.[344]

Various multi-stakeholder organizations are also working hard to introduce an "apex goal" for nature and biodiversity that includes protecting 30% of the terrestrial surface of the planet that is still in relatively pristine condition. Related restoration goals have been set (see the following section). This work entails the completion of a science-based target for biodiversity and its inclusion in the Convention on Biological Diversity's (CBD) post-2020 framework, currently being negotiated under the Conference of the Parties to the CBD.

Tracking and accelerating action

The Food and Agriculture Organization of the United Nations (FAO) recently published the *State of the World's Forests* (2020), a report that helps track the protection of lands. Global Forest Watch showcases data on protected areas, tree cover loss, and tree cover loss by dominant driver (e.g., commodity-driven deforestation, shifting agriculture, forestry, wildfire, and urbanization), and hot spots of primary forest loss, as well as primary forests, intact forest landscapes, mangrove forests, and land cover. Datasets exist for only some drivers of forest loss, such as land tenure.

Protected Planet has data on protected areas, including coverage, representation, connectedness, and areas of importance for biodiversity. The database on the downgrading, downsizing, and degazettement of protected areas maintained by Conservation International and WWF shows the downgrading, downsizing, and degazettement of protected areas after they were established. Conservation International, WWF, Birdlife, The Nature Conservancy, and the Royal Society for the Protection of Birds have put together an assessment of progress toward the CBD's Aichi Biodiversity Targets, which have relevant data on several indicators. The Tropical Forest Alliance has data on deforestation commitments and assesses how well they have been implemented. An assessment has been conducted on progress toward achieving the New York Declaration of Forests, which includes a large variety of organizations.

Despite the large number of different types of commitments (e.g., under the CBD, UNFCCC, the United Nations Convention to Combat Desertification, the New York Declaration of Forests, the Bonn Challenge, the SDGs, and various commodity roundtables), there is no strong accountability mechanism. However, the Tropical Forest Alliance has data on deforestation commitments and assesses how well they have been implemented. A multi-partner assessment of progress toward the New York Declaration of Forests has also been conducted.

Restore degraded landscapes

As a complement to halting deforestation and protecting forests and lands, we must restore our landscapes to improve air and water quality, control erosion, protect biodiversity, and sequester carbon.. Across developing countries, restoration can raise smallholders' incomes by $35 billion to $40 billion annually within the next 15 years.[345]

The New York Declaration calls for restoring 150 million hectares of degraded lands by 2020 and 350 million hectares by 2030. It is estimated that meeting the 150 million hectare restoration goal alone would bring $85 billion per year in net benefits.[346]

Tracking and accelerating action

The Bonn Challenge includes almost 60 pledges from countries, subnational jurisdictions, and companies. Regional restoration initiatives, such as the African Forest Landscape Restoration Initiative in Africa and Initiative 20x20 in Latin America and the Caribbean, also contribute to meeting the Bonn Challenge goal. However, restoration is often happening outside natural forests and only about 18% of the 2020 goal has been met.[347]

Data on tree canopy cover and on tree cover gain and loss can indicate positive or negative restoration progress. Data on tree cover outside forests can also be a relevant indicator. Such data are collected by the University of Maryland, SERVIR, and FAO. However, there is no definitive dataset that can be used to track restoration. Data on restoration are self-reported by some countries (e.g., under the Bonn Challenge Barometer of the International Union for Conservation of Nature [IUCN]), but by only a fraction of those that have made a commitment. There is no independent assessment of restoration achieved and no progress toward restoration pledges being tracked on a regular basis.

Manage land sustainably to increase yields 40% by 2050 without expanding agricultural land or degrading ecosystems

Human activities directly impact 70% of Earth's ice-free land, more than a quarter of which now suffers from degradation, and the many pressures currently placed on land will intensify in the coming decades.[348] Driven by land-use changes, primarily from the agricultural sector, and unsustainable management practices, land degradation,[349] which includes forest degradation, fuels biodiversity losses, releases GHG emissions, limits terrestrial ecosystems' carbon uptake, and threatens food security around the world. Since 1998, productivity declines across natural and managed ecosystems have occurred on one-fifth of the planet's vegetated surface.[350] Today, erosion on agricultural lands outpaces soil formation rates by a factor of 10 to 20 on untilled lands and by 100 on conventionally tilled fields.[351] These cropland soils have also become a source of GHG emissions, losing between 20% and 60% of soil organic carbon even before cultivation.[352] Against this backdrop, chemical pesticides and fertilizers use continues to rise as farmers strive to maintain yields as land productivity falls, but these synthetic inputs have come at a cost:

Across developing countries, restoration can raise smallholders' incomes by $35 billion to $40 billion annually within the next 15 years.

biodiversity losses, increased soil salinization, and pollution of nearby and downstream ecosystems.[353] The impacts, in turn, often lead to further degradation.

Already, climate change is increasing the rate and magnitude of land degradation, multiplying threats for the estimated 1.5 billion people whose livelihoods depend on degraded lands.[354] Many of those affected live in poverty across the developing world, and losses in land productivity heighten these households' vulnerability to climate impacts, hunger, and conflict over scarce natural resources.[355] Land degradation can also entrench rural families in a cycle of poverty. For example, when unproductive land yields smaller harvests, many families increase their reliance on activities in nearby forests or other wildlands, such as collecting and selling fuelwood. But as dependence on these ecosystems rises, they often begin to experience degradation, forcing families to return to unproductive farms.[356] Many are left with few choices but to migrate or to expand agricultural lands—decisions that, in aggregate, risk exacerbating climate change, biodiversity losses, freshwater depletion, deforestation, and land degradation.

Sustainable land management (SLM)—a suite of practices that use land resources, including animals, plants, soils, and water, to produce goods that meet humans' evolving needs, while also protecting the resources' future productive potential and environmental functions—can help avoid, reduce, and reverse land degradation.[357] Although SLM practices differ widely across contexts, they share a common set of objectives: improve soil management to reduce erosion, increase fertility, and minimize chemical inputs; curb GHG emissions, as well as increase carbon sequestration and storage; optimize water productivity by enhancing water cycling and storage; strengthen rural livelihoods by increasing yields and diversifying sources of income; conserve aboveground and belowground biodiversity; protect ecosystem services; and build resilience to intensifying climate impacts and natural disasters.[358] Sustainable forest management, one form of SLM, strives to minimize deforestation and forest degradation, enhance carbon sinks, safeguard biodiversity and ecosystem services, provide economic benefits to forest managers, and sustainably deliver goods, such as timber or fiber.[359] Agroforestry, silvopasture, integrated crop-livestock systems, intercropping perennials with annuals, integrated pest management, living fences, no-till agriculture, and terracing provide examples of well-known practices currently used around the world.[360] Implemented across scales, from smallholder fields to transboundary watersheds, SLM can generate many benefits. Meta-analyses find that readily available practices can improve land productivity, deliver economic returns, contribute to climate change mitigation efforts, and build resilience to climate impacts.[361]

However, systemic barriers to widespread adoption of SLM persist, including weak enabling environments (e.g., laws, policies, and institutions), scarce public and private finance (e.g., government grants, microcredit, insurance, and payment for ecosystem services), and poor access to knowledge and technologies throughout growing seasons. Overcoming these challenges will require a portfolio of strategies that enable farmers and land managers to choose the practices best suited to their contexts and goals, invest in appropriate technologies, and adapt as socioeconomic and environmental circumstances shift. Strengthening land tenure, co-creating knowledge informed by traditional practices and the best available science, mainstreaming SLM priorities across development initiatives, creating tax incentives, investing in participatory integrated land-use planning, supporting farmer networks, and establishing rural extension services are all proven measures that governments can adopt now to support SLM.[362] Doing so can help countries feed the world's growing population, strengthen rural livelihoods, deliver climate change mitigation commitments, and protect life-supporting ecosystems.

Tracking and accelerating action

Assessing land degradation poses several challenges to tracking this transition. Because there is no single indicator to measure land degradation, its global extent, rate, and intensity are not well quantified. Several proxy indicators, including vegetation-based parameters such as the normalized vegetation index, are available, and remote sensing of these proxy indicators, when used in combination with other information, can offer consistent, geographically specific data over decadal time scales.[363] But these metrics, many experts agree, miss facets of land degradation that are subjective and value-based. Data detailing the direct drivers of land degradation are more readily available, such as land-use changes (e.g. deforestation, urbanization, or agricultural expansion) and management practices (e.g., fertilizer or chemical use), but information needed to track indirect drivers is more limited and dispersed. Similarly, efforts to systematically track adoption and impact of SLM are nascent, with the World Overview of Conservation Approaches and Technologies' global SLM database of practices leading the way.

