Sustainability is at hand

Life in 2050 can be essentially the same with energy consumption at the level of the 1960s

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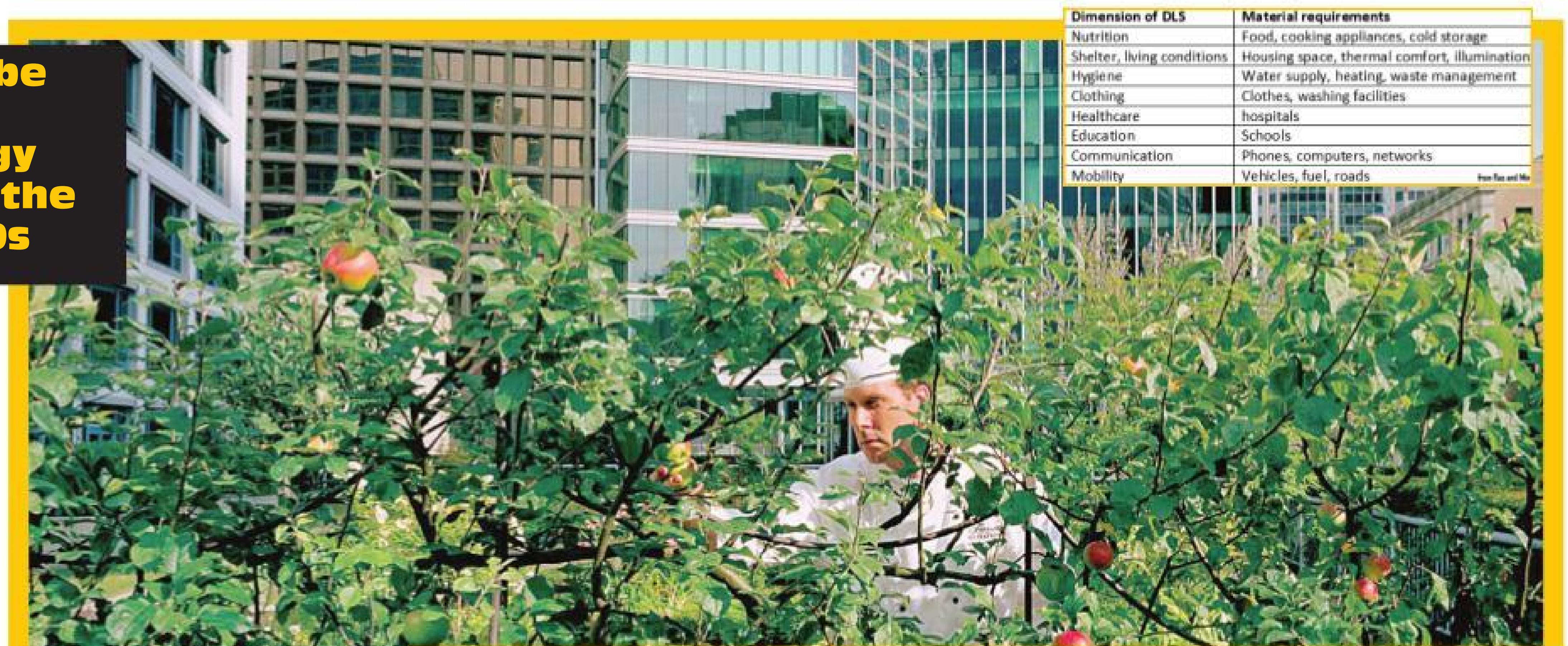


Dimension of DLS	Material requirements
Nutrition	Food, cooking appliances, cold storage
Shelter, living conditions	Housing space, thermal comfort, illumination
Hygiene	Water supply, heating, waste management
Clothing	Clothes, washing facilities
Healthcare	hospitals
Education	Schools
Communication	Phones, computers, networks
Mobility	Vehicles, fuel, roads

from Rao and Min

Pleas to cut down on consumption and save the planet are met with the question, "Would you like to go back and be cave dwellers?"

