The State of the

GLOBAL GRAND CHALLENGES

2019

An overview of our progress in addressing 12 global grand challenges as a community of global innovators, leaders, learners, and doers.

By Singularity University

Singularity UNIVERSITY

The State of the Global Grand Challenges: 2019

An overview of our progress in addressing 12 global grand challenges as a community of global innovators, leaders, learners, and doers.

By Singularity University

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Singularity
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FOREWORD

At SU, we've come to realize that the narrative arc is a critical tool in overcoming barriers to change and a status quo bias. We therefore seek to create a credible vision for a future where global grand challenges are solved, and scarcity is transformed into abundance—a story of the future that is so engaging and inspiring that it compels us to action.

In order to chart a path to this future we wish to co-create, we must also have a clear understanding of the world we're living in now. That's why we've produced this report on the state of the global grand challenges.

In this report, you'll find a compelling look at each of the twelve global grand challenges (GGCs). We start out with a frank assessment of each challenge and our collective progress to date in solving it. We discuss the key technologies that are converging to enable solutions and highlight some promising innovations coming out of the SU community. We end each chapter with some suggested ways you can become part of the solution and point you to resources for further exploration and inspiration.

I hope this report will motivate you to take action. There are so many ways you can get involved, and we hope you'll find your own pathway from idea to impact. And if you'd like a partner on that journey, we're here and eager to talk!

Rob Nail
CEO & Associate Founder
Singularity University

INTRODUCTION

Singularity University is a global learning and innovation community using exponential technologies to tackle the world's biggest challenges and build a better future for all.

Our collaborative platform empowers individuals and organizations across the globe to learn, connect, and innovate breakthrough solutions using accelerating technologies like artificial intelligence, robotics, and digital biology. We offer educational programs, courses, and summits; enterprise strategy, leadership, and innovation programs; programs to support and scale startups and promote social impact; and online news and content. The SU community includes entrepreneurs, corporations, global nonprofits, governments, investors, creatives, and academic institutions in more than 120 countries. Our community is driving positive change in the global grand challenge (GGCs) areas of health, environment, security, education, energy, food, prosperity, water, space, disaster resilience, shelter, and governance.

At SU, we believe that leveraging the convergence of exponential technologies will set us on the path to solve our GGCs and shift from an era of scarcity to abundance. Given that exponential technologies rapidly fall in cost while dramatically scaling and improving in sophistication, we believe an innovative person, team, company, organization, or ecosystem can solve a social problem that impacts billions of people, possibly within the next ten years.

This book provides an overview of the 12 GGCs, including their current status, examples of key technological solutions impacting the challenge, examples of promising solutions generated by the SU ecosystem, and a link to a companion website offering resources for further learning on each GGC. In addressing each GGC, we

encourage our community to solve from three perspectives: (1) ensuring basic needs are met for all people, (2) sustaining and improving quality of life, and (3) mitigating future risks. In addition, we remind our community that the challenges are deeply connected, interrelated, and interdependent and we must not accidentally create new problems in our efforts to solve current problems.

The GGCs are aligned with the United Nations Sustainable Development Goals (SDGs), and we often look to the SDGs to help us understand the current state of the challenge and different sub-components of the challenge. Each GGC has an objective that is framed to describe the overarching end-state we feel is achievable—especially if we can count on you to take up the cause with us.

As the SU ecosystem grows, we are looking to connect our community to help collaboratively solve the GGCs. Join us! Start by downloading the SU App (su.org/app) to become a member of our community of innovators. Then create an impact goal and share more about your work with us.

Darlene Damm
Vice Chair, Global Grand Challenges
Singularity University

ENERGY

We believe in creating a world with ample accessible, sustainable energy that meets the needs of humanity.

According to the SDGs,[1] the World Bank,[2] and the International Renewable Energy Agency,[3] one in seven people still lacks access to electricity, most notably in remote areas in Sub-Saharan Africa and South Asia. The good news is that about 150 million people gain access to electricity every year. According to the World Bank, "Notable progress has been made on energy access in recent years, with the number of people living without electricity dropping to roughly 840 million from one billion in 2016 and 1.2 billion in 2010."[4]

Despite these successes in improving access to energy, about two-thirds of electricity still comes from non-renewable sources and energy contributes to about 60 percent of greenhouse gasses. In addition, more than three billion people still use polluting and unhealthy energy sources for cooking. The energy global grand challenge is closely linked to solving the other grand challenges, including environment, health, shelter, food, water, and prosperity.

Exponential technologies can play a critical role in solving the energy global grand challenge. Energy infrastructure built with exponential technologies—such as solar power infrastructure, internet of energy grids, batteries, windmills, and all of the machines that make these technologies—will follow exponential trends. And given that these technologies harness free energy sources—such as sunlight, wind, geothermal heat, and moving water—they have a distinct advantage over fossil fuels, which are limited by the scarcity of the fossil fuel resource even if technologies to extract the fossil fuels also follow Moore's Law and the Law of Accelerating Returns. This is one of the reasons why we expect renewable energies to be so disruptive and successful in the future.

Solar technology in particular is making an impact in countries at all different economic levels. For example, MKOPA Solar,[5] a

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[1]https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-7-affordable-and-clean-energy.html
[2]https://www.worldbank.org/en/news/press-release/2019/05/22/tracking-sdg7-the-energy-prog-ress-report-2019
[3]https://www.irena.org/
[4]https://www.worldbank.org/en/news/press-release/2019/05/22/tracking-sdg7-the-energy-prog-ress-report-2019
[5]http://solar.m-kopa.com/about/company-overview/

Kenyan solar company, had connected more than 600,000 homes to affordable solar power by 2018. It is adding 500 more homes daily, creating 75 million hours of kerosene-free lighting per month. Similarly impactful is the India-based Barefoot College,[6] which has trained more than 2,600 women in 96 countries in solar technology; the company provides 1.4 megawatts of electricity per year. In June 2019, Dutch company Lightyear launched the Lightyear One, a solar car with a 450-mile range that can be charged either through its solar panels or conventional methods.[7] The company was originally founded at Eindhoven University of Technology in 2016 as part of a solar car challenge, and we are proud that the company's founder, Lex Hoefslot, participated in SU's 2017 Global Solutions Program (now Global Startup Program). Also in June 2019, Israeli company Eviation debuted its Alice plane, a nine-seater electric aircraft that can travel up to 650 miles at 10,000 feet at 276 miles per hour. It is expected to go into service in 2022 and only costs $8 to $12 to charge per 100 miles, compared to $400 in traditional jet fuel that a similar plane, like a turboprop Cessna Caravan, would require for 100 miles.[8]

Through these early-stage innovations—which are emerging in parallel with developments in battery storage, more efficient management of energy grids through predictive artificial intelligence, and blockchain marketplaces that allow people to exchange energy, as well as the transformation of our logistics and transport systems into more internet-like paradigms—we can see the emergence of a powerful new renewable energy sector.

How can you help?

How are you helping to solve the energy grand challenge? Are you investing in clean energy? Developing new R&D? Innovating with a company or organization? Launching a startup? Enacting new policies? Increasing education and awareness?

You can take small actions on a daily basis that will really add up. Start biking to work. Try video calls instead of flying to meetings. Make sure your next car (or car ride) uses renewable energy. Install solar panels, and purchase renewable energy through your power company. Finally, buy locally-grown food.

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[6] https://www.barefootcollege.org/solar-mamas-speak-at-the-international-solar-alliance-confer-ence-in-new-delhi/
[7] https://www.cnn.com/2019/06/26/business/lightyear-one-solar-powered-car/index.html
[8] https://www.bbc.com/news/business-48630656

"The thing we need to do, the big design question, the task ahead for our investment agendas and our R&D agendas is: cut out the middleman. The more we can utilise the power of the sun to answer our needs on a day-to-day basis, the more we have the energy to answer all the other demands and needs mankind has. Humanity could benefit enormously from natural abundance."

—Arash Aazami, SU Faculty, Energy

Visit our **companion web page** for valuable resources to learn more about the Energy GGC and the promising solutions that our SU ecosystem is developing.

How can I become part of the solution?

Who I can enlist to help me address this challenge:

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Top takeaways:

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ENVIRONMENT

We believe in creating a world with sustainable and equitable stewardship of Earth's ecosystems for optimal functioning both globally and locally.

Environmental sustainability encompasses a large number of areas, including biodiversity, oceans and water, forests, land, natural resources, global warming, air pollution, ecosystem management, disasters, chemicals, waste, and more. Clearly, the environment global grand challenge is closely linked to other GGCs including food, energy, prosperity, water, health, and disaster resilience.