Still, many institutions are contributing much-needed knowledge, identifying, monitoring, and evaluating practices, policies, and financial mechanisms needed to scale up SLM. United Nations entities (e.g., FAO, the Secretariat of the United Nations Convention to Combat Desertification Secretariat, and the Secretariat of the CBD), bilateral and multilateral funders (e.g., the World Bank, the Global Environment Facility, and the Swiss Agency for Development and Cooperation), and research institutes (e.g., the International Centre for Tropical Agriculture and the International Center for Agricultural Research in Dry Areas) are at the forefront of these efforts. The International Land Coalition, the World Overview of Conservation Approaches and Technologies global network, and the Food, Agriculture, Biodiversity, Land-Use, and Energy Consortium within the Food and Land-Use Coalition are also convening experts from around the world to create an enabling environment for and accelerate the transition to SLM. Although these efforts are critical, some have received criticism for excluding those most affected by the decision-making processes—smallholder farmers, Indigenous communities, women, and poor communities.[364] Inclusion of these often overlooked stakeholders, however, will prove critical to the successful scale-up of SLM.[365]

Halve food loss and waste by 2030

Currently, 24% of the world's food supply, as measured by calories, is lost or wasted rather than consumed.[366] Reducing food loss and waste is critical to increasing the efficacy of food supply chains, reducing the need for additional food production and therefore reducing agriculture's pressure on land, water, and the climate.[367] Halving consumer food waste could also generate $380 billion in annual cost savings by 2030; curbing losses along the supply chain could save another $365 billion each year.[368] SDG 12 seeks to "ensure sustainable consumption and production patterns" and specifies the need to halve global food waste and reduce food loss by 2030 in Target 12.3 in order to reduce the strain of agricultural production on natural resource systems.[369]

The principal strategy for meeting SDG Target 12.3 is the target–measure–act approach, which involves governments and businesses setting reduction targets, measuring food loss and waste to develop a baseline, and developing an action plan to reduce loss and waste.[370] Further actions include developing targeted consumer-focused interventions to encourage reducing food waste[371] and designing interventions specific to consumption environments.[372]

Tracking and accelerating action

Current challenges include a dearth of efforts to track food loss and waste at the national level and the absence of a standardized methodology for tracking. Some national-level tracking efforts, especially those led or co-led by nonprofit organizations, have been successful at quantifying food loss and waste, as is seen in the work of the Waste and Resources Action Programme in the United Kingdom. More recent efforts by the FAO and UNEP have involved the development of food loss and waste indicators that are being tracked at the global scale. Still, data collection and consistency challenges prevail. More grassroots efforts, such as the work of Champions 12.3, are attempting to build multi-sectoral coalitions to improve the efficiency of data collection and reporting on this issue, but are still in the early stages of enacting systemic change.

Shift diets and ensure equitable access to nutritious food to feed 10 billion people by 2050

Reducing the quantity of meat demanded by high-consuming populations is a necessary step for keeping the food system within planetary boundaries.[373] Between 1961 and 2009, the average per capita consumption of animal-based protein increased by almost 60%, while the consumption of plant-based protein grew by just 14% over the same period.[374]

As efforts to alleviate poverty take hold in places around the world, consumption patterns are expected to shift toward the current norms in Western countries, leading to an increase in the global consumption of meat, which has a much higher GHG impact for production than plant-based foods.[375] Livestock also contributes heavily to the degradation of land and the pollution of freshwater systems, and increased demand for meat has the potential to threaten the planetary boundaries for these essential resources.[376] Strategies to shift toward more sustainable diets include increasing product innovation, such as the development of meat alternatives,[377] developing promotional, behavior change, and marketing strategies to consciously and unconsciously shift consumer choices toward plant-based foods,[378] and influencing consumer choices through policy and pricing strategies.[379]

Embedded in this transformation is the realization of equitable access to nutritious food. Switching to healthier, more sustainable diets for all, including those who currently do not have reliable access to affordable, healthy, and safe food, will be critical if we are to be successful.

Tracking and accelerating action

Progress toward this transition is difficult to track, as tracking relies primarily on data collected through household surveys or provided by retailers. Intermediary indicators of progress, such as widespread awareness of the need to shift diets, are being tracked, with WRI playing a key role through initiatives such as the Better Buying Lab and the Cool Food Pledge. Accelerating progress toward this transition will require overcoming the lack of centralized data collection systems and methodological challenges (e.g., household surveys can vary from country to country, with a range of gaps and inaccuracies) and working with food suppliers and retailers, who often hesitate to share their data on consumer preferences with researchers. Individual studies on shifting diets represent isolated efforts to track and compile data on consumption patterns and tend to be country specific.

Ensure supply chains are sustainable, including localizing value chains where possible

Agricultural expansion is the primary driver of deforestation and forest degradation globally. Over the past three decades, the world has lost 420 million hectares of forest, and since 2015, an estimated 10 million hectares of forest have disappeared each year.[380] Commercial activities account for about 40% of this deforestation across developing countries, with just four commodities—beef, soybeans, palm oil, and wood products—responsible for nearly 113 million hectares of tropical forest loss from 2000 to 2012.[381] As conversion of forests into pastures, plantations, and croplands continues, so too do biodiversity losses, increases in carbon emissions, and the displacement of local communities. Protecting the world's remaining forests, as well as mitigating these harmful impacts, will require the private sector to eliminate deforestation from supply chains. Already, more than 480 companies with deforestation risks across their food and fiber supply chains have made 850 commitments to reducing deforestation associated with at least one commodity.[382] Yet most of these pledges, many of which were made in the context of the New York Declaration on Forests, the Consumer Goods Forum Zero Net Deforestation Commitment, and the Tropical Forest Alliance 2020, lack ambition.[383] Time-bound, verifiable, and zero-deforestation commitments that cover all of a company's commodities, sourcing regions, suppliers, and operations are needed to eradicate deforestation from supply chains. Yet less than 8% of 400 major companies' pledges align with this gold standard, and the majority of businesses have failed to set traceable, time-bound, and robust targets.[384]

Most commitments instead employ a combination of external guidelines and internal policies that establish conditions, incentives, or disincentives for upstream actors within companies' supply chains. Common tools adopted to achieve these pledges include securing certifications, such as those from the Forest Stewardship Council and the Roundtable for Sustainable Palm Oil; negotiating public-private agreements, including geographic moratoria, such as the soy moratorium in the Brazilian Amazon; or creating company-specific sourcing criteria in sectors without certifications. But this diversity in strategies—and in how companies define deforestation-free supply chains—poses challenges to suppliers, who must manage myriad complex procurement, traceability, and engagement approaches. Vague pledges and limited assistance for producers, particularly smallholders or small- to medium-scale growers, have also delayed implementation.[385] In fact, none of the most influential companies with forest-risk operations will fulfill their commitments to eliminate or reduce deforestation from their supply chains by 2020.[386]

Tracking and accelerating action

Insufficient voluntary reporting, poor transparency, and a lack of common performance metrics currently limit efforts to assess existing pledges' implementation and subsequent impacts. New tools that monitor, verify, and report on companies' progress are fast emerging, including the Accountability Framework Initiative, Global Forest Watch Pro, the Proforest Soy Toolkit, the Sustainable Palm Oil Transparency Toolkit, and the Transparency for Sustainable Economies' (Trase) tool.[387] Institutions involved in these efforts include CDP, Climate Focus, Forest Trends, Global Canopy (particularly its Forest 500 and Supply Chain Transparency Network initiatives), The Nature Conservancy, the Stockholm Environment Institute, the Tropical Forest Alliance, WRI, and WWF. But a comprehensive global assessment of supply chain commitments' impact on deforestation rates does not yet exist. Such a study would require new datasets that measure leakage (e.g., displacing deforestation in one region to another), track implementation of companies' commitments, monitor the portion of trade covered by supply chain pledges for key commodities, and map other drivers of deforestation. Without this information, today's progress reports instead tally the total number of deforestation-free commitments and analyze companies' levels of ambition within these pledges.[388] Thus, significant data constraints and existing uncertainties limit the ability to assess progress toward this transition.

Avoid overexploitation of terrestrial species

Biodiversity losses increasingly threaten life on Earth, growing more rapidly than at any other time in human history.[389] In addition to habitat loss and degradation, overexploitation (hunting and harvesting) is the second most prevalent threat to biodiversity and accounts for 17% of threats to birds, 35% of threats to mammals, and 24% of threats to reptiles and amphibians.[390] Species population declines are particularly pronounced in many biodiversity hotspots, with Central and South America experiencing a nearly 90% loss compared with 1970.[391]

Preserving land biodiversity is critical for human society. Throughout our existence, wild animals, plants, fungi, and microbes have underpinned human well-being. These species have inspired many medical treatments, while many bird, mammal, and insect species play a critical role in controlling disease and managing pests. And crops accounting for 35% of global food production rely on animal species for pollination.[392]

Sustainable harvesting of plants, animals, and other organisms can help minimize species extinction and the reverberating impacts of extinctions on ecosystems and their services. This transition requires managing the hunting and harvesting of living organisms to prevent the unsustainable exploitation of terrestrial species for domestic or international trade, including by actions agreed under the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES).[393] Many of the approaches to preservation and restoration of habitats can also help reduce overexploitation by extending protections to plant and animal species in those habitats.

