Technology Trends
Earth

Center for Learning in Retirement

CLR Fall 2020

Glen Maxson & Alan Freedman

Week 12

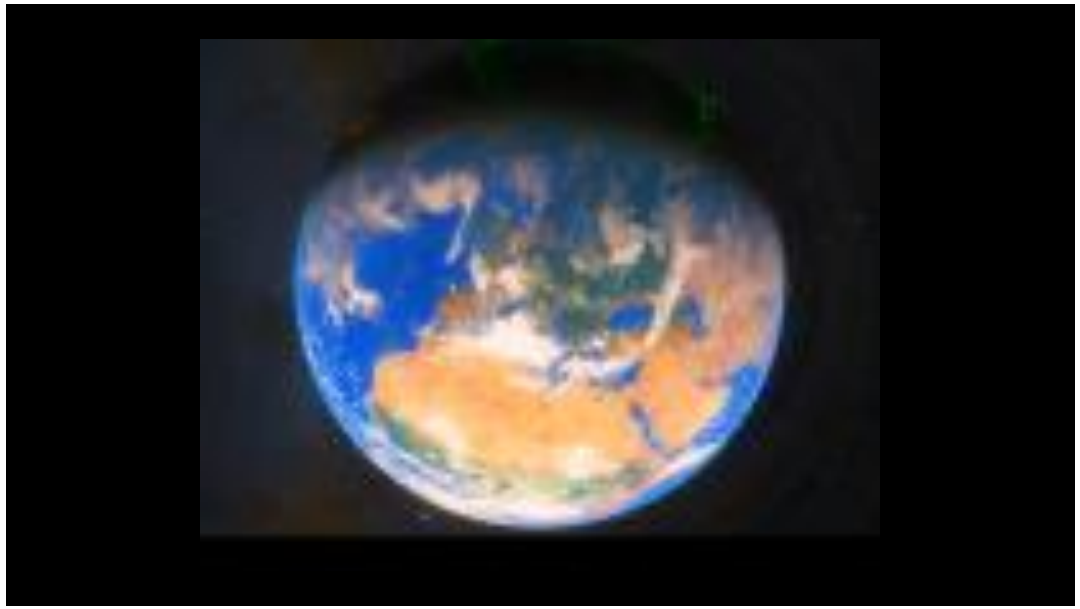
Public Service Announcement

- We are currently asking members who are currently enrolled in a Fall II and/or Fall term course(s) to please submit an anonymous evaluation for each course.
- The deadline to submit a Fall II and/or Fall Term CLR Course Evaluation form is Friday, December 4 by Noon (ET). Fall II & Fall Term CLR Course Evaluation Form

Thank you!

The What

- ~~Artificial Intelligence & Machine Learning~~
- ~~Robots & Drones~~
- ~~Autonomous Transportation Systems~~
- ~~Surveillance~~
- ~~(Cyber) Crime, Security & Warfare~~
- ~~Medical Tech~~
- ~~Media~~
- ~~(Virtual) Money & Blockchain~~
- ~~Communication~~
- ~~Space~~
- Earth



Elon’s take on Earth sustainability (source)

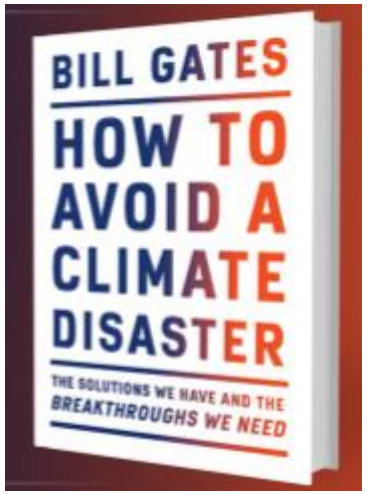
Jeff’s take on Earth sustainability (source)

What about Bill? (source)

See Also: 10 Ways Bill Gates Is Saving The World

How to Avoid a Climate Disaster: The Solutions We Have and the Breakthroughs We Need (February 16, 2021)

- It's inspiring to see so much passion these days for dealing with climate change, and to know that the world has set some ambitious goals for solving it. What we need now are practical plans to reach those goals.
- In my book, I'll share what I've learned from more than a decade of studying climate change with experts and investing in the innovations we'll need to address it. I hope to explain the science in a clear and compelling way. I'll also propose a plan for what we need to do over the next decade and beyond to build the tools that will help us eliminate greenhouse gas emissions while scaling up the powerful solutions we already have. And I'll suggest some concrete steps that individuals, governments, and companies can take to make it happen.



Why talk about Earth?

- “Our well-being solely depends on this **planet**. It gives food and water to all living things so it is our responsibility to take care of it.”

SO, what’s the problem?

And what role does ‘technology’ play?

How Many People Can Out Planet Really Support?

- "It is not the number of people on the planet that is the issue – but the number of consumers and the scale and nature of their consumption," says **David Satterthwaite**
- The number of "modern human beings" (*Homo sapiens*) on Earth has been comparatively small until very recently. Just 10,000 years ago there might have been no more than a few million people on the planet. The one billion mark was not passed until the early 1800s; the two billion mark not until the 1920s.

How Many People … continued (2)

- As it stands now, though, the world's population is over 7.3 billion. **According to United Nations predictions** it could reach 9.7 billion people by 2050, and over 11 billion by 2100.
- While the planet might hold over 11 billion people by the end of the century, our current level of knowledge does not allow us to predict whether such a large population is sustainable, simply because it has never happened before.

How Many People … continued (3)

- "We know of cities in low-income nations that emit less than one ton CO2-equivalent per person per year," says Satterthwaite. "Cities in high-income nations [can] have six to 30 tons CO2-equivalent per person per year.“
- The real concern would be if the people living in these areas decided to demand the lifestyles and consumption rates currently considered normal in high-income nations; something many would argue is only fair. If they do, the impact of urban population growth could be much larger.

How Many People … continued (4)

- People living in high-income nations must play their part if the world is to sustain a large human population. Only when wealthier groups are prepared to adopt low-carbon lifestyles, and to permit their governments to support such a seemingly unpopular move, will we reduce the pressure on global climate, resource and waste issues.
- There needs to be a fundamental change in the core values of developed societies: away from an emphasis on material wealth, and towards a model where individual and societal well-being are considered most important.

How Many People … continued (5)

- The trends are so deeply set, he says, that even a dramatic catastrophe might not change their course. **In a 2014 study**, Bradshaw concluded that if two billion people died tomorrow – or if every government adopted controversial fertility policies such as China's recently-ended one-child policy – there would still be as many if not more people on the planet by 2100 as there are today.
- So if a world population of 11 billion is probably unsustainable, how many people, in theory, could Earth support? Bradshaw says that it is nearly impossible to say what this number would be, because it is entirely dependent on technologies like farming, electricity production and transport – and on how many people we are willing to condemn to a life of poverty or malnutrition.

How Many People … continued (6)

- Many people argue that we are well over a sustainable number already, given the lifestyle choices many of us have made and our reluctance to change them. In support of this, they point to the problems of climate change, the biodiversity extinction crisis underway, mass ocean pollution, the fact that one billion people are already starving and that another one billion people have nutrient deficiencies.
- If some or all of us consume a lot of resources, the maximum sustainable population will be lower. If we find ways to each consume less, ideally without sacrificing our creature comforts, Earth will be able to support more of us.

How Many People … continued (7)

- Changes in technology, which are often wildly unpredictable, will also affect the maximum population.
- In the early 20th Century, the global population problem was as much about the fertility of soil as the fertility of women. George Knibbs, in his 1928 book ***The Shadow of the World's Future***, suggested that if global population reached 7.8 billion, there would have to be much more efficient use of its surface.
- In the very distant future, technology could lead to much larger sustainable human populations if some people could eventually live off planet Earth.

How Many People … continued (8)

- In the few decades since humans first ventured out into space, our ambitions have jumped from simple stargazing to the living away from Earth and inhabiting other planets. Many eminent thinkers, including physicist Stephen Hawking, say colonizing other worlds is **critical for the ultimate survival of our species**.
- For the foreseeable future, Earth is our only home and we must find a way to live on it sustainably. It seems clear that that requires scaling back our consumption, in particular a transition to low-carbon lifestyles, and improving the status of women worldwide. Only when we have done these things will we really be able to estimate how many people our planet can sustainably hold.

Can 10 billion people live and eat well on the planet? Yes.

- "There are too many people on too little land" says BBC presenter David Attenborough. "Every which way you look at it, a planet of 10 billion looks like a nightmare" says Stephen Emmott.
- Population explosion is a myth (what?). Today, we have 7.3 billion people. In 2050, we will have around 9 billion, and in 2100 the world population will possibly reach its peak with about 10-11 billion people.

Can 10 billion people… continued (2)

- The growth of supply needed for the future—about 2 percent annually—has to come mainly from available farmland to avoid an overly negative impact on fragile ecosystems. This requires finance, investments, innovation, and knowledge to improve the yields at existing farmlands. The yield gap between what's needed and what's being produced is still very high.
- On the demand side, reducing food waste can have a significant impact on the availability of food. Reducing food waste can improve the efficiency of food value chains and help to distribute food more evenly to those in need.

Can 10 billion people… continued (3)

- This means that we could quite easily provide food for 10 billion people on the planet. There is considerable potential on both the food supply and demand side to provide more food for all.
- Annual growth of demand can be met by helping farmers to intensify production where the yield gap is high. Conscious consumption and less waste in rich countries would already be a safe strategy to provide affordable food for all.

The human plague by Stephen Emmott

February 23, 2020

The World In 2050 [The Real Future Of Earth]

10 technologies are most likely to help save planet Earth

10. SOLAR GLASS

- What if every window in a skyscraper could generate energy? That's the promise of solar glass, an emerging technology that's getting a lot of buzz in design and sustainability circles. Just like it sounds, solar glass is suitably transparent window material but also captures the sun's energy and converts it into electricity.

- The big hurdle has been efficiency. High-performance solar cells can achieve 25% efficiency or greater, but maintaining transparency means sacrificing the efficiency with which light is converted into electricity. But a University of Michigan team is developing a solar glass product that offers 15% efficiency and climbing while letting a full 50% of light pass through. According to projections from nearby Michigan State, 5 to 7 billion square meters of usable window space exists, enough to power a full 40% of US energy needs with a solar glass product.

- See also: **Solar Glass Could Convert The Windows Of Every Building Into Power-Generating Panels**

9. GRAPHENE

- Stronger than steel, thinner than paper, more conductive than copper, graphene is truly a miracle material—and until recently a completely theoretical one. Graphene is an ultra-thin layer of graphite that was first discovered in 2004 at the University of Manchester. It is now the subject of intense research and speculation, with many predicting it will be next in line after bronze, iron, steel, and silicon in promulgating the cultural and technological evolution of our species.
- A mere one-atom thick, graphene is flexible, transparent, and highly conductive, making it suitable to a huge range of planet-healing applications. These include water filtration, superconductors capable of transferring energy across vast distances with minimal loss, and photovoltaic uses, to name a few. By vastly increasing efficiencies over current materials, graphene may prove to be a cornerstone in our green rebirth.

- See also: https://www.youtube.com/watch?v=dQCJpYR0og8

8. PLANT-BASED PLASTIC

- We have to put an end to single-use plastics! Initiatives are already underway across the U.S. to ban or severely limit their use. Where I live, in LA, plastic straws are only given out upon request and single-use plastic bags have disappeared from grocery stores. But the problem is deep-rooted and deeply ingrained in our consumption economy. I live near the ocean, and the quantity of plastic debris that's visible on an average day is devastating.

- Plant-based plastics that biodegrade are one palatable solution, as they could, in theory, replace many of the plastic products already in circulation. An Indonesian company called Avani Eco has been making bio-plastic out of cassava since 2014. Like fake meat and solar glass, this should become a booming sector in the years ahead. But beware: Not all bioplastics biodegrade, and the merit of some production techniques is debated. Part of becoming a responsible consumer in the next decade will be knowing the life cycle of the products we choose to buy, from creation to entropy.