According to the World Resource Institute,[9] more than 30 percent of the world's forests have been cleared, another 20 percent have been logged and identified as downgraded, and much of the rest has been fragmented—only about 15 percent of the world's forests are left intact. National Geographic[10] notes that half of deforestation is due to farming, livestock grazing, mining, and drilling. According to the UN SDGs,[11] more than 1.6 billion people depend on forests for their livelihoods and ecosystems as a whole are linked to $125 trillion in human livelihoods and well-being per year. Furthermore, the World Wildlife Fund[12] says that forests are home to 80 percent of the world's terrestrial biodiversity and are critical to mitigating climate change and supporting other ecosystems.

Similarly, the World Wildlife Fund notes that oceans contain the greatest diversity of species on the planet, feed more than one billion people per year, and are also critical to mitigating climate change and supporting other ecosystems. The UN SDGs[13] note that more than three billion people depend on marine and coastal biodiversity for their livelihoods. Oceans are facing overfishing, warming and acidification, the loss of coral reefs, and pollution, especially by plastics.

Climate change is also a critical threat to humanity. According to NASA,[14] rising temperatures due to human activity are simultaneously melting ice caps—resulting in rising ocean levels that threaten societies—and creating heat waves, droughts, floods, and other

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[9] https://www.wri.org/our-work/topics/forests
[10] https://www.nationalgeographic.com/environment/global-warming/deforestation/
[11] https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-15-life-on-land.html
[12] https://www.worldwildlife.org/threats/deforestation-and-forest-degradation
[13] https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-14-life-below-water.html
[14] https://climate.nasa.gov/effects/

weather patterns that impact agriculture. Industrialization not only impacts the climate, but also causes air pollution, which the World Health Organization (WHO)[15] estimates results in 4.2 million deaths per year. Additionally, WHO estimates that more than 91 percent of the world's population now lives in areas where air pollution exceeds healthy limits.

A number of exponential technologies can help solve the environment global grand challenge. Satellites, drones, robotics, and sensors are improving the collection of environmental data as well as contributing to concrete solutions that can help restore the environment. For example, the World Resources Institute's Global Forest Watch[16] program combines satellite data with crowdsourced data to monitor deforestation and makes it actionable to governments, companies, journalists, and citizen groups. Rainforest Connection[17] and tribes in the Amazon have used Google's open source AI software TensorFlow to create a scalable real-time alert system for illegal logging in the Amazon. The U.S. Department of Commerce's National Oceanic and Atmospheric Administration has opened up satellite data[18] on oceans to the world, helping more people participate in scientific research and solutions. Similarly, space companies like Planet Labs[19] provide satellite data on fishing boats, oil spills, and maritime activity.

In May of 2019, the XPRIZE Foundation awarded prizes to several companies working in autonomous ocean exploration, including ones mapping the seafloor and detecting underwater biological and chemical signals.[20] Tools like FishFace, developed by the Nature Conservancy and Refind Technologies, are creating image recognition techniques to better manage fish.[21] Greenwave is pioneering high-tech underwater farms to grow sustainable seafood as well as transition fishing communities into 21st century jobs.[22] The

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[15] https://www.who.int/airpollution/en/
[16] https://www.wri.org/our-work/project/global-forest-watch
[17] https://www.blog.google/technology/ai/fight-against-illegal-deforestation-tensorflow/
[18] https://eos.org/project-updates/interactive-online-maps-make-satellite-ocean-data-accessible
[19] https://www.planet.com/markets/maritime/
[20] https://www.xprize.org/articles/ocean-discovery-winners-announced
[21] https://en.reset.org/blog/fishface-tackling-overfishing-fish-photobooth-and-artificial-intelligence-01082019
[22] https://www.greenwave.org/
[23] https://theoceancleanup.com/

Ocean Cleanup Project[23] is building autonomous, energy-neutral, scalable boats with the goal of cleaning up more than five trillion tons of pollution that currently litter the oceans, starting with the Great Pacific Garbage Patch.

In addition, innovations in the food industry like cultured meat, and energy industries like renewables, are promising given that environmental destruction, pollution, and global warming are largely caused by these two sectors.

How can you help?

How are you helping to solve the environment global grand challenge? Are you investing in or launching an environmental startup? Developing new R&D? Innovating with a company or organization? Enacting new policies? Increasing education and awareness?

You can take a lot of personal steps that together can have a big impact. Carry around with you a reusable water bottle and utensils. Use compostable utensils and plates in your office, schools, and community organizations. Use one bag for multiple types of produce at the grocery store. Pick up trash and plastics left on the ground and beaches. Create a capsule wardrobe to reduce fashion waste. Reduce your consumption of meat. Finally, seek out or advocate for renewable sources of energy from your power distributor.

"The best news in the global fight against climate change is the pace at which clean technology is advancing. That technology is on a path to disrupt fossil fuel electricity, oil, and the automotive industry as solar and wind power, batteries, self-driving cars, and electric drive trains all come of age in a wave of mutually amplifying technologies."

—Ramez Naam, SU Faculty Chair, Energy & Environmental Systems
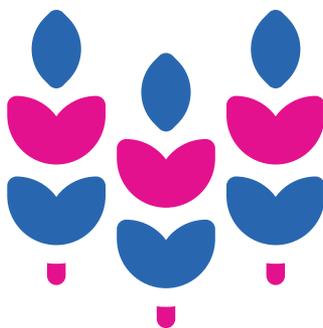
How can I become part of the solution?

Visit our **companion web page** for valuable resources to learn more about the Environment GGC and the promising solutions that our SU ecosystem is developing.

Who I can enlist to help me address this challenge:

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Top takeaways:

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FOOD

We believe in creating a world where all people have sufficient, safe, and nutritious food to maintain healthy and active lives at all times.

Food plays an essential role in all of our lives. According to the World Food Programme,[24] about 815 million people are chronically undernourished. One-third of the global population is malnourished, experiencing either undernourishment or suffering from obesity, diabetes, or other food-related diseases.

Food is not only essential to our individual well-being, but is also linked to several other global grand challenges, including health, prosperity, environment, disaster resilience, water, energy, governance, and more. According to the UN SDGs, 26 percent of the global workforce is employed in agriculture,[25] and, according to the 2015 McKinsey Global Institute, food and agribusiness are a $5 trillion—and growing—industry.[26] More recently, Plunket Research claimed the industry reached nearly $8 trillion in 2018.[27]

In recent years, a new generation of exponential technologies has emerged to disrupt the food industry from seed to table. In particular, robotic and autonomous farm equipment, including tractors and planting and harvesting equipment, are working in our fields; robotic dairies are managing livestock; and robotic fish farms are transforming our oceans. Agriculture itself is also being reinvented through robotics that enable farmers to grow vegetables in urban environments and hostile climates. For example, Iron Ox[28] in California identifies itself as the first fully autonomous farm in the world. In an indoor space, its moving autonomous robots can grow 30 acres worth of organic leafy vegetables in just one acre, dramatically reduce water and fertilizer inputs, decrease food waste, and cut food transport costs as it can live directly within communities. Other companies, such as San Francisco's Plenty and Plenty in Japan, have also created tech-infused indoor vertical farms that use less space and fewer resources.

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[24]https://www1.wfp.org/
[25]https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-2-zero-hunger.html
[26]https://www.mckinsey.com/~/media/McKinsey/Industries/Private%20Equity%20and%20Principal%20Investors/Our%20Insights/Global%20agricultures%20many%20opportunities/Global%20agricultures%20many%20opportunities.ashx
[27]https://www.plunkettresearch.com/statistics/Industry-Statistics-Global-Food-Industry-Statistics-and-Market-Size-Overview/
[28]http://ironox.com/

As we bring technology into farming and livestock, it is changing the game—it can work 24 hours a day as well as customize delivery of water, fertilizer, and light. As we increase our ability to grow food anywhere, anytime, in a decentralized fashion, technology can solve some of our biggest challenges in undernourishment caused by lack of access to food because of political instability, conflict, economic instability, or drought.