Tracking and accelerating action

Several key conventions and organizations actively work to address and monitor species exploitation. Some threatened terrestrial species populations receive dedicated attention, such as African elephants and other key species monitored by the wildlife trade specialist, TRAFFIC; not all are exploited terrestrial species are so rigorously monitored. Bird species are especially vulnerable to overexploitation and BirdLife International manages a comprehensive data collection with detailed information on species and important bird and biodiversity areas. Many other entities are actively working to address and monitor overexploitation, including the Secretariat of the CBD, CITES, and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), as well as WWF, FAO, OECD, the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), and many others.

Stop invasive species

The introduction of invasive species is another critical threat to terrestrial biodiversity. For example, *Batrachochytrium dendrobatidis*, a single invasive pathogen species, threatens nearly 400 amphibian species around the world and has already triggered extinctions.[394] Cumulative introductions of non-native species to new habitats have increased by 40% since 1980 because of improvements in transportation and the globalization of trade.[395]

Introductions may be intentional, for commercial purposes, or unintentional, such as with traded goods (e.g., lumber). To thwart the transmission of invasive alien species, introduction pathways, such as trade routes and tourism, must be effectively managed, and invasive species must be controlled and eradicated.

Tracking and accelerating action

National governments often monitor invasive alien species distribution and numbers in order to support domestic or regional eradication programs. CBD, UNEP, IUCN, and the National Wildlife Federation, as well as many other international, national, and subnational entities, also monitor and support efforts to curb invasive species. Nevertheless, to date there has been no significant global progress; worldwide, the number of invasive species introductions continues to rise.[396]

FRESHWATER MANAGEMENT

Essential to life on Earth, freshwater systems face mounting pressures. Population growth, coupled with economic development and changing consumption patterns, are increasing global water demand. Worldwide, water use grew eightfold over the past 100 years, and since 1960, water withdrawals have more than doubled.[397] By 2050, the world's demand will rise by 20% to 30%, reaching between 5,500 to 6,000 cubic kilometers annually.[398] These global projections, however, mask significant disparities in water use both between and within countries. Americans, on average, consume 2,842 cubic meters of water per year—more than twice the amount that average consumers in India and China use.[399] And today, nearly 2.2 billion people lack access to clean, safely managed drinking water, while 2 billion still rely on improved sanitation services. These underserved and unserved communities are concentrated within rural areas, often stretching across the world's poorest countries.[400]

Yet as countries strive to meet growing demand and deliver clean water, sanitation, and hygiene services to all, climate and land-use changes will alter the spatial and temporal distribution of water supply, complicating efforts to manage this resource sustainably. Precipitation patterns around the world will shift, heightening water scarcity across arid and semi-arid areas and intensifying

flooding in wet regions.[401] An estimated 4 billion people already experience severe water scarcity for at least one month each year, and if business continues as usual, this number could reach 5.7 billion by 2050 (this is likely an underestimation).[402] Pollution, a challenge predicted to intensify over the coming decades, further limits global water supply for human use. Industries currently discharge upwards of 400 million tons of toxic waste into the world's waters each year; an estimated 90% of sewage in developing countries flows untreated into surface water and groundwater; and nitrogen and phosphorous effluents will more than double over the next three decades. Not only will rising pollution levels threaten human health, but they will also degrade aquatic ecosystems, already accounting for more than 30% of global biodiversity losses.[403] Poor management, enabled by weak governance, has entrenched this unsustainable, unequitable paradigm, with cascading effects on the entire system's resilience. Protecting this global common good will require comprehensive water assessment and management, radical water efficiency improvements, and substantial efforts to protect freshwater biodiversity.

Perform comprehensive water assessments and management

Freshwater managers of the past century have traditionally opted for the "hard path," a supply-oriented approach that depends on large, centralized infrastructure, such as dams, levees, canals, and wells. This path, however, has often had unintended consequences. For example, dams, a technology emblematic of this trajectory, often provide reliable water sources, minimize flood damage, and generate hydropower, but they can also fragment and degrade river ecosystems, limit nutrients flowing to downstream lands, displace local communities, and impair water quality.[404] Similarly, engineering waterways, such as constructing extensive levee systems or dredging canals, can also heighten nearby communities' vulnerability to flooding or extreme weather events. Building inter-basin water transfers can lead to the aridification, salinization, and ecological degradation of donor basins, as well increased consumption in water-scarce recipient basins.[405]

Integrated, comprehensive management can help address both water quantity and quality challenges, while also strengthening governance. This new approach should seek to balance the many demands exerted on freshwater systems (e.g., water resources for domestic consumption, irrigation, hydropower, and environmental conservation) by coordinating water management across sectors and at all levels of government. Comprehensive management must also strive to integrate projected climate change impacts into water development plans; maximize water efficiency while ensuring equitable distribution of benefits; focus on reducing water demand and improving quality, rather than solely on securing new supply; consider providing water services rather than water itself whenever possible (e.g., rather than provide a specific amount of water needed to flush a toilet, decision-makers would instead focus on ensuring that all households can safely dispose of excreta); and evaluate the impacts on future generations and ecosystems when developing management plans. Adopting inclusive decision-making processes, balancing the best available science with local knowledge, and establishing strong, adaptive governance systems within and between countries will also prove critical to sustainable, equitable water management. Integrated water resources management, a framework championed by the Global Water Partnership and included within the SDGs, the Pacific Institute's "soft path" framework, and the EPA's watershed approach all embrace many of these principles.[406] Although 80% of countries around the world have created strong foundations for integrated water resources management, implementation remains difficult in practice, and many have criticized this approach, claiming that it lacks a clear, actionable definition, concrete indicators, and monitoring systems.[407]

Tracking and accelerating action

Effective comprehensive water management depends on robust, in-depth data and extensive assessments. Such evaluations require environmental, social, economic, and cultural data collected across spatial and temporal scales, including hydrologic and hydraulic data for surface and groundwater systems; physical, chemical, and biological data to assess water quality; soil and land-use maps; census data that provide information on variables that determine per capita water consumption, such as household size and income level; information on land and water rights; and additional cultural and social survey results. Basic data is often available at the national level, but limited funding, capacity, and access to technologies have restricted many developing countries' ability to collect this information and perform comprehensive assessments.[408]

Although the responsibility to manage water resources rests with governments, often at local or regional levels, a variety of organizations also work to quantify, track, project, and assess freshwater-related items. These include Climate Is Water, the Pacific Institute, the International Institute for Applied Systems Analysis, the Alliance for Global Water Adaptation, the International Water Management Institute, the Stockholm Resilience Centre, WRI, the World Meteorological Organization, the Blue Planet Network, the Global Water Partnership, and the United Nations.

Radically improve water efficiency

The improvement of water efficiency speaks directly to the threat of a decreased supply of water. One cause of decreased supply is a lack of efficiency in how water is used. Assuming the use of current technologies used to grow food for human consumption, the amount of water needed to feed the growing population is staggering. If the global human population reaches 9 billion by 2050, water requirements will increase by about 2,100 cubic kilometers.[409] Currently, agriculture accounts for 70% of all global water use. Thus, it is critical to develop agricultural technology that is more water efficient. This is just one example of many that illustrate the ways in which adjusting the water intensity of human activity could have significant effects.

Tracking and accelerating action

Various entities are tracking the numerous strands of this transformation. Given the significance of agriculture and in buildings, some of the key coalitions working in this space include the World Bank, the FAO, the International Water Association, the Alliance for Water Stewardship, the CEO Water Mandate, and the United Nations.

Protect and restore freshwater systems

Freshwater ecosystems—groundwaters, streams, rivers, lakes, ponds, and wetlands—cover just 2% of the planet, account for less than 1% of its water, and hold more than 10% of the world's species. These ecosystems deliver critical, life-supporting services—maintaining hydroclimatic regimes, supplying water and food, providing flood mitigation, and cycling nutrients. Yet they face intensifying threats from a slew of anthropogenic pressures— climate change, pollution, land-use change (e.g., urbanization and agricultural expansion), overfishing, habitat alteration, fragmentation, and flow regulation.[410] Around the world, rivers suffer from increasing fragmentation, with just 37% of waterways longer than 1,000 kilometers flowing freely.[411] Rising water withdrawals and diversions also interrupt rivers, now causing roughly a quarter to run dry before reaching the ocean and draining some of the world's largest inland lakes, such as the Aral Sea.[412] Nearly a third of groundwater systems are also in distress, and the planet has lost upwards of 71% of wetlands in the past century, with the fastest, most significant declines experienced in inland systems.[413]

Freshwater managers of the past century have traditionally opted for the "hard path," a supply-oriented approach that depends on large, centralized infrastructure, such as dams, levees, canals, and wells. This path, however, has often had unintended consequences.