Joel Millward-Hopkins, Julia K Steinberger, Narasimha D Rao and Yannick Oswald, from the Universities of Leeds, Lausanne and Yale, and the International Institute for Applied Systems Analysis in Ladenburg, Austria, describe in the journal, *Global Environmental Change*, a study that shows comfortable and modern, but sustainable living is entirely within reach. If the planet is being pushed over its limits, it is because of avoidable waste and not the essentials, the study shows. It is possible for the world population, in 2050 to have shelter, mobility, food, hygiene access to healthcare, education and the Internet, with less than 40 per cent of the current energy bill, the study shows.

The total energy, including food and fuel, used by a person in the later Stone Age, some 12,000 years ago, was under 300 kWh in a year, the paper says. By 1850, with the growth that agriculture enabled, this figure rose to some 5,600 kWh, a 20-fold increase. And now, after 170 years of fossil fuel-driven development, the total energy the world consumes is some 180 million GWhs, which comes to around 23,000 kWh for every person. Along with the attendant harm to the environment and climate change.

A question arises, has this rise in energy consumption made for better quality of life? During most of the first 10,000 years of agriculture, the paper says, most populations had a harder time than their forager ancestors. While it has changed in recent centuries, with all round improvements in health indicators, the paper wonders whether our current situation is really better than that of ancient foragers. While ancient societies were socially and politically quite sophisticated, unlike what is often assumed, there are some things about modern society, the paper says, that can be said with certainty:

* The levels of energy use have led to scarcity of resources and geopolitical instability, in a growth-dependent economy -- with the poorest the worst affected

* There have been great improvement in efficiency of industrial processes, but they have mainly enabled more production, and more growth.

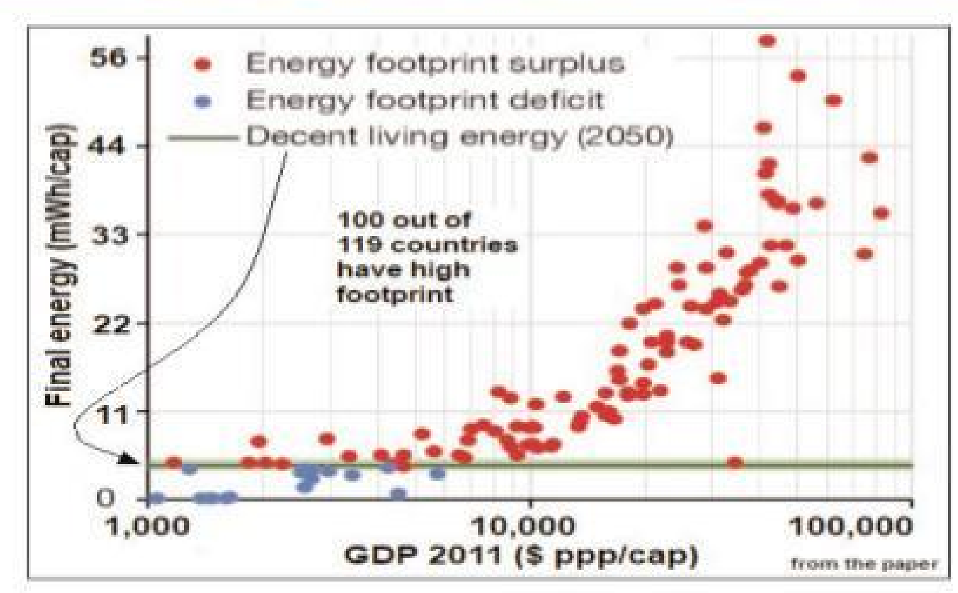
* There have been huge, recent increases in energy consumption, but with meagre social returns. Still, "some countries achieve high social outcomes with far lower energy consumption than others, but none currently manage to achieve high social outcomes while staying within planetary boundaries," the paper says.