While biotechnology is historically—and often controversially—known for genetically modifying crops, the new industry of cellular agriculture is now allowing businesses to grow beef, poultry, pork, seafood, dairy products, and more from the cell up in bioreactors; this is similar to how we now grow human organs and tissues using biotechnology. Like decentralized, tech-infused vertical farms, cellular agriculture holds the promise of growing animal and animal-like products anytime and anywhere. Cellular meats will provide a huge benefit to the environment given that agriculture, livestock, and fishing are major contributors to deforestation, overfishing, and pollution. Cellular meats are less controversial from an ethical perspective because they remove concerns about the treatment of animals. Over the last few years, the cellular agriculture and cultured meat industry has grown rapidly. Genetically-modified, plant-based meat alternatives such as the Impossible Burger have now scaled into national grocery stores, and fast food chains and large players such as Tysons and Cargill have invested in the industry.[29]

Exponential technologies are also disrupting food processing and distribution. New sensors and artificial intelligence are being used to sort food and inspect it for spoilage, contamination, and authenticity, which reduces food waste and food-borne diseases. Entrepreneurs are building self-driving kitchens and restaurants, complete with robotic cooks, grocery stores without checkers, and food delivery bots. The World Food Programme is using blockchain and iris scanning to more efficiently deliver food coupons to refugees, thereby reducing costs and increasing transparency.[30]

The combination of these technologies will dramatically impact employment, considering that all of these technologies are expected to rapidly scale due to their exponential nature. During this decade,

[29] https://www.cbinsights.com/research/future-of-meat-industrial-farming/
[30] https://innovation.wfp.org/project/building-blocks

we may see the end of farming as a profession, which is the largest employer of humans in the world. Given that food has historically been linked to family, culture, and religion, we may reinvent our relationship with food. Ultimately, our relationship to food may serve as a reflection of our humanity, and, as we add technology to it, we will also be transforming ourselves and our culture.

How can you help?

How are you helping to solve the food global grand challenge? Are you investing in or launching a food tech startup? Developing new R&D? Innovating with a company or organization? Enacting new policies? Increasing education and awareness?

There's actually a lot you can do to help address this challenge. Consider building a small tech-infused vertical garden in your home to grow organic herbs. Teach your friends and family how to cook Impossible Burgers. Set up a composting site for food waste. Learn about and write an op-ed for your local newspaper on new farming and food technologies and how they might impact your local economy.

"The world that we are working toward is one in which food waste has been eliminated, which is in stark contrast to today's world where a third of all the food produced in the world is wasted. We have a big challenge ahead of us! If we could reduce the amount of wasted food by 25 percent, we could feed the world with the food we produce today."

—Abi Ramanan, CEO and Co-founder of ImpactVision and SU GSP15 alumna

How can I become part of the solution?

Visit our **companion web page** for valuable resources to learn more about the Food GGC and the promising solutions that our SU ecosystem is developing.

Who I can enlist to help me address this challenge:

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Top takeaways:

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SHELTER

We believe in creating a world with secure, safe, and sustainable shelter for residence, recreation, and industry for all people at all times.

According to the United Nations SDGs,[31] by 2050, more than two-thirds of humanity—that's more than 6.5 billion people—will live in urban areas. Currently, more than 828 million people are estimated to live in slums, generally in cities. In recent years, natural and manmade disasters as well as political instability have created some of the most high profile challenges in the housing industry, contributing to the worldwide increase of people living in temporary shelters. According to the United Nations Refugee Agency,[32] more than 70.8 million people were displaced from their homes, with over half coming from Afghanistan, Syria, and South Sudan. Securing permanent housing can also be most challenging for specific groups of people, including those who are elderly, people with disabilities, indigenous populations, and women and children. Sufficient, safe shelter is closely linked to several other global grand challenges, including security, health, governance, prosperity, disaster resilience, and more.

Exponential technologies can play a critical role in helping solve the shelter global grand challenge. At the most basic level, digitization of the architecture, construction, and real estate sectors allows increased efficiencies between building design, cost and bid estimates, project management, supply chain management, and equipment management; it also allows workers and customers to virtually visit sites. With increasing sophistication and the robotization of the construction industry, we are also seeing the first pilots in 3D printed houses. In 2016, Beijing-based company HuaSheng Tengda made headlines by printing a 4,305-square-foot, two-story villa in 45 days that can withstand a magnitude 8.0 earthquake. In 2018, 3D Prinhuset (now COBOD), created Europe's first 3D printed house in Denmark.[33] Perhaps most exciting is the work of ICON and New Story, a collaboration between a Texan technology company and a nonprofit with historic expertise in

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[31]https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-11-sustainable-cit-ies-and-communities.html
[32]https://www.unhcr.org/en-us/figures-at-a-glance.html
[33]https://all3dp.com/1/3d-printed-house-homes-buildings-3d-printing-construction/

housing for the world's most vulnerable populations. They released a demo of their 3D printed house at South by Southwest in 2018, claiming they could lower costs to $4,000 to $10,000 per house as well as build each house within 24 hours. Since then, the organizations have started building a 3D printed community for 400 people in El Salvador, which is expected to be completed in 2019. They are also working in the city of Austin to build affordable housing.

Entrepreneurs and organizations are also using exponential technologies to address the social and political challenges related to shelter. For example, the World Bank has started using blockchain technologies to track land administration and property rights as well as identity and access to financial services, which are key drivers to ensuring that the poorest of the poor and marginalized groups can own property, pass on assets to children, and avoid corruption. Miracle Messages, a nonprofit in the US founded by SU alumnus Kevin Adler, uses social media to connect homeless individuals experiencing mental health challenges to the family members who are searching for them. They also work to combat bias toward unhoused individuals. ReGen Villages, founded by SU Faculty James Ehrlich, is addressing the shelter challenge by building tech-infused futuristic communities that generate income by selling excess energy, food, and water outside the village. A number of governments around the world are taking this one step further by designing futuristic communities—and even entire cities and economic zones, such as Masdar City and NEOM in the Middle East.

While many organizations are using the benefits of exponential technologies to make traditional construction methods more efficient, others are using exponential technologies to disrupt housing and cities entirely. For example, Amy Kurzweil, illustrator of *Danielle: Chronicles of a Superheroine* written by Ray Kurzweil, articulated a future of moving fluid cities with a vision of self-driving houses. Her self-driving tiny houses are smart and connected, and they include vertical gardens to provide food. Given that others are working on autonomous markets, restaurants, and offices, the future of shelter—and how we live in the future—may be the most surprising development of all.

How can you help?

How are you helping to solve the shelter global grand challenge? Are you launching or investing in a shelter startup? Developing new R&D? Innovating with a company or organization? Enacting new policies? Increasing education and awareness?

You can take many individual actions that will help immeasurably. Consider volunteering with a nonprofit such as Habitat for Humanity. Visit a local homeless shelter and offer to teach people a new skill. Reach out to local lawmakers and encourage them to incorporate environmentally-friendly energy and water solutions into new housing divisions.

"I was laying out all of the components required to build a city—one building at a time. [My cofounder] looked at it and just said, 'We'll have an AI do this.' To think that with AI we might potentially do that in a single system and be able to optimize it—that's when my moonshot idea came together for me. That's when I knew we could build a city like a forest, with each building one of the trees integrated into the whole, and at the same time answer the universal need for shelter."

—Olivia Ramos Co-founder and CEO at Deep Blocks and SU GSP16 alumna

How can I become part of the solution?

Visit our **companion web page** for valuable resources to learn more about the Shelter GGC and the promising solutions that our SU ecosystem is developing.

Who I can enlist to help me address this challenge:

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Top takeaways:

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SPACE

We believe in creating a world with safe and equitable use, and stewardship of, space resources and technologies for the benefit of humanity and our future as a multi-planetary species.

Historically, governments were the primary players in the space industry, but in the early 2000s the cost of exponential space technologies began to fall far enough for a private space sector to emerge. In 2004, the private company Scaled Composites won the Ansari XPRIZE,[34] which offered $10 million to the first non-governmental group to send humans into space in a reusable spacecraft twice within two weeks. Today, thousands of private space companies and startups now exist in launch, satellites and communications, space robotics, space manufacturing, space mining, and other industries. In addition, multiple governments have either revived their space programs or are launching new space programs.

In 2018, Goldman Sachs made waves by stating that the world's first trillionaire will be produced by the space industry.[35] American venture capital firm Space Angels reported that, at the end of 2018, investors poured more than $18 billion into the industry since 2009.[36] As launch costs are overcome, it will become possible to send and build more infrastructure in space. This infrastructure could range from an array of new private space stations to what The Atlantic author Maria Koren referred to as Earth's "exoskeleton," tens of thousands of sophisticated satellites that are instantaneously communicating with the internet of robots on Earth and exchanging massive amounts of data for communication and monitoring the Earth and humanity. This infrastructure can also serve as a stepping stone—both in terms of generating further revenue for their industry as well as advancing technology—for further space exploration and settlement.

As the space industry develops, exponential technologies will be linked to solving the space global grand challenge in myriad ways. First, as we build the Earth's exoskeleton with sophisticated

[34]https://en.wikipedia.org/wiki/Ansari_X_Prize
[35]https://www.rt.com/business/424800-first-trillionaire-space-miner/
[36]https://www.spaceangels.com/post/space-investment-quarterly-q4-2018

satellites, robotics, and a space-based manufacturing industry, the massive amounts of data collected by the exoskeleton will increasingly interface with terrestrial industries. While much attention is given to how these satellites can link the last few billion people to the internet, this space-based data can also be used to monitor in real-time everything from the climate to the oceans, land masses, forests to biodiversity and more. Furthermore, this data will eventually be integrated with robotic infrastructure on Earth, which will likely include autonomous ships, air drones, land transport, and smart cities.