Protecting freshwater ecosystems requires a portfolio of strategies that vary by watershed. In highly urbanized basins, for example, reducing impervious surfaces, improving stormwater management, restoring natural flow regimes, and establishing no-build zones along riverbanks will help conserve and restore waterways.[414] But in agricultural watersheds, managers should focus their efforts on curbing chemical fertilizer use, adopting more efficient irrigation systems, switching to crops better suited to local precipitation regimes, improving manure management, controlling erosion, and creating riparian buffer zones. Although adopting the right management strategies for the right context is important, managers should also consider a common set of market-based incentives and regulations. These include setting sustainable withdrawal and diversion limits for rivers and aquifers; reducing inter-basin water transfers; halting wetland drainage; setting aside water for environmental flows; adopting and enforcing wastewater treatment standards, as well as strong regulations for point and nonpoint sources of pollution; establishing protected areas, including for headwaters; and, requiring decision-making processes across sectors to evaluate and account for impacts on freshwater ecosystems.[415]

Tracking and accelerating action

Efforts to track biodiversity loss, including those undertaken by the CBD Secretariat and the IUCN, often encompass impacts on freshwater ecosystems. Yet this work generally focuses on outcomes rather than the drivers of degradation, for which data availability and quality vary by country; such data are also often dispersed across different sectors. Working alongside many national conservation organizations, WWF, Wetlands International, Conservation International, and UNEP have programs dedicated to protecting freshwater systems. A growing number of organizations, including the World Bank, WRI, and the Pacific Institute, are also advancing nature-based solutions or green infrastructure in the water sector.

Avoid overexploitation of freshwater species

For freshwater ecosystems, the direct exploitation of fish, shellfish, and other organisms has had the second largest relative negative impact on nature since 1970. Populations of vertebrate freshwater species have declined 83% since 1970, partly because of overexploitation.[416] Overexploitation of freshwater ecosystems generally receives less attention than overexploitation of marine ecosystems, although the consequences are similar. Global protection targets for freshwater species are insufficient; only marine fisheries are included under SDG Target 14, although both freshwater and marine fisheries are covered under the Aichi Biodiversity Targets, outlined in the CBD's Strategic Plan for Biodiversity 2011 to 2020. Rampant illegal fishing using unregulated tactics has caused fish stocks to collapse and has both destroyed and significantly altered important freshwater habitats across the globe.[417]

Several actions can support a transition to more sustainable fishing and harvesting of freshwater species—actions that complement other transformations in the freshwater and ocean systems. These include integrated water resource management and planning, inclusive water governance and collaborative management systems, reducing the fragmentation of freshwater policies, and developing and promoting incentive structures to minimize overexploitation.[418]

Tracking and accelerating action

The WWF's World Wide Fund for Nature, Wetlands International, National Geographic, and the IUCN, are among those monitoring and working on this topic.

Stop invasive species

Invasive species are a key threat to biodiversity in freshwater ecosystems and their services. Because bodies of water are interconnected, invasive species released in one body of water can quickly spread. For example, the European zebra mussel was unintentionally introduced into Lake St. Clair (in the United States and Canada) in 1988, and within 10 years, the mussel had spread to all five neighboring Great Lakes. The mussels have caused tremendous disruption, reducing the population of native mussels and clogging underwater structures, such as intake pipes for power plants. The zebra mussels have also reduced the food available in the lakes to larval fish and many invertebrates because of their efficiency at filtering the water and removing algae and microorganisms.[419]

Tracking and accelerating action

Invasive species are often monitored and managed at the national or subnational level because of their direct biological and economic effects on local ecosystems. The Invasive Species Specialist Group of the IUCN manages the Global Invasive Species Database, which aims to increase awareness and facilitate prevention and management techniques. There are also several international and regional binding agreements as well as voluntary guidelines that include regulations on invasive species, such as the CBD, CITES, and the United Nations Convention on the Law of the Sea.

OCEAN MANAGEMENT

The ocean keeps Earth habitable by absorbing excess CO_2 and regulating climate. But it is also facing several anthropogenic pressures that will likely lead to irreversible impacts on marine ecosystems.

Overfishing and hunting of marine life are among the earliest human threats to the ocean, and have increased over time with more extensive and invasive fishing practices. Rising temperatures, acidification, deoxygenation, and pollution from chemicals, heavy metals, and plastics, along with agriculture, urbanization and industrialization, growing world trade flows, and shipping have all put the ocean at risk. Habitat loss along the shoreline, rising human populations in coastal areas and land-use changes, and harnessing rivers have together led to changes in the materials flowing into the ocean. These impact the ocean ecosystem and the services it provides.[420] Human activities such as tourism, urban infrastructure expansion, shrimp aquacultures, port development, and oil and gas exploration, all continue to affect marine life and ocean health. These pressures, coupled with weak governance structures, are causing changes that may not be linear and reversible.

Ensure 30% of the ocean is fully protected by 2030

The ocean covers 70% of the Earth's surface, but it remains grossly under-protected. Areas designated or proposed for protection cover just 7.4% of the ocean, and when considering highly or fully protected areas, this number drops to 2.5%.[421] The CBD's Aichi Biodiversity Target 11 commits governments to protecting 10% of marine environment by 2020. Further, more than 10,000 marine protected areas (MPAs) that currently exist differ substantially in the level of protection offered and the activities that are allowed. There is a need for effective implementation, monitoring, and management.

Protecting 30% of the ocean by 2030 (30x30), a new target called for by the IUCN (with the scientific community rallying behind it), is projected to bring a range of environmental and economic benefits. This target seeks to establish a network of highly protected MPAs and related conservation measures to support healthier, more resilient ecosystems, greater species diversity, climate change mitigation, human livelihoods through increased financial returns, and food security by boosting fisheries' productivity.[422] The call for the 30x30 target also coincides with efforts to negotiate a legally binding international instrument to enable the protection and sustainable use of biodiverse areas that extend beyond national jurisdictions.

MPA coverage needed can vary significantly depending on the place, habitat type, or species, or the specific goals (e.g., rebuilding fisheries or focusing on a particular species or habitat).[423] Further, it is important that countries meet the target by creating MPAs that go beyond offering minimum protection and are effectively implemented and managed. MPAs are also likely to get a boost through a new treaty under the United Nations Convention on the Law of the Sea; this international agreement, which the United Nations General Assembly is currently negotiating, will focus on the sustainable use of marine biodiversity in areas beyond national jurisdictions. In addition to using area-based management tools, including MPAs, to protect the wildlife of the high seas and the deep sea, the agreement covers measures such as comprehensive environmental impact assessments for activities in biodiversity beyond national jurisdiction areas, capacity building for management and conservation, and global sharing of benefits derived from marine genetic resources.[424]

Tracking and accelerating action

Because of the widely projected positive socioeconomic and environmental benefits that come with greater levels of marine protection, numerous new stakeholder campaigns and coalitions have been launched to raise awareness and drive adoption of the 30% target. The Campaign for Nature (a coalition of more than 100 conservation organizations) and Antarctica 2020 are key examples of these. The United Kingdom is also leading the Global Ocean Alliance, a coalition of signatory countries calling for the adoption of the 30x30 ocean goal. The Alliance currently has 22 signatory countries, working toward the adoption of new ambitious global biodiversity targets under the CBD at the 15th Conference of Parties in Kunming, China, in 2021.

The UNEP-WCMC maintains a World Database on Protected Areas that acts as a keystone resource in facilitating data tracking of protected marine areas. The Marine Protection Atlas also serves as a useful resource, providing data breakdowns on the basis of the level of protection.

Sustainably manage fisheries and aquaculture and avoid overexploitation of marine species

Overexploitation of marine organisms (mainly by fishing, but also by the hunting of marine mammals, invertebrates, and plants) has had the most adverse impact on biodiversity in marine systems.[425] An increasing proportion of the ocean's fish stocks suffer from overfishing. Today, fishing threatens more than 1,000 species with extinction, and at least 55% of the ocean is subject to industrial fishing, which is concentrated in a few countries and among a few corporations.[426] Additionally, climate change is leading to the rise of ocean temperatures and acidification, putting additional pressure on fisheries as species migrate and reach their tolerance limits, necessitating new management techniques and greater protections. The ocean is a source of protein as well as other macronutrients and micronutrients and it is critical for food security, nutrition, and economic stability. With careful management of wild fisheries and aquaculture, the ocean could provide six times more nutritious, affordable food than it currently does, sustainably feeding the world's ever-growing population.[427] Sustainably managing wild fisheries, for example, could generate $40 billion in annual savings by 2030 in part by minimizing economic losses (e.g., traveling further to find fish) that stem from overexploitation.[428]

Conservation and restoration of marine ecosystems can be achieved through the sustainable management of wild fisheries and marine organisms and the sustainable development of marine aquaculture. Rebuilding overfished stocks and restoring marine ecosystems entails addressing challenges related to lack of alternative employment, subsidies, and poverty; eliminating fishing, hunting, and harvesting that is currently unreported, unregulated, and illegal; and implementing ecosystem-based fisheries management. It is also necessary to discourage destructive fishing practices; prohibit certain subsidies that contribute to overcapacity, overfishing, and illegal, unreported, and unregulated fishing; deal with poor local and institutional governance and enforcement; and increase—and equitably share—economic benefits from sustainable use of marine resources.[429]

This transition also requires ensuring that no marine species is unsustainably exploited for domestic or international trade, including by actions agreed under CITES. For some marine species, monitoring and management efforts are more challenging, given limited information, for example, on harvests of aquatic invertebrates and plants.[430]

There is also a need to sustainably expand unfed marine aquaculture or operations based on non-fish feed without shifting pressure from fish stocks to land (e.g., by using soy).[431] Alternative and innovative ingredients (such as seaweed, algae, and microalgae) are needed. Sustainable aquaculture (marine and freshwater) is required. This can be promoted through measures such as voluntary certification, international agreements on allowable catches, fishing techniques, protected zones, monitoring, and bans, along with sanctions for noncompliance, and designating protected zones for endangered habitats and species.[432]

Mechanisms driving toward sustainable fish stocks have been introduced at national, regional, and international levels. These include the United Nations Fish Stocks Agreement (1995), the FAO Code of Conduct for Responsible Fisheries (1995), and regional fisheries management organizations.