7. FAKE MEAT

- Dear carnivores, I have good news and bad news. First the bad: Meat production is absolutely atrocious for the planet. In 2017, more than 15,000 world scientists signed a Warning to Humanity calling for, among other things, drastically diminishing our per capita consumption of meat. One issue is land use. The production of beef relies on 164 square meters of grazing land per 100 grams of meat and is one of the major causes of deforestation in Central and South America, leading to unprecedented carbon release into the atmosphere. The Food and Agriculture Organization believes livestock accounts for about 14.5% of anthropogenic greenhouse gas emissions. Animals also use huge amounts of freshwater while the contaminated runoff from industrial livestock operations pollutes local waterways.

- The good news? Fake meat is finally good. Really good. Companies like Beyond Meat and Impossible Foods are delivering delicious alternatives to meat that stand as pretty decent substitutes for the real thing. As much as the technological achievement and advanced food science, the real triumph of these companies is that they've made fake meat culturally hip. You can now order meatless burgers at Burger King and get a meat-free taco at Del Taco.

6. BATTERIES

- Power is the limiting factor holding back a lot of green technologies. Wind and solar, for example, are capable of generating vast amounts of electricity, but adoption of the technologies has been throttled by a major shortcoming: Sometimes it isn't windy or sunny. Electric cars, similarly, are making huge strides, but until range increases and charging times diminish, fossil fuels are going to rule.

- Existing battery technology won't cut it. For one thing, it's too expensive. According to the Clean Air Task Force, for California to meet ambitious goals of powering itself through renewables only, the state would need to spend $360 billion on energy storage systems. One company called Form Energy is developing what are known as aqueous sulfur-flow batteries that will cost somewhere between $1 to $10 per kilowatt-hour, compared with lithium's $200 per kilowatt-hour cost. Storage times should increase, too, perhaps lasting months. Form's solution could help California meet its energy targets before the middle of the century, providing a roadmap for the rest of the world.

See also: https://www.youtube.com/watch?v=Dr6bqG04zks

5. ENVIRONMENTAL SENSORS

- To heal the planet, we need to measure it. Distributed sensors are one of the unsung technologies allowing that to happen, and the continued spread of the networked sensor environment will be one of the undergirding technologies behind nearly every sustainability effort imaginable.

- Want an example? Back in the 1980s, taller smokestacks helped reduce local air pollution on the east coast. The problem was the smokestacks were correlated to a higher rate of acid rain, which was leading to vast deforestation. How was the connection drawn? Early networked pollution sensors.

- The technology, of course, has advanced since then. Networked sensors as small as a dime are already monitoring air and water quality, identifying pollutants, tracking acidification, and capturing real-time data on phenomena that are crucial to our social and economic wellbeing. Wearable air quality sensors are on their way, and localized sensor networks monitoring energy and water usage in buildings are cutting down on waste. The further proliferation of these sensors will dramatically impact the way we live.

4. SMART GRIDS

- The way our power infrastructure -- collectively known as the grid -- works now is a troubling holdover from the 19th and 20th centuries. Power production is still largely centralized and distributed downstream, eventually reaching end users. The problem is that these grids are highly sensitive to fluctuations in usage and output. To make them work reliably, they demand an overproduction of energy. They're prone to attack, and they tend to rely on pollution-emitting energy sources.

- Smart grids are already being rolled out in testbeds in the US and internationally. The concept isn't so much a single technology as the deployment of numerous energy, distribution, networking, automation, and sensing technologies to design a new grid for the 21st century. Smart grids will enable local production of energy down to the household level, which can be fed back into the grid upstream. Sensing technology and more accurate prediction models will fine-tune energy production to avoid overproduction, and better battery technology (see #7 on this list) will enable storage of renewably sourced energy. According to a study by the Electric Power Research Institute, by 2030, Smart Grid technologies might help us reduce carbon emissions by 58% compared to levels from ten years ago.

See also: https://www.youtube.com/watch?v=yofGtxEgpI8

3. CARBON CAPTURE

- There's too much carbon dioxide in the air, and it's warming our planet. What if we could capture and sequester it?

- That's the premise of Carbon Capture and Storage (CCS), an emerging class of technologies that are primed to play an important role in the health of our planet in the decades ahead. According to the CCS Association, capture technologies allow the separation of carbon dioxide from gases produced in electricity generation and industrial processes by one of three methods: pre-combustion capture, post-combustion capture, and oxyfuel combustion. The carbon is transported by pipeline and stored in rock formations far below ground.
- In 2017, the world's first CO2 capture plant went live in Switzerland. Startups in the US and Canada have developed carbon capture plants of their own. At scale, the technology could help reverse one of the most alarming environmental trends of our time.

See also: https://www.youtube.com/watch?v=ecxCL84n26g

2. NUCLEAR FUSION

- Our sun is powered by the fusion of hydrogen nuclei, forming helium. For decades, scientists have been working on harnessing the same process to create sustainable terrestrial power. The effort is extremely compelling from an ecological standpoint because it represents a zero-carbon emissions form of energy. Unlike nuclear fission, the process that powers current nuclear plants, fusion does not result in the production of long-lived radioactive nuclear waste.

- The problem is heat. To generate net positive energy when two particles fuse, the reaction has to take place at millions of degrees Celsius, and that means whatever vessel you're using to do the fusing will, well, melt. The answer is to suspend the reaction in a floating plasma so the extreme heat doesn't touch the chamber, a process researchers believe can be achieved using high-powered magnets. The typical timeline offered for fusion power is 30 years, but a team at MIT working with a new class of magnets believes it can get fusion power into the grid in just 15 years, which would be a huge boon in the fight to slow the planet's warming trend.

See aso: https://www.youtube.com/watch?v=Wc8SJqAPVaM

1. ARTIFICIAL INTELLIGENCE

- Artificial intelligence also might be our best bet computing ourselves out of the grave state we find ourselves in.
- Microsoft's AI for Earth program is one effort underway to harness the potential of AI for the good of the planet. The program has given more than 200 research grants to teams applying AI technologies to planetary health in one of four areas: biodiversity, climate, water, and agriculture. Primitive AI and machine learning algorithms are currently analyzing icy surfaces to measure changes over time, helping researchers plant new forests with precise layouts to maximize carbon sequestration, and enabling warning systems to help stem destructive algae blooms.
- AI is having an impact on agricultural practices and will soon transform how farming is done in industrialized nations, reducing our reliance on pesticides and drastically lowering water consumption. AI will make autonomous vehicles more navigate more efficiently, lowering air pollution. AI is being deployed by material scientists to develop biodegradable replacements to plastics and develop strategies to clean our oceans, which receive some eight million metric tons of plastics annually.

- Fundamentally, AI will be the bedrock of our future efforts to undo the damage already done to the planet while figuring out scalable solutions to sustaining our species' energy, food, and water needs.

Technology is only part of the answer…

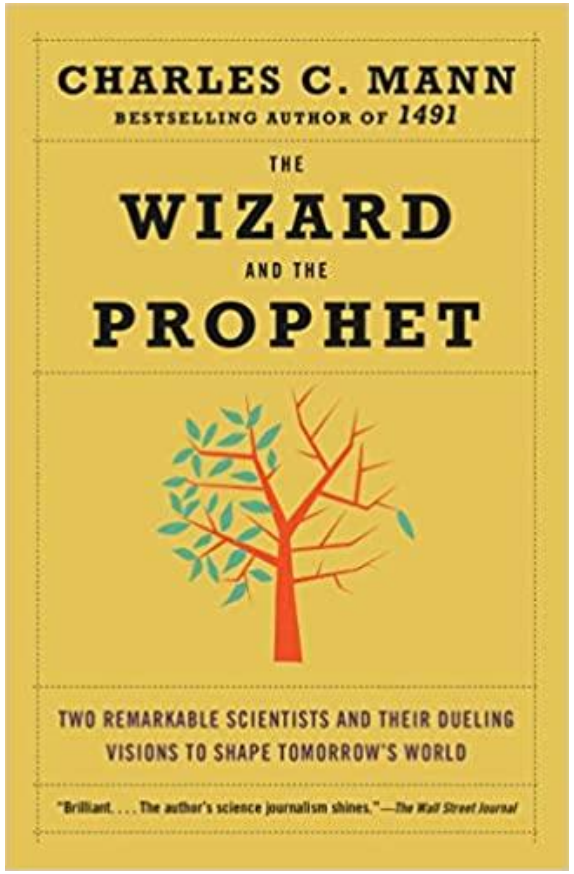
The solution is us:
Our behavior
Our leadership
Our resolve

And technology…

Can Planet Earth Feed 10 Billion People?

Humanity has 30 years to find out. (Charles C. Mann)

William Vogt, born in 1902, laid out the basic ideas for the modern environmental movement. In particular, he founded what the Hampshire College population researcher Betsy Hartmann has called "apocalyptic environmentalism"—the belief that unless humankind drastically reduces consumption and limits population, it will ravage global ecosystems. If we continue taking more than the Earth can give, he said, the unavoidable result will be devastation on a global scale. *Cut back! Cut back!* was his mantra.



PROPHET

Can Planet Earth Feed 10 Billion... continued (2)

Norman Borlaug, born 12 years after Vogt, has become the emblem of "techno-optimism"—the view that science and technology, properly applied, will let us produce a way out of our predicament. He was the best-known figure in the research that in the 1960s created the Green Revolution, the combination of high-yielding crop varieties and agronomic techniques that increased grain harvests around the world, helping to avert tens of millions of deaths from hunger. To Borlaug, affluence was not the problem but the solution. Only by getting richer and more knowledgeable can humankind create the science that will resolve our environmental dilemmas. *Innovate! Innovate!* was his cry.

WIZARD

Can Planet Earth Feed 10 Billion... continued (3)

Wizards view the Prophets' emphasis on cutting back as intellectually dishonest, indifferent to the poor, even racist (because most of the world's hungry are non-Caucasian). Following Vogt, they say, is a path toward regression, narrowness, poverty, and hunger—toward a world where billions live in misery despite the scientific knowledge that could free them.

Can Planet Earth Feed 10 Billion... continued (4)

- Prophets sneer that the Wizards' faith in human resourcefulness is unthinking, ignorant, even driven by greed (because refusing to push beyond ecological limits will cut into corporate profits). High-intensity, Borlaug-style industrial farming, Prophets say, may pay off in the short run, but in the long run will make the day of ecological reckoning hit harder. The ruination of soil and water by heedless overuse will lead to environmental collapse, which will in turn create worldwide social convulsion.

Quote?

- *It is as if humankind were packed into a bus racing through an impenetrable fog. Somewhere ahead is a cliff: a calamitous reversal of humanity's fortune.*

Can Planet Earth Feed 10 Billion… continued (5)

- What to do? Some of the strategies that were available during the first Green Revolution aren't anymore. Farmers can't plant much more land, because almost every accessible acre of arable soil is already in use. Nor can the use of fertilizer be increased; it is already being overused everywhere except some parts of Africa, and the runoff is polluting rivers, lakes, and oceans.
- Irrigation, too, cannot be greatly expanded—most land that can be irrigated already is. Wizards think the best course is to use genetic modification to create more-productive crops. Prophets see that as a route to further overwhelming the planet's carrying capacity. We must go in the opposite direction, they say: use less land, waste less water, stop pouring chemicals into both.

Can Planet Earth Feed 10 Billion... continued (6)

- About 40 percent of the fertilizer applied in the past 60 years was not absorbed by plants. Instead, it washed away into rivers or seeped into the air in the form of nitrous oxides. Fertilizer flushed into water still fertilizes: It boosts the growth of algae, weeds, and other aquatic organisms. When these die, they fall to the floor of the river, lake, or ocean, where microbes consume their remains.
- So rapidly do the microbes grow on the manna of dead algae and weeds that their respiration drains oxygen from the lower depths, killing off most other life. Nitrogen from Midwestern farms flows down the Mississippi to the Gulf of Mexico every summer, creating an oxygen desert that in 2016 covered almost 7,000 square miles. The next year a still larger dead zone—23,000 square miles—was mapped in the Bay of Bengal, off the east coast of India.