Second, the exploration of space has historically resulted in technological developments that have applications that improve life here on Earth. The high-stakes Apollo missions were known for helping to advance the use of computers for navigation and guidance. NASA has a long list of products ranging from memory foam to freeze-dried food that resulted from space exploration efforts. New types of space suits, space shelters, space farming equipment, and medical devices can also be used to benefit people in isolated and resource-scare parts of the planet.

Third, growing the space industry will help defend against long-term space-based threats to Earth. While risks of asteroids hitting our planet or solar flares taking out our communications infrastructure are rare, they are very serious problems when they do occur. The more we understand about space, the better prepared we will be.

Finally, we have reached a moment in history where humans, including the private space industry, are much closer to exploring other planets and celestial bodies. This will likely be a combined effort of sending humans and robots deeper into outer space as well as using new types of tools to conduct research from afar.

Right now, we have a window of opportunity to think through how we wisely explore space. What laws will govern these explorations and settlements? Who will be able to participate? What values should these pioneers take with them for future generations of humans? Although we think of the space global grand challenge as a technology endeavor, it is also very closely linked to governance and prosperity GGCs, and requires the involvement of a diverse group of people to succeed.

How can you help?

How are you helping solve the space global grand challenge? Are you launching or investing in a space startup? Developing new R&D? Innovating with a company or organization? Enacting new policies? Increasing education and awareness?

There's actually a lot you can do to have a significant impact on this challenge. Consider teaching the children in your life how to track online space stations and satellites as they pass overhead at night. Visit the Planetary Society website and become a space advocate. Read Anousheh Ansari's memoir *My Dream of Stars* to better understand the life of the world's first private female space explorer.

"As the major space players prepare for big, bold missions off-planet, and as new sub-segments of the space industry begin to arise due to the growing satellite industry, more niche markets—precision engineering, digital manufacturing, habitat design, health and life support systems, and food for extreme environments—are up for grabs by emerging nations and entrepreneurs to take advantage of this growing democratized industry."

—Emeline Paat-Dahlstrom, SU Faculty, Space and Impact, and Co-founder of SpaceBase

How can I become part of the solution?
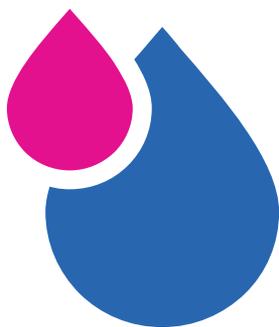
Visit our **companion web page** for valuable resources to learn more about the Space GGC and the promising solutions that our SU ecosystem is developing.

Who I can enlist to help me address this challenge:

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Top takeaways:

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WATER

We believe in creating a world with ample and safe water for consumption, sanitation, industry, and recreation for all people at all times.

According to the United Nations SDGs, more than 844 million people currently lack access to basic drinking water. In addition, more than 4.5 billion people lack safely-managed sanitation services, including toilets, sewers, and wastewater, while 2.3 billion people lack access to even basic sanitation services.[37] According to the World Health Organization, more than 1.7 billion children contract diarrhoeal diseases every year— it is the second leading cause of death of children globally— which are preventable with safe water and sanitation.[38] Water is not only essential for sanitation, drinking, and cooking, but also necessary for agriculture, industrial activities, recreation, and healthy environmental ecosystems. The International Food Research Institute states that currently 40 percent of the world's grain production and one-fourth of the global economy are at risk due to unsustainable water use.[39]

Additionally, access to water is often at the heart of conflict between different nations and among ethnic groups, particularly among vulnerable populations. The Pacific Institute has tracked more than 650 incidents of water conflict globally.[40] In this sense, the water global grand challenge is closely linked to the food, health, security, governance, and environment GGCs.

Exponential technologies can help address the water GGC on a few different levels. Several companies are working on extracting drinkable water from air. Zero Mass Water technology absorbs water from thin air with the help of energy generated by solar panels; it can extract about one gallon of fresh water per day. Watergen, which is powered by traditional energy sources, can produce about five gallons of safe water daily.

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[37]https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-6-clean-water-and-sanitation.html
[38]https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease
[39]http://www.growingblue.com/water-in-2050/
[40]http://www.worldwater.org/conflict/list/

While these are promising developments, further work is needed to create systems that can generate more water at lower costs.[41] Additional developments in energy generation and storage could hold the key. We are also seeing the growth of the desalination industry, with more than 16,000 desalination facilities now operating worldwide. Unfortunately, these systems require high levels of energy and also produce a lot of brine as well as other chemicals and metals—this process presents an opportunity for innovators to improve the systems.[42]

Exponential technologies may also play a role in reducing water waste in the agricultural industry. Some of the new robotic farms, such as Iron Ox, report that they reduce water inputs by more than 90 percent.[43] Scientists have been working for years to genetically engineer plants to make them more drought resistant. The satellite company Planet Labs has published a number of papers on how their images can be used in precision agriculture as well as assess the well-being of rivers and other freshwater sources.[44] The housing community, ReGen Villages, is looking to build tech-infused communities to better manage water and wastewater[45] in the housing sector. Across all industries, researchers are also looking at the use of artificial intelligence to better predict and optimize water systems. For example, in Australia, Melbourne Water is using past data and artificial intelligence to predict water usage and calibrate pumps, which also saves energy usage.[46]

Exponential technologies are particularly making a difference in lower-income countries. For example, India's Center for Rural Information and Action is partnering with Hamilton Labs to help install 100 million new 3D printed toilets across India.[47] Water is an interesting GGC to solve because there are so many angles that must be considered to truly address scarcity, from housing to agriculture to industry, using a range of exponential technologies.

[41]https://www.cnn.com/2019/01/31/tech/water-from-air-startups/index.html
[42]https://www.wired.com/story/desalination-is-booming-but-what-about-all-that-toxic-brine/
[43]https://venturebeat.com/2018/10/03/__trashed-7/
[44]https://www.planet.com/pulse/publications-tag/water-use/
[45]http://www.regenvillages.com/
[46]https://news.itu.int/melbourne-cut-down-water-costs-using-ai/
[47]https://3dprintingindustry.com/news/worlds-first-3d-printed-toilets-coming-india-singapores-hamilton-labs-127575/

How can you help?

How are you helping solve the water global grand challenge? Are you launching or investing in a water startup? Developing new R&D? Innovating with a company or organization? Enacting new policies? Increasing education and awareness?

You can take many small actions daily that will amount to big changes over time. Consider conserving water by running only full loads of laundry, installing a greywater re-suse system in your house, or upgrading to highly efficient toilets, showerheads, and dishwashers. You could also encourage your family, business, and/or school to try to care for a local river or pond by cleaning it up, monitoring it for pollution, or tracking local wildlife that depend on the ecosystem.

"I have a focus in two areas. One is on the importance of water and how to encourage companies and investors to look at water quality more urgently. The second is how genetic engineering and synthetic biology will revolutionize how we think about how to impact water. The great thing about FREDsense is we drive impact every time we get our technology into the market and help someone with one of their challenges. It's not just a revenue metric for us but an impact metric."

—David Lloyd, CEO and Founder, FREDsense Technologies and 2015 SU Ventures alumnus

How can I become part of the solution?

Visit our **companion web page** for valuable resources to learn more about the Water GGC and the promising solutions that our SU ecosystem is developing.

Who I can enlist to help me address this challenge:

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Top takeaways:

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DISASTER RESILIENCE

We believe in creating a world with effective and efficient disaster risk reduction, emergency response, and rehabilitation that saves lives and livelihoods, minimizes economic loss, and builds resilience both globally and locally.

According to the Center for Research on the Epidemiology of Disasters (CRED), more than 18,000 mass disasters—including earthquakes, tsunamis, hurricanes, cyclones, floods, and droughts as well as industrial and technical accidents—have rocked civilizations since 1900.[48] This figure does not include wars and conflict or the many small-scale disasters, such as house fires, that the Red Cross estimates affect about 60,000 households per year in the US alone.[49] Disasters are expensive; the UN and CRED estimate natural disasters have caused nearly $3 trillion in damages over the last twenty years.[50] Disasters also often lead to long-term environmental damage, such as toxic spills, nuclear accidents, or leftover landmines, that make it impossible for citizens to live, work, or farm in the area.