Tracking and accelerating action

The FAO's biennial report, *The State of World Fisheries and Aquaculture*, monitors how sustainably global fish stocks are managed.

The Stop Funding Overfishing campaign brings together numerous civil society groups to press for a World Trade Organization agreement on fishing rules that prohibit harmful subsidies. There also exist numerous private certifications of whether a fish stock is fished sustainably, or aquaculture is performed in such a way that fulfills sustainability criteria; these include Marine Stewardship Council and Aquaculture Stewardship Council certifications.

The nongovernmental organization TRAFFIC is a specialist on the global wildlife trade, including on the illegal poaching and trade of marine species including turtles, sharks, eels, and abalone, among many others. TRAFFIC conducts research, investigations, and analysis to compile the evidence to catalyze action and help ensure that the wildlife trade does not threaten conservation efforts.

Sharply reduce marine litter and pollution

Pollution from ocean and land-based activities can degrade ecosystems and adversely impact fish abundance, affecting food safety and security.[433] Since 1980, marine plastic pollution has grown by a factor of 10, affecting at least 267 species (turtles, seabirds, and marine mammals) and, through food chains, humans.[434] Pollution in the ocean comes from a variety of sources, including municipal sources, agriculture (including aquaculture), and industrial and maritime sources. Curtailing marine litter and pollution through effective pollution management services can safeguard marine ecosystems while ensuring a sustainable ocean economy.

There is a need to control, and radically reduce, marine litter by removing abandoned, lost, or derelict fishing gear from the waters; reducing the use of nonrecyclable, single-use plastics; and imposing fees on single-use items, strengthening markets for recycled plastics, and providing incentives for recycling. Other approaches include developing new, biodegradable materials that have the desirable performance characteristics of plastics, reducing solid waste, and shifting to a circular economy that recovers and regenerates materials to effectively eliminate waste. This may require changes in cultural norms and behavior shifts.[435]

In regard to marine pollution, reducing both point and nonpoint source pollution (e.g., plastics, mercury, chemicals, toxins, and nutrients) through effective solid waste, wastewater, and stormwater management, incentives, innovation, and sanctions; the safe use and disposal of chemicals; addressing the development and degradation of coastal zones; and improving access to sanitation is required. Pollutant inputs to marine ecosystems from industrial discharges, dumping, and accidents; from agricultural sources, such as chemical fertilizers and pesticides; and from ship-generated pollutants (e.g., dumping and tank flushing) must be curtailed.[436] At the same time, an enabling environment should be created to designate protected zones for coastal areas, shelf seas, and deep ocean, as well as to monitor compliance.[437]

As awareness of the crisis of plastic in the ocean has risen in recent years, so has the number of coalitions seeking to combat the issue. The Alliance to End Plastic Waste, the Global Plastics Action Partnership (which works with governments to track instead of measure to mitigate plastic leakage), the Ellen MacArthur Foundation's New Plastics Economy, and the Global Ghost Gear Initiative (working to reduce pollution from the fishing industry) are some prominent examples of these coalitions. Many smaller, regionally focused efforts toward similar ends also exist.

Because of the dispersed nature of how much ocean-based pollution enters the ocean and circulates, data reporting and availability on this issue are challenges. In regard to plastic, a global, legally binding treaty to combat marine plastic pollution has been suggested by Norway; the hope is to achieve this by 2023. Further, the Hong Kong Convention aims to ensure the safe recycling of end-of-life ships.

Stop invasive species

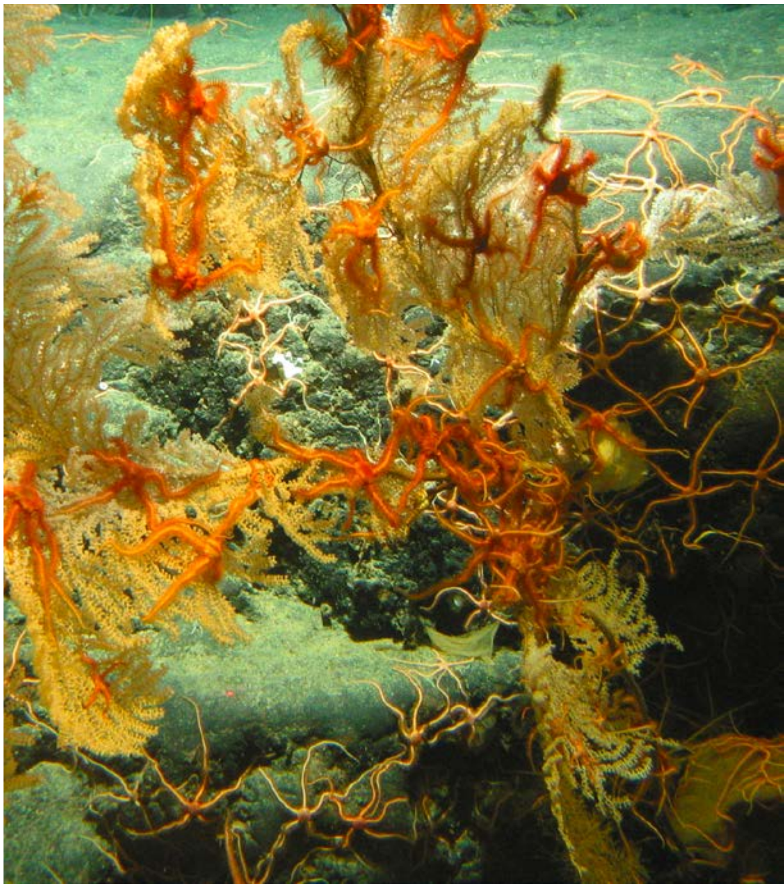
Invasive species are a critical ocean threat as they can destroy marine biodiversity, permanently alter habitats, and lead to the extinction of native plants and animals.[438] Invasive species introductions are partly responsible for more than half of global animal extinctions with known causes.[439] The transfer of invasive species may occur unintentionally, for example, by ballast water discharge and hull fouling from the shipping industry, or intentionally, such as the introduction of the Manila clam to the Venice Lagoon; the clam, which has high commercial profitability, has decimated local bivalve populations since the 1980s.[440] We continue to see a rise in the number of invasive species introductions globally.[441]

It is in our own self-interest to protect marine biodiversity and minimize further loss. The ocean provides critical goods and services that are the foundations for life on Earth. It supplies food and raw materials, detoxifies and decomposes wastes, and stabilizes and moderates the Earth's climate, among much else.[442] Marine biodiversity loss hinders the ocean's ability to supply for food for the growing human population, with fish currently providing a primary source of dietary protein to an estimated 3 billion people. The global economy also depends on healthy oceans, which deliver an estimated $2.5 trillion of goods and services every year and may yield many more, currently unknown, benefits.[443] For example, *Serinicoccu*, a rare, recently discovered genus of marine bacteria, can selectively destroy melanoma cancer cells.[444]

To thwart the transmission of invasive alien species, this transition involves managing introduction pathways, such as global shipping, and controlling and eradicating invasive species when they are found. The management of invasive species in the ocean is especially challenging because different ecosystems are connected; however, it is more likely to succeed when an invasive species is detected early and the response is rapid.[445] Controlling transmission pathways may require global or regional coordination and policy, while eradication of species and remediation techniques can vary greatly depending on the species, the ecosystem, and the extent to which the species is embedded in the ecosystem. In some cases, it may be impossible to fully reverse the impacts.

Tracking and accelerating action

Coalitions are actively working to monitor and reduce invasive alien species. The IUCN Invasive Species Specialist Group raises awareness of invasive alien species' harmful impacts and shares approaches to prevent, control, or eradicate them. The group includes 196 core members from more than 40 countries and hosts an informal global network of more than 2,000 conservation practitioners and experts. Other organizations and institutions include UNEP-WCMC, IPBES, and many regional partnerships.



CHAPTER 5

The Cross-Cutting Transformations We Need

In addition to the sectoral shifts described in the previous chapter, we will need cross-cutting systems change: how we measure progress, approach inclusion, equity, and the just transition, and govern the global commons.