Can Planet Earth Feed 10 Billion... continued (7)

- Rising into the air, nitrous oxides from fertilizers is a major cause of pollution. High in the stratosphere, it combines with and neutralizes the planet's ozone, which guards life on the surface by blocking cancer-causing ultraviolet rays. Were it not for climate change, suggests the science writer Oliver Morton, the spread of nitrogen's empire would probably be our biggest ecological worry

Can Planet Earth Feed 10 Billion... continued (8)

- Rubisco is an enzyme that plays a key role in the process. Enzymes are biological catalysts. Like jaywalking pedestrians who cause automobile accidents but escape untouched, enzymes cause biochemical reactions to occur but are unchanged by those reactions.
- Rubisco takes carbon dioxide from the air, inserts it into the maelstrom of photosynthesis, then goes back for more. Because these movements are central to the process, photosynthesis walks at the speed of rubisco.

Can Planet Earth Feed 10 Billion... continued (9)

- *Rather than tinker with individual genes, the scientists are trying to refashion photosynthesis.*
- Rubisco. “Nearly the world’s worst, most incompetent enzyme”
- And the C4 work-around
- Running short of rice would be a human catastrophe with consequences that would ripple around the world.
- The C4 Rice Consortium is an attempt to ensure that that never happens. Funded largely by the Bill & Melinda Gates Foundation, the consortium is the world’s most ambitious genetic-engineering project.

Can Planet Earth Feed 10 Billion… continued (10)

- Rather than tinker with individual genes in order to monetize seeds, the scientists are trying to refashion photosynthesis, one of the most fundamental processes of life.

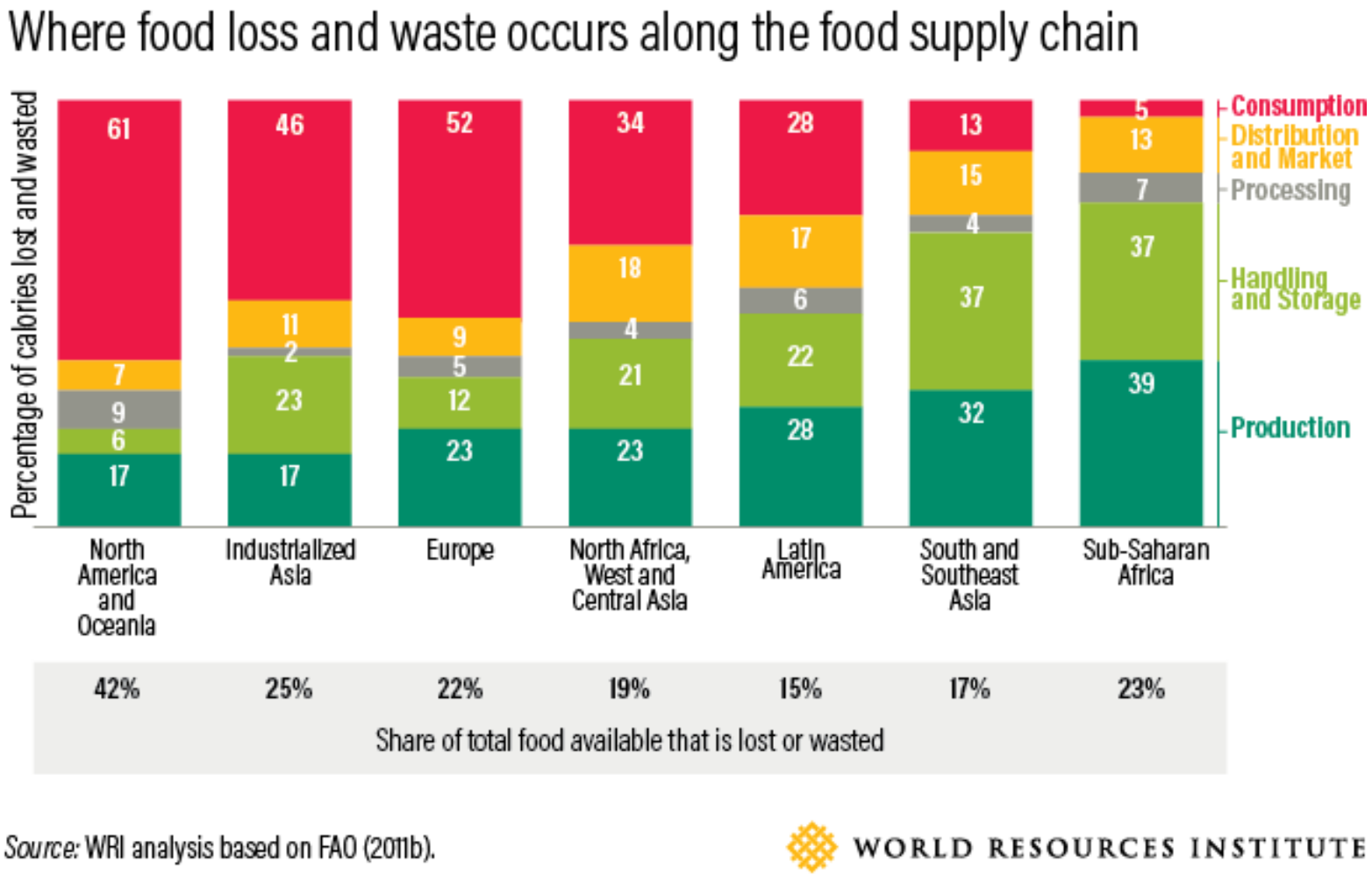
How to Sustainably Feed 10 Billion People by 2050, in 21 Charts

Feeding 10 billion people *sustainably* by 2050, then, requires closing three gaps:

- **A 56 percent food gap** between crop calories produced in 2010 and those needed in 2050 under “business as usual” growth;
- **A 593 million-hectare land gap** (an area nearly twice the size of India) between global agricultural land area in 2010 and expected agricultural expansion by 2050; and
- **An 11-gigaton GHG mitigation gap** between expected agricultural emissions in 2050 and the target level needed to hold global warming below 2ºC (3.6°F), the level necessary for preventing the worst climate impacts.

Reduce Growth In Demand for Food and Other Agricultural Products

1. Reduce food loss and waste



Source: WRI analysis based on FAO (2011b).

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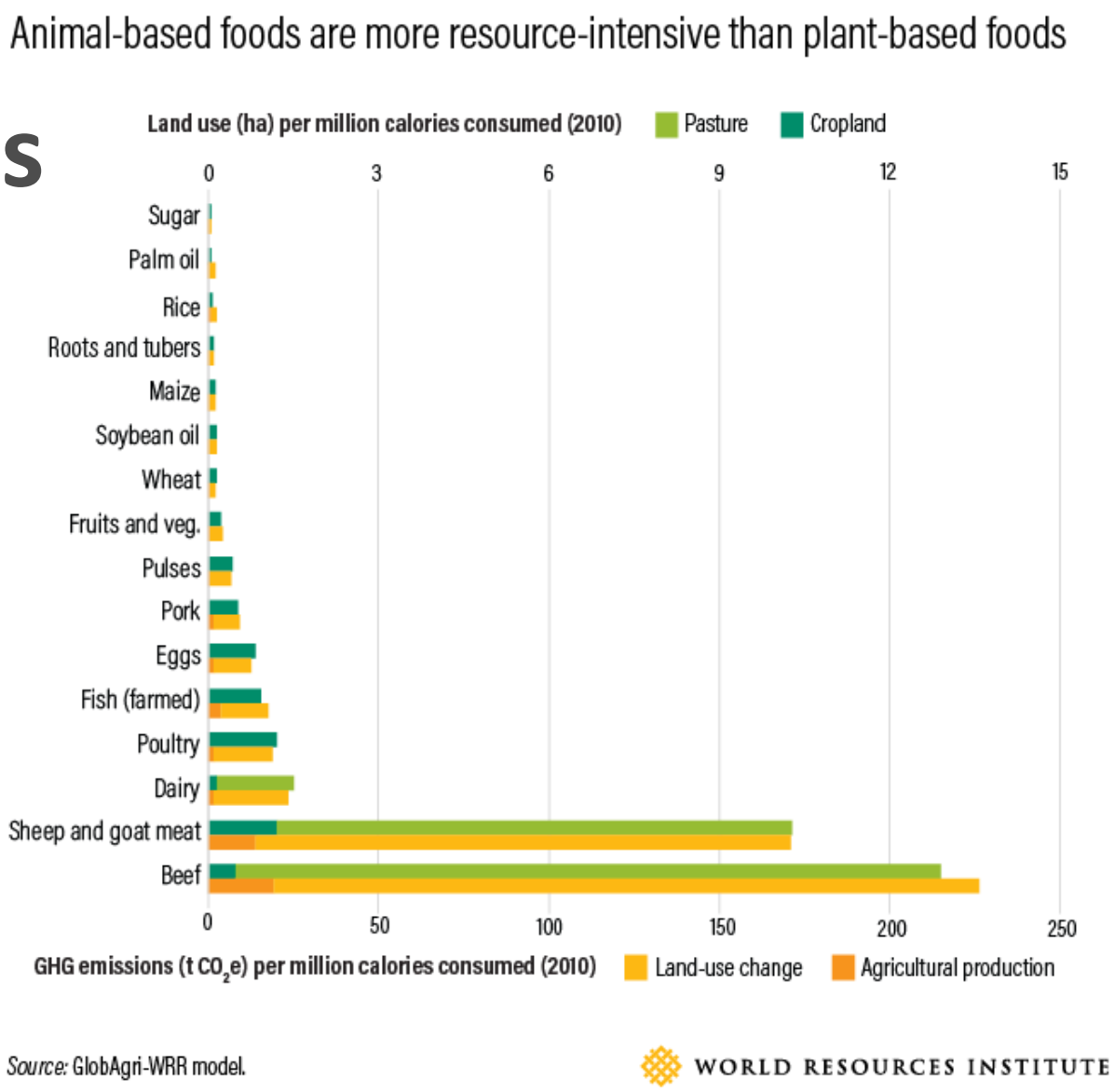
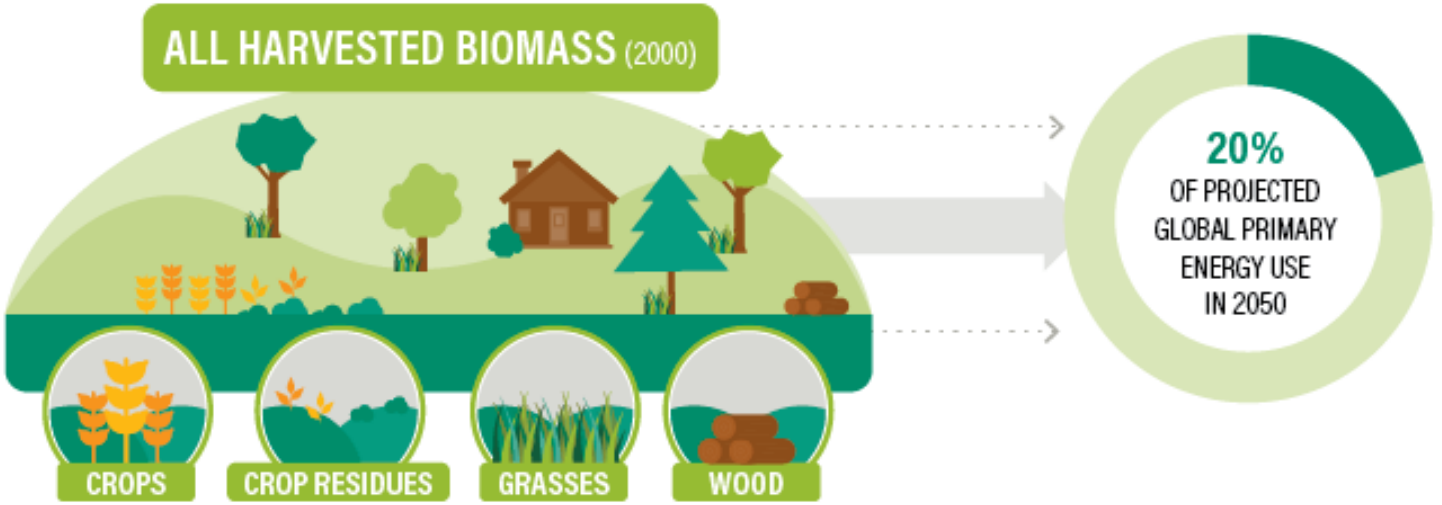
2. Shift to healthier, more sustainable diets



3. Avoid competition from bioenergy for food crops and land

All of world's harvested biomass would supply only 20% of global energy needs in 2050



Note: Assumes primary to final energy conversion for biomass is 24% lower than for fossil energy.
Source: Authors' calculations based on Haberl et al. (2007); IEA (2017); and JRC (2011).