The disaster resilience GGC is closely linked to the governance and security GGCs as well as the food, water, health, prosperity, learning, and environment challenges. At Singularity University, we also consider how disaster resilience is linked to the space global grand challenge because space poses risks to humans ranging from asteroid strikes to solar flares that could damage our digital infrastructure.

Exponential technologies are playing an important role in preventing, preparing for, and responding to disasters. The digitization of the architecture, engineering, construction, real estate, and urban planning industries is helping us design more disaster-resilient cities—constructing new homes and buildings and replacing old infrastructure, including bridges, dams, roads, locks, and ports. These innovations include new types of construction materials and building equipment, software solutions that allow communities to rebuild safely and quickly, and predictive power about what types of disasters communities may be vulnerable to.

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[48] https://www.cred.be/
[49] https://www.redcross.org/get-help/how-to-prepare-for-emergencies/types-of-emergencies/fire/prevent-home-fire.html
[50] https://www.voanews.com/usa/un-economic-losses-natural-disasters-soar

Low-cost sensors are also helping people predict impending disasters. These include early warning devices for earthquakes and tsunamis as well as sensors that detect air and water pollution or terrorist attacks. These sensors can be placed in many locations, including cell phones, city walls, poles, and posts, and can also be combined with satellite data. One interesting example is Mexico City-based SkyAlert, an app that provides earthquake warnings to millions of people and connects with smart home devices to shut off gas and alert people through lights and speakers as soon as disaster strikes.[51] Researchers at Japan's Tohoku University are even exploring ways quantum computers can quickly predict evacuation routes during a tsunami.[52] Also, once a disaster has happened, sensors on satellites, drones, and robots can help assess situations and relay information to first responders.

First responders are also using exponential technologies in new ways. Virtual and augmented reality can make rescue workers more effective during disaster responses. More than familiarizing responders with an area, exponential tech can address challenging issues at the heart of the work. For example, the International Committee of the Red Cross has created a virtual reality training in Bangkok, Thailand that helps prepare workers for dealing with dead bodies and other potentially traumatic experiences. In addition, the XPRIZE Foundation and California Governor Gavin Newsom have announced they are working on a new incentive challenge to figure out how to autonomously and quickly detect and extinguish wildfires. These systems are not only more efficient and effective, but they do not risk human lives.[53]

While exponential technologies can play an important role in improving prevention, prediction, and response to disasters, they can also increase the severity of certain human-made disasters. For example, as knowledge and tools in science and engineering become democratized and scale through exponential technologies, opportunities arise for individuals or small groups of people to create or threaten a bioterrorism attack or nuclear attack, which could cause widespread damage or panic. Therefore, it is just as important to address misuse of exponential technologies as using them to create solutions.

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[51] https://abc7news.com/technology/new-earthquake-system-in-menlo-park-a-first-in-nor cal-/5388252/
[52] https://www.dwavesys.com/sites/default/files/Ohzeki.pdf
[53] https://www.xprize.org/articles/xprize-gov-gavin-newsom-battle-wildfires

How can you help?

How are you helping solve the disaster resilience global grand challenge? Are you launching or investing in a disaster resilience startup? Developing new R&D? Innovating with a company or organization? Enacting new policies? Increasing education and awareness?

There are small actions you can take that can have a significant impact on your family and community and beyond. Consider downloading an earthquake alert app on your phone and creating an emergency preparation kit. Make sure you have working fire alarms and know the location of the nearest fire extinguisher. Create a plan to help elderly or vulnerable people in your neighborhood during a disaster. Start a fundraiser to purchase earthquake or other survival kits for others in the community. You might also consider entering the upcoming XPRIZE Challenge: XPRIZE and California Governor Gavin Newsom Partner to Design an Incentive Prize for Innovation to Battle Wildfires.

"We were students, sitting in our design studio, thinking about what we could design that may help in a situation like [the earthquake in] Haiti. We noticed that organizations were distributing food, water, shelter, and medical supplies, but they were not shipping any lights or ways for people to have portable power. We focused our semester on designing lightweight, portable energy products that could be cost-effectively shipped in emergencies and the LuminAID Solar Light was one of the designs we came up with."

—Andrea Sreshta & Anna Stork, Founders of LuminAID and winners of SU's 2017 Global Grand Challenges Award for Disaster Resilience

How can I become part of the solution?
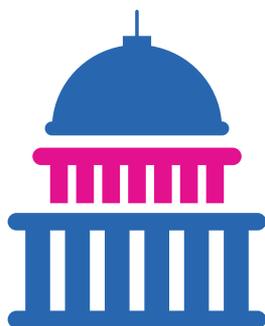

Visit our **companion web page** for valuable resources to learn more about the Disaster Resilience GGC and the promising solutions that our SU ecosystem is developing.

Who I can enlist to help me address this challenge:

Top takeaways:

GOVERNANCE

We believe in creating a world where people equally participate in formal and societal governance according to principles of justice and individual rights, free from discrimination and identity-based prejudices and able to meet the needs of an exponentially changing world.

Governance—the process of enacting policies and decisions by the group in charge—happens not only among formal political governments but across multiple social systems, including businesses, organizations, families, schools, and other institutions. Governance happens through laws, regulations, social norms, and power structures and rests on a set of core values critical to human rights, dignity, and self-expression. Because governance impacts decision-making processes, it is directly related to access to power and resources.

According to Pew Research, at the end of 2017 about 57 percent of the world's countries were considered democracies, about 13 percent were considered autocracies, and the rest were mixed.[54] People living under these governments experience different degrees of basic freedoms, including freedom of expression, freedom of association, the right to take part in public affairs, access to the rule of law and justice, and the right to vote and express political opinions. In addition, various marginalized groups, such as women and minorities, refugees, or those living in conflict or war zones, are subject to challenges ranging from discrimination to human slavery, rape, torture, and death.

Historically, the spread of democracy has been deeply linked to the invention and spread of technology. Our major social and political revolutions—democratization, decolonization, and civil rights and women's movements—have been accompanied by developments in technology ranging from the invention of the printing press to the globalization of radio and television to the arrival of the internet and social media. These technologies, which spread information and allow people to collaborate in new ways, are by nature disruptive to governance and existing power structures.

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[54]https://www.pewresearch.org/fact-tank/2019/05/14/more-than-half-of-countries-are-democratic/

As more sophisticated digital technologies emerge, such as artificial intelligence, robotics, and digital biology, suddenly anyone can be powerful—and people can use their power to help or harm others. Our governance systems are both struggling in this modern world, as well as seeing people participate in civic life in new ways.

A number of governments, international bodies, startups, and nonprofits have started using exponential technologies to help governance become more efficient, transparent, accountable, personalized, and accessible to their constituents. For example, Estonia has become one of the world's first countries to embrace digital public services for its citizens, creating digital identities for all citizens and enabling digital access for paying taxes, opening bank accounts, signing up for mortgages, voting, and using digital currencies. Estonia has also declared access to the internet a human right and prioritized data privacy, data security, and decentralization of data to maximize individual citizens' control of their data.[55]

While Estonia's efforts are intended to help the country become more efficient, streamlined, and prosperous, other governments that have embraced digital technologies are facing criticism for being too authoritarian. China, for example, is under scrutiny for its efforts to use facial recognition technologies, artificial intelligence, and big data to identify and classify individual citizens in the name of reducing crime and terrorism.

A number of new GovTech startups are building infrastructure to allow individuals to participate more deeply in the democratic process. These range from simple applications such as the Spothole app, which allows Indian citizens to report road potholes in need of repair by the city government, to apps like Hollaback, Safecity, and Harassmap that allow people to report sexual harassment and abuse in cities around the world. More complex projects, such as those run by Democracy Earth Foundation, are spearheading new forms of collective decision-making through digital voting among borderless communities.[56] In 2019, youth in Hong Kong started using the private app Telegram to create "leaderless and anonymous"

[55] https://e-estonia.com/
[56] https://democracy.earth/
[57] https://www.bbc.com/news/technology-48802125

protests to protest the government's proposed extradition laws.[57]

International governing bodies like the United Nations, World Bank, and the World Food Programme are also embracing exponential technologies to improve services, cut costs, and reduce corruption. The World Food Programme piloted Building Blocks to use blockchain to track and deliver services to individuals living in refugee camps, and the World Bank is using blockchain to track land rights. The United Nations and Amnesty International developed some of the first humanitarian applications for virtual reality by creating powerful experiences for both leaders and the general public to virtually visit refugee camps and conflict zones, increasing empathy and funding for these challenges.

However, governments are experiencing new challenges related to keeping up with the pace of technological change and regulations. Governments around the world are struggling with how to regulate social media and data privacy as well as other exponential technologies, including scientists using biotechnologies to create the first genetically engineered humans through CRISPR/Cas9.[58]

The governance GGC will continue to be one of the most important challenges in the coming years to all of us.