MEASURING PROGRESS

Monitoring the trajectories of these required transformations plays a critical role in spurring durable, just systems change. Doing so enables decision-makers everywhere to identify effective catalysts of transformation, learn from past failures, and understand the distribution of benefits across society as transitions unfold. By tracking progress, we can adjust course as circumstances evolve, share good practices with fellow agents of change, and maximize the impact of limited resources. Yet not only do considerable gaps within existing data systems limit our ability to assess gains made, but the metrics by which we measure success also fail to align with a more holistic conceptualization of well-being. Fundamentally shifting how we define and monitor progress is needed to steer the world toward a sustainable, resilient, and equitable future.

Leverage the digital revolution and improve data systems, including tracking equity of progress

Today, a standard tablet contains the processing power of 5,000 desktop computers from the mid-1980s. In 2008, the first "app" was developed, and in just a decade, the industry's value has reached $1.3 trillion. And over the past 20 years, the proportion of the global population with a cell phone has risen from 12% to 63%.[446] These rapid changes mark the onset of the Fourth Industrial Revolution, a transformation "characterized by the fusion of the digital, biological, and physical worlds, as well as the growing utilization of new technologies such as artificial intelligence, cloud computing, robotics, 3D printing, the Internet of Things, and advanced wireless technologies, among others."[447] Already reshaping many sectors, from healthcare to education to mobility, these frontier technologies possess the power to accelerate the transformations needed to protect the global commons, offering the promise of better, cheaper, faster, scalable, and accessible environmental solutions. The Internet of Things (e.g., remote sensing from satellites, on-site terrestrial sensing systems, geographical information systems, sensor networks, and the internet), for example, could dramatically improve water management by providing more accurate water resource maps, weather forecasts, water usage data, and real-time alerts of leaks across water distribution systems.[448] Similarly, geospatial data monitoring platforms, such as Global Fishing Watch and Global Forest Watch, already employ big-data analytics, along with advanced sensor systems and satellite imagery, in ways that allow people around the world to monitor these environmental systems on their smartphones. Such initiatives could soon rely on artificial intelligence to predict where illegal logging or fishing may occur.[449]

Although these frontier technologies promise to close substantial data gaps at local, national, and global levels, they also pose considerable governance challenges. If people wear devices that collect air quality data, who owns the data, who has access to the data, and what ends does the information serve? How can we ensure that the algorithms that underpin machine learning do not reproduce—or worse, amplify—human biases? In the United States, for example, automated risk assessments designed to inform bail and prison term hearings have consistently recommended that judges impose longer sentences, higher bail, or both, on people of color.[450] And in this new digital age, how can we respect citizens' privacy and secure data, while also providing the level of access needed to support innovation for the public good?[451] It is critical that countries begin to address these risks now, setting strong regulations for data collection, privacy, security, access, and usage. Governments must also establish new institutions that will monitor data sharing and use, ensure transparency and oversight of algorithms, as well as adopt flexible governance systems that allows officials to adapt as technologies evolve.[452] And officials must prepare for how the Fourth Industrial Revolution will affect their economies and job markets to ensure that no one is left behind, particularly in developing countries. Investments in education, retraining programs, technology transfers, and relevant infrastructure (e.g., electricity and internet connectivity) can help ease this disruptive transition.[453]

In addition to leveraging the digital revolution, improvements must be made in data systems and monitoring progress. For certain indicators, no methodology exists to track progress; for others, there are data gaps or a lack of updated data. For many datasets, the high level at which data are presented obscures important underlying trends, including those related to the distribution of impacts. If we are to secure a just and inclusive future, we will also need to enhance our ability to track the equity of progress.

Advocate for and accept new measures of progress

Shifting to a new growth paradigm—one centered on well-being—will require moving away from fetishizing GDP as the sole indicator of economic prosperity.[454] Overreliance on GDP has led to a "growth at all costs" mentality and has obscured other essential parts of the economy, such as community and ecosystem health. We must instead increasingly recognize our dependence on natural resources as well as the value these ecological assets provide for well-being and the quality of economic growth. Doing so will require the development of new metrics that measure well-being and prosperity more holistically.

Although great advancements have been made in measuring well-being, national accounts continue to track profit margins and economic growth. Many have yet to reflect progress as defined by the wealth of peoples' experience as well as citizens' and environmental well-being.[455] But these new national measures of well-being should ultimately inform decision-making, policy debates, and alternatives.[456]

INCLUSION, EQUITY, AND THE JUST TRANSITION

The world needs an inclusive, equitable response to the many crises it now faces. Solutions must be just and fair, generating benefits shared among all rather than adverse impacts shouldered by a few. Equity must be procedural, distributional, structural, and transgenerational:[457]

- Procedural equity ensures that everyone, everywhere has the voice, power, and ability to shape decision-making processes; equitable programs and policies include those that are developed and implemented utilizing inclusive, accessible, and representative processes.
- Distributional equity involves the fair distribution of costs and benefits across society.
- Structural equity recognizes historical, cultural, institutional, and political structures and relationships, which exist to maintain the status quo by prioritizing the privileged and the powerful, while disadvantaging the marginalized.
- Transgenerational equity considers the generational impacts of today's decisions, with a focus on reducing burdens on future generations.

Provide universal access to basic services and opportunities

Today, 689 million people earn less than $1.90 per day, and an estimated 4 billion people do not benefit from social protection programs—initiatives that not only support poor households through crises and shocks such as the COVID-19 pandemic, but also improve their access to education and economic opportunities.[458] A large percentage of world's population also live without basic services that underpin efforts to reduce poverty, such as safe housing, clean water, sanitation, energy, and transportation. Globally, 880 million city dwellers reside in slums, 579 million people drink water from unimproved sources, 2.8 billion people still rely on polluting cooking fuels, and 789 million lack electricity.[459] Even when poor communities can access these basic services, the quality may be inferior and the supply intermittent, unreliable, or expensive. Poor households in large cities across the developing world, for example, often spend more than 25% of their income on transportation.[460] Unable to afford these basic services, residents often depend on local governments to subsidize the cost, but in many countries, public per capita budgets are low.[461]

Strategies to improve access to basic services vary substantially. In cities, for example, promoting rental homes or converting underutilized urban land into affordable housing can help poor residents secure adequate, affordable, and safe housing.[462] Extending basic sanitation services to unserved communities also requires a portfolio of solutions, including expansions of the sewer network to household, communal, and public toilets or on-site sanitation options, such as septic tanks and pit latrines.[463] And in cities with a large informal economy—currently, 50% to 80% of urban dwellers across the global South are employed in an informal economy—access to jobs and public space are interlinked challenges that require coordinated solutions.[464] Yet, there is also a set of interventions that cuts across service areas (such as the need for stronger social protection programs and citywide approaches to in situ upgrading of informal settlements) that are important for housing, sanitation, energy, water access, and mobility, among others.[465]

Universalizing access to basic services within rural areas requires similarly diverse approaches tailored to the challenges of smaller population sizes, lower densities, and larger distances between service providers and users.[466] Delivering affordable, reliable, and clean energy to remote households, for example, will likely depend on nontraditional, distributed electricity options, such as mini-grids and solar home systems, rather than expansion of the central grid.[467] Combining decentralized, on-site sanitation systems, such as double ventilated improved pit latrines, compositing toilets, or septic tanks, with technologies that safely manage waste may also be more affordable, feasible, and sustainable than traditional sewer systems.[468] Investing in rural infrastructure, particularly roads, can improve households' connection to markets, while expanding communities' broadband connections can enable farmers to adopt new digital technologies. Such strategies, alongside social protection programs, not only increase access to economic opportunities, but they can also support improved service delivery in rural areas.[469]

Across both rural and urban interventions, there are common factors—governance, finance, planning, and management—that underpin and can accelerate progress.[470] Diverse coalitions, particularly those that include poor communities, can solve challenges in service provision by coming up with innovative solutions that fill gaps in other areas and respond to the policy environment. By formally supporting pro-poor initiatives led by civil society organizations, governments can help scale up these programs by providing financial stability as well as legitimacy. Evidence-based advocacy can be critical in gathering the support needed to scale up an initiative, and knowledge partnerships can be key to collecting the necessary data. The national policy environment can incentivize certain service arrangements and collaborations that otherwise might not have been considered. Local actors, particularly from within the government, can play a key role in accelerating innovative partnerships and institutionalizing change by mobilizing public opinion and resolving internal conflicts. Greater autonomy at the local level can play a critical role in establishing a long-term agenda that is catered to the local context.