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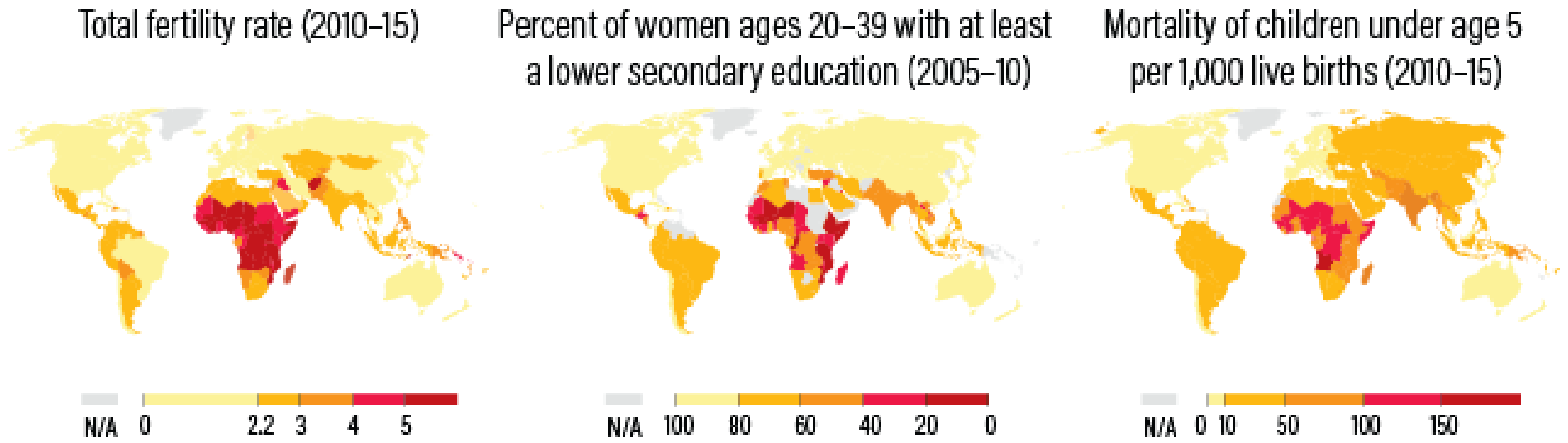
4. Achieve replacement-level fertility rates

Sub-Saharan Africa has the world's lowest performance in key indicators of total fertility rate, women's education, and child mortality



Sources: UNDESA (2017); Harper (2012); World Bank (2017a).

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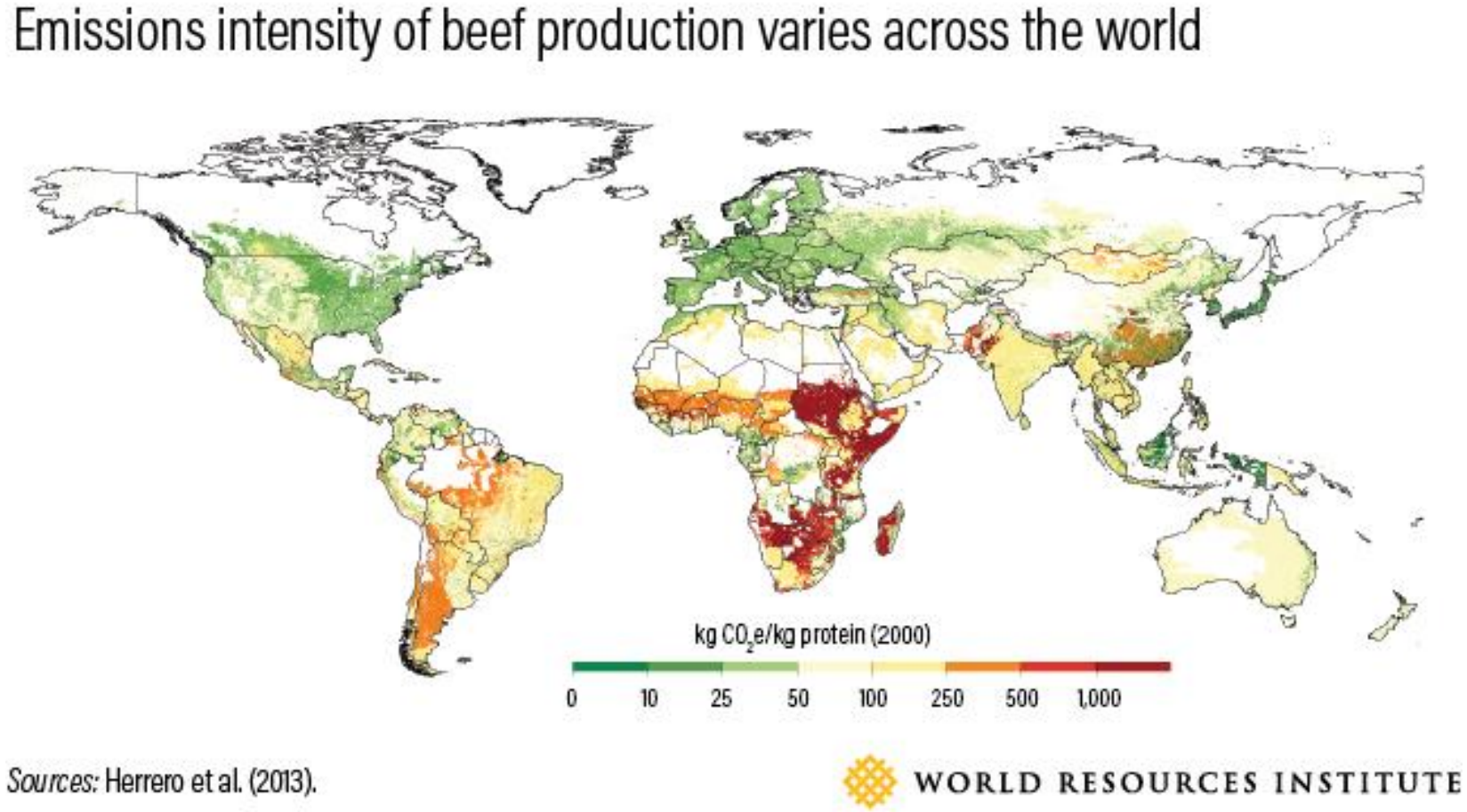
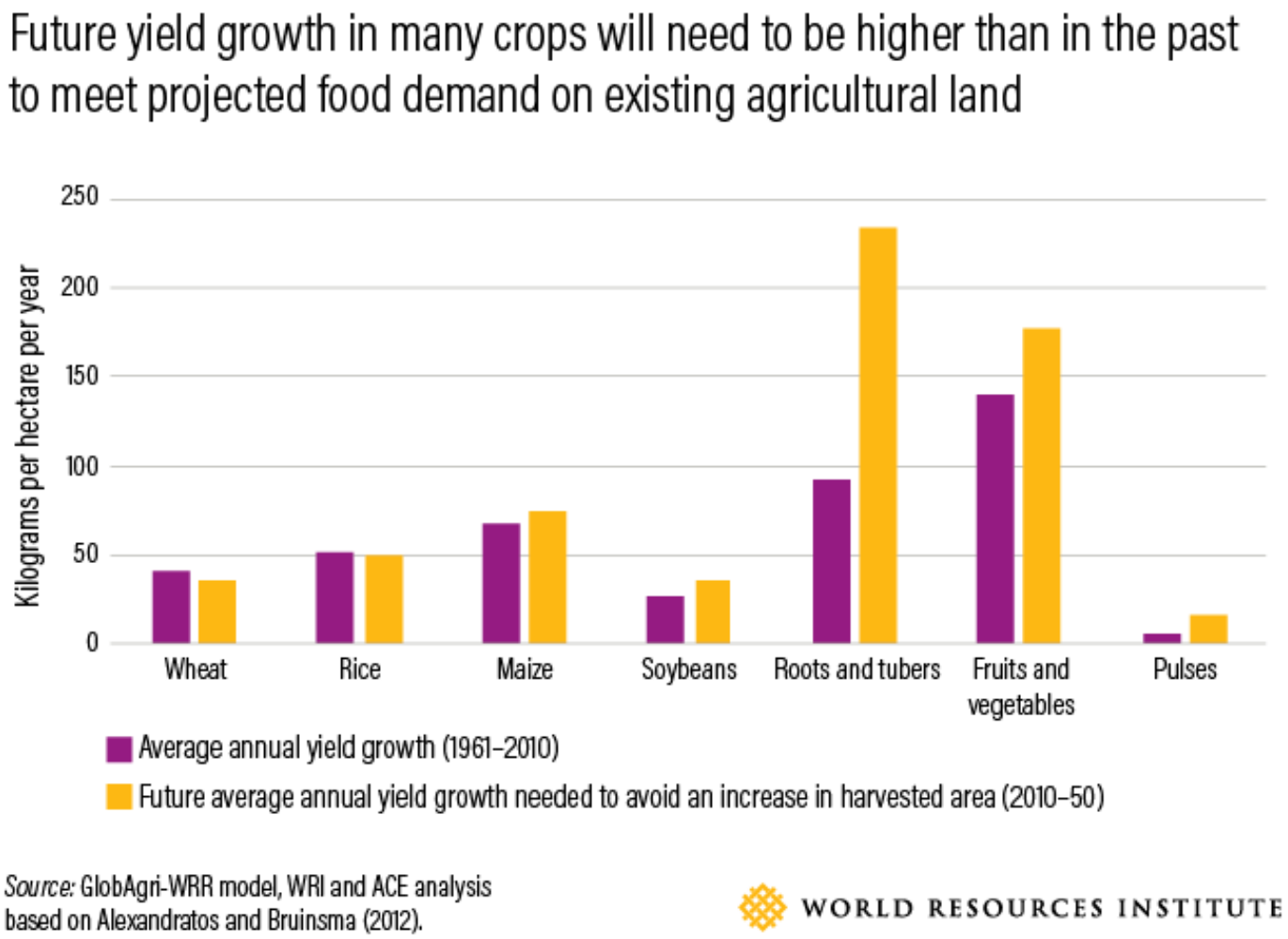
Increase Food Production Without Expanding Agricultural Land

5. Increase livestock and pasture productivity



6. Improve crop breeding



Source: GlobAgri-WRR model, WRI and ACE analysis based on Alexandratos and Bruinsma (2012).