While it is clear that we need to cut down our energy use, it also appears possible to cut energy use without affecting our state of well-being. But does this mean we go back to primitive living? No, not even if we wished to, as primitive foraging cannot cater for the current global population, and there are cultural and technological realities that need to be provided for. The question then is, what is that reduced level of energy we need, for well-being, with the comforts and conveniences of modern living?

The authors refer to recent attempts to make this estimation, and the belief that, despite the variety of cultural, historical and technological factors, one can identify a set of satiable needs, which apply to all, that lie at the base of human satisfaction. The authors make use of a study, "Decent living standards: material prerequisites for human wellbeing," by Rao (one of the current authors) and Min, which had drawn up a list of such basic, material needs, and based on the study, they estimate how much energy it would take to provide these needs, to the whole world.

From the paper

"To the clichéd populist objection, that environmentalists are proposing that we return to living in caves, a response, with tongue firmly in cheek: 'Yes, perhaps, but these caves have highly-efficient facilities for cooking, storing food and washing clothes, low-energy lighting, 50L of clean water daily, with 15L heated to bathing temperature, air temperature of around 20°C, a computer with access to global ICT networks, extensive transport networks, healthcare, education – all with substantially reduced working hours.'"



Rao and Min had drawn on concepts of poverty and basic justice, as well as the formulation of the Human Development Index, which considers health, education as well as per capita income rather than only the GDP, as the appropriate indicator of development of a country. And based on these indicators of well-being, they devised a set of essential material conditions, to provide a Decent Living Standard (DLS in the figure), universally applicable, with corrections in the context of local customs and choices.

Now, for estimating what energy it would take to assure a given level of life quality, the paper says, one approach is to consider environmental measures, like energy use, carbon footprint and corresponding measures of well-being, like life expectancy or HDI, or indices derived from the United Nations' Sustainable Development Goals. This approach, however, is affected by the range and changeability of the indicators and the variety of factors that drive consumption.

The other approach, which the authors have followed, is to compile inventories of the essential items, and then to estimate the ecological impact, and energy demand, that these requirements would have. Factors like unequal shares or overconsumption by groups can be built in. And care taken to list all essentials, and the ecological impact of the entire supply chain.

Based on the Rao and Min list of essentials, values have been set for these requirements, like 2,000-2,150 Kcal of daily nutrition for a person, 15 sqm to live and 5,000-15,000 km of travel. And on these bases, energy requirements have been worked out for a population of 10 billion, expected in 2050. And the result, with these levels of consumption, is that the projected global energy need comes to what the world consumed in the 1960s – when the population was just three billion.

The estimate is well below those of the International Energy Agency, mainly because, the paper says, the IEA's estimate is focused on fulfilling the United Nations' Sustainable Development Goals by increasing things like electricity access and availability of clean cooking stoves to 100 per cent. It only sets the minimum of energy needed and does not consider putting a cap on the world's largest consumers. Of the 119 countries considered, the paper says, 100 were consuming well over what was estimated as required for decent living standards. And the answer to saving power is to rein in this wasteful use, with no loss of comforts to those concerned.

Achieving energy use at this level, obviously, would require sweeping changes in current consumption, widespread deployment of advanced technologies and the elimination of mass global inequalities. This would call for people of the world to become conscious, and for the richer countries to realise that the change is not to benefit poor countries, but themselves. That said, the argument that we would need to turn back the dial of modernisation to achieve sustainability is firmly rebutted.

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SIMPLE & BEAUTIFUL

This year's Nobel Prize in chemistry honours an exquisitely precise gene-editing technique. A gene engineer explains how it works

PIYUSH K JAIN

Jennifer Doudna and Emmanuelle Charpentier

Researchers have been able to manipulate large chunks of genetic code for almost 50 years. But it is only within the last decade that they have been able to do it with exquisite precision -- adding, deleting and substituting single units of the genetic code just as an editor can manipulate a single letter in a document. This newfound ability is called gene editing, the tool is called CRISPR and it's being used worldwide to engineer plants and livestock and treat diseases in people.