Shift to defining prosperity by inclusive well-being

One of the greatest root causes of environmental decline is the continued focus on economic growth at virtually any cost. Profit motives often avoid social and environmental costs, and markets fail to recognize these costs unless corrected by government. We need a new vision of prosperity that is defined by inclusive well-being—one in which economic opportunities are widely and equitably available; one in which communities, families, and overall quality of life and livelihoods are the pursuit; and one in which we value current and future generations and the environment that will sustain them.[471]

Shift to a new decision-making model, with more inclusive and community-driven leadership

Nearly 700 million people currently live in extreme poverty, and the COVID-19 pandemic could push as many as an additional 115 million people below the threshold. Meanwhile, income inequality is rising in most developed and developing countries.[472] The COVID-19 pandemic has also uncovered the lack of inclusivity and equity of current governance models. The pursuit of systems that are more inclusive and representative is a growing priority to foster more peaceful, resilient states and societies.[473] However, the transformation to more effective and inclusive political systems is complex and requires rearranging the rules of the game, including changing the distribution of power and resources and revising the social contract. This also requires reforming the institutions and the underlying political economy that facilitates modern governance models to be more inclusive and community-driven. The current model of governing in many countries gives disproportionate influence and access to the wealthy and large corporations; instead, we will need to move to empowering marginalized groups and giving more power to the hands of the people, strengthening democracy and forging new alliances.[474]

GOVERNANCE FOR THE GLOBAL COMMONS

Make the global architecture more fit-for-purpose to address challenges

The current architecture for addressing global environmental challenges and advancing sustainable development lacks the strength needed to support systems change at the speed and scale required. Treaties and conventions, along with their goals and targets, remain aspirational rather than realistic, and when it becomes clear that additional action is needed, a new attempt is made to refresh these collective objectives—iteration, not innovation. Instead, transformational structural changes in global governance must occur, replacing the historically fragmented and incremental approach of the past 50 years.[475]

With the diversity of environmental crises, acknowledging interconnections among international agreements and issue areas is critically important. Although it can be difficult to manage disparate themes across agreements, focusing on these linkages may help raise the ambition of the system as a whole.[476] There is increased attention to addressing these gaps in environmental governance and to leveraging the connections between environmental systems, through global discourse (supported by organizations such as the Global Pact for the Environment) and new scientific assessments (such as the IPCC's *Special Report on the Ocean and Cryosphere in a Changing Climate* and its *Special Report on Climate Change and Land*). There is also a growing need to recognize the relationships between environmental and nonenvironmental systems, including health, trade, human rights, and migration.[477] Key elements of this transformation may encompass balancing reform with the development of new institutions, fostering coherent pluralism, transforming multilateralism to acknowledge and adapt to the prevailing political economy, and improving accountability.[478]

Reset the social contract between government, corporations, and citizens

The COVID-19 pandemic has affected the livelihoods of nearly half of the global workforce, deepening existing economic and social inequalities. The world needs to establish a stronger, more sustainable, and more inclusive social contract among governments, corporations, and citizens.[479] The current health, political, economic, and social disruptions are exposing inconsistencies, inadequacies, and contradictions of multiple systems and fundamentally changing the traditional context for decision-making.[480] We will need a new social contract focused on sustainable well-being and societal progress, putting people and the planet at the center of these efforts.

> Treaties and conventions, along with their goals and targets, remain aspirational rather than realistic, and when it becomes clear that additional action is needed, a new attempt is made to refresh these collective objectives—iteration, not innovation.

CHAPTER 6

Systems Change Lab

Given the scale of the transformations required, there is a need for a space from which to monitor, learn from, promote, and accelerate systems change. Such a space can act as a lighthouse for change agents grappling with the long-term, structural challenges that have caused this perfect storm of social, political, economic and environmental crises.

The Systems Change Lab will provide this much-needed space by

- Monitoring the required transformations,
- Learning and sharing about the ingredients for change, and
- Nudging and campaigning for the transformations at greatest risk.

There are important connections between these three objectives and they should not be seen as sequential. Monitoring reveals the transitions in acceleration, creating opportunities to deepen our understanding of what drives these changes. At the same time, monitoring reveals transitions at risk, focusing nudging and campaigning efforts on where they are needed most. Learning identifies ingredients of change that, in turn, can inform indicators for monitoring. And learning about these drivers of systems change can also inform nudging and campaigns.

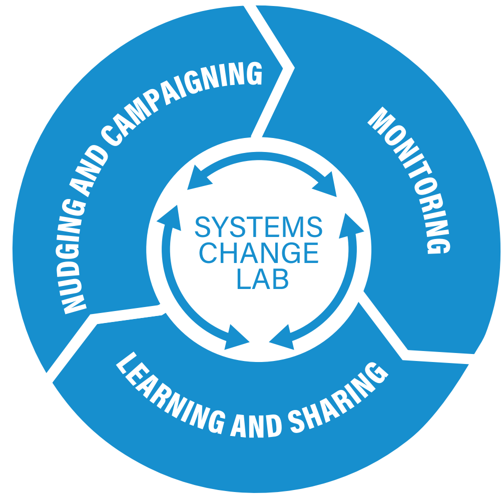
The inception phase of the Systems Change Lab was conducted with the generous support of the Global Environment Facility and builds upon the foundation of Steer, Waughray et al. (2016) and discussions held under the Global Commons Alliance.

MONITORING

There is currently no one centralized place for measuring progress across all required transformations. Although efforts to track some of these transformations exist, many data gaps remain. Additionally, monitoring often focuses on outcomes (e.g., in the case of forest restoration, hectares restored), and not also on the forces that drive outcomes (e.g., land tenure rights, restoration commitments, among others). And although this information does allow assessment of the state of play for the required transformations, it does not provide the data needed to understand key roadblocks, catalysts of systems change, effective polices, or successful coalitions.

The Systems Change Lab will increase understanding of the progress that is made toward required transformations and interconnections and interdependencies across them, to inform the setting of agendas and the prioritization of activities by governments, companies, investors, funders, and nongovernmental organizations. On the basis of its tracking of drivers of systems change, the lab could lead to the development and uptake of new metrics

Figure 3 | A New Systems Change Lab



for assessing action, as well as informing campaigns and initiatives. Tracking these transformations would in turn uncover data gaps, which can inform research agendas.

More specifically, the Systems Change Lab will work with data providers and targeted users to develop a tracking platform, where required transformations, and their drivers can be regularly monitored. This platform will provide the first complete picture of progress across systems, informing adjustments in policy and practice. It will provide compelling evidence of major progress that is in line with science (transformations in acceleration), identify gaps that have to be addressed (transformations at risk), and reveal trends across systems. The monitoring system will be designed to provide information in different ways for a variety of users as well as to be portable (i.e., it will allow the data to be accessed in different places, to meet users where they are). It can also be integrated with the Global Commons Alliance's Earth Dashboard data on the conditions and trends of the global commons and the actions taken by companies and cities.

In addition to the tracking platform, the Systems Change Lab will produce an annual report that provides clear, actionable data findings, accompanied by compelling data visualizations, that will depict both the progress made and the gaps in action that remain, as well as major leaders and laggards. The lab will also pursue associated communications and outreach, and lessons learned will be shared at major events and during key moments.

Phase I: Design of Options for Tracking; Identification of Indicators, Data Sets, and Benchmarks

In the first phase, the Systems Change Lab will pursue design options for a tracking system that would assess progress toward all of the required transformations, including working with a vendor on wireframes. In testing out different possible designs and functionalities for the online tracking system, we will seek feedback from future user communities.

A critical first phase for the Systems Change Lab will be to work hand in hand with experts to identify the key indicators for each of the necessary transformations, as well as those that support multiple transformations; the most complete, accurate and open source datasets associated with each indicator that are regularly updated and sustained over time; and the organizations that are developing these datasets to so the lab can start to establish partnerships for data sharing. Indicators would be identified not only for the transformations, but also the underlying drivers, including various actors' incentives, policies, and commitments of various actors. An initial step of this phase will be to develop criteria for indicators and dataset selection.

In addition, informed by the work of the Earth Commission, the Systems Change Lab will assess whether benchmarks exist in the literature for each of these indicators—benchmarks that are aligned with the latest science, as well as taking into account other sustainability criteria. These would be guideposts for assessing progress. The lab will seek to monitor each of the transformations, not only as to how they have changed historically, but also how they speak to the gap in actions that are still required, for example, to 2030 and 2050. However, monitoring requires benchmarks to do so. Some of these already exist in the literature (e.g., outputs of integrated assessment models for climate). For benchmarks not readily accessible in the literature, the lab would partner with other organizations that are pursuing modeling and research efforts that could inform these benchmarks.

Phase II: Collection of Data

Once the indicators and datasets are identified, data will be curated, made accessible and usable, and visualized. The Systems Change Lab will partner with the leading data providers and make significant efforts to partner with a diversity of organizations, including those in developing countries.

Phase III: State of Play Assessment

On the basis of the collected data, the Systems Change Lab will produce an annual assessment that illustrates where progress is accelerating in line with science—and, to the extent possible, also identifies drivers of such change (see "Learning and Sharing"). The assessment will also identify where progress is too slow, is stalled, or is moving in the wrong way altogether. Associated communications and outreach will be pursued.

Future Phases

Future phases could include the following efforts:

- Release of regular assessments by sector and in addition to annual assessments (these periodic installments could be led by other partners);
- Expansion of global indicators to country level or country data platforms;
- Creation of new types of data where they do not now exist, and expansion of existing data collection efforts; and
- Compiling new datasets for tracking political and social realities on the ground.