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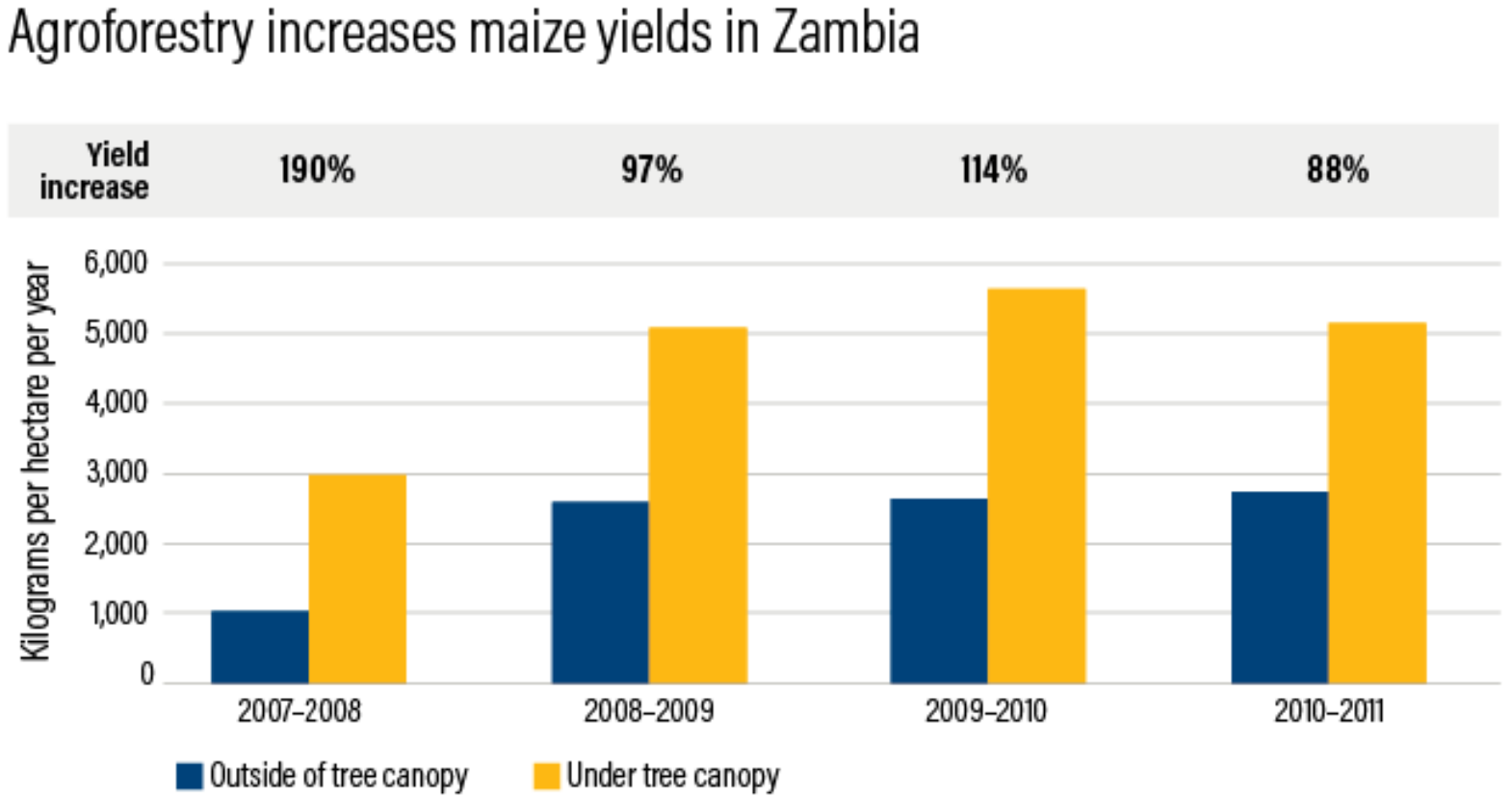
7. Improve soil and water management



Note: Average maize grain yields from trial sites under and outside canopies of mature Faidherbia albida trees across regions in Zambia.
Source: Shitumbanuma (2012).

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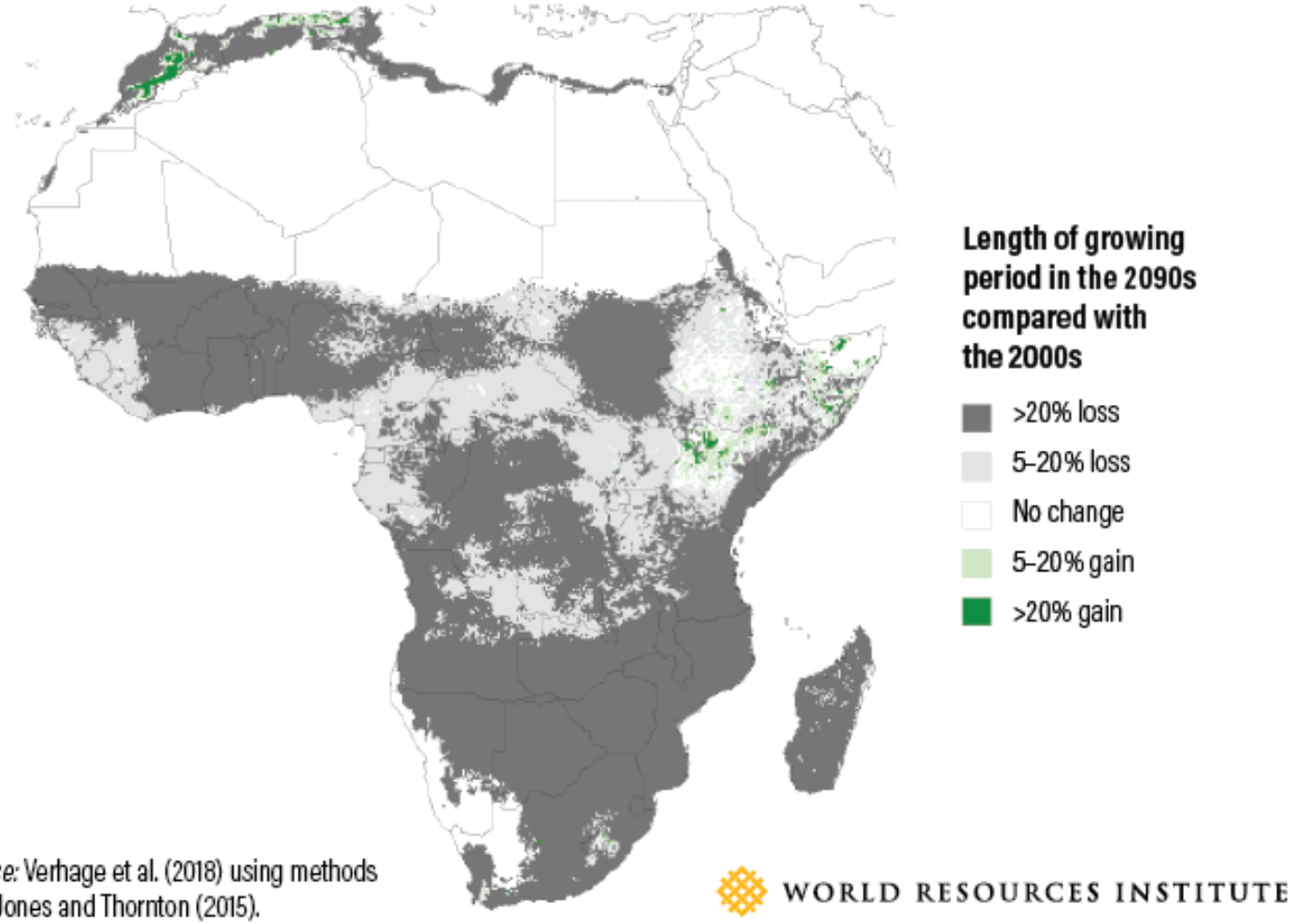
8. Plant existing cropland more frequently

Planting and harvesting existing croplands more frequently, either by reducing fallow land or by increasing “double cropping” (planting two crops in a field in the same year), can boost food production without requiring new land. Increasing annual cropping intensity by 5 percent beyond the 2050 baseline of 87 percent would shrink the land gap by 14 percent and the GHG mitigation gap by 6 percent.

9. Adapt to climate change

Climate change could shorten growing seasons in much of sub-Saharan Africa by more than 20 percent by 2100



Source: Verhage et al. (2018) using methods from Jones and Thornton (2015).

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Protect and Restore Natural Ecosystems and Limit Agricultural Land-Shifting

10. Link productivity gains with protection of natural ecosystems

ANALYSIS

BRAZIL

In 2010, **Brazil** had **3.79Gha** of natural forest, extending over **30%** of its land area. In **2019**, it lost **22.5Mha** of natural forest, equivalent to **6.03Gt** of CO_2 of emissions.