For these reasons the 2020 Nobel Prize in chemistry has been awarded to Emmanuelle Charpentier, director of the Max Planck Unit for the Science of Pathogens in Germany, and Jennifer Doudna, professor at the University of California, Berkeley, for discovering and transforming CRISPR into a gene-editing technology. It's the first time two women have shared a Nobel Prize. I'm a CRISPR engineer, interested in developing novel CRISPR-based gene-editing tools and delivery methods to improve their precision and function.

In the past, my colleagues and I have created a version of CRISPR that can be controlled using light, which allows precise control of where and when gene editing is performed in cells, and can be potentially used in animals and humans. We've also created a targeted system that can package and deliver the editing components to desirable cell types -- it's like GPS for cells. Most recently, we engineered a tool that improved the speed and precision of CRISPR so it could be used in rapid diagnostic kits for Covid-19, HIV, HCV and prostate cancer.

While CRISPR scientists like me have been speculating about a Nobel Prize for CRISPR, it was exciting to see Charpentier and Doudna win. This will encourage young, talented engineers and researchers to enter the field of gene editing, which can be leveraged for designing new diagnostics, treatments and cures for a range of diseases.

CRISPR/Cas systems as gene editors

Many variants of CRISPR/Cas systems have been discovered, engineered and applied to edit genes. There are already over 20,000 scientific publications on the topic.

CRISPR dates to 1987, when a Japanese molecular biologist, Yoshizumi Ishino, and colleagues discovered a CRISPR DNA sequence in *E coli*. The CRISPR sequence was later characterised by a Spanish scientist, Francisco Mojica, and colleagues, who named it CRISPR, which stands for clustered regularly interspaced short palindromic repeats.

While people and animals have evolved complex immune systems to fight viral attacks, single-cell microorganisms rely on CRISPR to find and destroy a virus's genetic material to stop it from multiplying. Charpentier and Doudna figured out how to borrow this innate biological capability from microbes and apply it to genetic engineering of bacteria.

In a landmark paper, published online on 28 June 2012, Charpentier and Doudna showed that the CRISPR gene-editing machinery includes two components – a guide molecule that serves as sort of a GPS to find and bind the target gene site on the DNA of an invading virus, which then teams up with a CRISPR-associated protein (Cas) that serves as a molecular scissor that snips the DNA.

Around the same time, Virginijus Siksnys, a Lithuanian biochemist at the University of Vilnius, made a similar discovery and submitted results for publication that appeared a few months later, in September 2012. Feng Zhang, a biologist at the Broad Institute in Cambridge, Massachusetts, and colleagues showed that CRISPR can be improved and used for editing mammalian cells. He currently owns one of the first patents on using CRISPR for gene editing, which is being contested by Doudna's institution, UC Berkeley.

Once the DNA has been cut in the right spot, the cell will try to repair the cut. But the repair mechanism is error prone, and oftentimes the cells fail to fix the cuts perfectly, ultimately disabling the gene. Disrupting a gene is particularly useful for studying its function and find out what happens if you stop a gene from working. This technique is also useful for treating cancer and infections, where turning off a gene can potentially stop cancer cells and pathogens from dividing or kill them outright.

During this cutting-repair process, one can fool the cells by providing a new piece of DNA. The cells will then incorporate this piece of DNA with desirable edits into the genetic code. This enables researchers to correct a genetic mutation that causes a genetic disease or replace a defective gene with a healthy one.

The beauty of CRISPR lies in its simplicity. CRISPR can be easily customised to target any gene of interest, whether it is in plants, animals or people. CRISPR applications range from tools for understanding biology, as diagnostics and as new kinds of therapeutics to applications in producing better crops, biofuels and transplantable organs.

Why CRISPR deserved a Nobel Prize

While there is still plenty of room for improvement of these technologies, scientists have already begun testing CRISPR in several clinical trials for treating cancer and genetic disorders. CRISPR-based diagnostics have also been approved by the US Food and Drug Administration under emergency use authorisation for Covid-19 testing.