LEARNING AND SHARING

There have been tremendous gains in academia and elsewhere on systems change, including drivers of historical systems change, and the Systems Change Lab will by no means duplicate this work. However, there are several challenges. Although monitoring progress reveals where transformations are accelerating, monitoring does not show why change is occurring. There are also gaps in understanding the drivers of recent exponential changes, such as the rise of the youth climate action movement, public consciousness about plastic pollution or the prioritization of nature-based solutions. And the literature on systems change is not always translated into language accessible to decision-makers. The Systems Change Lab will address these key gaps and translate the information into impactful and compelling analysis.

Phase I

The Systems Change Lab will work to instill greater confidence that systems change is possible, as change agents are armed with an evidence base across key transformations and with compelling stories. In the first phase of work, the lab will choose a number of transformations to study, partnering with research institutions and researchers with expertise in those fields. Initial steps will be determining case study research principles, especially about making claims of causality; selecting criteria for identifying case studies; and finding research partners with relevant expertise.

We will also convene leaders of coalitions to learn from them on where they are succeeding, and why, and to share lessons across systems and in real time.

The lab will pursue related communications and outreach activities to various actors and networks about the drivers of systems change, informing campaigns, commitments, and principles.

Future Phases

Future phases could commission new research on drivers of transformations on a thematic basis. For example, research on ingredients of systems change in ocean management or sustainable consumption could be published in installments.

NUDGING AND CAMPAIGNING

The Systems Change Lab will conduct outreach, engagement, and communication activities to bring findings from its monitoring and learning activities to help support many existing coalitions on their efforts to campaign and nudge. In doing so, it will help identify where there are gaps and work with partners to fill those, and co-ordinate around major moments to ensure impactful engagement that can help accelerate the transformations.

Phase I: Convenings to Share Results and Mapping Coalitions

The lab will work with partners to share its results as described above ("Monitoring and Learning"). For example, results will be fed into ongoing processes, such as the upcoming COP26 and COP26 Champions dialogues, CBD, World Cities Summit, Stockholm + 50, among others. In addition to intergovernmental processes, the lab will seek to bring its results into related convenings in various regions, reaching out to related industries, policymakers, and nongovernmental organizations working in relevant spaces.

The Systems Change Lab will also catalogue top coalitions seeking to advance each transformation. This will better help the lab identify where to target support and establish partnerships. The lab will seek to partner with leading coalitions, for example, with Mission 2020, the World Economic Forum, C40 Cities, the Food and Land Use Coalition, the Platform for Accelerating the Circular Economy, and others in a distributed ownership model, in which they lead convenings, as well as participate in and lead select research efforts referenced above.

Future Phases: Development of New Coalitions to Advance Change

For the transformations at greatest risk, the Systems Change Lab will work with coalitions to try to address those risks and with champions to call for greater action to fill gaps at critical moments. The lab will use a variety of means to assess gaps and barriers and to map the actors affecting each transformation. For example, the lab will conduct systems mapping to better understand the various actors, relationships, vested interests, drivers, and barriers in select systems. Complementing this exercise, through participatory dialogue, working with partners, the lab will seek to identify solutions that will be transformational—that is, they will increase support over time, ratchet up ambitions to accomplish change, and become more durable. The lab will also identify possible disruptors that could unlock systems change and will enlist top leaders and champions to advocate for such changes.

GOVERNANCE

The Systems Change Lab will work with diverse and visionary high-level champions and coalitions and meticulous technical experts who will together provide the intellectual firepower behind the operation. Top data providers can help the lab track progress toward the required transformations. Leading researchers can help distill and communicate drivers of change. Coalitions and champions can help drive greater action. The lab's partners will be critical to its success.

We hope partners would include leaders from broad-based organizations such as the Global Environment Facility, WEF, World Business Council for Sustainable Development, multilateral development banks, and the United Nations; specific coalitions for change in key sectors, such as the Energy Transitions Commission, C40, the Food and Land Use Coalition, and the Platform for Accelerating the Circular Economy; and leading NGOs and academic institutions, such as the World Wildlife Fund (WWF), the International Union for Conservation of Nature (IUCN), the Energy and Resources Institute, Potsdam Institute for Climate Impact Research, the University of Tokyo, Tsinghua University, and others. The Lab would thus have a distributed ownership model, in which these institutions would lead convenings and select research efforts. WRI and WEF have agreed to play a coordinating role.

In addition to partners on various research and outreach efforts, the lab will establish transformation working groups and a leadership council to help guide its efforts.

Transformations Working Groups

The lab will establish working groups for each of the required sets of transformations (Tables 1 and 2, above) and will ensure a diversity of participating organizations. Working groups will validate indicators and dataset selection for the monitoring of transformations, the selection of benchmarks, the choice of case studies, and the development of a strategy for nudging and campaigning to affect change.

High-Level Leadership Council

A high-level steering panel will be established to help guide and advise on the Systems Change Lab's efforts. The lab will work with leaders of coalitions, as well as expert researchers on systems change, to learn from them about what has successfully driven system change, hypothesize about what could trigger and sustain such change in the future, and foster learning across systems.

CHAPTER 7

Conclusion

We are living through a change of historic scale and scope. This shift will be as significant as the change from a world of hunter-gatherers to an agrarian society, and then again into an industrialized world. Fifteen years ago, smartphones were rare and social media barely started. In the blink of an eye, both have fundamentally altered how we give and receive information. The coming decade will see no less seismic shifts than the past decade. But whether the next 10 years see improvement in people's lives and in the state of the natural world is yet to be determined.

Today, we face a convergence of crises that threaten lives and livelihoods around the world. From unabated climate change and accelerating biodiversity losses to rising inequality and pervasive hunger, there is a burning need and an imperative to address these crises.[481]

The world is at a crossroads. If we continue to invest in yesterday's economy, we will be forced into a path of dependency on dirty energy, continued loss of nature, and deeply unsustainable habits. We can let change wash over us, undirected, and watch as global temperatures rise, species go extinct, and ecosystems are lost.

Or we can seize the opportunity for disruptive change, harness it and shape it to solve the world's greatest social and environmental challenges—to reduce poverty and hunger, to expand energy access, to deliver equity and justice, and to safeguard the forests, fresh water, the ocean, and the climate.

An historic global reset is necessary and possible in this decisive decade. To achieve this, we need to take a hard look at our collective approach to addressing these urgent challenges. We need to work smarter and faster. We need to understand which interventions and movements are working, which aren't and why. We must then rapidly deploy resources to those initiatives poised for success and revise the approach where efforts are insufficient. That is why a central hub that monitors, learns from and accelerates transformational change is needed. The Systems Change Lab under the Global Commons Alliance will fill this gap.

The world is at a crossroads. If we continue to invest in yesterday's economy, we will be forced into a path of dependency on dirty energy, continued loss of nature, and deeply unsustainable habits. We can let change wash over us, undirected, and watch as global temperatures rise, species go extinct, and ecosystems are forever transformed. Or we can seize the opportunity for disruptive change, harness it and shape it to solve the world's greatest social and environmental challenges.

Transformational change is necessary. It is also feasible and desirable. Indeed, change is natural. Human survival has been secured by our capacity to change and adapt. But we do not want only to survive—people and the planet must thrive. It is time to elevate our collective efforts from the instinctive to the conscious, in the coordinated pursuit of a stronger, cleaner, and fairer world.

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ABBREVIATIONS

BECCS	bioenergy with carbon capture and storage
BNEF	Bloomberg New Energy Finance
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CCS	carbon capture and storage
DAC	direct air capture
EPA	U.S. Environmental Protection Agency
EV	electric vehicle
FMNR	farmer-managed natural regeneration
GDP	gross domestic product
GHG	greenhouse gas
HFLD	high forest cover and low deforestation
ICAO	International Civil Aviation Organization
ICAT	Initiative for Climate Action Transparency
ICESI	International Coalition for Energy Storage and Innovation
ICT	Information and Communication Technology
IEA	International Energy Agency
IMF	International Monetary Fund
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ITF	International Transport Forum
IUCN	International Union for Conservation of Nature
MPA	marine protected area
MSW	municipal solid waste
NDC	nationally determined contributions
NRC	National Research Council
OECD	Organisation for Economic Co-operation and Development
REDD+	reducing emissions from deforestation and forest degradation plus sustainable management of forests and the conservation and enhancement of forest carbon stocks
SDG	Sustainable Development Goal
SLM	sustainable land management
SPH	solar thermal process heat
SuRe®	Standard for Sustainable and Resilience Infrastructure
TCFD	Task Force on Climate-Related Financial Disclosures
TOD	transit-oriented development
TRI	Toxics Release Inventory
UNEP	United Nations Environment Programme
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
UNFCCC	United Nations Framework Convention on Climate Change
VKT	vehicle kilometers traveled
WBCSD	World Business Council for Sustainable Development
WHO	World Health Organization
WRI	World Resources Institute
WWF	World Wildlife Fund

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