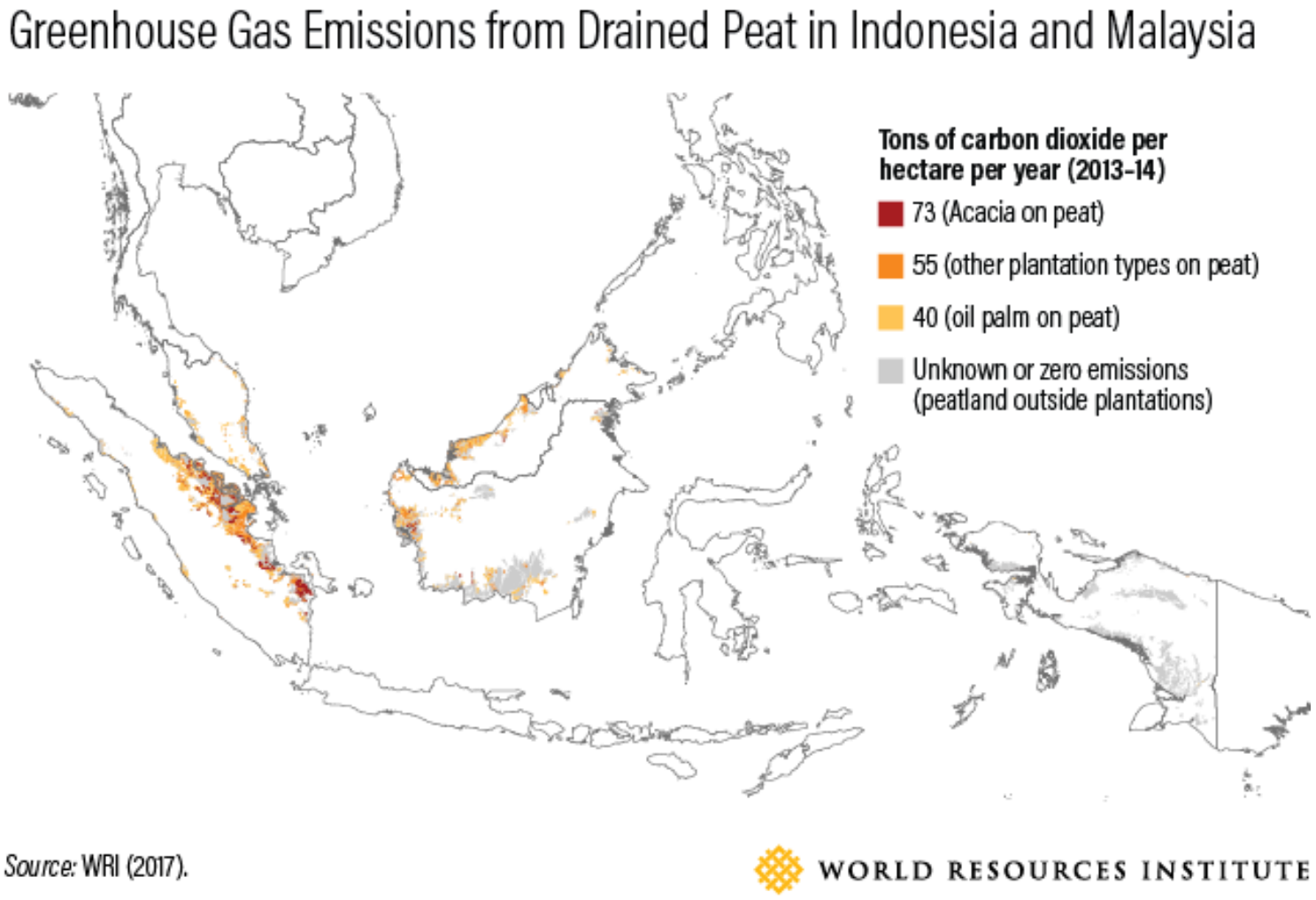
https://www.globalforestwatch.org/

11. Limit inevitable cropland expansion to lands with low environmental opportunity costs

12. Reforest agricultural lands with little intensification potential

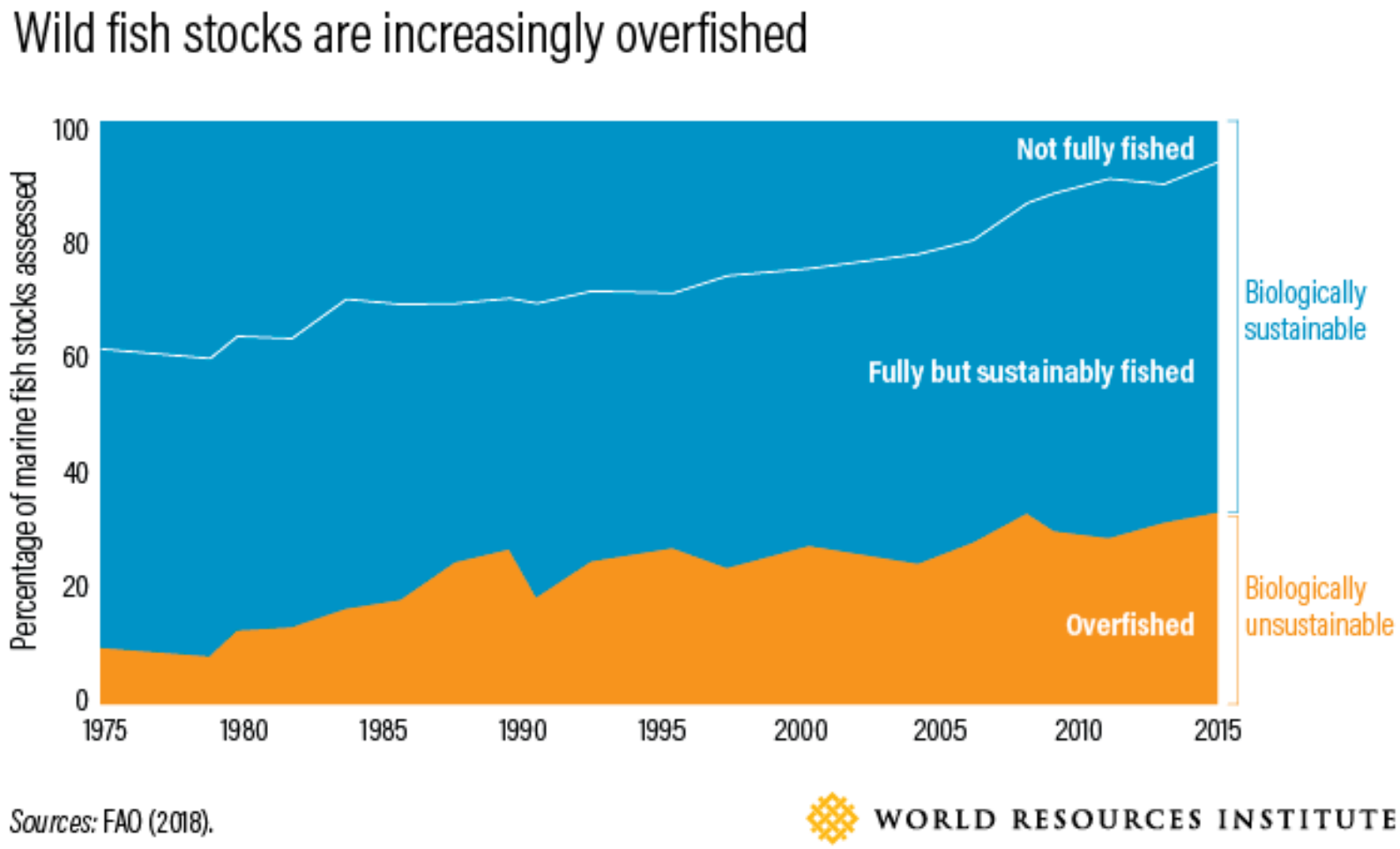
Before and After, Reforesting Brazil's Atlantic Forest

13. Conserve and restore peatlands

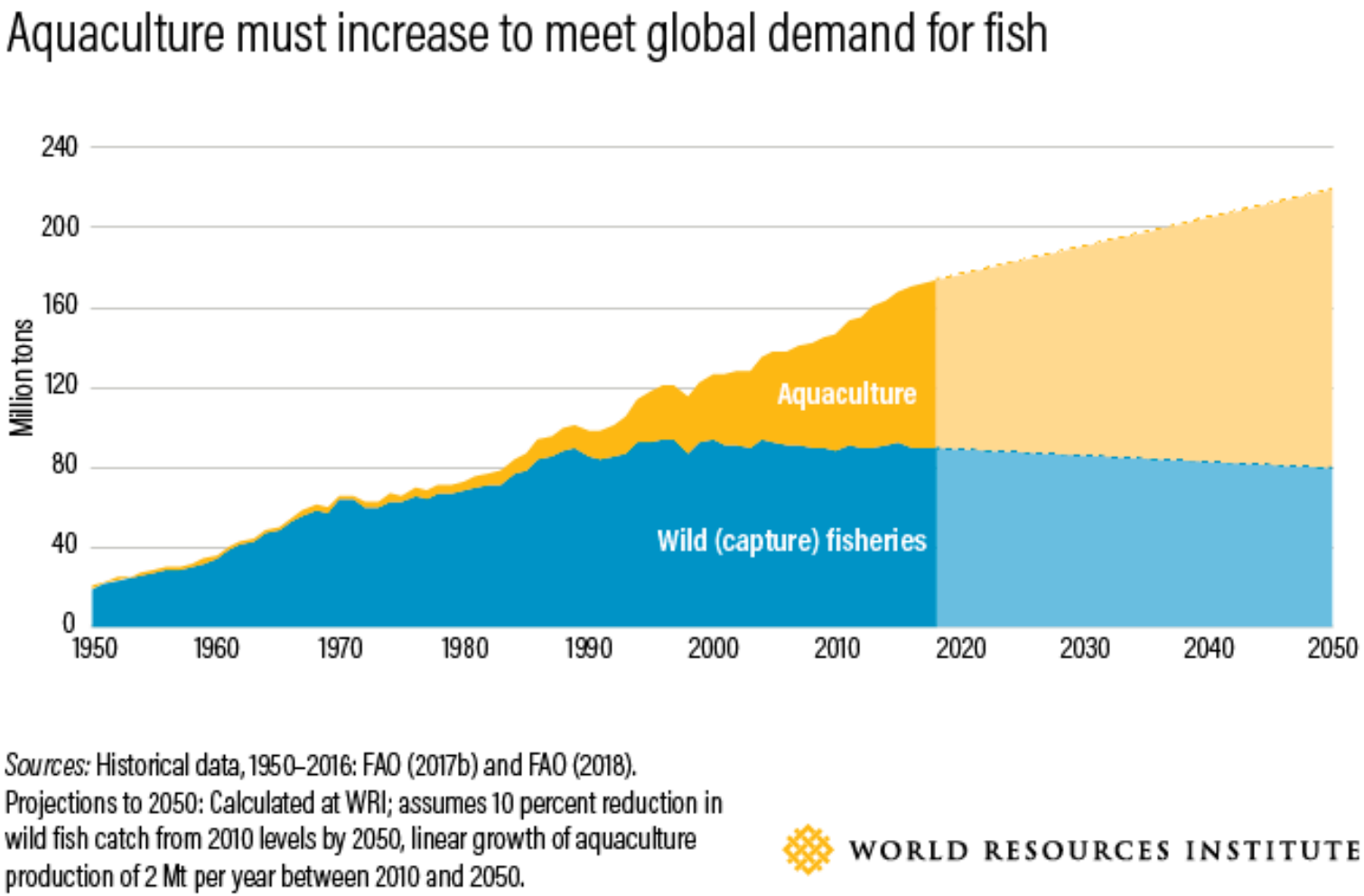


Increase Fish Supply

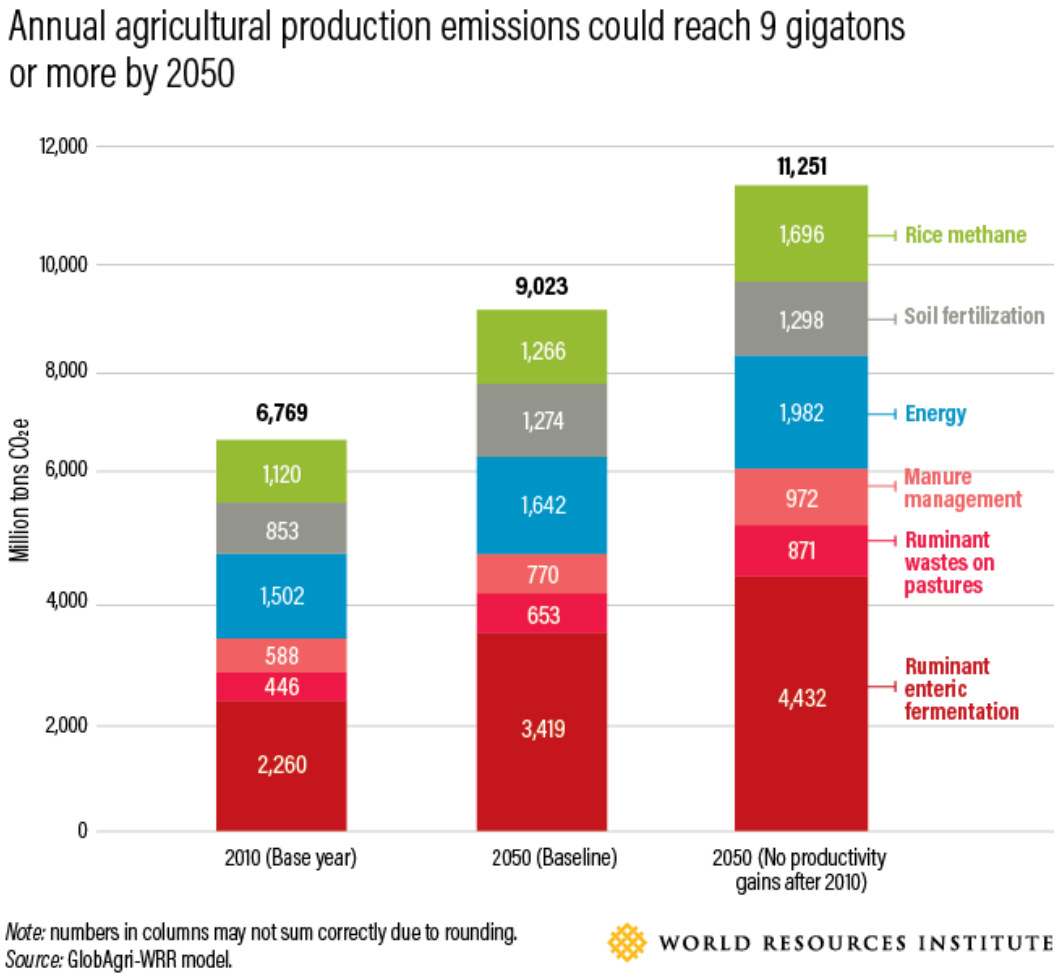
14. Improve wild fisheries management



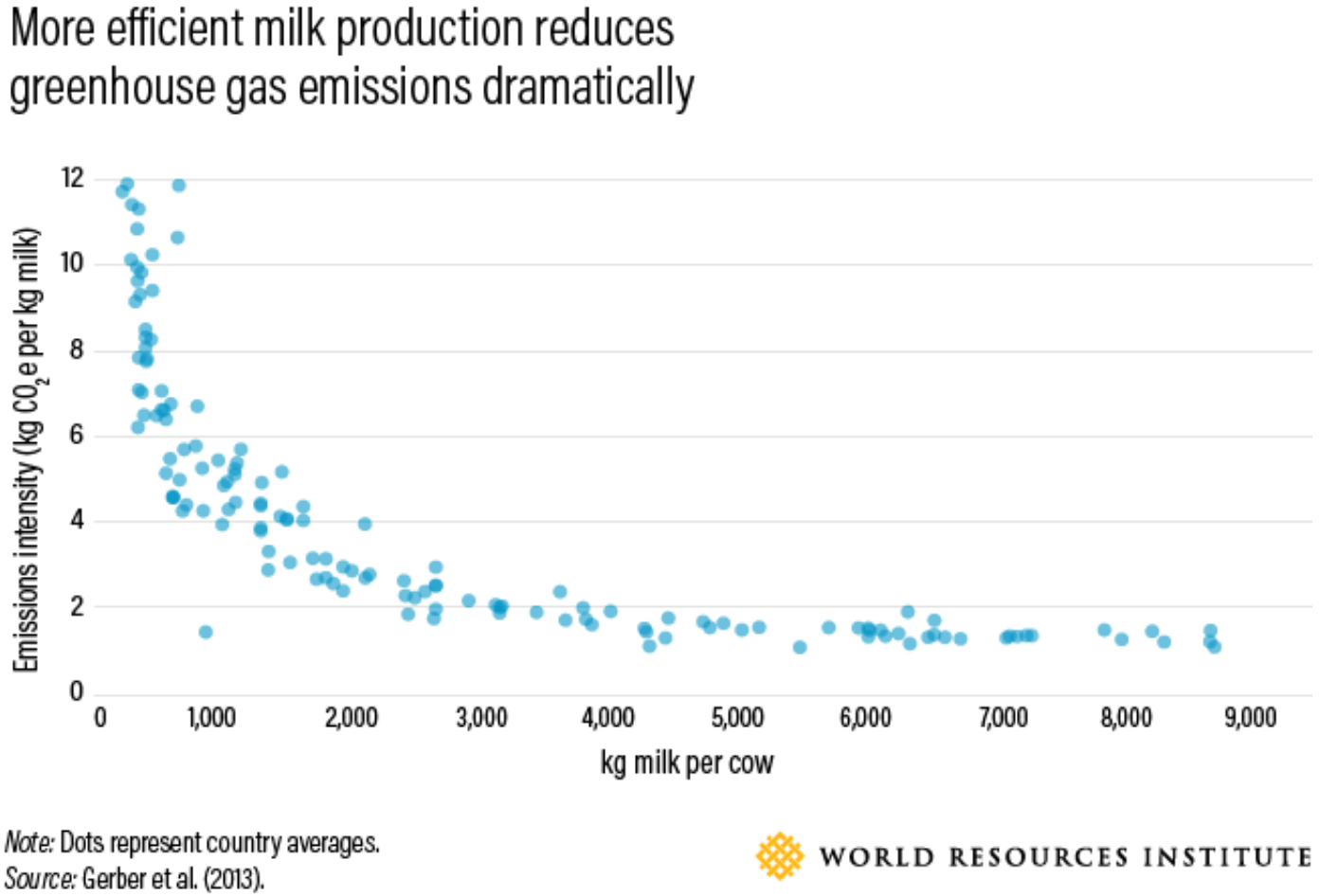
15. Improve productivity and environmental performance of aquaculture



Reduce Greenhouse Gas Emissions from Agricultural Production



16. Reduce enteric fermentation through new technologies



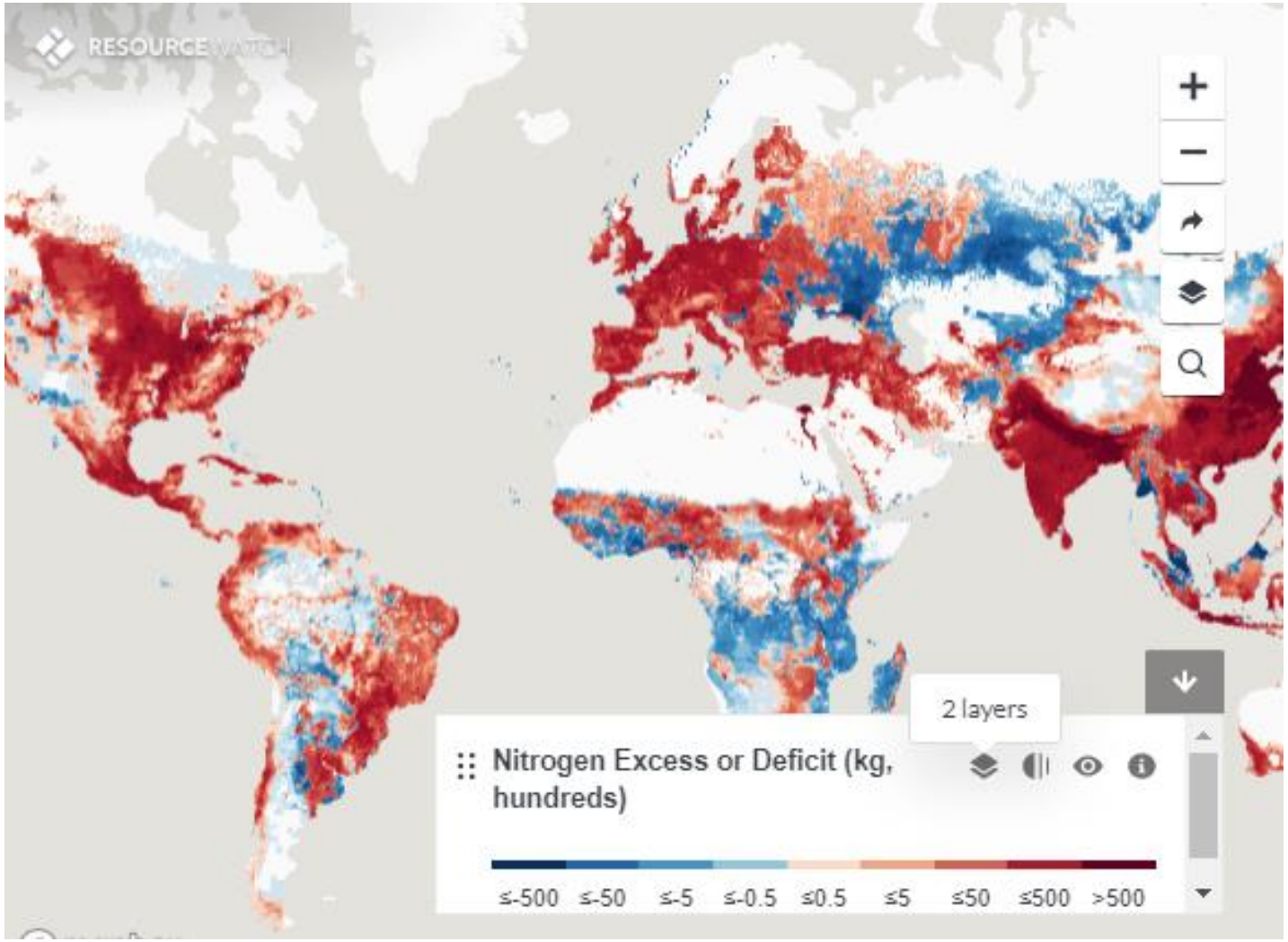
17. Reduce emissions through improved manure management

Emissions from “managed” manure, originating from animals raised in confined settings, represented around 9 percent of agricultural production emissions in 2010. Improving manure management by better separating liquids from solids, capturing methane, and other strategies can greatly reduce emissions.

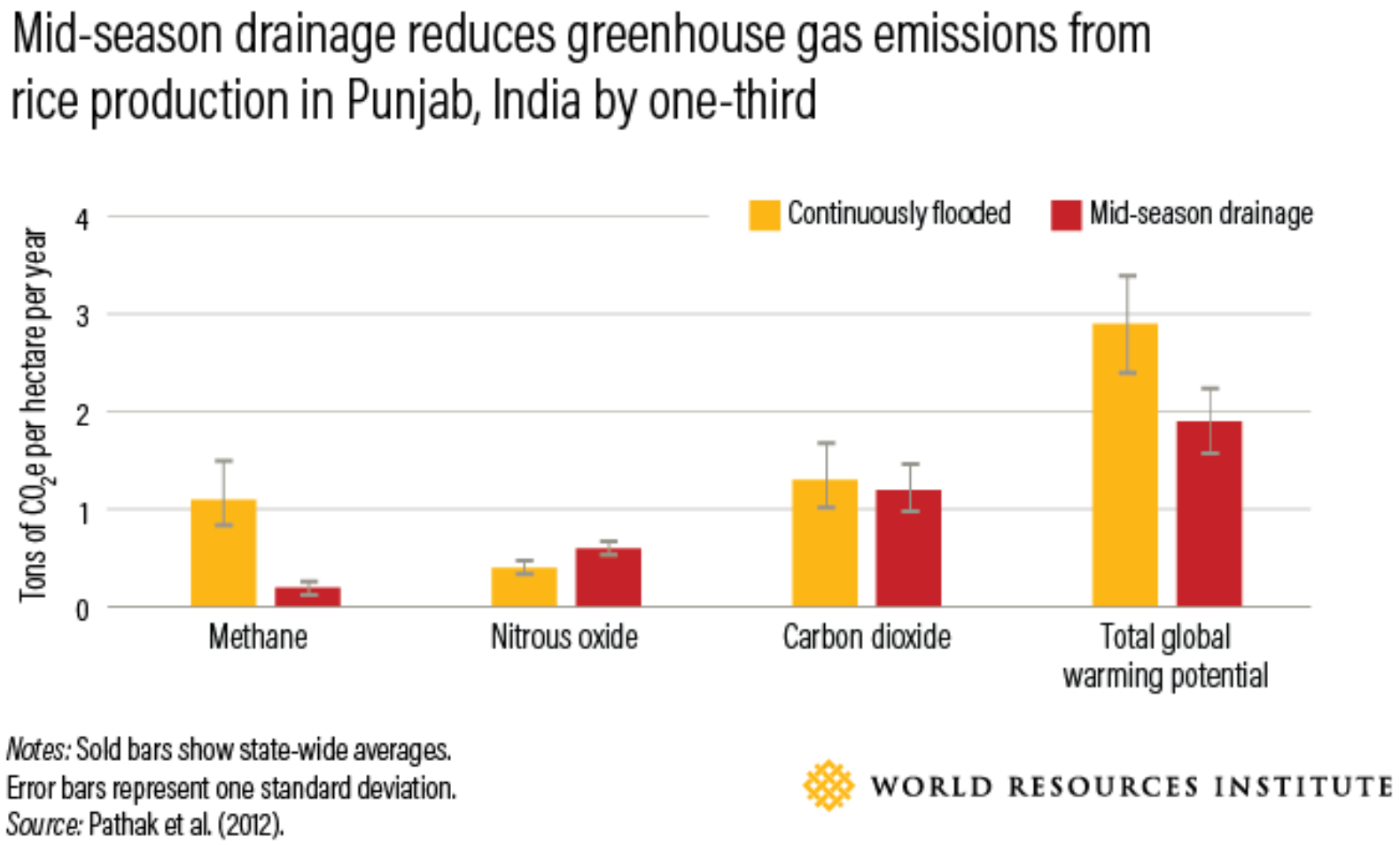
18. Reduce emissions from manure left on pasture

Livestock feces and urine deposited in fields turns into nitrous oxide, a potent greenhouse gas. This unmanaged manure accounted for 12 percent of agricultural production emissions in 2010. Emerging approaches involve applying chemicals that prevent nitrogen from turning into nitrous oxide, and growing grasses that prevent this process naturally.