How can you help?

How are you helping solve the governance global grand challenge? Are you launching or investing in a governance startup? Developing new R&D? Innovating with a company or organization? Enacting new policies? Increasing education and awareness?

You can take many small actions to address this challenge in a meaningful way. Consider spending a few hours researching how to determine if what you are reading is fake news. Help stop the flow of fake news by scrutinizing the content you share. Take part in a voter registration drive. Join a local campaign that you're passionate about. Hold a dinner party to discuss exponential technologies and property rights using New America's Primer, "How New and Emerging Technologies Can Be Harnessed for Property Rights."

[58]https://www.nytimes.com/2018/11/26/health/gene-editing-babies-china.html

"The opportunity of creating Social Glass emerged two years ago when we were thinking about how to connect governments with technology tools that would allow us to make better decisions. We wanted to leverage all these exponential technologies like artificial intelligence and machine learning so we can see better what governments are doing and improve that decision-making and transform governments into high-performing entities."

—Paola Santana, Founder and CEO at Social Glass, SU Faculty Faculty for Entrepreneurship and Drones, and GSP11 alumna.

How can I become part of the solution?

Visit our **companion web page** for valuable resources to learn more about the Governance GGC and the promising solutions that our SU ecosystem is developing.

Who I can enlist to help me address this challenge:

Top takeaways:

HEALTH

We believe in creating a world where people have optimal physical and mental health, including access to cost-effective prevention, early diagnosis, and personalized therapy for individuals and communities.

According to the United Nations SDGs, more than 400 million people have no basic healthcare and another 1.6 billion people live in fragile settings where their health and healthcare are at risk. Nearly 28 million people live with HIV, and another 15 million are awaiting treatment. Every two seconds, someone between the ages of 30 and 70 dies of a non-communicable disease such as cardiovascular disease, chronic respiratory disease, diabetes, or cancer.[59] In 2019, NPR reported that although people around the world are living longer, we still have health challenges to overcome including cholera outbreaks in Yemen, Ebola outbreaks in the Congo, and global air pollution. In addition, nearly ten million people died in 2017 because they had no access to health care or the quality of healthcare was too poor.[60] Health impacts each of us on a personal level and is also a major cornerstone of the well-being of society and our economy. In the United States, the healthcare sector is now the largest employer,[61] and globally, healthcare is poised to become a nearly $9 trillion industry by 2020.[62]

Exponential technologies are continuing to make strong headway in solving the health GGC—in almost too many ways to count. With the digitization of healthcare, scientists are able to use big data, machine learning, and other tools to better understand the causes of health problems as well as their possible treatments. We live in an age of personal wearables, electronic medical records, consumer DNA and microbiome kits, new forms of medical imaging technology, and "Alexas" that listen in when you cough. As a result,

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[59]https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-3-good-health-and-well-being.html
[60]https://www.npr.org/sections/goatsandsoda/2018/12/28/674618294/the-health-of-the-world-in-2018-by-the-numbers
[61]https://www.theatlantic.com/business/archive/2018/01/health-care-america-jobs/550079/
[62]https://www2.deloitte.com/global/en/pages/life-sciences-and-healthcare/articles/global-health-care-sector-outlook.html

data is increasingly available to both better understand large-scale trends that may contribute to diseases impacting millions of people and to inform personalized precision medicine approaches to treat individuals in a way that was unimaginable in the past.

New technology devices continue to emerge, ranging from lab-on-a-chip diagnostics that make identifying health challenges quicker, cheaper and more convenient, to sophisticated printers that use human biogels to print organs. In 2019, Tel Aviv University announced it had printed the first (rodent-sized) human heart.[63] Additionally, robotic surgery is now commonplace in certain areas of the world, allowing for minimal incisions, less mistakes, and less postoperative pain. The Robot Business Review reports that the surgical robot market is expected to nearly double in size from $3.9 billion in 2018 to $6.5 billion in 2023.[64] Speaking of robots, in 2019, drone company Zipline reported it is now delivering medical goods to 22 million people in Ghana and Rwanda,[65] and SU Portfolio Company Matternet, in partnership with UPS, reported the first commercial drone logistics system for delivering medical goods in the United States sanctioned by the Federal Aviation Agency.

In 2018 and 2019, scientists and the public alike grappled with the ethics of genetic engineering when a scientist in China claimed to have genetically engineered the first humans. This, along with other developments in the field of longevity tech, will no doubt continue to make us wrestle with what it means to be human as we transform ourselves through technology.

How can you help?

How are you helping solve the health global grand challenge? Are you launching or investing in a health startup? Developing new R&D? Innovating with a company or organization? Enacting new policies? Increasing education and awareness?

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[63]https://www.sciencealert.com/researchers-have-just-3d-printed-a-mini-heart-using-human-tissue
[64]https://www.roboticsbusinessreview.com/health-medical/5-surgical-robots-2019/
[65]https://www.cnbc.com/2019/04/24/with-ghana-expansion-ziplines-medical-drones-now-reach-22m-people.html

Your personal actions can have a large cumulative impact. Consider creating a "walking meeting" club at your place of work or school to get exercise during the day. Test out a headset such as a "Muse" that can sense your brain activity and provide feedback on your mental well-being. Try sharing recipes for your favorite healthy meals online. Encourage your community to open up a well-being lab where citizens can go learn about and innovate solutions to improve their own and their community's health.

"I always say Illness starts with 'I' and wellness starts with 'we.' That sentiment began at SU's Exponential Medicine in 2012 and it's become my life mission and the foundation of the Dr. Steven Show. We're now the leading digital health program online."

—Steven Eisenberg, CEO, drsteven.com and Exponential Medicine Faculty
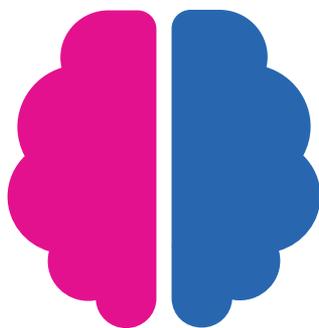
How can I become part of the solution?

Visit our **companion web page** for valuable resources to learn more about the Health GGC and the promising solutions that our SU ecosystem is developing.

Who I can enlist to help me address this challenge:

Top takeaways:

LEARNING

We believe in creating a world where all people have access to information and experiences that build knowledge and skills at all stages of their lives for personal fulfillment and benefit to society.

Over the last century, the world has made great strides in improving access to education for children. The most significant challenges today include improving the quality of the education that currently exists, reaching the last groups of children who are still not in school, and ensuring that adults can continue harnessing new skills for our rapidly changing world.

Education quality varies widely around the world. Challenges include poorly trained teachers and administrators; under-resourced infrastructure; outdated, rote-based curricula that do not teach skills relevant to today's needs; and socio-economic problems that interfere with learning, including malnourishment, illness, poverty, school shootings, and mental health problems.

According to the United Nations SDGs, more than 91 percent of the world's children now attend primary school, leaving 57 million children out of school. Most of the children who don't attend school live in Sub-Saharan Africa, conflict or war zones, or rural areas lacking transportation, or they face additional challenges such as disabilities. Girls in particular locations are kept out of school due to personal safety issues, hygiene and health challenges, and cultural challenges.

Increasingly, the world demands lifelong learning from adults, well after one's formal education has ended. In a world of dramatic technological and economic change, all of us may face a future of rapidly changing jobs.

Innovators have been looking to use exponential technologies to solve our learning challenges for several decades. With the arrival of the household computer and mainstreaming of the internet, universities like MIT and Stanford led the way by simply recording their classes and allowing anyone to view them online. As it became easier and cheaper to build interactive websites, we

saw the arrival in the mid-2000s of Massive Online Open Courses (MOOCs) in which content became interactive and sophisticated, demonstrating that education could reach millions of people via the internet. Organizations like One Laptop per Child, first formed in 2005, saw the potential for providing an affordable education to everyone and tried to solve the problem by distributing laptops and internet access to poor populations. While its initial efforts were challenging, historically it was one of the first steps in digitizing education for the world's poor and set the foundation for more sophisticated solutions.

Two key breakthroughs came with the arrival of cheap tablets and smartphones and the ability for anyone to create content. This unleashed the creation of many new edtech startups and, eventually, the mainstreaming of digitized curriculum. Today, we live in a world of personalized learning—some of it is even driven by artificial intelligence—the gamification of learning; learning through augmented and virtual reality; and advanced technology systems to manage grades, the operations of schools, and communications with parents and other stakeholders.