CRISPR does come with a lot of ethical concerns that warrant caution. For example, in 2018, a Chinese scientist prematurely and unethically used CRISPR for editing human embryos and created CRISPR-edited babies that could pass these genetic alterations to their offspring for generations to come. Some have used the technology for other CRISPR-related "do it yourself" biohacks that raise more concerns over regulating the gene-editing technology.

Despite these concerns, CRISPR has huge potential to transform how scientists can detect, treat and even eradicate diseases as well as improve agricultural products. Society is already seeing the benefits of this Nobel Prize-winning technology.

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PLUS POINTS

We are evolving

Some babies are now being born without wisdom teeth, and more people have a previously rare additional artery in their forearm, as humans undergo a "micro-evolution", a new study suggests.

Scientists in Australia have discovered several changes in humans which are appearing over a short period of time. Teghan Lucas, of Flinders University in Adelaide, said faces are also becoming shorter, due to changes in our diet, and our smaller jaws mean there is less room for teeth. "This is happening in time as we have learnt to use fire and process foods more. A lot of people are just being born without wisdom teeth," she said.

In addition, the investigation by Lucas, along with University of Adelaide professors Maciej Henneberg and Jaliya Kumaratilake, showed a "significant increase" in the prevalence of the median artery since the late 19th century. The artery forms while a baby is in the womb and is the main vessel that supplies blood to the forearm and hand, but it disappears during gestation and is replaced by the radial and ulnar arteries.

"Since the 18th century, anatomists have been studying the prevalence of this artery in adults and our study shows it's clearly increasing," Lucas said, "This increase could have resulted from mutations of genes involved in median artery development or health problems in mothers during pregnancy, or both actually. If this trend continues, most people will have a median artery of the forearm by 2100."

Lucas said the study demonstrates that humans are evolving at a faster rate than at any point in the past 250 years. The investigation's authors suggested changes in natural selection could be the major reason for micro-evolution.

The research is published in the *Journal of Anatomy*.

– THE INDEPENDENT

Food wrapping

Indian Institute of Technology-Madras has developed a sustainable antimicrobial wrapping material that can tackle two major problems – prevent packaged food contamination by bacteria as well as reduce the plastic waste generated in the environment when disposing the wrappers.

The IIT-Madras team was recently awarded the "SITARE- Gandhian Young Technological Innovation Appreciation 2020" for their project. The researchers have also filed for an Indian patent. The research was led by Mukesh Doble, department of biotechnology, IIT-Madras, and Puja Kumari, research scholar, department of biotechnology, IIT-Madras.

Doble said, "We have developed a biodegradable wrapping material with in-built antibacterial activity to prevent bacterial growth in stored food. The wrapping material also degrades at various environmental conditions with the rate of degradation varying from four to 98 per cent in 21 days. It degraded rapidly in moist conditions when compared to dry ones. Hence, our wrapper is eco-friendly and can play a major role in plastic waste reduction."

The films developed by IIT-Madras researchers were made with polymeric blends containing starch, polyvinyl alcohol and cyclic beta glycans. The composition was optimised to achieve the best film with a smooth texture, flexibility, uniform thickness and good clarity. The polymers used are approved by the United States Food and Drug Administration.

The antibacterial agent selected is also approved by the food authority for consumption and includes eugenol, chlorogenic acid, betanin, curcumin and gallic acid, among others. These compounds are used regularly in Indian food and are known to possess antibacterial, antioxidant and many other beneficial bioactivities. The compound is either immobilised on the surface or coated or mixed with polymer before preparation.

Kumari said, "Our study found 99.999 per cent reduction in the bacterial colonies in food samples wrapped with our antibacterial wrap and stored at 30oC for 10 days when compared with a plain wrapper. This study also suggests that our antimicrobial wrapper can, to some extent overcome, the reduced availability of cold storage units."