19. Reduce emissions from fertilizers by increasing nitrogen use efficiency



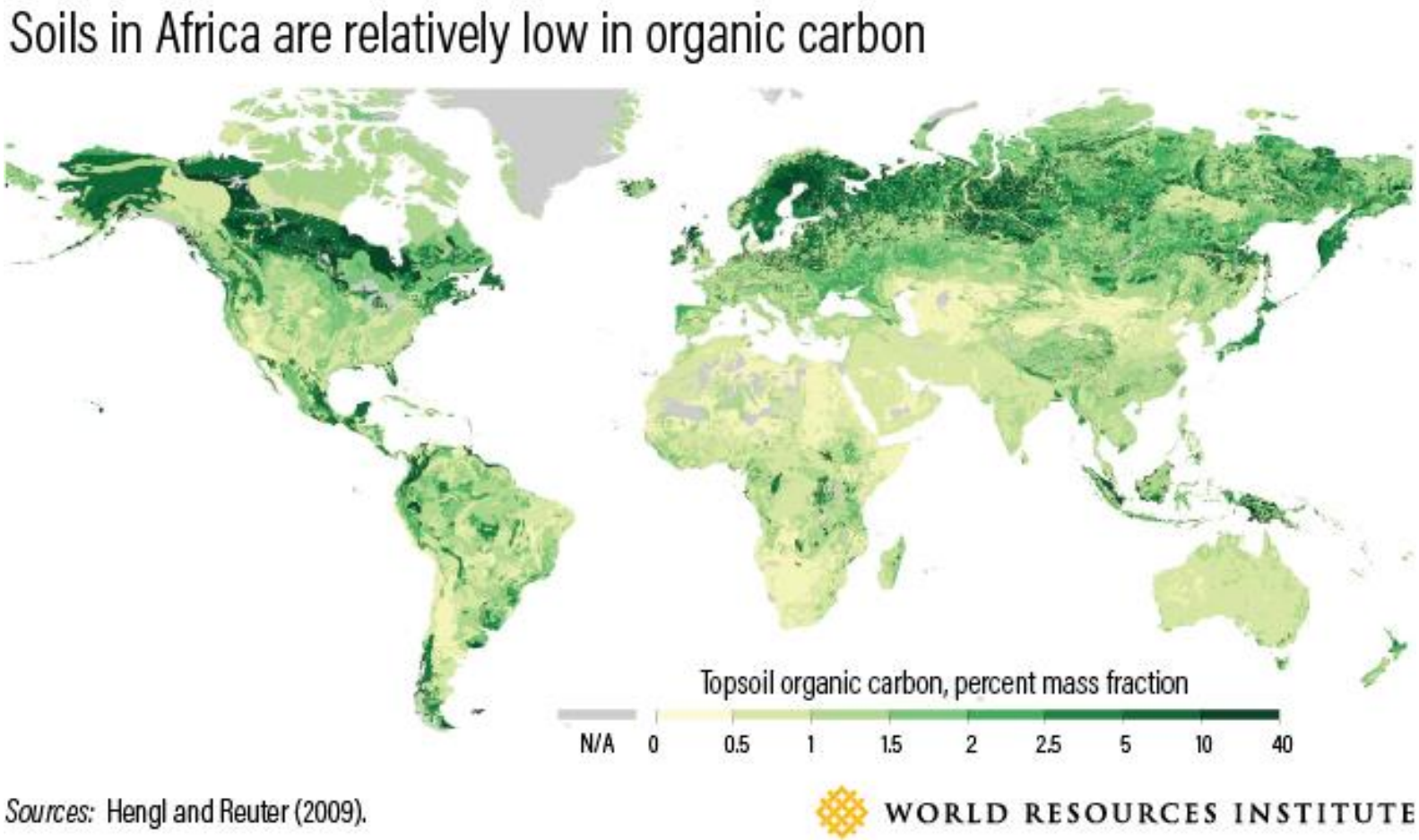
20. Adopt emissions-reducing rice management and varieties



21. Increase agricultural energy efficiency and shift to non-fossil energy sources

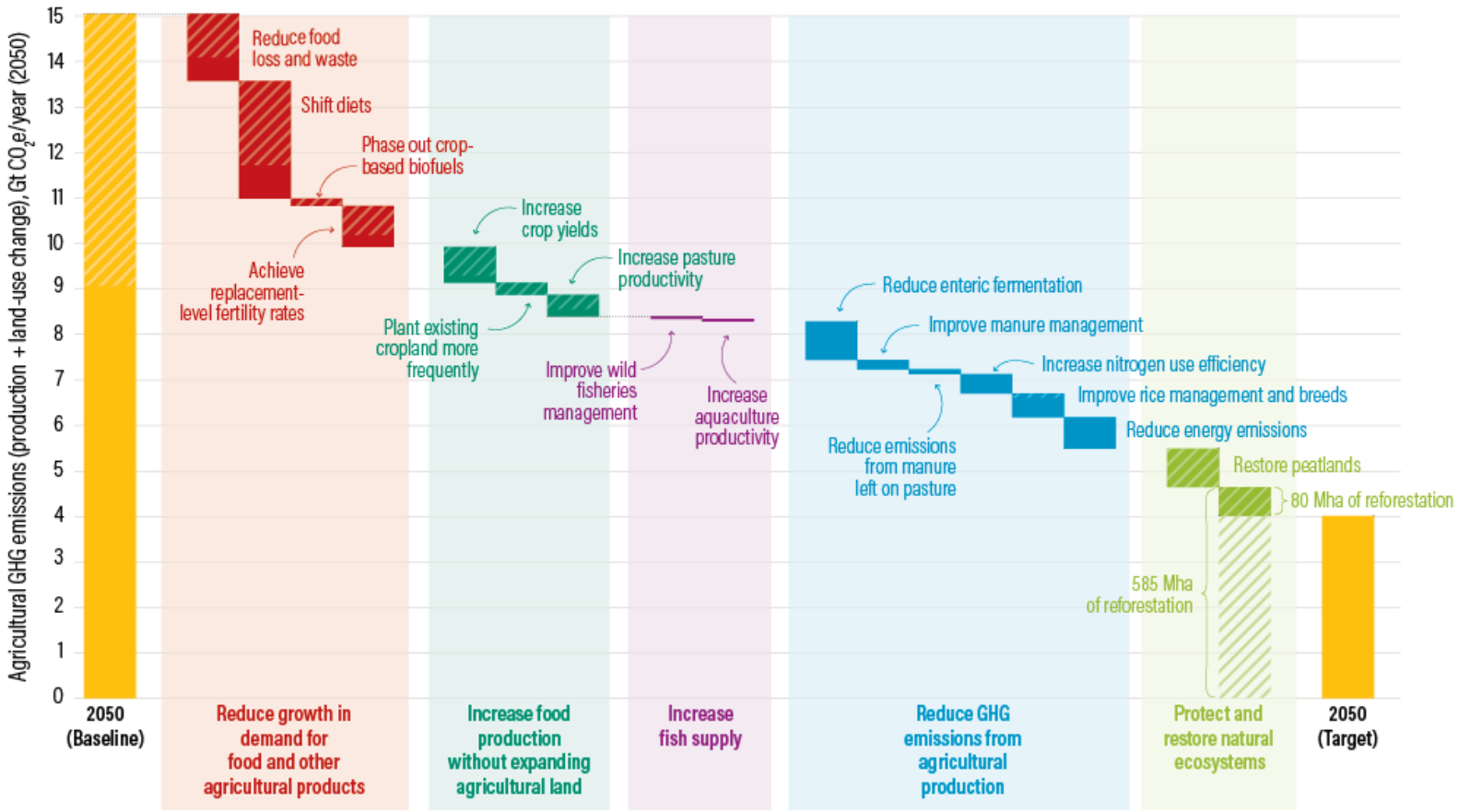
Emissions from fossil energy use in agriculture accounted for 24 percent of agricultural production emissions in 2010. The basic opportunities include increasing energy efficiency, which has been only modestly explored in agricultural settings, and switching to solar and wind.

22. Implement realistic options to sequester carbon in soils



Moving Toward a Sustainable Food Future

A 5-Course Menu of Solutions Can Reduce Agricultural Emissions by More than 70%



Note: Solid areas represent agricultural production emissions. Hatched areas represent emissions from land-use change.
Source: GlobAgri-WRR model.

WORLD RESOURCES INSTITUTE

Sustainability

- How We Can Make the World a Better Place by 2030 | Michael Green | TED Talks
- How to Save Our Planet
- Anthropocene: the age of human impact on Earth | Sustainability
- Should we mine the moon if it makes earth more sustainable?
- Can 100% renewable energy power the world? - Federico Rosei and Renzo Rosei
- Sustainable City | Fully Charged
- Which Power Source Is Most Efficient?
- Why We Need to Think Differently About Sustainability: Leyla Acaroglu at TEDxMelbourne
- Sustainability - Full Documentary
- 5 transformational policies for a prosperous and sustainable world | Johan Rockström
- S.E.A. - Sustainable Earth Actions
- Our Sustainable Earth
- THE DEBATE - Earth Overshoot Day: How Can We Create a Sustainable Future?
- 3 interesting ways to use the Sustainable Development Goals | Environment United Nations
- What Is Sustainability?
- How to Survive on Earth: Energy Materials for a Sustainable Future
- The human plague by Stephen Emmott
- The best news of 2020? Humanity may never hit the 10 billion mark
- How Many People Can Earth Support?
- Can the Planet Support 11 Billion People?

A few quotes on sustainability issues...

- “... what sets wilderness apart in the modern day is not that it's dangerous … it's that five miles out in the woods you can't buy anything.”
  — **Bill McKibben, The Age of Missing Information**
- “In fact, corporations are the infants of our society - they know very little except how to grow (though they're very good at that), and they howl when you set limits. Socializing them is the work of politics.”
  — **Bill McKibben, The Bill McKibben Reader: Pieces from an Active Life**
- “Very few people on earth ever get to say: "I am doing, right now, the most important thing I could possibly be doing." If you'll join this fight, that's what you'll get to say.”
  — **Bill McKibben**
- ... money supplants skill; it's possession allows us to become happily stupid.”
  — **Bill McKibben, The Age of Missing Information**
- “Thus human beings are now carrying out a large scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future. Within a few centuries we are returning to the atmosphere and oceans the concentrated organic carbon stored in sedimentary rocks over hundreds of millions of years.”
  — **Bill McKibben, The Global Warming Reader: A Century of Writing about Climate Change**
- “Put simply, between ecological destruction and technological hubris, the human experiment is now in question.”
  — **Bill McKibben, Falter: Has the Human Game Begun to Play Itself Out?**

More optimistically, from an April 2019 McKibben interview

... it's not really a failure of human beings and human nature that's the problem here. It's a hijacking of our political and economic system by the fossil fuel industry and a small number of like-minded people. It was our bad luck that this idea that markets solve all problems and that government should be left to wither away crested just at the moment when it could do the most damage. Against that now, we've spent the last 10 years building movements. We waited too long to get started, and I kick myself regularly for that.

But now that power is showing itself. Even in the last few weeks, just to watch Extinction Rebellion and [16-year-old Swedish activist] Greta Thunberg's followers around the world shutting down schools, and the remarkable young people from the Green New Deal fanning out across this country – those things to me are signs that the fever the planet is running is producing in quantity antibodies to fight back.

I was just in Denver, where I spent part of the evening with a wonderful 12-year-old girl named Haven Coleman, who was one of the leaders of the U.S. climate strikes. What we were talking about, what she and Greta and everybody else from that movement have been saying, is: "Time for adults to back us up." And it is.

India is now putting up more renewable energy than it is coal.

The Green New Deal completely moves people's understanding of what needs to happen. The [climate activist group] Sunrise Movement folks have done a great job of building the first piece of legislation that's on the same scale as the problem. That at least helps us have a serious conversation about all this.

Quiz Questions

- Week 1 “The coming era of Artificial Intelligence will not be the era of war, but be the era of deep compassion, non-violence, and love.”
- Week 2 “The world of the future will be an even more demanding struggle against the limitations of our intelligence, not a comfortable hammock in which we can lie down to be waited upon by our robot slaves.”
- Week 3 “The algorithm would then inadvertently penalize the poor by providing them smaller buffers and slightly increasing their risk of being hit when out for a walk.”
- Week 4 "We have secured ourselves from the NSA, except for the parts that we either don't know about or can't talk about.”
- Week 6a “Cyber warfare is as much about psychological strategy as technical prowess.”
- Week 6b “It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change.”

Quiz Questions (Who said…?)

- Week 7 “Do not mistake that the ballot is stronger than the bullet.”
- Week 8 *"Lost coins only make everyone else's coins worth slightly more. Think of it as a donation to everyone."*
- Week 9 "It would be a disaster for the health of Californians to be exposed to the antennas envisioned in SB.649."
- Week 10 "The notion that we’ll soon set up colonies inhabited by hundreds or thousands of people is pure nonsense."
- Week 11 *“Anyone who sits on top of the largest hydrogen-oxygen fueled system in the world, knowing they’re going to light the bottom, and doesn’t get a little worried, does not fully understand the situation*.”
- Week 12 “ The most sustainable way is to not make things. The second most sustainable way is to make something very useful, to solve a problem that hasn’t been solved.”

Quiz Answers

- Week 1 Amit Ray, CEO, Compassionate AI Lab.
- Week 2 Norbert Wiener
- Week 3 Noah Goodall, Res. Scientist, VA Transportation Institute
- Week 4 Bruce Schneier
- Week 6a James Scott
- Week 6b Charles Darwin
- Week 7 Abe Lincoln 1856, address to Republican Convention, Illinois.
- Week 8 Satoshi Nakamoto (aka Craig Wright)
- Week 9 Martin Pall, PhD, Profesor Emeritus, Washington State University.
- Week 10 George Dvorsky, Futurist and Transhumanist
- Week 11 John Young
- Week 12 Thomas Sigisgaard, Danish architect and award-winning designer.

Thank you!