While there are tens of thousands of initiatives now in the global edtech sector, a few of our favorites hail from the SU community. For example, during our Global Solutions Program (now Global Startup Program) in 2016, three participants formed 360ed, which is now one of the most successful edtech companies serving children in Myanmar. Previously in Myanmar, more than 90 percent of students were learning from rote-based text books that hadn't been updated in 30+ years. In addition, more than 70 percent of schools in the country lacked electricity. Despite these challenges, the majority of children had access to smartphones and tablets, so 360ed released a world-class, student-centered learning curriculum using augmented reality apps. Thousands of teachers, parents, and children downloaded the apps, and 360ed is now building content for more than 1.3 million children in Myanmar, expanding to other nations, and working on a global initiative to support teachers from low-income countries with cutting-edge technologies.

Lucrezia Bisignani, another SU Global Startup Program (GSP) alumna from 2014, formed the Nairobi- and London-based edtech company Kukua, an education entertainment company building a pan-African children's franchise around Super Sema, Africa's first animated child heroine. Sema serves not only as a role model

but provides magical learning experiences through game-based learning apps, an animated television series, and toys. Also hailing from Kenya, *The Art of Unlearning*, a graphic novel by GSP alumnus Chief Nyamweya, explores Nyamweya's time at SU and his impression of how digital natives from Kenya are interfacing with the digital future.

How can you help?

How are you helping solve the learning global grand challenge? Are you launching or investing in a learning startup? Developing new R&D? Innovating with a company or organization? Enacting new policies? Increasing education and awareness?

Your small personal actions can amount to a big change. Consider taking a class to develop a new skill that could be good for a new career five years from now. If you have a specialized skill that will be valuable to the future, volunteer to teach it at a local community center or school. Create your own lesson plan about a topic you are passionate about and share it freely on a website such as Teachers Pay Teachers. Mentor a coworker or ask for a coworker to mentor you.

> *"Ninety-nine percent of Myanmar students have never been outside of the country. Now, with VR they can go to the moon. We are removing the barriers to education— that's very satisfying."*
>
> *—Hla Hla Win, Founder and CEO, 360ed and GSP16 alumna*

How can I become part of the solution?

Visit our **companion web page** for valuable resources to learn more about the Learning GGC and the promising solutions that our SU ecosystem is developing.

Who I can enlist to help me address this challenge:

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Top takeaways:

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PROSPERITY

We believe in creating a world with equitable access to economic and other opportunities for self-fulfillment where all people are free from poverty and able to thrive.

According to the United Nations SDGs, about 736 million people still lived in extreme poverty in 2015, earning less than $1.90 per day.[66] About 50 percent of those people were under the age of 18, and the majority lived in South Asia and Sub-Saharan Africa. Poverty also exists in high-income countries. For example, in 2017, the US Census Bureau estimated that 12.3 percent of Americans lived in poverty.[67] Prosperity has a major impact on many other global grand challenges, including access to food, water, energy, healthcare, learning opportunities, and more.

One of SU's core theses is that exponential technologies, through their price/performance curves, can create a world of abundance. As we digitize industries like food, shelter, energy, learning and more, technology should dramatically lower the cost of products, goods, and services in these industries. Dr. Peter H. Diamandis, Executive Founder and Director of SU, suggests that we may have a future where everything from food to cars to shelter will eventually all cost $1 per pound. We have already seen this trend in the learning GGC with the digitization of education, in the health GGC in such areas as DNA sequencing, and in the shelter GGC with such innovations as the ICON 3D printed house. But how do we know if this trend will eventually make basic goods truly affordable to everyone? After all, income inequality is rising rapidly in many countries around the world.

Several factors seem to influence how evenly abundance spreads. Note first, a country without access to the internet and reliable energy may be unlikely to benefit from the fruits of digitization— although some argue they are poised for leapfrogging legacy technologies that hold wealthier countries back. Leaders and innovators need to pay close attention to this dynamic when developing solutions.

Second, business models impact the spread of abundance. When an innovator infuses technology into his or her company, it will eventually generate profits or reduce costs even if it's initially

[66]https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-1-no-poverty.html
[67]https://www.census.gov/topics/income-poverty/poverty.html

expensive. Who will reap those gains? Companies like ReGen Villages (see the Shelter GGC) that are creating tech-infused communities with new technologies to generate food, water, and energy onsite allow excess goods to be sold outside the village to pay community fees, mortgages, or possibly even generate life-long incomes for residents. This abundance-based business model shares the benefits of technology with customers, creating more value for everyone—and a more competitive business model. It matters to the whole of society if founders keep profits for themselves or redistribute them in the form of high wages or stocks to employees or lower prices for customers. Innovators need to think through the long-term consequences of their business models.

When we think of prosperity, we also think of digitizing the financial services industry. Over the last decade, companies like Kiva. org have pioneered solutions for poverty through small digital peer-to-peer loans as well as a plethora of new blockchain and cryptocurrency companies. At a high level, these digital financial companies and services could increase prosperity in the same way as companies like ReGen Villages—by redistributing profits and efficiencies, often by transforming how transactions happen between different players in the economy, whether that is creating a new type of transaction or eliminating a transaction and reducing the cut that goes to the middle person. Remember, though, that at the end of the day, people are deciding who benefits from the profit of the technology—the founder, the investor, the worker, or the customer. Our values lie at the heart of how abundance spreads.

In addition to business and economic models, it also matters how new technology companies and industries are developed. Currently, new technology companies often come from existing technologists and displace legacy companies or non-technologists. But there are better ways to operate. For example, ICON collaborated with the nonprofit New Story (see the Shelter GGC) to ensure that their affordable 3D printed houses were designed to work for lower-income communities and engage existing workers in the housing industry.

Similarly, many technology companies now working on new agtech robots or cultured meat have an opportunity to engage the legacy industries. While the legacy industries may not have access to the latest technologies, they have access to industry

knowledge, customer knowledge, and other industry players. By not collaborating, tech industries risk losing that critical information and destroying local economies. Governments might consider their role in bridging collaborations between new tech companies and legacy companies.

Finally, exponential technologies can also help track progress in tackling poverty. Groups such as the World Poverty Clock[68] are using big data collected from international organizations and the predictive power of artificial intelligence to analyze poverty rates in real time at the country level. Groups such as the ixo Foundation are using blockchain to automatically release international development funds when social organizations achieve their impact goals. The Millenium Villages Project uses satellite data to assess poverty at the village level.[69]

Another key question relates to the future of jobs and technological unemployment: How will technology impact the jobs sector? Currently, many different individuals and institutions are trying to predict the answer. While these projections vary greatly in the medium term and long term, they are more consistent when predicting the short term. For example, we can see that people working in transportation, retail, and agriculture are in danger of being displaced in the next five years. Given that, we can start helping those people today.

While part of the technological unemployment challenge is to ensure that people have access to work to support themselves economically, many people wonder about the future of human purpose and meaning when robots increasingly take over our jobs. In this sense, part of solving the prosperity challenge also means helping humanity find purpose and meaning in a world where work may not be a primary source of satisfaction.

At SU, we believe in the power of people and that if we can help them understand the new rules of how the future will work, they can once again feel ownership of it, which brings pride, dignity, community, and optimism for the future.

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[68] https://worldpoverty.io/
[69] https://learningenglish.voanews.com/a/can-satellites-identify-extreme-poverty-world/4737579.html

How can you help?

How are you helping solve the prosperity global grand challenge? Are you launching or investing in a prosperity startup? Developing new R&D? Innovating with a company or organization? Enacting new policies? Increasing education and awareness?

Individual actions can have a big impact. Consider learning more about abundance-based business models and see if they would work for your company. If you haven't already done so, investigate giving out stock to your employees to increase economic equity in your community. Hold a neighborhood meeting in your community to discuss the sources of poverty in your community and what your neighborhood can do about it. Help your children set up their first bank accounts and encourage a young adult to open up a retirement account.

> *"It was 10am and a group of Syrian women got on stage to speak on a panel. These women had all escaped Syria and were living in a refugee camp in Lebanon. They spoke to our group of 2,500 CEOs about the atrocities of the treatment that women endured during the Syrian civil war, and in listening to this, that was where my purpose formed. It was instantaneous. I knew immediately that I needed to take my energy, experience, and enthusiasm and create something that improves the livelihoods of individuals and communities. That was the day that I became a social entrepreneur, with the mission of tackling global poverty and social inequality through the use of exponential technologies."*
>
> *—Sean Hinton, CEO, Co-Founder, SkyHive (an SU Portfolio Company)*

How can I become part of the solution?

Visit our **companion web page** for valuable resources to learn more about the Prosperity GGC and the promising solutions that our SU ecosystem is developing.

Who I can enlist to help me address this challenge:

Top takeaways:

SECURITY

We believe in creating a world where all people are safe from physical and psychological harm, including in virtual worlds; and protection of physical, financial, digital systems.

Security is a broad topic that impacts almost every industry and every person in the world today. Although national and local governments traditionally have been responsible for ensuring the security of their citizens, private organizations have stepped up to help protect people from increasingly complex security risks. People move freely around the globe, military-grade weapons are available to more and more people, and digital security—including privacy, online banks, and digital infrastructure—is just as important as physical security.

Exponential technologies are playing an important role in helping protect people who might fall through the cracks, such as stateless refugees, those living in war zones, minorities, or those facing human trafficking or sexual exploitation. Several websites and mobile apps have emerged to serve vulnerable people, who are increasingly likely to have access to the internet through smartphones. For example, Crisis Info Hub[70] provides details about resources, such as laws, legal assistance, and community support, in different languages to refugees. The Jornalero app[71] allows day laborers to rate their employers, log their hours and wages, identify employers who withhold wages, photograph and document workplace violations, and send instant alerts to other workers. The Igarape Institute,[72] led by SU Faculty Robert Muggah, has built several apps for monitoring homicides and crimes in cities and tracking small arms trade and human security issues.

Globally, a number of blockchain initiatives, such as those created by the World Food Programme, the World Bank, Finland, and ID2020, are creating blockchain-based identities for refugees.[73] Without identities, people remain vulnerable without access to their bank accounts, health services, and other government services and are unable to vote or own property. In addition, blockchain can reduce corruption, improve logistics, and ensure safety.

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[70]https://github.com/google/crisis-info-hub/blob/master/README.md
[71]https://play.google.com/store/apps/details?id=jornalero.droid&hl=en_US
[72]https://igarape.org.br/en/robert-muggah/
[73]https://www.wired.com/story/refugees-but-on-the-blockchain/

Artificial intelligence and image recognition applications, such as technologies developed by Thorn, are playing a role in ending sex trafficking by scanning the many images of exploited children online.[74] Through pattern recognition, these applications provided law enforcement officials with identification of over 10,000 kids as of 2018.

Also, new sensors are helping keep vulnerable groups like women achieve physical safety. For example, Leaf Wearables, winner of the Anu and Naveen Jain XPRIZE on Women's Safety, is a $40 wearable device that autonomously and inconspicuously triggers an emergency alert to community responders if the wearer is attacked.[75] In addition, citizen scientists such as CeCe Moore, a genetic genealogist, have been pioneering the use of DNA ancestry databases to solve cold cases.[76] While many rapists and murders could previously escape their crimes, these databases now hold enough data for police and citizen scientists to find almost anyone, hopefully deterring such crimes in the future.

In addition, Amnesty International and the United Nations Development Programme have spearheaded the use of virtual reality to prevent conflict and develop empathy for those living in conflict. The UN released "Clouds Over Sidra" at the World Economic Forum in 2015; this movie teleports policymakers and donors into the Za'atari Refugee Camp in Jordan—and helped raise more than $3.8 billion dollars.[77] Amnesty International also launched a successful virtual reality fundraising campaign to transport citizens into war-torn Aleppo,[78] which raised funds and awareness. They noted that individuals who had been attacked in Aleppo began creating their own virtual reality films to share with the world about their situation, rather than resorting to retaliatory violence.

Citizen groups can more easily participate in security challenges that governments used to handle, thanks to the falling costs of exponential technologies. For example, the nonprofit NSquare is encouraging citizens and startups to develop technologies to make the world safe from nuclear threats.[79] The organization has explored efforts that allow citizens to use their cell phones to

[74] https://bigthink.com/robby-berman/ai-joins-the-battle-to-end-online-sex-trafficking
[75] https://safety.xprize.org/prizes/womens-safety
[76] https://www.technologyreview.com/s/611529/the-citizen-scientist-who-finds-killers-from-her-couch/
[77] http://unvr.sdgactioncampaign.org/cloudsoversidra/#.XSke-JNKiYU
[78] https://www.amnesty.org.uk/press-releases/first-use-virtual-reality-fundraising-hit-members-public
[79] https://nsquare.org/

help detect radiation, virtual reality experiences to train workers in nuclear facilities, and blockchain applications to better track nuclear weapons and materials.

While exponential technologies are helping improve human security, they can also endanger it. Big data, software, and facial recognition systems can help save trafficked children, but they can also be used by governments, criminal organizations, or corporations to track individuals, invade privacy, and possibly violate human rights. For more on human security, digital security, and security of infrastructure, we recommend SU Faculty Marc Goodman's book *Future Crimes*.

How can you help?

How are you helping solve the security global grand challenge? Are you launching or investing in a security startup? Developing new R&D? Innovating with a company or organization? Enacting new policies? Increasing education and awareness?

You can take any number of personal actions daily to have an impact. Consider visiting a website like Stay Safe Online to learn more about cybersecurity. Report incidents of street harassment that you witness to law enforcement and business owners, even if you don't feel comfortable personally intervening in an incident. Assess the needs of local nonprofits and schools to see how you can use your skills to help. Create an online safety kit for school children or build an app to help victims of human trafficking or domestic violence or identify theft.

"I recognized that the biggest threat to peace inside of Syria was the indiscriminate bombing of civilians. We simply thought that there was more that the international community could and should do to warn civilians in advance of this indiscriminate violence."

—John Jaeger, CEO and Co-founder of Hala Systems (an SU Portfolio Company)

How can I become part of the solution?

Visit our **companion web page** for valuable resources to learn more about the Security GGC and the promising solutions that our SU ecosystem is developing.

Who I can enlist to help me address this challenge:

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Top takeaways:

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CONCLUSION

Exponential technologies are helping us to make headway in solving in solving the challenges that have plagued humanity for centuries. Even so, new problems are emerging caused by the very same technologies. In this sense, we live in times that are both hopeful and confusing.

Part of what we do at SU is help people develop the mindset for this new era. The rules of the past no longer hold, so it's time to understand the new rules of how the world works. In fact, many of the most powerful people, organizations, and companies in the world are successful right now precisely because they understand these new rules. Part of our job is to help everyone understand those rules, so that with that understanding people will feel empowered and have ownership over building their futures once again.

In 2019, Singularity University also launched a new strategy to more proactively solve the GGCs. In the past, we have encouraged everyone who walks through our virtual or physical doors to use exponential technologies to solve a GGC, but going forward we are pulling our community together to tip the challenge as much as possible toward one of healthy abundance. For example, in February we held our first Science Fiction Design Intelligence workshop on the future of learning. We brought together more than 50 members of the SU ecosystem, including alumni, Faculty, startups, Chapters, and corporate partners from around the world as well as local educators and social innovators. During this workshop, we collectively envisioned a powerful future of learning, then released it to the world in a form of a graphic novel. In the process, we also created an Exponential Guide to the Future of Learning on the SU website (su.org/learning-guide) featuring a wide array of learning and educational solutions coming out of the SU ecosystem and encouraged people to share localized versions of what learning might look like in their community in fifteen years.

This work is also meant to provide specific recommendations to our community in the field of learning along our six impact pathways—recommendations for new R&D, new investments, and new innovations for startups, corporations, organizations and policy makers. It is also intended to provide general education and awareness.

We hope this report has provided you with a sense of the possibilities for how we can all use exponential technology to solve our social problems and encourages you to more deeply engage in our ecosystem to collaboratively solve the global grand challenges. We also aim to inspire people to take up the mantle of change, including the nurturing of upcoming generations of change agents. In this regard, we recommend you read SU Co-founder and Chancellor Ray Kurzweil's novel, *Danielle: Chronicles of a Superheroine*, about a precocious girl who uses her intelligence and exponential technologies to solve the world's biggest challenges. Danielle's journey casts a hopeful vision of humanity's future—and two free companion books show how you can achieve it. Learn more at https://www.danielleworld.com/.

AFTERWORD

This book came into being when we were looking for a way to provide new insights into the global grand challenges (GGCs) that we could share with attendees at SU's Global Summit and the SU community at large. We speak often about the GGCs, but we wanted to catalyze more action, so we settled on this report as a way to give you more context into the GGCs and a greater sense of the stakes involved in solving them and the progress we're seeing.

I hope you'll see this book as the motivation and inspiration you might have been looking for to point you in a new direction or recommit to a project that's gone into your backlog. Through your own actions, no matter how small, you can help create positive change in the world.

What can you do? Lots. Pick a cause. Build something that matters. Make one change in your behavior (something as simple as changing how or where or what you buy). Start volunteering in your community or online. Join the SU community, where you can engage with others who share your passion and become part of the solution.

So, what will you do? I'd love to know.

Tell me at **adam.hofmann@su.org.**

Adam Hofmann
Vice President, Marketing
Singularity University

My action plan:

Notes to my future self:

Notes to my future self: