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Measuring Human Development for the Anthropocene

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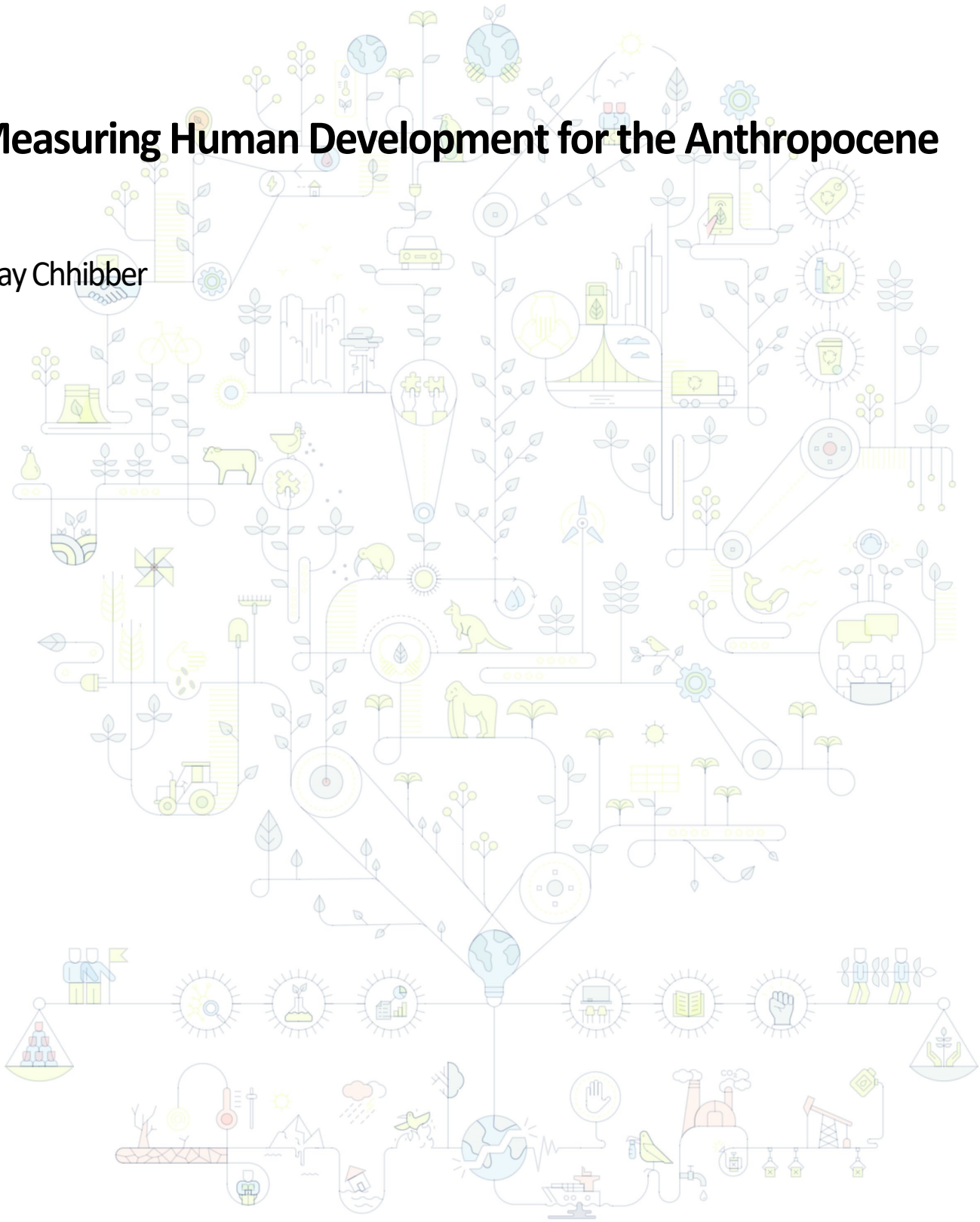

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ABSTRACT

This paper makes the case for an adjusted Human Development Index (HDI) that adds sustainability, vulnerability and human security to the existing HDI components of income, health and education. It shows that these additional elements were part of the discourse in many original writings on human development. They are also central in any discourse on development today. The HDI has made progress by adding gender and inequality in its formulations, but is more reflective of the Millennium Development Goal (MDG) agenda than the more comprehensive Sustainable Development Goals (SDGs) agreed in 2015. The paper reviews existing indicators and suggests a way towards an adjusted HDI. It shows that above an HDI level of 0.8, the cut-off for very high human development, major trade-offs emerge with ecology. It argues for incorporating ecological and human security variables into the HDI, and creating a vulnerability-adjusted HDI that measures resilience to ecological, health and economic shocks, akin to the Inequality-adjusted HDI.

Introduction

The world still looks at human progress in almost exclusively economic terms. Countries view growth in their stock markets and their gross domestic product (GDP) per capita with chest-thumping pride. Almost three decades ago, the United Nations Development Programme (UNDP) tried to produce a more nuanced measure of progress by including life expectancy and education along with income in its Human Development Index (HDI). While a welcome innovation, the original HDI is still relatively crude, failing to account for sustainability, human insecurity and vulnerability, and until recently, inequality, among other issues.

How much those omissions matter became clear recently, after UNDP added an Inequality-adjusted HDI. Including inequality as a factor dramatically altered country rankings. The United States of America, for instance, fell from 13th on the original index to 25th on the adjusted one. Brazil fell the most from 79th to 102nd position, 23 ranks down. By contrast, Japan rose 15 ranks, and Ukraine and Kyrgyzstan rose over 21 and 23 ranks, respectively.

Accounting for climate damage would likely have an even bigger impact. Countries that rank high on the HDI use more carbon and deplete more natural resources than those below them. In other words, our metrics favour unsustainable, environmentally damaging growth. Using more energy produces a higher ranking but only up to roughly 100 gigajoules per person; beyond that, countries are wasting energy in inefficient systems, not improving human development.

The same applies to the relationship between the HDI rankings and a measure known as an 'ecological footprint'. In the middle of the HDI rankings, where around 140 mostly low- and middle-income countries sit, the footprint is relatively small, less than 2 global hectares per capita, a measure of the world's global ecological capacity per person. That number rises sharply among countries with higher development levels, however, increasing to as much as 8 to 10 global hectares.

If we want leaders to consider how badly their policies are damaging the environment, we need a new development index, one that takes account of various environmental variables such as carbon dioxide emissions (CO2) per capita, sulphur dioxide (SO2) emissions (a measure of air quality), groundwater extraction and share of renewable energy. Doing so would drop the rankings of countries such as Australia, Kuwait, Saudi Arabia and the United States by over 15 spots apiece. If the ecological footprints of countries were considered, the rankings of Canada, Estonia and, surprisingly, Finland would drop by over 20 places. The new index must also consider other factors that hinder human development such as conflict, criminality and insecurity as well as broader vulnerabilities to economic, health and ecological shocks.

Other attempts to produce a more sophisticated measure of development have not gained traction. While the Member States of the United Nations agreed to pursue the Sustainable Development Goals (SDGs) in 2015, a

combination of 17 goals and 169 indicators is too complicated to measure succinctly. A Sustainable Development Goals Index (SDGI) has been produced by taking measurable indicators from the SDGs, but it is subjective in its use of measures and weights—what counts is what can be measured. It also, surprisingly, correlates strongly with the HDI. A Social Progress Index (SPI), inspired by the writings of Nobel-winning economists such as Amartya Sen, Joseph Stiglitz and Douglas North, also tries to build from the SDGs, but more selectively than the SDGI. It nevertheless produces rankings that do not differ all that much from the HDI.

The Happy Planet Index (HPI) does not correlate with the HDI but has not gained wide acceptability because it mixes observed data on issues like life expectancy and inequality with survey results measuring well-being. Its rankings show Costa Rica and Viet Nam in the top two positions, with New Zealand the only fully industrialized country among the top 20: the United States ranks 105th. The latest new index is called the Sustainable Development Index (SDI), which adds CO2 emissions and material use in GDP to the HDI, and produces quite dramatic changes in global rankings. It also tries to attribute emissions and material use to consumption rather than production by netting out for trade.

The World Bank has introduced the concept of adjusted net savings to measure changes to wealth (a stock) rather than GDP (a flow), while accounting for additions or depletion of natural capital. But the measure does not adequately address the huge stock of accumulating CO2, SO2 or methane in the atmosphere, the country-sized swarms of plastic now floating in the oceans or the melting of glaciers—all things that show we may be at an environmental tipping point.[1] The United Nations Environment Programme (UNEP) has produced a similar Inclusive Wealth Index (IWI) that improves on the World Bank's Adjusted Net Savings database by measuring changes in natural capital by country, with an alarming picture of unsustainable development across the globe.

2020 was be the thirtieth anniversary of the first *Human Development Report* published in 1990. It constituted a true paradigm shift, moving beyond the focus on economic growth prevalent at the time, and conceptualizing development in terms of human capabilities. Since then, various Human Development Reports have expounded on this idea and analysed a variety of themes from this human-centred perspective, including, but not limited to, the use of the HDI.

In the ensuing three decades, many emerging challenges have come to the attention of the international community; first and foremost is sustainability. Rising inequalities, violent conflict and increasingly the effects of climate change have all called into question existing development models around the world. This process of thinking culminated in the global adoption of the 2030 Agenda for Sustainable Development and the SDGs in 2015. While various Human Development Reports throughout the years have addressed different dimensions

[1] Better terminology would be 'ecological tripping points' as the risks are growing to very high levels, no longer a tipping point but more of a tripping point.

of sustainability, the thirtieth anniversary of the report presents an opportunity to rethink the concept and measurement of human development to reflect these emerging challenges, and thus possibly bring about a second paradigm shift.

Over the last 30 years, the shift from looking just at GDP to judging countries on health and education outcomes has produced real progress, as the world has improved HDI values by over 20 percent since 1990 and, more meaningfully, in the least developed countries by over 50 percent. If we now want real action on climate and ecology, we need to include damage to the environment and depletion of natural resources, conflict and security as factors in measuring development. We also see growing risks and uncertainty, and rising vulnerabilities that COVID-19 has exposed very starkly.

The next section of this paper provides a review of changes in development thinking over the last 30 years. The section after that reviews various indicators devised to measure development since the introduction of the HDI, and their strengths and weaknesses. This is followed by suggestions to extend the HDI while keeping its core essence.[2]

Broadening human development: a look back and the SDG agenda

"Nothing has such power to broaden the mind as the ability to investigate systematically and truly all that comes under thy observation in life." Marcus Aurelius

Despite the absence of a clear consensus on the definition of development, it is well recognized as multidimensional. What constitutes development has evolved considerably throughout recent decades. Traditionally, economists made little, if any, distinction between income growth and economic development, often using the terms almost synonymously. The association between income growth and development takes root in the welfarist approach where the goal is utility maximization. If utility is a monotonous function of consumption, then economic growth automatically implies improvement in utility or well-being. Even under the welfarist approach, however, this straightforward relationship between utility and income would be indisputable only if markets were perfect. If all goods and services can be bought, then, given his or her own preferences, the individual rationally uses income to maximize his utility. Therefore, the only way to augment an individual's utility is to increase real income. But the presence of well-known market failures weakens the argument that income and development are synonymous.

A second flaw in the association of development with income is the effect of income distribution. Even under the assumption of market perfection, economic growth will not necessarily imply an increase in utility if it leads

[2] Some of the ideas in this paper were explored in Chhibber and Laajaj 2008.

to greater inequality. Neoclassical economics has used the concept of pareto-optimality to get around this issue by arguing that if the overall economic pie gets bigger, then the gainers can more than compensate the losers so that the overall utility of society is strictly higher. Given the general absence of compensation, and the well-known problems of utility aggregation, there are difficulties with this approach that are often acknowledged in passing but fundamentally ignored by the continuous focus on income as a measure of development (Sen 1999). For many decades, income growth has been the main target of policymakers. It is now commonly admitted that income is not an end by itself, however, but a means to achieve development objectives and, for convenience in measurement, it is often considered a proxy for factors that influence well-being.

The most fundamental critique of using income as a measure of development goes beyond the issue of market failure and income distribution. Nafziger (2005) identifies two milestones in the recent evolution of the concept of development: Dudley Seers with "The Meaning of Development" (1969) and Amartya Sen with "Development as Freedom" (1999a). Both considerably influenced development researchers as well as policymakers.

Seers opposed the neoclassical approach, stating that the purpose of development is to reduce poverty, inequality and unemployment. He was among the first to stress the need for indicators of well-being other than income, especially in less-developed countries. Seers noted that they have "virtually no statistics anywhere on most of the aspects of life that really matter—the average distance people have to carry water and food; the numbers without shoes; the extent of overcrowding, the prevalence of violence; how many are unable to multiply one number by another, or summarize their own country's history. Naturally, there are no official data anywhere on the number tortured or killed by the police, or how many are in prison for political reasons.... Many of the more important social factors are inherently unquantifiable: how safe it is to criticize the government publicly, or the chance of a fair trial, or how corruption affects policy decisions. But to say that these factors cannot be quantified and are embarrassing subjects for those in power . . . does not mean that they are unimportant or can be overlooked [when assessing] a country's development" (Seers 1983). Seers' thinking is a precursor to recent emphasis on governance, and he noted the contrast between the economic goals set by governments and what really matters for their population.

Amartya Sen, the noted economist and philosopher, introduced the second major step in the evolution of the concept of development, and according to the Nobel Prize Committee "restored an ethical dimension to the discussion of economic problems." Sen (1989) conceives human development as the process of enlarging a person's "functionings and capabilities to function, the range of things that a person could do and be in her life". For Sen (1999a), freedom (not development) is the ultimate goal of economic life as well as the most efficient means of realizing general welfare. Overcoming deprivations is central to development. Unfreedoms include hunger, famine, ignorance, an unsustainable economic life, unemployment, barriers to economic fulfilment by women or minority communities, premature death, violation of political freedom and basic

liberty, threats to the environment, and little access to health, sanitation or clean water. Freedom of exchange, labour contracts, social opportunities and protective security are not just ends or constituent components of development but also important means to development and freedom.

Sen's work on capabilities provided the conceptual foundation for a new paradigm: the human development approach. Its objectives are that people can live in freedom and dignity, and are able to exercise choices, and pursue a full and creative life. Development consists of removing obstacles to these freedoms. The human development paradigm that Sen introduced also included the idea of sustainability. As argued by Anand and Sen (2000a) over two decades ago, "There is in fact no basic difficulty in broadening the concept of human development […] to accommodate the claims of future generations and the urgency of environmental protection." Additionally, many capabilities are the direct result of social interactions.

At the time Sen was developing his ideas on human development, Rawls (1976) was developing his theory of justice, which he later elaborated and modified (Rawls 2001). His ideas can be summarized under two principles. To start, each person has the same indefeasible claim to a fully adequate scheme of equal basic liberties that is compatible with the same scheme of liberties for all. Further, social and economic equalities are to satisfy two conditions: first, they are to be attached to offices and positions open to all under conditions of fair equality of opportunity; and second, they are to be to the greatest benefit of the least-advantaged members of society (the difference principle).

Subsequently, Roemer (1998) pointed out that there are two views of equality of opportunity that are widely held today. The first, which he calls the non-discrimination principle, states that in the competition for positions in society, individuals should be judged only on attributes relevant to the performance of the duties of the position in question. Attributes such as race or sex should not be considered. The second states that society should do what it can to level the playing field among persons who compete for positions, especially during their formative years, so that all those who have the relevant potential attributes can be considered.

Robeyns (2005) observed that: "The capability approach does account for social relations and the constraints and opportunities of social structures and institutions on individuals…." Security matters in realizing one's capabilities. One way to think about it is akin to the concept of 'productivity' in economics. Just as a migrant with a given level of education sees a huge increase in their productivity as soon as they leave a low-productivity poor country to go to a high-productivity rich country—despite no change in their education and health—the same idea can be used to judge the importance of living in an environment where the rule of law prevails, life and property are more secure, and the government is honest and responsive. A person is much better able to take advantage of opportunities to enhance their capabilities in a better governed, more secure environment.

As early as 1685 In *Leviathan*, Hobbes gave the most direct link between governance and violence. He thought that at heart we all are evil, and that it is only the rule of law and the threat of punishment that keep us in check. The consequence of this, he argued, was that if society broke down and you had to live in what he called 'a state of nature', without laws or anyone with the power to back them up, you, like everyone else, would steal and murder when necessary. Life becomes in his words "solitary, poor, nasty, brutish and short," and the solution, Hobbes argued, was to put some powerful individual or parliament in charge. The individuals in the state of nature would have to enter a 'social contract', an agreement to give up some of their dangerous freedoms for the sake of safety. Without what he called a 'sovereign', life would be a kind of hell. This sovereign would be given the right to inflict severe punishment on anyone who stepped out of line. Laws are no good if there is not someone or something strong enough to make everyone follow them. While not everyone may agree with his strong views there is no longer any way to deny that societies cannot function or develop with large insecurities and lawlessness.

Security, including security from other crimes, which are strongly correlated to killings, is by itself an essential capability. Robeyns (2005) explained that: "A person living in a safe area has a much greater capability to leave the house than a person who lives in a town with high level of criminality and theft." It could be argued that deaths from intentional injuries are already counted as part of the health component since these reduce life expectancy. Yet as the literature suggests, these extreme events reflect a separate criterion of societal malaise. Deaths from intentional injuries are a measure of anti-social behaviours. Violence is aroused by frustrations, and the resulting fear and hatred accentuate a society's fragmentation.

Human security was a major theme of the 1994 *Human Development Report*, which stated that for too long, the concept of security was shaped by the potential for conflict between states, and equated with threats to a country's borders. For too long, nations have sought arms to protect their security. For most people today, a feeling of insecurity arises more from worries about daily life than from the dread of a cataclysmic world event. Job security, income security, health security, environmental security and security from crime—these are the emerging concerns of human security all over the world. But this theme was not subsequently integrated into measures of human development except peripherally and coincidentally through inequality.

Suicide is a complicated issue, as it is an intentional death but self-inflicted, and not linked to crime and lawlessness. Yet it does suggest some deeper problems in society. In 1897, Durkheim found that suicides occur less frequently among individuals associated with tighter and more integrated religions, families and societies, pointing to exclusion as a primary cause. More recently, using data from 50 countries between 1980 and 2000, Helliwell (2004) confirmed a strong negative correlation between average national suicide rates and both social capital (using general trust from surveys) and subjective well-being.

In general, human security and human development require strong institutions and good governance. There is widespread literature—best captured in the works of Nobel Prize winner Douglas North (1990), and subsequently by Acemoglu and Robinson (2010)—investigating how and why institutions matter for economic prosperity and poverty. The prevailing wisdom, that institutions matter, is by now widely accepted. But debate rages on how and why they matter? How do institution-building and economic development interact (Constantine 2017)? And is it possible to even help build institutions that are often deeply embedded in social and political structures? Despite a lack of clarity on the links and relationships between economic development and institutions, it is nevertheless true, that, despite the same levels of education and health, achieving desired outcomes is much more constrained in a conflict-ridden, lawless, insecure environment with weak institutions.

Conflicts can also arise if there is an imbalance between aspirations and opportunities. As shown in the 2010 *Human Development Report,* more education but without opportunities and jobs for a better life can lead to vicious spirals of conflict and further loss of opportunities. A more educated population in Latin America in the 1970s and the Middle East in the first decade of this century shows us that a lack of jobs due to insufficient economic development, poor governance and inequities has often led to massive conflict, which has then bred even less opportunity. Latin America experienced decades of conflict as a more educated population, with no jobs and huge inequality, resorted to conflict and crime. The Arab Spring that erupted in 2010 came after two decades when education spread widely in the Middle East but was not followed by inclusive rapid growth.

Climate change is the other major factor driving rethinking on economic development. As far back as 40 years ago, scientists from 50 nations met at the First World Climate Conference and agreed that alarming trends in climate change made it urgent to act. Since then, similar alarms have been raised through the 1992 Rio Summit, the 1997 Kyoto Protocol and the 2015 Paris Agreement, as well as scores of other global assemblies, and in scientists' explicit warnings of insufficient progress. But these have been ignored (O'Neill et al. 2018).

Climate scientists have warned that despite 40 years of global climate negotiations, with few exceptions, we have generally conducted business as usual and have largely failed to address this predicament. The climate crisis has arrived and is accelerating faster than most scientists expected. It is more severe than anticipated, threatening natural ecosystems and the fate of humanity. Especially worrisome are potential irreversible climate tipping points and nature's reinforcing feedbacks (atmospheric, marine and terrestrial) that could lead to a catastrophic 'hothouse' Earth, well beyond the control of humans (Steffen et al. 2015). These climate chain reactions could cause significant disruptions to ecosystems, societies and economies, potentially making large areas of Earth uninhabitable.

The International Panel on Climate Change report in 2018 was a game changer. It proposed that the world would need to reach 'zero emissions' by 2050. Within this global target, the developed world would need to reach zero emissions by 2030, i.e., within a decade. But despite the 2015 Paris climate accord, action on the

ground was insufficient. By 2019, with fires blazing through Australia and California and the Amazon, floods swamping northern England, droughts driving migration and record heatwaves searing Antarctica, people began to realize that the status quo has us hurtling toward disaster. And now COVID-19 will fundamentally change the way people look at the relationships between human development and ecology. We will likely pay more attention to the risks, uncertainties and vulnerabilities in our economic and social systems. All of this means, in a nutshell, that we need to widen the way we measure human development.

PROGRESS UNDER THE MDGS AND ITS LIMITATIONS

Until 2015, the world was committed to the Millennium Development Goals (MDGs), where the focus of the first six goals was reducing poverty and hunger, expanding education and health, and reducing gender discrimination, with progress measured with concrete targets. A seventh goal was on environmental sustainability and an eighth on global partnerships, but these had no measurable targets. As a result, much of the focus of countries and international organizations was on the achievement of the first six goals.

As the UN MDG task force report in 2015 summarizes:

- The percentage of people below the poverty line (defined as US$1.25 per person per day) fell from 50 percent in 1990 to 14 percent by 2015. Over 1 billion people came out of extreme poverty, and the proportion of undernourished people was halved.
- The primary net school enrolment rate increased from 83 percent in 2000 to 91 percent by 2015, girls increased more than boys, and, in that period, the number of out-of-school children dropped from 100 million to 57 million. Progress was also made in access to water (although there are issues with how this progress is measured).
- The under-5 mortality rate dropped from 90 per 1,000 live births to 43 between 1990 and 2015. Maternal mortality dropped by more than 45 percent with the fastest reductions in South Asia and Africa; more children were born with skilled birth attendance. Progress was made in the fight against HIV/AIDS, tuberculosis and malaria.

Perhaps the slowest progress was on gender disparity, but even so, there was overall improvement in women's and girls' access to primary, secondary and tertiary education, along with parliamentary representation and employment. But as could be expected, progress was uneven, with many parts of the world making huge progress and others, such as Africa, taking shorter strides. Gender discrimination remains a huge issue in many countries, especially in access to jobs and assets. Other disparities persist between rural and urban areas in terms of services and the basics of life such as water, housing and sanitation, with almost 50 percent of rural people not having adequate access to these facilities. The disparity between the rich and poor not just in

income but in access to basic services remains significant; rising inequality adds to these challenges. Children from the bottom 20 percent of the population by income are twice as likely to be stunted and four times as likely to be out of school compared to children from the top 20 percent. The MDGs proved valuable in focusing the world's attention on more inclusive development, but the run-up to 2015 also revealed their weaknesses.

Despite MDG 7, progress on the environmental front was very weak. In fact, some would argue that during the MDG era, the world went backward on the environment. There is some evidence in the 2019 *Human Development Report* that in recent years, developed countries have made a small reduction in emissions per capita, but from very high levels. These declines have been overwhelmed by rising emissions in the developing world, especially in the middle-income countries. Global emissions of CO2 have increased by 50 percent since 1990. An area about the size of Costa Rica was lost to forest cover in 2010; marine stocks have been depleted on a major scale. Air quality has gone down in many cities in the developing world to critical levels. Water scarcity is becoming so intense that it is linked to rising conflict. And the world is still searching for an economic development model that improves the quality of life but with a much smaller carbon footprint.

Conflict and insecurity were not directly addressed in the MDGs but played a key role in explaining why progress was so varied. No low-income, conflict-affected country achieved any of the MDGs; fragile states were the most off track on the goals. Of the 34 countries furthest from achieving the MDGs, some 25 were conflict affected. The strong correlation between conflict and poverty does not imply causality, as poverty breeds conflict and conflict makes it harder to get out of poverty, creating 'poverty traps'. But clearly, more focus on peace and conflict was needed in going forward from the MDGs to the SDGs.

The difficulties in meeting the MDGs for fragile, conflict-affected states led to the creation of the Group of 7+, a voluntary group of 20 countries—Afghanistan, Burundi, Central African Republic, Chad, Comoros ,Côte d'Ivoire, Democratic Republic of the Congo, Guinea, Guinea-Bissau, Haiti, Liberia, Papua New Guinea, Sao Tome and Principe, Sierra Leone, Somalia, Solomon Islands, South Sudan, Timor-Leste, Togo and Yemen (Wyeth 2012). The focus of these countries is on peacebuilding and State-building goals: legitimate and inclusive politics, security, justice, economic foundations, and revenue and services, towards addressing so-called poverty traps. The SDGs have now made ending conflict and peacebuilding a central goal.

THE SUSTAINABLE DEVELOPMENT GOALS: ALL ENCOMPASSING BUT HARD TO TRACK

The SDGs came out of a deliberate, consultative, bottom-up process. They reflect the collective thinking of many different constituencies summarized into 17 goals and 169 agreed targets. They have the endorsement of 193 United Nations Member States as well as regional bodies. Now comes the harder part of implementation and ensuring that the world can come together behind the SDGs.

This comprehensive agenda will be much harder to monitor as a substantial number of targets will be difficult to measure and track. Just to give a few examples:

- Target 10.2: By 2030 empower and promote the social, economic and political inclusion of all.
- Target 12.2: By 2030 achieve the sustainable management and efficient use of natural resources.
- Target 12.8: By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyle in harmony with nature.
- Target 16.3: Promote the rule of law at the national and international levels and ensure equal access to justice for all.
- Target 16.12: Promote and enforce non-discriminatory laws and policies for sustainable development.

Some goals may complement each other, synergistically. At a simple level, the targets on universal education and universal health care also help the targets on gender equality. Universal access ensures that girls get the same as boys and catch up. But goals may also complement each other in additional ways. For example, health outcomes will depend on access to health, but also on clean water and sanitation, education (especially for girls), clean air, transport, better housing and access to modern energy, among some key factors. How well these are provided in a coordinated package at the local level makes all the difference. Further, a priority for better health, for instance, does not simply mean more health expenditure. In many countries at earlier stages of development, health spending may be the third or fourth most important variable in determining health outcomes after girls' education, access to clean water and sanitation, and more nutritious food intake, especially in early childhood.

The United Nations Statistics Commission is tasked with finding ways to measure these targets. But even if they can come up with measurable indicators, many countries will not have the capacity to track and monitor so many targets. *The Economist* critiqued the SDGs by calling them the 169 Commandments and suggested reducing these to around 10. Kydland et al. (2015), based on surveys of 82 of the world's top economists and 44 sector experts under the Copenhagen Consensus, suggest that the number of targets should be reduced to 19 to give the biggest return on investment and effort.[3] These include child malnutrition, eradicating tuberculosis, freer trade, protecting coral reefs, eliminating fossil fuel subsidies and eradicating poverty. The High-Level Panel on Sustainable Development suggested a more realistic 12 goals and 54 targets. But now that world leaders have endorsed and agreed on the 17 SDGs and 169 targets for 2030, the question is, how we can find a practical and realistic way to move forward? Kenny (2015) suggested tweaking the SDGs to make them

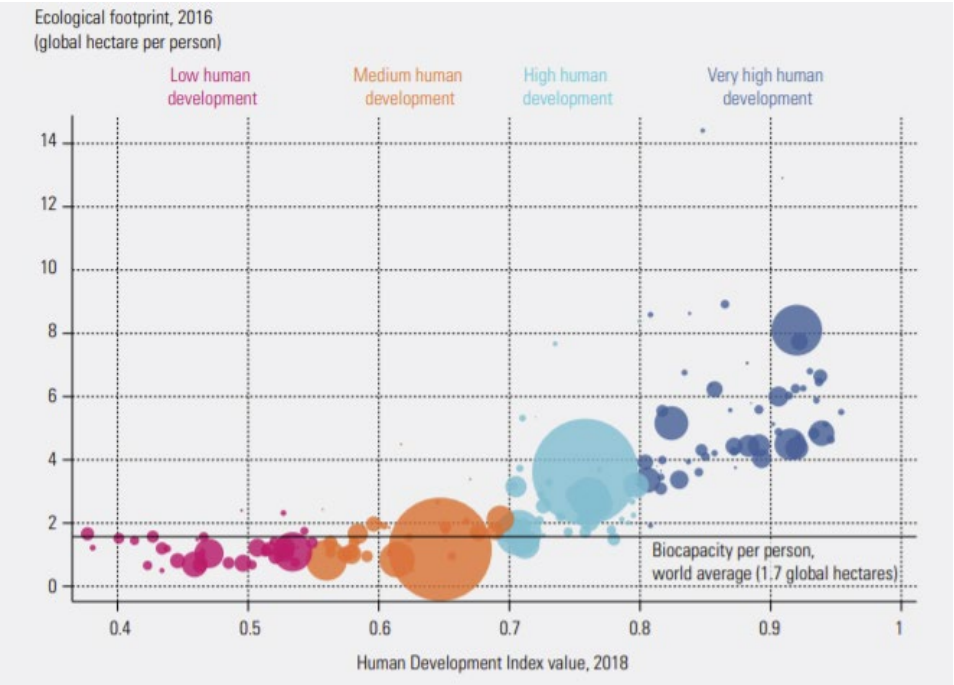
[3] It is not clear how returns to each intervention have been estimated, however. They may simply reflect the biases of experts surveyed.

more precise. Foster and Hatzimosoura (2015) have proposed a multidimensional framework for monitoring progress building on the methodology developed by Alkire and Foster on multidimensional poverty.

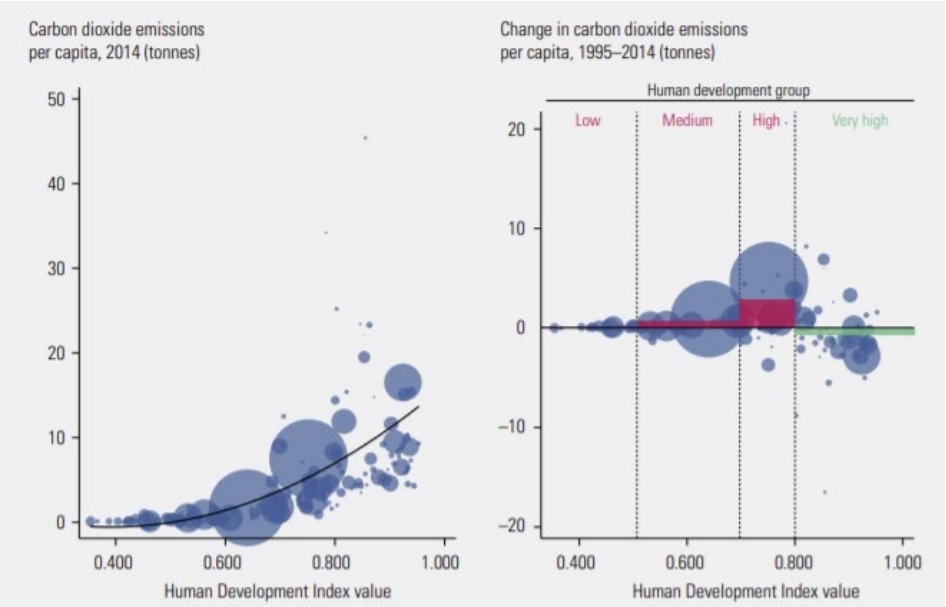
Some of the goals compete against each other. For example, the goal of faster growth and an increasing share of industrialization will inevitably lead to higher carbon emissions but is needed given low levels of income in some countries. Better technology and renewable energy may reduce some of this trade-off, but it will still be there. Similarly, increasing access to energy for the more than 1 billion people around the world who do not have it will increase carbon emissions even if there is an effort made to supply some of it through renewable energy. But even with a rising share of renewables as urbanization increases and rural areas get connected, energy emissions will increase, especially in the middle-income countries. And as Zeng et al. (2020) show, the loss of biodiversity is not fully accounted for even in the SDGs

One major and glaring trade-off, relevant for this paper, is that higher human development as measured by the HDI comes with greater energy use per capita and pressure on ecological capacity. Daly (1996) highlighted these trade-offs and showed how a steady state economy that does not surpass ecological constraints should be the goal. The energy markets have shifted from denial to begin embracing the need to fight climate change. How seriously they take this is not yet clear, but most major oil and gas companies globally are now supporting the development of new technologies to reduce energy dependence and advance renewable energy. The change in CO2 emissions per capita is declining more rapidly in the developed countries, albeit from very high levels. But it is rising by much larger amounts in the middle-income countries, especially China (Figure 1).

Figure 1: Human development, ecological footprint and CO2 emissions

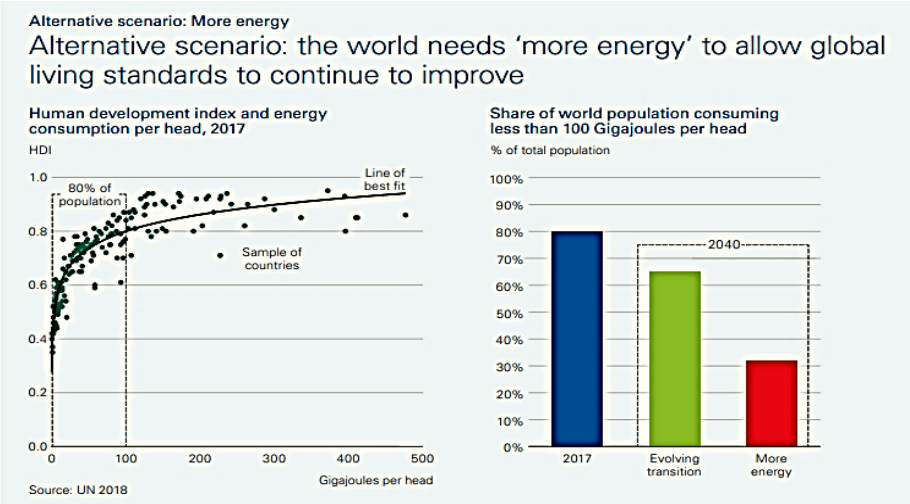


Note: Data cover 175 countries in the Global Ecological Footprint Network database (www.footprintnetwork.org/resources/data/; accessed 17 July 2018). As used here, the ecological footprint is a per capita measure of how much area of biologically productive land and water a country requires, domestically and abroad, to produce all the resources it consumes and to absorb the waste it generates. Each bubble represents a country, and the size of the bubble is proportional to the country's population.
Source: Cumming and von Cramon-Taubadel 2018.



Note: Each bubble represents a country, and the size of the bubble is proportional to the country's population.
Source: UNDP 2019 based on data from the World Bank's World Development Indicators database.

Figure 2: Human development and energy consumption



Source: BP 2019.

A 2019 report from British Petroleum (BP) provides some answers. Energy use rises with higher HDI scores (Figure 2), but at very high levels of human development (above 0.8) the relationship breaks down. The same is true in reverse. On average, as energy consumption rises to about 100 gigajoules per head, the HDI score goes up, but beyond that, does not result in human development gains. This means countries with low levels of human development must be allowed to increase their energy use in an efficient manner. Countries consuming more than 100 gigajoules must reduce their per capita energy use. How to manage these global needs while reducing CO2 emissions is critical. Continuing emissions even at current levels will not allow us to reach the target of holding temperature rise to 1.5 C. The same calculation holds true for ecological capacity use, as no country in the 'very high' HDI category is within the global biocapacity limit.

GROWING RISKS, UNCERTAINTY AND VULNERABILITY

Climate change is an obvious risk, but as COVID-19 has shown, there are much broader risks from human interaction with ecology that threaten human development. In this section, we develop conceptually the ways in which these risks, their underlying uncertainties and resulting vulnerabilities can be addressed.

The risks in the illustrative BP scenarios are obvious. No change in very high HDI countries and business as usual in low HDI countries with insufficient attention to mitigation will lead to explosive increase in CO2 emissions. The current trajectory the world is following will not do. According to the BP report, sharp reduction is possible with a combination of large shifts to renewables, zero coal and heavy doses of carbon sequestration to reach the target of zero emissions by 2050—and for the developed world to reach it by 2030. But the world is not anywhere close to that trajectory. In fact, we are likely to see global temperatures rise by as much as 8.5 degrees. Moody's (2018) has evaluated the economic effects of climate change across six distinct impact channels: sea-level rise, human health effects, a heat effect on labour productivity, agricultural productivity,

tourism and energy demand. It shows that the effects on countries could be huge, with many losers and perhaps some winners. Developing countries and oil-producing countries appear to lose the most in their scenarios, as much as -2.5 percent for India in terms of GDP and -8 percent for Saudi Arabia.

Growing uncertainty due to climate change will also create substantial problems for financial and capital markets. Risk is measurable (in a probabilistic sense) and therefore can be priced by financial markets and the insurance industry. But with climate change, uncertainty is rising, so that it may become difficult to price many financial variables we take for given. By how much will the ocean level rise 10 years from now or 30 years from now? What will be the intensity of cyclonic activity? What will be the intensity of fires? Will 100-year levels of flooding now occur every 10 years or 20 years? These uncertainties and the problems they create are now being recognized by financial markets. One major financial firm, BlackRock International (2020), states it very bluntly: "Will cities, for example, be able to afford their infrastructure needs as climate risk reshapes the market for municipal bonds? What will happen to the 30-year mortgage – a key building block of finance – if lenders can't estimate the impact of climate risk over such a long timeline, and if there is no viable market for flood or fire insurance in impacted areas? What happens to inflation, and in turn interest rates, if the cost of food climbs from drought and flooding? How can we model economic growth if emerging markets see their productivity decline due to extreme heat and other climate impacts? Investors are increasingly reckoning with these questions and recognizing that climate risk is investment risk..... They are seeking to understand both the physical risks associated with climate change as well as the ways that climate policy will impact prices, costs, and demand across the entire economy."

If risk and uncertainty are increasing, what does that mean for the way we measure development? Do we have a development model that is increasing our risks? And how are countries able to handle those risks? Do they have resilience in their institutions and frameworks to protect people and reduce their vulnerability?

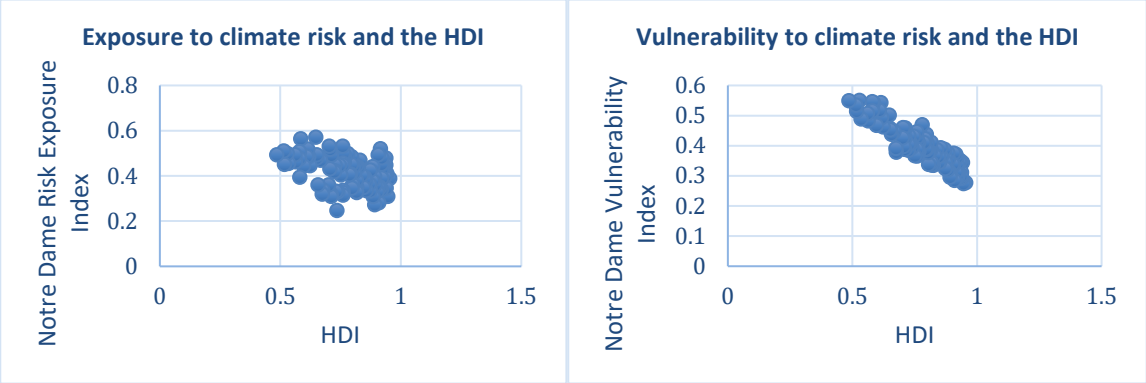
We can think of Vulnerability $V = f(IR, P, RS)$, where IR is the intensity of risks, P is the proportion of populations subject to those risks and RS is the degree of resilience in that society or country.

We can illustrate this with data from the Notre Dame Global Adaptation Index, which looks at risk exposure to climate change along different sectors—food, water, health, ecosystem services, human habitat, infrastructure and readiness along three dimensions, economic, social and governance. It first examines exposure risk and then the adaptability to that risk, which it terms vulnerability.

Using the most recent data from that index, we see that countries with lower income already have much greater exposure to climate risk, but the correlation is low (0.3). Exposure to risk also has a low correlation with the HDI (0.4). The correlation with vulnerability, after considering a country's ability to adapt to that risk, rises to 0.8 with income and 0.9 with the HDI. Countries with higher incomes not only start with less exposure to

climate risk, but are able to manage that risk much better and are less vulnerable. Countries with higher HDI are in an even better position to handle vulnerability to climate risk (Figure 3). This might also explain the lack of sufficient action on climate change as the richer countries appear less vulnerable to it. Those that might be most vulnerable, the poorer countries, do not have the resources and systems to handle it and are therefore most exposed to those risks. With rising global temperatures, those risks, and the resulting vulnerabilities are increasing and/or are costing more resources to insure and protect against. But risk and uncertainty and the resulting vulnerabilities arise not just from climate change, but can come from financial crisis, or as we see now on a huge global scale from pandemics.

Figure 3: Climate risk, vulnerability and the HDI



Source: Notre Dame Global Adaptation Index and UNDP 2019.

The United Nations Economic Vulnerability Index, which is largely used to define the least developed countries, has been developed with somewhat similar approaches (Guillaumont 2011). It distinguishes between structural vulnerability and vulnerability derived from policy. The Asian financial crisis, according to Guillaumont, was created by policy design, not underlying structural vulnerability. He also distinguished between structural vulnerability and state fragility or governance capability, and between economic and ecological fragility.

There is a vast literature on identifying vulnerability and especially vulnerability to poverty, drawing also on Sen's work, which says it is not enough to measure poverty ex post, but also to identify who is vulnerable to it. But the concept of vulnerability is broader than just vulnerability to poverty as surveyed in Gallardo (2018). According to this survey, Hoddinott and Quisumbing (2003) classify vulnerability approaches based on their defining elements: vulnerability as uninsured exposure to risk, vulnerability as expected poverty and vulnerability as low expected utility. The proposal by Povel (2010) follows the definition of the World Bank, according to which vulnerability measures the resilience against a shock – the likelihood that a shock will result in a decline in welfare. This approach develops a general concept of vulnerability focusing on the risk of falling below the current status quo, rather than on the risk of being poor. Vulnerability is thus understood as the risk of incurring future welfare losses. One of the most recent approaches to emphasizing

the risk element is the proposal developed by Dutta, Foster and Mishra (2011). As in Povel (2010), these authors maintain that vulnerability relates to the risk of falling below a certain welfare threshold in the future. This threshold may correspond to various dimensions, such as health, food, income, etc.

Another approach that many countries have followed is to establish extended poverty lines. According to Cafiero and Vakis (2006), vulnerable individuals are identified by an extended poverty line that includes the cost of insuring against socially unacceptable risk, that is, the poverty line that includes the minimum amount of consumption required to achieve basic needs plus the cost needed for acquiring enough insurance to mitigate against falling below that poverty line.

These ideas were discussed in considerable detail in the 2014 *Human Development Report,* which emphasized that real progress on human development is not only a matter of enlarging people's critical choices and their ability to be educated, healthy, have a reasonable standard of living and feel safe. It is also a matter of how secure these achievements are and whether conditions are sufficient for sustained human development. An account of progress in human development is incomplete without exploring and assessing vulnerability. Traditionally, the concept of vulnerability is used to describe exposure to risk and risk management, including insuring against shocks, and diversifying assets and income. The 2014 report took a broader approach, emphasizing the close links between reducing vulnerability and advancing human development. It introduced the concept of human vulnerability to describe the prospects for eroding people's capabilities and choices, but surprisingly, just like the 1994 *Human Development Report* on human security, it did not change any of the measures used to rank countries on the HDI.

While climate change is being ignored, ecological tipping points were breached with the animal kingdom leading to the COVID-19 pandemic. Ecological damage has now sent the world into a huge global economic repression, similar in size to the Great Depression. The damage is widespread, but will fall heavier on the most vulnerable populations. There were warnings, but these were ignored. Bill Gates said that the world needs to prepare for pandemics in the same serious way as it prepares for war but was not taken seriously. There were warnings with the swine flu in 2009 and Ebola in 2014-2016, yet these were forgotten when those viruses subsided. A 2011 Hollywood movie, *Contagion,* was amazingly prescient in showing the havoc a pandemic can cause, but the attention it brought soon faded away. A secret 2017 US intelligence report also warned of a pandemic and shortages in medical equipment—such as masks and ventilators—similar to what we are seeing, but this was not acted upon.

The Global Health Security Index produced in October 2019 by the Nuclear Threat Initiative and the Johns Hopkins Global Health Center—just a few weeks before the onset of the coronavirus—showed that no country was adequately prepared to deal with pandemics. The world was increasing defence expenditures but reducing health spending. Military spending was higher than public health expenditure in the Middle East, Eastern

Europe, North Africa, and Central and South Asia. The need now is for more weapons to fight a virus—not more weapons to kill each other—but the world is clearly underprepared.

And now the world, especially the developing one, will see huge declines in income, lowered life expectancy, and many children, especially girls, being pulled out of schools. A plunge in HDI scores is on the horizon. But can we do better? Can we improve the HDI to measure, ex ante, different vulnerabilities so that it can spur policymakers to protect their citizens and economies better against future catastrophes and pandemics?

We will come back to this issue. First, we review the crop of indicators that have sprung up to measure development better, their professed logic, their strengths and weaknesses, and more critically for this paper, how they compare with the HDI.

Alternate measures of development: strengths and weaknesses

"*Measurement is the first step that leads to control and eventually to improvement*." James Harrington

Beyond a certain point, which high-income countries have long since surpassed, the relationship between GDP and human well-being completely breaks down (Hickel 2020. As Hickel shows, the United States of America has a GDP per capita of $60,000, making it one of the richest countries in the world. People in the United States can expect to live 78.5 years. But dozens of countries beat the United States in life expectancy with only a fraction of the income. The Republic of Korea has 50 percent less GDP per capita and a life expectancy of 82.6 years. Portugal has 65 percent less GDP per capita and a life expectancy of 81.1 years.

Spain spends $2,300 per person on health care, which is enough to secure one of the highest life expectancies in the world (83.3 years). The United States spends four times more to get worse results. We can see the same pattern playing out when it comes to education. Finland has one of the best education systems in the world, despite having a GDP per capita that is 23 percent less than the United States. Estonia ranks highly too, with 66 percent less GDP per capita. Poland outperforms the United States with 77 percent less. While the HDI has made progress in some areas, such as in measuring gender and inequality, it has not incorporated any measure of sustainability and climate, or other dimensions of concern such as the social and political environment in which opportunities are provided or denied to people. It has remained an indicator with three basic ingredients, income, knowledge and health, all of which are attributes embedded in an individual, and not the milieu in which they can be used to give a person a better life.

The ecological limitations of the HDI, as explained in Hickel (2020), have been explored by a number of scholars (Desai 1995, Sagar and Najam 1998, de la Vega and Urrutia 2001, Neumayer 2001, Morse 2003, Pelenc et al. 2013). Several attempts have been made to integrate environmental dimensions into the HDI (Hirai 2017). The

most notable is the index developed by Togtokh and Gaffney (2010) and improved by Bravo (2014), which includes an index of per capita CO2 emissions in a geometric mean alongside the three original HDI indicators. Kai, Heijungs and de Snoot (2015) developed an alternative that incorporates material footprint (the total weight of material extraction and consumption, including biomass, minerals, fossil fuels and construction materials) into the mean alongside the three original indicators. Türe (2013) takes a different approach and divides the HDI by the ecological footprint, which accounts for not only carbon emissions, but also the biocapacity of cropland, grazing land, forests and fisheries. Most recently, Biggeri and Mauro (2018) have developed an alternative index that incorporates not only an ecological indicator (CO2 emissions) but also an additional social indicator: freedom (defined as political rights and civil liberties). Despite detailed discussions on human security in the 1994 *Human Development Report* and vulnerability in the 2014 *Human Development Report,* none of these concepts have been used to expand the HDI.

All of these alternatives build on the underlying logic and structure of the HDI. Many others do not. The Happy Planet Index (HPI), developed by the New Economics Foundation (see Jeffrey, Wheatley and Abdallah 2016), abandons income and education altogether, and incorporates happiness and equality instead, alongside life expectancy, and then divides the result by ecological footprint. More recently, attempts have been made to dispense with a single index altogether in favour of disaggregated metrics that cover a range of key ecological indicators (such as those captured by the planetary boundary framework) as well as a range of social indicators (such as those covered by the SDGs), allowing us to see important information that is otherwise hidden in single indexes. The method developed by O'Neill et al. (2018) is perhaps the most comprehensive attempt at this to date, building directly on the 'safe and just space' approach articulated by Raworth (2012). Finally, a number of national accounting metrics have been developed specifically to correct or complement GDP, such as the Index of Sustainable Economic Welfare and the Genuine Progress Indicator, both of which start with personal consumption expenditure (also the starting point for GDP) and then adjust for ecological and social costs not captured by GDP (while including the benefits of non-market activity and accounting for inequality). We do not discuss these in this paper.

In this section we review six indicators[4] developed ostensibly to improve on the HDI and broaden its dimensions by bringing in environmental sustainability, freedom, governance, social dimensions and opportunities (Table 1). We review the Gross Happiness Index (GHI) and the Legatum Prosperity Index (LPI), which are based on perception surveys; then two linked to the SDGs, the SDGI and the SPI; and then two that build in environmental and ecological costs directly, the HPI and the SDI. The SDGI is also sometimes referred

[4] All the comparisons use data for 102 countries where all indicators are available.

to as the Sustainable Development Index (SDI). But the SDGI is built from the SDGs, whereas the SDI discussed here is another index developed to address the ecological efficiency of human development. [5]

Table 1: Correlation between the HDI and other indices

	HDI	*Inequality-adjusted HDI*
GHI	0.74	0.70
SDGI	0.89	0.89
SPI	0.95	0.92
LPI	0.92	0.91
HPI	0.12	0.09
SDI	-0.53	-0.55

We also discuss two new measures of capital stock—physical (produced), human and ecological—recently developed by the World Bank and oddly called Adjusted Net Savings, and another by UNEP, the IWI. These two indicators are different from others in that they measure stocks not flows, and face considerable data challenges, but nevertheless, they are included as they provide much insight into the issues of weak and strong sustainability. *Weak sustainability* states that 'human capital' can substitute for 'natural capital'. *Strong sustainability* assumes that 'human capital' and 'natural capital' are complementary but not interchangeable. Under weak sustainability, progress is made even if natural capita is destroyed, but not so under strong sustainability. These concepts are not seen as alternates to the HDI, but as complements that shed light on sustainability.

GROSS HAPPINESS INDEX

The variables currently used to construct the GHI include: real GDP per capita, social support, healthy life expectancy, freedom to make life choices, generosity and perceptions of corruption. Data are collected from people in over 150 countries. Each variable measured reveals a populated-weighted average score on a scale running from 0 to 10 that is tracked over time and compared against other countries.

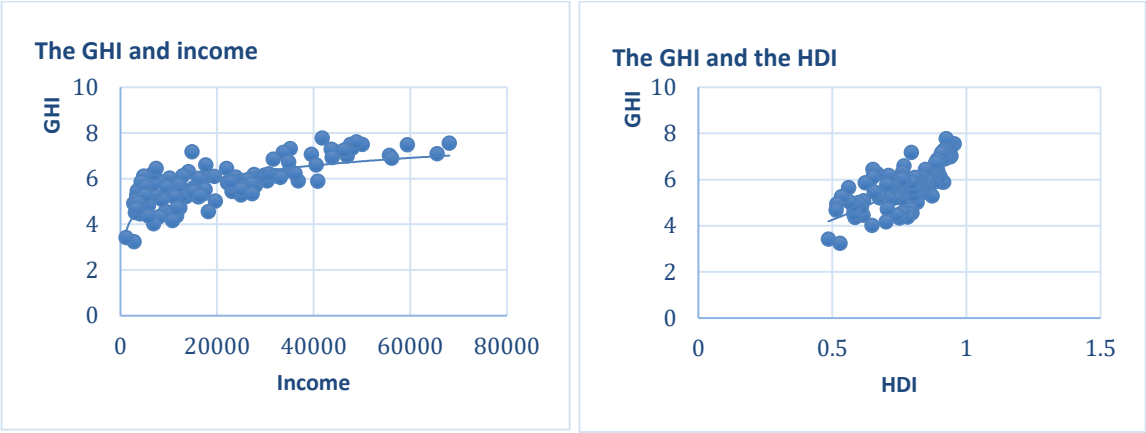
The rankings in the *World Happiness Report 2020* use data from the Gallup World Poll (for more information, see the poll methodology). The rankings are based on answers to the main life evaluation question asked in the poll. This is called the Cantril ladder: It asks respondents to think of a ladder, with the best possible life for them being a 10, and the worst possible life being a 0. They are then asked to rate their own current lives on that 0 to 10 scale. The rankings are from nationally representative samples for the years 2016 to 2018. They are based entirely on survey scores, using the Gallup weights to make the estimates representative. Sub-bars show the estimated extent to which each of six factors—levels of GDP, life expectancy, generosity, social support, freedom and corruption—contribute to making life evaluations higher in each country than they are

[5] There are other indices such as the Gross Well-being Index, but they are entirely perception based and are not included here. The ones reviewed partially use perception-based components.

in Dystopia, a hypothetical country that has values equal to the world's lowest national averages for each of the six factors.

Not surprisingly, as real GDP per capita and healthy life expectancy are used in this index as well as in the HDI, we see a similar pattern. As incomes rise, happiness increases, but more and more income buys you less and less happiness. The relationship between the GHI and HDI is also positive—more pronounced at a very high level on the HDI, above 0.8. At lower levels, more HDI does correlate with more happiness, but the relationship is quite flat (Figure 4). The main problem with the GHI is that it uses perception-based indicators, so it is not useful for measuring human development, given all the problems with such indices.

Figure 4: The GHI, income and the HDI



SUSTAINABLE DEVELOPMENT GOALS INDEX

The SDGI tracks country performance on all 17 SDGs. As such, the goals are weighted equally in the index. The score signifies a country's position between the worst (0) and the best or target (100) outcomes. Denmark's overall Index score (85) suggests that the country is on average 85 percent of the way to the best possible outcomes across the 17 SDGs. To ensure transparency and encourage further analyses, all underlying data are made available publicly. The index scores and ranks are not comparable to previous editions primarily due to changes in the basket of indicators. The SDGs are part of a dynamic agenda including inside the statistical community. Therefore, the number of indicators evolves when new evidence become available. In certain cases, the methodologies for certain indicators, including those produced by international institutions, are also revised based on global efforts to improve the quality of measures to monitor the SDGs.

The SDGI and its dashboard results are not directly comparable from one year to another considering slight adjustments made to the methodology and conclusions from an independent statistical audit. Three Scandinavian countries (Denmark, Finland and Sweden) top the 2019 SDGI. All countries in the top 20 are in

the Organisation for Economic Co-operation and Development. Even countries that perform well on the index, however, perform significantly below the maximum score of 100. Looking at trends, many high-income countries are not making significant progress on issues related to sustainable consumption and production, and the protection of biodiversity in relation to Goal 14 (life below water). Low-income countries tend to have lower SDGI scores. This is partly due to the nature of the SDGs, which focus to a large extent on ending extreme poverty and on access to basic services and infrastructure (SDGs 1 to 9). Moreover, poorer countries tend to lack adequate infrastructure and mechanisms to manage key environmental issues that are the focus of the SDGs. Except for those facing armed conflicts and civil wars, most low-income countries are making progress in ending extreme poverty and providing access to basic services and infrastructure, particularly under SDG 3 (good health and well-being) and SDG 8 (decent work and economic growth), as illustrated by the SDG trends dashboards.

It is hard to determine priorities from an index like the SDGI as it covers everything, but the United Nations SDG report for 2020 pushes for six clusters across the goals. These are:

Education, gender and inequality

Involving ministries of education, science and technology, gender equality and family affairs, this cluster covers investments in education (early childhood development, primary and secondary education, vocational training and higher education), social protection systems and labour standards, and research and development. It directly targets SDGs 1, 2, 4, 5, 8, 9 and 10, and reinforces other SDG outcomes.

Health, well-being and demography

This covers interventions to ensure universal health coverage, promote healthy behaviours, and address social determinants of health and well-being. It directly targets SDGs 2, 3 and 5 with strong synergies with many other goals. Implementation will need to be led by ministries of health.

Energy decarbonization and sustainable industry

This cluster groups investments in energy access; the decarbonization of power, transport, buildings and industry; and curbing industrial pollution. It directly targets SDGs 3, 6, 7, 9, and 11 to 15, and reinforces several other goals. Implementation will require coordination across many industries, including energy, transport, buildings and the environment.

Sustainable food, land, water and oceans

Interventions to make food and other agricultural or forest production systems more productive and resilient to climate change must be coordinated with efforts to conserve and restore biodiversity, and promote healthy

diets, alongside major reductions in food waste and losses. Important trade-offs exist among these interventions. Identifying and addressing these requires mobilizing a broad range of ministries, such as agriculture, forestry, environment, natural resources and health. This cluster directly promotes SDGs 2, 3, 6, and 12 to 15. Many other SDGs are reinforced by these investments.

Sustainable cities and communities

Cities, towns and other communities require integrated investments in infrastructure, urban services and resilience to climate change. These interventions target SDG 11 and contribute directly to SDGs 6, 9 and 11. Indirectly, virtually all SDGs are supported by this cluster, which relies on leadership from ministries of transport, urban development and water resources.

Harnessing the digital revolution for sustainable development

If managed well, digital technologies, such as artificial intelligence and modern communication technologies, can make major contributions to virtually all of the SDGs.

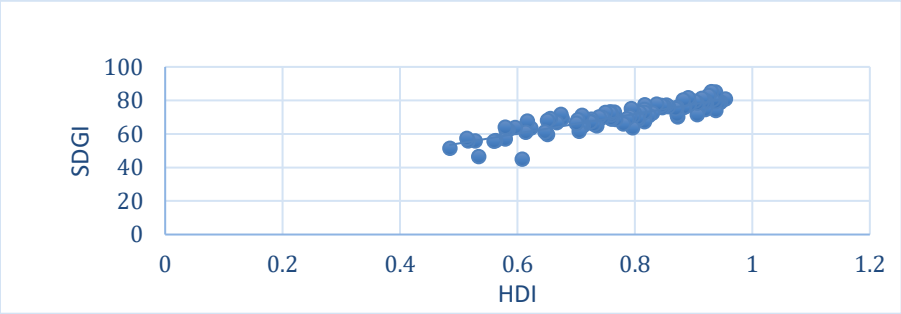
These are suggested pathways to progress, and while they could have been used to create an index with six components, the SDGI instead tries to measure progress on all 17 Goals. In those six synergistic clusters, had they been used to create an index, four would have had sustainability in their construction. The current SDGI otherwise suffers from 'weak' sustainability, since variables that measure climate action or ecological use are measured by only three goals on climate action, sustainable production and consumption, and life under water. It is therefore not surprising that sustainability does not have a strong impact on rankings. A country could make progress on 14 goals but do very badly on the 3 goals indicating progress on sustainability, and still do well on the overall index. The index suffers from what might be called TMI—'too much information'—and therefore cannot separate the forest from the trees.

Despite using 17 components, the SDGI, surprisingly, correlates strongly with the HDI, with a correlation coefficient of 0.89 (Figure 5). Nevertheless, there are some big changes in ranks among some countries. The United States drops from a rank of 15th on the HDI to 35th on the SDGI, Israel from 22nd to 49th, Saudi Arabia from 36th to 98th, and the United Arab Emirates from 35th to 65th. Other countries go the other way. France moves from 26th on the HDI to 4th on the SDGI, Costa Rica from 68th to 33rd, Thailand from 77th to 40th, Ecuador from 85th to 46th, the Maldives from 104th to 47th, and, surprisingly, China, considered to be a high polluter and the world's largest emitter of CO2, moves from 85th to 39th.[6]

[6] The HDI ranking covers 189 countries, while the SDGI ranking covers only 162 countries. Changes in rank are not standardized but nevertheless illustrate the direction of big changes.

One positive aspect of the SDGI is that through Goal 17, it tries to assess each country on its level of international cooperation; no other index does that. But the indicators contained under SDG 17 remain very much subject to country preferences.

Figure 5: The SDGI and HDI



SOCIAL PROGRESS INDEX

The SPI also attempts to measure well-being, but unlike the Gross Well-being Index, it tries to use measurable indicators and to link the measurement to the SDGs. The SPI claims to capture outcomes related to all 17 SDGs in a simple but rigorous framework, making SDG implementation a tangible reality for social innovators all over the world. With barely a third of the SDG indicators currently measured in a rigorous manner for most countries, the SPI claims to address a core measurement challenge. The index uses 52 indicators drawn from official United Nations data but also from globally respected research institutions and polling organizations to provide a comprehensive estimate of SDG performance even where formal indicators do not exist.

The index combines three dimensions: basic human needs, foundations of well-being and opportunity. Each dimension includes four components basic human needs, foundations of well-being and opportunity comprising. Basic human needs include – nutrition and basic medical care, water and sanitation, shelter and personal safety. Well-being includes access to knowledge, communications, health and wellness and environmental quality. Opportunity includes personal rights, personal freedom, inclusiveness and access to higher education.

Two key features of the SPI are the exclusion of economic variables, and the use of outcome measures rather than inputs. Nevertheless, the index also correlates very closely with the HDI, which is somewhat surprising as it does not include income (Figure 6, Table 2). But it does include many attributes of higher income such as access to higher education, shelter, justice, institutions and health care, which are found generally in greater abundance in higher-income countries. Its correlation coefficient at 0.95 with the HDI is the highest among all the indexes, as it also suffers from 'weak' sustainability. But there are differences. The United States and Saudi Arabia score much higher on the HDI compared to the SPI, whereas France, Ecuador and Jamaica see the opposite.

Figure 6: The SPI and the HDI

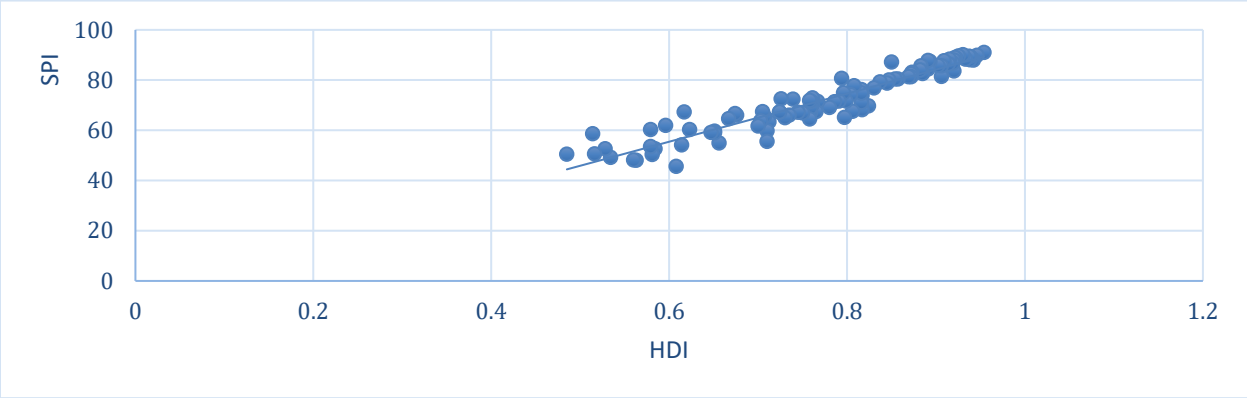


Table 2: Comparing ranks on the HDI and SPI[7]

	Country	*HDI rank*	*SPI rank*
	Norway	1	1
	Iceland	6	6
	Holland	10	11
	Republic of Korea	22	23
	Sri Lanka	71	65
	Thailand	77	72
	China	85	89
Higher HDI			
	United States	15	26
	Saudi Arabia	36	90
Lower HDI			
	France	26	15
	Ecuador	85	52
	Jamaica	96	50

[7] These are not standardized for the number of countries in each index: 189 for the HDI and 142 for the SPI. But nevertheless, they show the direction of change.

LEGATUM PROSPERITY INDEX

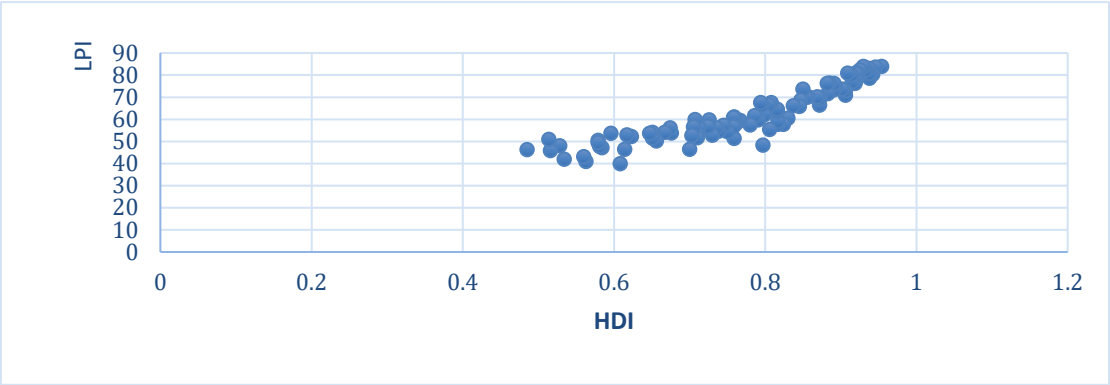
The Legatum Investment firm produces the LPI to measure prosperity. It is composed of 12 pillars that are given equal weight.

1. The Safety and Security pillar measures the degree to which conflict, terror and crime have destabilized the security of individuals, both immediately and through longer lasting effects.
2. The Personal Freedom pillar measures countrywide progress towards basic legal rights, individual liberties and social tolerance.
3. The Governance pillar measures the extent to which there are checks and restraints on power, and whether governments operate effectively and without corruption.
4. The Social Capital pillar measures the strength of personal and social relationships, social norms and civic participation in a country.
5. The Investment Environment pillar measures the extent to which investments are adequately protected and readily accessible.
6. The Enterprise Conditions pillar measures the degree to which regulations enable businesses to start, compete and expand.
7. The Market Access and Infrastructure pillar measures the quality of the infrastructure that enables trade, and distortions in the market for goods and services.
8. The Economic Quality pillar measures how well a state's economy is equipped to generate wealth sustainably and with the full engagement of its workforce.
9. The Living Conditions pillar measures the degree to which a reasonable quality of life is experienced by all, including material resources, shelter, basic services and connectivity.
10. The Health pillar measures the extent to which people are healthy and have access to the necessary services to maintain good health, including health outcomes, healthy systems, illness and risk factors, and mortality rates.
11. The Education pillar measures enrolment, outcomes and quality across four stages of education (pre-primary, primary, secondary and tertiary education) as well as skills in the adult population.
12. The Natural Environment pillar measures the aspects of the physical environment that have a direct effect on people in their daily lives and changes that might impact the prosperity of future generations.

The pillars have almost 250 indicators. Some are given higher weights than others, but it is not very clear how that is decided, presumably by several experts assigned to each pillar. Many indicators are judgments of experts or perception-survey based, such as corruption. Since the LPI also has weak sustainability—the natural capital pillar has a weight of one twelfth—it correlates very closely with the HDI, with a correlation coefficient of 0.92 (Figure 7). Like the GHI and the SDGI, the LPI has so many indicators, with some based on judgments, some based on perception surveys, and some on inputs and outcomes, that it is mélange of desirable elements. But

this makes it difficult to judge what is driving the results. The LPI also focuses heavily on markets, political freedoms and investment climate, and is like investment and competitiveness indices produced by the World Economic Forum.

Figure 7: The LPI and the HDI



HAPPY PLANET INDEX

The HPI is an index of human well-being and environmental impact introduced by the New Economics Foundation in 2006. The index is weighted to give progressively higher scores to nations with lower ecological footprints.

The index is designed to challenge well-established indices of national development, such as GDP and the HDI, which are seen as not taking sustainability into account. In particular, GDP is perceived as inappropriate, as the usual ultimate aim of most people is not to be rich, but to be happy and healthy. Furthermore, it is built on the belief that sustainable development requires a measure of the environmental costs, in other words, 'strong' sustainability.

The HPI combines four elements to show how efficiently residents of different countries are using environmental resources to lead long, happy lives.

1. Well-being: How satisfied the residents of each country feel with life overall, on a scale from 0 to 10, based on data collected as part of the Gallup World Poll.
2. Life expectancy: The average number of years a person is expected to live in each country based on data collected by the United Nations.
3. Inequality of outcomes: The inequalities between people within a country in terms of how long they live and how happy they feel, based on the distribution in each country's life expectancy and well-being data.

4. Ecological footprint: The average impact that each resident of a country places on the environment, based on data prepared by the Global Footprint Network.

HPI = (Well-being) x (Life Expectancy) x (Inequality of Outcomes) / (Ecological Footprint)

The HPI tries to measure sustainable well-being for all, and how well nations are doing at achieving long, happy sustainable lives. Wealthy Western countries, often seen globally as representing success, do not rank highly on the HPI. Instead, several countries in Latin America and the Asia and the Pacific region lead the way by achieving relatively high life expectancy and well-being with much smaller ecological footprints. The HPI shows that it is possible to live good lives without costing the Earth. Its correlation coefficient with the HDI is a low 0.12 (Figure 8, Table 3).

Figure 8: The HPI, HDI and Inequality-adjusted HDI

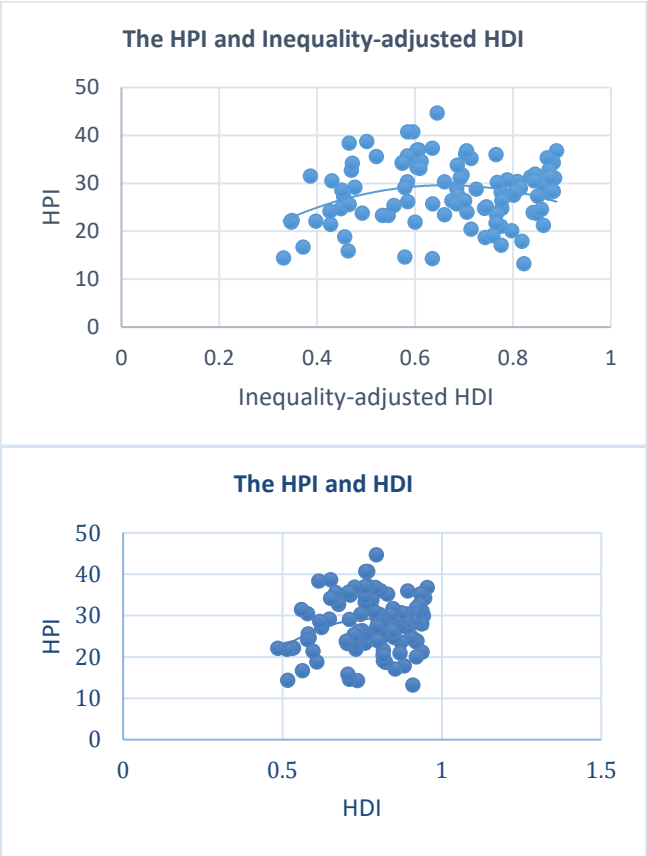


Table 3: Top 10 countries on the HPI

Country	*HDI* Rank	*HDI* Score	*HPI* Rank
Costa Rica	68	0.794	1
Mexico	76	0.767	2
Colombia	79	0.761	3
Australia	6	0.938	105
Canada	13	0.922	85
United States	15	0.92	108
Netherlands	10	0.933	18
Spain	25	0.893	15
Nicaragua	126	0.651	7
Bangladesh	135	0.614	8

The HPI peaks at around an HDI value of 0.8, the cut-off value for countries to move from high to very high human development. The optimal range for the HPI appears to be in the HDI range of 0.7 to 0.8, which is classified as high human development. In the latest rankings of the HPI, Costa Rica is number 1, compared to 68th on the HDI with a score of 0.794. Panama is ranked 67th on the HDI with a score of 0.795, but 6th on the HPI. Mexico is ranked 76th on the HDI but 2nd on the HPI.

A notable feature of the HPI is its simplicity. It includes ecological sustainability as well as inequality in outcomes. It is a perception-based index as well-being is taken from the World Gallup Poll, which is also used in the GHI, SDGI and SPI. The HPI gives very high scores to countries like Colombia, Costa Rica and Mexico, and very low scores to ecology-intensive countries such as Australia, Canada and the United States. The index has many flaws, starting with being a perception-based index. As a result, it ends up giving surprisingly high scores to much poorer countries like Bangladesh and Nicaragua. Since inequality features heavily in the HPI, it may be more correlated with the Inequality-adjusted HDI, but surprisingly that is not the case. The correlation between the two falls to 0.09. The plot between the Inequality-adjusted HDI and HPI is not very different from that with the HDI. This suggests that the main reason for high rankings on the HPI is not inequality, but the introduction of ecological footprint. Countries with the highest rank on the HPI—Costa Rica, Mexico and Colombia—have quite high inequality resulting in losses on the HDI of 18.7 percent, 22.5 percent and 23.1 percent. respectively.

SUSTAINABLE DEVELOPMENT INDEX

The SDI measures the ecological efficiency of human development, recognizing that development must be achieved within planetary boundaries. It was created to update the HDI for the ecological realities of the Anthropocene. The SDI starts with each nation's human development score (life expectancy, education and income) and divides it by the ecological overshoot, or the extent to which consumption-based CO2 emissions and material footprint exceed per capita shares of planetary boundaries. Countries that achieve relatively high

human development while remaining within or near planetary boundaries rise to the top. But unlike the HPI, which uses ecological capacity as a measure of ecological overshoot, the SDI uses other indicators of sustainability: CO2 emissions and material footprint.

The SDI is calculated as the quotient of two figures: a 'development index' calculated as the geometric mean of the education index, life expectancy index and modified income index, and an 'ecological impact index' calculated as the average overshoot[8] of CO2 emissions and material footprint vis-à-vis their per capita planetary boundaries, indexed on a natural exponential scale.

The formula can be described as follows:

SDI=Development Index / Ecological Impact Index

Development Index = Geometric Mean of Education *Life Expectancy *Income; Education Index is as in HDI; Life Expectancy Index is as in HDI

Income Index = there is no extra benefit for income above $20,000.

Ecological Impact Index = is the average overshoot of CO2 emissions and material use over planetary boundaries

The SDI divides human development by a composite metric of ecological impact that incorporates both CO2 emissions per capita and material footprint per capita. This is the first development index to take this dual approach. It renders both indicators in consumption-based terms; in other words, it accounts for international trade by adding the emissions and materials embodied in imports (including upstream emissions and resources involved in producing and shipping imported goods) and subtracting that of exports (see Wiedmann et al. 2015; Gutowski, Cooper and Sahni 2017). This allows it to account for the fact that, in an era of globalization, high-income countries have shifted much of the extraction and production side of their consumption abroad, effectively outsourcing their ecological impact.

[8] Average overshoot (AO) is calculated as follows. Material footprint and emissions values are each divided by their respective per capita planetary boundary (which varies by year depending on population size) to determine the extent of boundary overshoot (or undershoot). This also standardizes the units. If the result of either division is less than 1 (undershoot) it is rendered as 1. Then the results are averaged using the geometric mean. This method ensures that a country cannot compensate for overshooting one boundary by undershooting the other. Overshoot of either boundary will yield average overshoot greater than 1. In the ecological impact index, AO is indexed on a natural exponential scale. Given the uncertainties around the precise definition of planetary boundaries, this allows some leeway for small amounts of overshoot. Adding 1 ensures that the minimum result is 1 (no overshoot). For countries that have no overshoot, their development index is therefore unaffected. Once overshoot reaches four times the planetary boundary, the ecological impact index registers 2, thus cutting the development index in half. Thereafter a linear function applies. This method ensures that the SDI is an indicator of strong sustainability. Countries cannot use low ecological impact to compensate for poor performance in human development. And strong performance in development cannot compensate for high negative ecological impact.

Given strong constraints on valuing income above $20,000, the results of the index are not surprising. The SDI is highest at a level of income of $15,000 per capita in purchasing power parity (PPP). Countries such as Cuba, Costa Rica and Sri Lanka score very high (Table 4), whereas developed countries, especially Australia, Canada and the United States, score very low. Among the middle-income countries, China is a huge outlier, and despite the adjustments in trade to account for consumption not production, it scores quite low on the SDI.

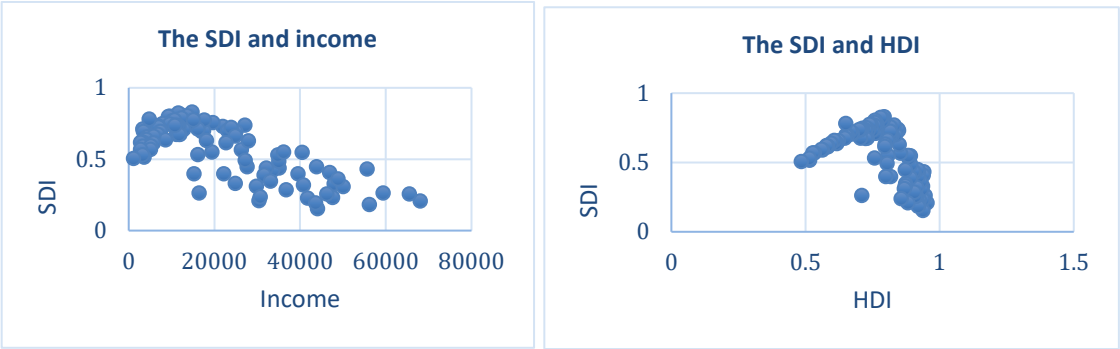
Table 4: Top 10 countries on the SDI

SDI rank	*Country*	*SDI*	*Life expectancy (years)*	*Education index*	*GNI per capita (PPP)*	*Material footprint (tons per capita)*	*CO2 emissions (tons per capita)*
1	Cuba	0.859	79.6	0.768	21,000	8.04	3.42
2	Costa Rica	0.830	79.6	0.713	14,086	8.08	2.66
3	Sri Lanka	0.825	75.1	0.751	10,791	3.88	1.03
4	Albania	0.811	78.2	0.733	11,083	10.92	2.32
5	Panama	0.808	77.8	0.681	18,167	7.85	3.77
6	Algeria	0.805	75.9	0.662	13,338	3.03	1.96
7	Georgia	0.801	73.1	0.831	8,766	9.12	3.07
8	Armenia	0.800	74.4	0.746	8,517	7.63	1.99
9	Azerbaijan	0.798	71.9	0.709	16,334	5.91	3.24
10	Peru	0.788	74.7	0.686	11,420	9.38	2.14

The relationship between the HDI and the SDI is also very interesting. As with the HPI, as the HDI rises above 0.8 as the threshold for very high human development, the SDI drops. But in this case, because the ecological variables are even stronger, accounting not only for material use but also for CO2 emissions, the drop is much sharper. This drop-off is also due to income levels above $20,000 in PPP terms not contributing to a higher score on the SDI scale. Any increase in income above that only adds to the ecological cost, which drives down the score (Figure 9).[9]

[9] Instead of putting an arbitrary cap on income, another option would be to take a logarithmic scale for income.

Figure 9: The SDI, income and the HDI



ADJUSTED NET SAVINGS: MEASURING THE WEALTH OF NATIONS

Adjusted net savings is derived from the standard national accounting measure of gross savings by making four adjustments:

1. Consumption of fixed capital is deducted to obtain net national savings.
2. Current public expenditure on education is added to account for investment in human capital.
3. Estimates of the depletion of a variety of natural resources are deducted to reflect the decline in asset values associated with extraction and depletion.
4. Deductions are made for damages from CO2 and particulate emissions.

The indicator is then computed by dividing adjusted net savings by gross national income (GNI).

Adjusted net savings provides a measure of a country's sustainability by measuring the change in comprehensive wealth during a specified accounting period. In particular, it provides a test to check the extent to which today's rents from a number of natural resources (i.e., changes in natural capital) and changes in human capital are balanced by net savings (i.e., changes in human-made capital), that is, this generation's bequest to future generations.

Adjusted net savings measures the change in value of a specified set of assets, excluding capital gains. If a country's net savings is positive, and the accounting includes a sufficiently broad range of assets, economic theory suggests that the present value of social welfare is increasing. Conversely, persistently negative adjusted net savings indicates that an economy is on an unsustainable path.

Gross savings are the difference between GNI and public and private consumption, plus net current transfers. Consumption of fixed capital represents the replacement value of capital used in production. Net savings are gross savings minus the value of consumption of fixed capital. Education expenditure refers to public current

operating expenditures in education, including wages and salaries, and excluding capital investments in buildings and equipment. Energy depletion is the product of unit resource rents and the physical quantities of energy extracted. It covers coal, crude oil and natural gas. Mineral depletion is the product of unit resource rents and the physical quantities of minerals extracted. It refers to tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite and phosphate. Net forest depletion is the product of unit resource rents and the excess of round wood harvest over natural growth. Carbon dioxide damage is estimated to be $20 per ton of carbon (the unit damage in 1995 US dollars) times the number of tons of carbon emitted. Particulate emission damage is the willingness to pay to avoid mortality and morbidity attributable to particulate emissions. Adjusted net savings are net savings plus education expenditure and minus energy depletion, mineral depletion, net forest depletion, and CO2 and particulate emissions damage.

Adjusted net savings is calculated as: ANS = GNS – CFC + EDU – NRD – GHG – POL, where ANS = adjusted net savings; GNS = gross national savings, calculated as the difference between GNI and public and private consumption, a standard item in the System of National Accounts; CFC = consumption of fixed capital, the replacement value of capital used in production, also a standard item in the System of National Accounts; NRD = net resource depletion; GHG = greenhouse gas emissions; POL = air pollution; and EDU = current public expenditure on education.

Standard savings measures only count as an investment in the portion of total expenditure on education (usually less than 10 percent) that goes towards fixed capital such as school buildings; the rest is considered consumption. Within the adjusted net savings framework, which considers human capital to be an asset, expenditure on its formation cannot be labelled as simple consumption. As a lower-bound first approximation, the calculation thus includes current operating expenditures in education, including wages and salaries, and excludes capital investments in buildings and equipment. Natural resource depletion is calculated as the sum of net forest depletion, the depletion of fossil energy resources, and metals and minerals depletion. Net forest depletion is unit resource rents times the excess of round wood harvest over natural growth.

The accounting of natural resource depletion and pollution costs still has some gaps. Key estimates missing on the resource side include the value of fossil water extracted from aquifers, net depletion of fish stocks, and depletion and degradation of soils. The energy and mineral depletion figures are part of a range of depletion estimates that are possible depending on assumptions made about future quantities, prices and costs, likely at the high end of the range. Because the net forest depletion estimates reflect only timber values, they ignore all external and non-timber benefits associated with standing forests.

Changes in total wealth provide a measure of 'weak' sustainability in assuming a high degree of substitution possibilities among different kinds of assets. Where assets are complements rather than substitutes, and where serious irreversibility is likely to occur, this assumption does not hold. For example, an increase in fishing vessels

cannot compensate for heavily depleted fish stocks. We have seen that in some countries, the conversion of forestland to agricultural land did not reduce total wealth, but the impacts on sustainability are likely not fully captured. Wealth should be paired with biophysical measures of natural capital, particularly critical natural capital that performs important and irreplaceable functions, as well as with measures of good governance and institutions needed for sound management of wealth. Given this, it is not surprising that the growth in wealth per capita is highly correlated with growth in GDP per capita.

INCLUSIVE WEALTH INDEX

UNEP has created a wealth index similar in concept to the Adjusted Net Savings database, but with some differences. First, the IWI measures education capital not through education expenditures but as returns to education. Second, it recognizes additions to natural capital coming from increases in agricultural land, non-renewable capital, and capital gains to existing stocks of natural capital. In World Bank calculations, urban land is classified as produced capital and protected land is included in natural capital. The IWI incudes estimate of fish stocks and their changes. Nevertheless, overall global shares of capital between produced, human and natural capital are very similar at 24 percent, 64 percent and 11 percent, respectively, for the IWI, and 27 percent, 64 percent and 9 percent, respectively, for the World Bank calculations.

One advantage of the IWI is that it provides separate estimates of the different types of capital, helping to delineate 'weak' versus 'strong' sustainability. Yamaguchi, Islam and Managi (2019) analyse the 2018 IWI and show that of the 140 countries included, most see an increase in inclusive wealth. But if we adjust for population growth, only about 60 percent show an increase per capita. In most cases, countries use up natural capital to produce human and produced capital. The rate of conversion is 4 to 3; roughly, a 20 percent decline in natural capital increases human capital by 15 percent. If strong sustainability criteria are applied—namely, that natural capital per capita does not decline—only 14 countries meet these. They have very limited stocks of natural capital to start with, or have very large oil stocks revalued over time. The biggest difficulty in all these estimates is the reliability and comparability of data across countries.

IWI correlations are possible only between changes in IWI per capita and the HDI, and show very low correlation. But they do show that in a very large number of countries (almost 40 percent of those included), where HDI growth is positive, IWI per capita growth is negative. This result holds under different measures of IWI per capita. But more work is needed to understand these results as there are some surprising findings. For example, both China and India, the two largest countries in the world, show very positive growth in HDI and IWI per capita despite huge CO2 emissions and massive environmental problems in terms of both air and water quality (UNEP 2018). Overall, the results provide yet another compelling reason to include sustainability in an expanded HDI.

A way forward: bringing sustainability, human security and vulnerability into the HDI

"That roars so loud and thunders in the index." William Shakespeare

The HDI clearly needs a revision. But how can we do this while keeping its essence? Amartya Sen's original writings include freedoms but also unfreedoms, those that constrain humans in exercising their opportunities. These could arise from an environment affected by climate change, but also from societies affected by crime and conflict, or from living under corrupt and unresponsive government. At a minimum, if we follow the logic of the original writings on the concept of human development, we need to consider expanding the HDI along two dimensions—security and climate change/ecological use.

Human rights and democratic rights are also important issues, but are open to interpretation and definition, and are therefore excluded here. In general, indicators that are perception-based are also excluded. Governance is now an accepted contributor to economic and social development, but there is no good measure available,[10] and it is a means to an end, not the end itself. Human rights and democracy are subject to various interpretations. With no global consensus on how best to define let alone measure them, their inclusion will generate more controversy and political debate.

The SDG agenda covers many of these issues but with 17 goals and 169 targets is unmanageable as a useful way to capture progress in an index. The SDGI tries to do that, but it is hard to see the forest from the trees. We need a more compact measure that captures the main drivers of human development. The HDI must be expanded, no doubt, but in a way that makes it as useful as the HDI became in its initial decade. Otherwise, we end up with comprehensive measures that are hard to understand and unpack.

One practical way forward is to look at people's revealed priorities. The United Nations My World survey[11] asks people around the world to vote on their priorities. The top nine global priorities based on the latest results of the survey are:

- Good health
- Decent work and economic growth
- Quality education
- Gender equality
- Clean water and sanitation

[10] Only perception-based indicators are available.
[11] This is an ongoing web-based survey that the United Nations started at the inception of the SDGs—with over 1 million respondents.

- No poverty
- Reduced inequalities
- Peace (security), justice and strong institutions (responsive government)
- Climate action

The current HDI includes many of these priorities. Missing elements comprise clean water and sanitation; peace (security), justice and strong institutions (responsive government); and climate action. These gaps are surprisingly similar to what we see coming from a review of development literature. Ecological sustainability must be introduced even with the crude variables available, such as CO2 emissions or ecological capacity use, keeping in mind these are not cruder than the ones in the existing HDI. Human security is also a key freedom that must be addressed as laid out so clearly in the 1994 *Human Development Report* and subsequently in the 2014 *Human Development Report*. But we need to find measurable and universal indicators for it. Intentional deaths are the only clear and straightforward measure available universally. This indicator may not be perfect but would be a start and an opportunity to spur more attention to human security measures.

REPLACE INCOME IN THE HDI WITH OTHER MEASURES OF WELL-BEING?

One critique of the HDI is that if the index was developed to replace income, then why include income in it with a weight of one third? Even Anand and Sen (2000b) agonize over this issue. So the question arises: Why not include other attributes of well-being such as food, housing, clothing, energy or even Internet access instead of income?

The HPI does not use income, but a perception-based measure of well-being from the World Gallup Poll survey. The SDI uses GNI but caps it at $20,000 GNI per capita (PPP). Income above that threshold does not provide any extra credit to the country's score. Even though the SDI is maximized at an income below that threshold, at around $15,000 per capita (PPP), the income constraint itself is not the binding factor. As we have also seen, when we compare the HDI to several indicators, such as the GHI, the SDGI, the SPI or the LPI, none of which use income in their calculations, it does not matter so much. These indicators correlate very much with income, as one would expect they would.

Yet if the entire purpose of developing the HDI was to explore an alternate to income, then it makes sense to bring in other measurable attributes of well-being for at least two reasons. First, there are countries where the GNI comes from purely exploiting the ecological resource base. Second, the introduction of multidimensional poverty indicators shows that not only is it possible to get better measures of poverty than just income poverty, but that such measures, which are gaining wider acceptance, allow more actionable programmes to address poverty. They give a better picture of deprivations by country and even within different regions in a country, shedding greater clarity on how to address those deprivations. Similarly, if the HDI used access to shelter, water

and sanitation, electricity, the Internet, food and clothing instead of food alone, it would provide a better measure of various areas in which countries must progress to gain better quality of life and better opportunities for people to improve their lives.

The Multidimensional Poverty Index (MDPI) uses 10 input indicators – years of schooling, school enrolment, nutrition, child mortality, cooking fuel, sanitation, water, electricity, flooring and asset ownership. It does not use any outcome indicators, such as life expectancy or income (Alkire and Foster 2011). For health, it combines child mortality and nutrition. The HDI could keep its existing indicators on education and health (health-adjusted life expectancy) and combine it with standard of living indicators from the MDPI or some modifications thereof. One item that is missing in the MDPI, but which might be considered a vital necessity, is access to the Internet and mobile telephony. In today's world, the poor cannot survive without some basic access to information technology. Like with many other things that provide better life, access across the world correlates highly with income.

INEQUALITY: HOW TO HANDLE?

As we saw, the HPI introduces inequality directly into the measure, but only captures inequality in well-being based on the distribution of the survey data it uses and the distribution in life expectancy. It does not tell us about other inequalities such as in access to education, or related to gender, race, religion, etc.

It is important to include all types of inequalities not just in well-being and life expectancy as is the case in the HPI, but also in other aspects, such as access to education, health, income and opportunity. The HDI has handled this issue by creating the Inequality-adjusted HDI indicators, and building indicators for gender development and gender inequality. These give a good picture of the nature and depth of inequality; the methodology could be applied to any revised HDI as well. There is a huge drop in the HDI when it is adjusted for inequality. For countries for which an Inequality-adjusted HDI is available, the loss in human development due to inequality reduces the number of countries with very high human development scores from 51 to 26, and with high scores from 53 to 23. It increases those rated as low human development from 35 to 55. More than 40 countries drop from high and very high scores; 20 countries fall into the low category (Table 5).

Table 5: How inequality affects the HDI

Number of countries	HDI, 2018	Inequality- adjusted HDI, 2018
Very high human development	51	26
High human development	39	23
Medium human development	36	39
Low human development	35	55

Any measure of human development must capture inequalities. In fact, inequality often correlates with aspects of criminality, conflict and vulnerability. Very unequal societies also tend to generate more social conflict and have more vulnerable population shares, affecting many aspects of well-being and life expectancy (Wilkinson and Picket 2018). But as we will see, vulnerability and inequality adjustments to the HDI produce somewhat different results because not all unequal societies are vulnerable, and not all vulnerable societies are necessarily unequal. These dimensions often occur together but not always, and must be addressed in different ways.

INTRODUCING ECOLOGY AND SUSTAINABILITY INTO THE HDI

There is no doubt that the existing HDI is inadequate in not including any measure of sustainability. Two other indices, the SDGI and the SPI, use environmental variables, but achieve at best 'weak' sustainability. They capture some elements of sustainability, but their use will not lead the world down a path towards zero emissions by 2050 and the target of even a 2 degree Celsius temperature rise, let alone 1.5 degrees. Two other indices, the HPI and the SDI, use 'strong' sustainability indicators. The relationship between these indicators and the HDI peaks at an HDI value of around 0.8, the level at which currently countries move from high human development to very high human development. In that sense, 'high HDI', with a score of 0.7 to 0.8, is the optimal level of human development under today's economic model and technology. Any effort to go above that level to very high human development appears to run into ecological constraints.

The HPI uses ecological capacity in its measurement, but is not updated regularly. Nevertheless, it is a meaningful indicator that could be used to extend the HDI. The SDI uses a combination of CO2 emissions and material use. The former is an obvious measure as its effects are so evident globally. CO2 mitigation is probably the most significant climate action, having huge global externalities. Other pollutants could also be considered, as they have more local externalities, such as air quality. They could be captured broadly by SO2 emissions. If ecological use is not regularly updated, some measure of water depletion, land degradation or forest cover could be utilized as well. Biodiversity loss is also important. These are all to some extent captured in ecological capacity use.

It is clear is that a combination of CO2 emissions and ecological use must be introduced to measure the sustainability of human development. Having accepted that, should we penalize countries based on production or consumption? Norway produces a lot of oil, which makes it rich, but does not consume any of it. It powers its own economy mostly with hydropower. But it is exporting vast quantities of oil consumed elsewhere, possibly even to produce goods consumed by Norwegians. This creates CO2 emissions and air pollution in those places. At the same time, Norway ranks first on the HDI and SPI. Costa Rica scores high on sustainability, but relies on tourism and consumes many items produced elsewhere that cause pollution. The big question that

arises when sustainability indicators are introduced is whether to count them against the consuming or producing country.

One could make the case for both. If a country does not follow sustainable methods of production to produce cheaply for the rest of the world, it should be penalized in the rankings for sustainability. But one could also argue that consumers, especially richer countries, shift production to countries with weaker environmental standards and are equally to blame for the resultant environmental degradations. No clear conclusion is available on this issue; it could be quite easy to produce variants of the HDI that provide both measures.

The SDGI includes measures for sustainable consumption as well as production as one of its goals, so Norway drops in rank there to 12th. The SDI provides measures based on consumption and adjusts production figures for net trade. Going forward, it should be possible to provide indicators with both measure, production as well as consumption, since trade data are available in sufficient detail to make the calculations both for consumption and production.

INTRODUCING HUMAN SECURITY

Goal 16 of the SDGs on peace, justice and institutions is an important recognition of the importance of human security, stronger institutions and better government The World Bank produces the Worldwide Governance Indicators (WGI), but they are largely based on perception surveys or judgments of experts. Governance is defined in these indicators as the traditions and institutions by which authority in a country is exercised. This includes the process by which governments are selected, monitored and replaced; the capacity of the government to effectively formulate and implement sound policies; and the respect of citizens and the State for the institutions that govern economic and social interactions among them.

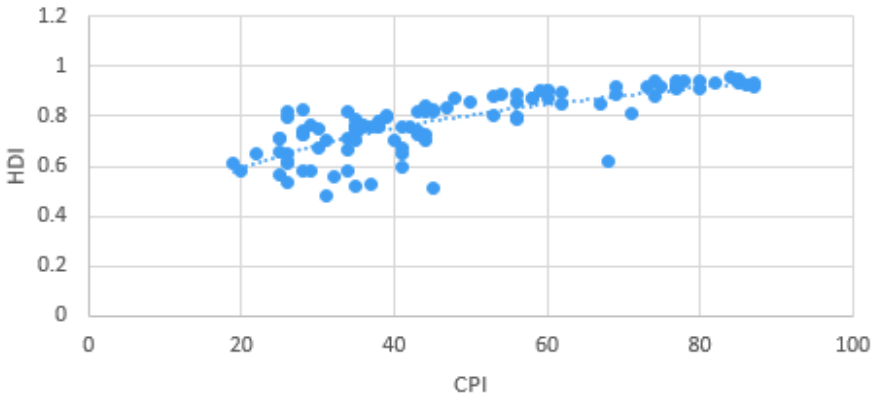
The WGI cover six broad dimensions of governance for over 200 countries and territories from 1996 to 2018: voice and accountability, political stability and absence of violence, governance effectiveness, regulatory quality, rule of law and control of corruption (Figure 10).

As composite governance indicators, the WGI are based on over 30 underlying data sources, typically surveys and expert judgments These data sources are rescaled and combined to create the six aggregate indicators using a statistical methodology known as an unobserved components model. If perception survey indicators are included in an extension of the HDI, corruption surveys could be used.But it may be better not to include perception surveys, as they are subject to considerable error when used across countries. Perception-based corruption indicators such as those from Transparency International are also available and correlate strongly with the HDI.

Some well-known criticisms of the WGI are:

- Too complex: The WGI 'control of corruption' index uses 23 combinations of sources just for Eastern Europe and Central Asia. The number and diversity of indicators produced by others in a single WGI index makes it very difficult to understand. Only four pairs of country ratings are based on a common set of sources.
- Arbitrary: For example, the WGI use the indicator 'environmental regulations hurt competitiveness' from the World Economic Forum's Executive Opinion Survey, but ignores that survey's questions that give high ratings to countries with a high standard of environmental protection.
- Absence of an underlying theory of 'good' governance: No normative concept or unifying single theory to distinguish between good or bad governance is applied. When are taxes, labour or environmental regulatory protection desirable, and when are they excessive? The six governance indicators measure a broad underlying concept of 'effective governance'. They appear to say the same thing, with different words, and do not discriminate usefully among different aspects of governance. Each of the indexes, whatever its label, merely reflects perceptions of the quality of governance more broadly.
- Hidden biases: A low weight is given to household surveys relative to the weights of expert assessments and firm surveys.

Figure 10: The HDI and the WGI Corruption Perception Index



Source : World Bank WGI and author's calculations.

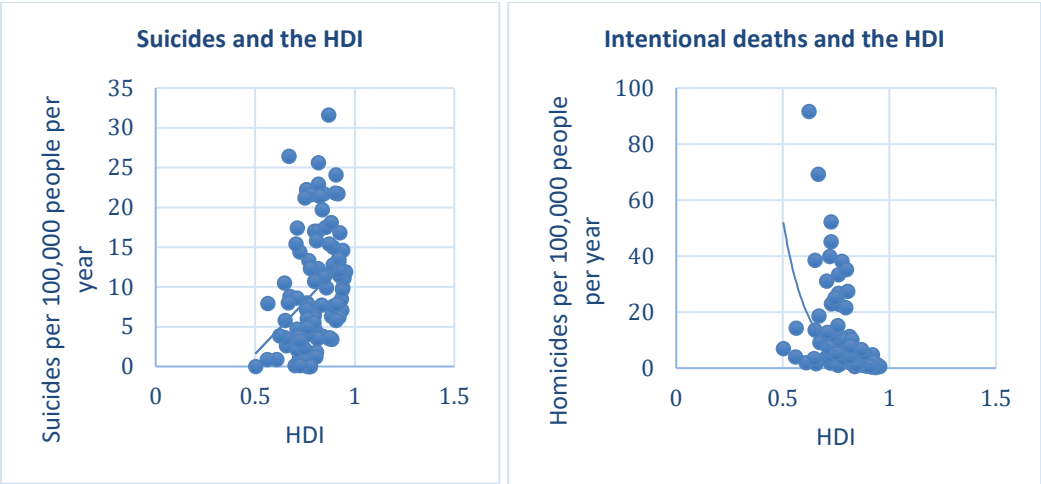
Governance and institutions are both an outcome and an input into economic development. The direction of causality is not clear, and the interactions between institutions and economic development is complex. Nevertheless, without security and reasonably honest government, there is ample evidence that economic and social development is impaired. It is not so easy to measure institutional strength except through perception surveys. They inevitably show that more developed countries have better institutions, almost tautologically. Unpacking peace, justice and strong institutions into more practical measures leads to what people want: safety from crime and violence, and honest, responsive government.

What is measurable is intentional deaths (homicide and conflict-related deaths) per 100,000 per year for most countries. This is the most basic outcome indicator of insecurity and lawlessness. And while it may also be subject to accurate measurement, it is clear, universal and available.

Also available are measures of the proportion of the population subject to sexual violence, and the number of victims of human trafficking per 100,000 population. There are survey-based indicators of corruption for people and businesses as well as indicators of responsive government based on delivery of services. Some combination of these could be used, but the number of intentional deaths (including suicides) and some indicators of sexual violence would be a good place to start. Data are also available on prison populations, but largely depend not only on the extent of criminality, but on widely disparate laws and procedures. For example, the United States prison population numbers swell because of minor drug-related offences. China has a huge prison population due to political crimes. Such figures are not a reliable measure of criminality itself.

Suicide data are also available, but reflect a society's underlying social malaise and loneliness, not a governance related problem per se. Suicide rates appear to rise with higher levels of human development, a somewhat surprising result, and homicides and conflict-related deaths fall with higher HDI. Studies have shown that suicide rates climb with increasing levels of HDI, and there is significant correlation between the incidence of suicide and GNI, life expectancy, urbanization, etc. (Figure 11). For example, Khazaei et al. (2017) showed that the global prevalence of suicide was 10.5 per 100,000 individuals, which significantly varied according to gender (16.3 in males compared to 4.6 in females) and different levels of human development (11.64 per 100,000 individuals in very high development countries, 7.93 per 100,000 individuals in medium development countries, and 13.94 per 100,000 individuals in high development countries).

Figure 11: Suicides, intentional deaths (homicides) and the HDI



Source: WHO and the author's calculations.

At a minimum we could include intentional deaths if not suicides as an outcome-based, measurable indicator of human security. If intentional deaths were included in a new HDI, one would expect that Latin America, except for Argentina, Chile and Peru, will drop in rankings. Countries in Africa mired in conflict such as the Democratic Republic of the Congo and Sudan would also drop. In South Africa, criminality would cause a drop, and in Japan, Finland, Iceland and the Republic of Korea, high suicide rates would come into the equation. In some countries such as Belarus and Russia, both suicide and homicides are high and would affect the rankings. But clearly, we do not yet have a very satisfactory way of handling security and issues like governance in the HDI. More work would be needed on these measures.

INTRODUCING VULNERABILITY INTO THE HDI

Earlier we discussed risk and uncertainty, and the concept of vulnerability, which was a major theme of the 2014 *Human Development Report*. Dealing with any risk, whether it be economic, health or ecological, involves mitigation and adaption. The inability to adapt is a major factor increasing vulnerability. But vulnerabilities arise not just from lack of ecological or climate mitigation. Some structural vulnerabilities arise from many other weaknesses in economic and social systems around the world and across geographies. Following Guillaumont (2011), it is useful to distinguish between economic and ecological shocks and the resulting vulnerabilities even though some policy and institutional safety nets address both types of risks. There is an obvious need to address vulnerability in any new HDI. How best to introduce it into the index is not so straightforward. Here we offer two suggestions.

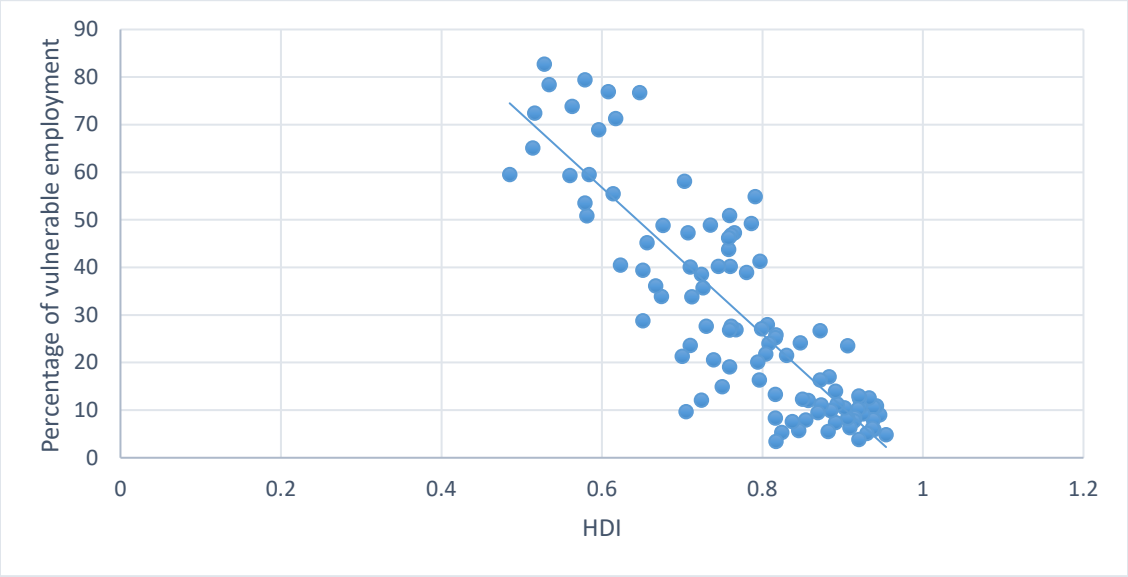
One option is to create a vulnerability-adjusted HDI, just like the Inequality-adjusted HDI. It would capture the proportion of people who could fall back into poverty or suffer a drastic fall in consumption due to an exogenous ecological shock. This could be a pandemic or a climate-induced natural disaster, such as a typhoon, tornado, cyclone, flood or fires. It might affect income and health and possibly education. Vulnerability-adjusted indices would indicate the types of policies, such as for better social safety nets or more sustainable livelihoods, that are needed to reduce vulnerability or the potential loss in human development from an unforeseen future shock.

The United Nations Department of Economic and Social Affairs produces the Economic Vulnerability Index to classify countries as least developed and define graduation criterion. The index comprises eight indicators: population size; remoteness; merchandise export concentration; share of agriculture, forestry and fisheries in GDP; homelessness owing to natural disasters; instability of agricultural production; instability of exports of goods and services; and the share of the population living in low elevation coastal zones. It is only available for about 60 developing countries, although in principle the data could be assembled for all countries. This index could also be a candidate for use in the HDI, but is missing several aspects of vulnerability, such as vulnerable employment, health-related vulnerabilities, and vulnerability to crime and conflict. It was designed,

and is perhaps more suited, for classifying countries as least developed but not as a broader index of vulnerability.

The level of vulnerable employment could be a much broader measure of vulnerability (Figure 12). It is highly correlated with the HDI, but that itself points to the need for social safety nets. Appendix 1 provides variations of a vulnerability-adjusted HDI using the share of vulnerable employment as a measure of vulnerability. These are based on three different probabilities of shocks to livelihoods—1 percent, 2 percent and 5 percent—for the 102 countries used in all calculations for this paper with data across all indicators. An extended HDI with ecological vulnerability using the Notre Dame Vulnerability Index is also calculated. The proportion of the population without health insurance would be another measure of vulnerability, as any illness would knock these people into poverty or make them suffer a substantial decline in their living standard. UNDP puts out a measure of relative poverty, which classifies you as poor if you fall below a median income level, but this is akin to measuring inequality and not necessarily vulnerability.

Figure 12: Vulnerable employment and the HDI



Source: UNDP 2019 and author's calculations.

Table 6 shows the impact of these adjustments on the number of countries in different categories of the HDI. At a shock probability of 2 percent, the number of countries in the low HDI category increases from 5 to 17, and with a 5 percent shock probability increases further to 36 countries out of 102 countries, including some large countries like India. In this case, 18 countries drop out of the very high human development category. Vulnerability affects the high human development category quite dramatically as well as 19 countries drop out. The combined drop of high and very high human development countries is 37 out of 79. The changes in the vulnerability-adjusted HDI are quite different from those coming from the Inequality-adjusted HDI. For

example, the low human development category sees a much bigger increase, and the high human development category sees a much bigger decline from vulnerability than from inequality. This provides a new perspective on challenges to progress on human development.

Table 6: How vulnerability affects the HDI

Number of countries by HDI category	HDI	Inequality-adjusted HDI	Vulnerability-adjusted HDI (2% shock)	Vulnerability-adjusted HDI (5% shock)	Extended HDI with Notre Dame Vulnerability Index added
Very high	47	25	38	29	30
High	32	21	18	13	34
Medium	18	35	29	24	31
Low	5	21	17	36	7
Total	102	102	102	102	102

Source: See Appendix 1 for detailed calculations.

A second approach would be to introduce vulnerability directly into the HDI by measuring the degree of risk exposure as the extent of insurance one needs to protect against vulnerability. In Appendix 1, for illustration, we add the Notre Dame Vulnerability Index as a fourth variable into the HDI in equal weights. The revised index shows that many countries drop out of the very high human development category and from the high to the medium category and so on. In general, accounting for risk and scoring for vulnerability reduces the HDI across the board, in some countries much more than in others. In Table 6, for 104 countries where this calculation was made, 17 countries drop out of the very high human development category into the high development category, and about 12 countries drop from the high to the medium human development category. This is illustrative of how a vulnerability-adjusted index can be prepared, although clearly more work will be needed by statisticians to figure out how exactly to do this.

CONCLUSIONS

"Nothing is more powerful than an idea whose time has come." Victor Hugo

The HDI has had a very good run. But some 30 years since its inception in 1990, there is no doubt that it needs revision. Despite many innovative additions, such as the Gender Development Index, Gender Inequality Index and the Inequality-adjusted HDI, the HDI does not adequately capture the development challenges that confront us today. It was a precursor to the MDGs and captured their essence well. New innovations such as the Gender Development Index and the Inequality-adjusted HDI have allowed it to better reflect the glaring disparities in the world.

But now with the world having moved on to the SDGs, it is time to improve the HDI and extend it to better reflect these global goals. In short, there should be a New HDI fit for the twenty-first century. If the HDI was able to have such a huge impact on human development for the last 30 years, a New HDI now can influence development into the next 30 years. The SDGs are with us until 2030 but will probably be extended to 2050 in some form. The New HDI must reflect the essence of the SDGs to be relevant for the coming decades. For example, with increasing commitment to reducing carbon emissions to net zero by 2050, if climate change is not included in a development index it will soon become irrelevant, especially if it is highly correlated with carbon emissions and ecological damage.

The SDGI and SPI, which are built directly from the SDGs, are comprehensive, no doubt. But given the difficulties of measuring many of the SDGs and their indicators, it is not easy to fully understand what drives progress on their scorecards. They are also surprisingly highly correlated with the HDI, as they suffer from 'weak' sustainability and do not penalize ecological damage and climate change, sufficiently. This is also the case for the LPI. Following them as a guide to future development priorities is unlikely to lead the world to net-zero carbon emissions by 2050. Adjusted net savings as a stock of capital concept, also suffers from 'weak' sustainability. While the IWI has 'strong' sustainability measures, it does not consider different forms of capital to be substitutable. It is a useful measure but as with any stock measure has huge issues of measurement across countries.

The HPI and SDI do not suffer from 'weak sustainability but have other problems. The HPI is compelling in its simplicity, as it uses life expectancy and well-being and their inequalities divided by ecological use. But it relies on a perception-based well-being index as one of its components, which leaves it open to criticism that applies to all perception-based indices. The SDI is the clearest extension of the existing HDI, as it adds sustainability in a very direct manner to the existing HDI. It has 'strong' sustainability characteristics built into it, which is a positive feature that shows how important it is to bring ecological use into the HDI. But it caps income arbitrarily at $ 20,000 per capita in PPP, and is therefore unlikely to be acceptable to countries whose incomes are above this level. It also does not address other issues such as human security.

What is very interesting is that both the HPI and SDI reach their highest levels at an HDI score of around 0.8, which is the cut-off between high and very high levels of human development. This shows that under our current models of development, the lifestyle above high human development has very heavy trade-offs with sustainability and the ecological base of our planet. This does not mean that there are no countries with very high HDI who also do not pursue sustainable lifestyles—Chile, Hungary and even to some extent France and Italy score high on the SDI as well as the HDI—but they are very few.

As the HDI is an outcome-based index, we need to extend it into dimensions where outcomes are clearly measurable and universally acceptable. The HDI succeeded because it used components—health, education

and income—that were broadly acceptable and easily measurable across many countries. This means that aspects of human rights and democratic freedoms cannot be included, as there are no universally accepted measures for them, however laudable these principles are. Good governance is also a worthwhile objective, but it helps produce better human development outcomes and is not an end itself. It is also measured across the world with perception-based indices that are subject to considerable criticism and debate.

As the paper has shown, human insecurity, climate change and ecological damage are outcomes of patterns of economic and social development (or the lack of these) that should be part of the new HDI. Leaving them out, in a world ridden with conflict and visibly reaching ecological and climate-related tipping points, is no longer an acceptable option for a global measure of human development.

To conclude, the paper suggests extending the HDI along three dimensions:

1. Introduce measures of damage to ecology and sustainability—CO2 emissions, intensity of material use for global impact, and measures of air pollution and water use for local impacts.

2. Introduce some measure of human security, such as intentional deaths and sexual violence as obvious measures that are universally available and are clear outcomes. Sexual violence could be used in the existing gender indices in the HDI. Intentional deaths is a clear outcome variable measured in many countries and readily available. It may not appear to everyone to be an adequate measure of human security, but would be a starting point.

3. Possibly, substitute income with measures of standard of living used in the MDPI, which include clean water and sanitation, shelter, cooking fuel and electricity. But also produce an index including income to allow comparisons with the old HDI. This would be comparable to measures of income poverty and multidimensional poverty.

The paper has shown that a vulnerability-adjusted HDI, akin to the Inequality-adjusted HDI, would be an obvious extension especially given the huge vulnerabilities exposed by the current pandemic. An alternative would be to introduce vulnerability directly into the index to help better understand the resilience of existing pathways of economic and social development. The paper illustrates how this could be done, but proposes keeping the index simple and adjusting it for ex ante vulnerabilities using a vulnerability-adjusted index.

The HDI, cobbled together in 1990, is not a perfect index, yet it has had a huge impact as it spoke to dissatisfaction with GDP by adding health (long life) and education (knowledge) as measures of development. Likewise, the New HDI, while not perfect, could broaden our measure of human development to include major missing elements such as security and sustainability, and also introduce the concept of vulnerability, directly or indirectly, through a vulnerability-adjusted HDI.

This paper has also shown that enough experimentation with different indices is already underway. The HDI now risks becoming less and less relevant. If changing it involves some risk then we must remember that "if you risk nothing, you risk everything." It is a change whose time has come.

Appendix 1: Illustrative calculation of a vulnerability-adjusted HDI: economic and ecological risks

Rank	Country	HDI	Inequality-adjusted HDI	Vulnerability-adjusted HDI1	Vulnerability-adjusted HDI2	Vulnerability-adjusted HDI3	Vulnerability-adjusted HDI4	Combined vulnerability-adjusted HDI5	HDI with vulnerability added
1	Norway	0.954	0.889	0.9492	0.9444	0.93	0.9262	0.9214	0.889
2	Swiss	0.946	0.882	0.937	0.928	0.901	0.9186	0.9096	0.885
3	Ireland	0.942	0.865	0.9311	0.9202	0.8875	0.9075	0.8966	0.86
4	Germany	0.939	0.861	0.9331	0.9272	0.9095	0.9098	0.9039	0.875
5	Australia	0.938	0.862	0.9273	0.9166	0.8845	0.9085	0.8978	0.873
6	Iceland	0.938	0.885	0.93	0.922	0.898	0.9068	0.8988	0.868
7	Sweden	0.937	0.874	0.9308	0.9246	0.906	0.9069	0.9007	0.870
8	Holland	0.933	0.87	0.9204	0.9078	0.87	0.8979	0.8853	0.852
9	Denmark	0.93	0.873	0.9249	0.9198	0.9045	0.8956	0.8905	0.852
10	Finland	0.925	0.876	0.9158	0.9066	0.879	0.8942	0.885	0.860
11	Canada	0.922	0.841	0.9113	0.9006	0.8685	0.8924	0.8817	0.862
12	New Zealand	0.921	0.836	0.9086	0.8962	0.859	0.8879	0.8755	0.850
13	UK	0.92	0.845	0.907	0.894	0.855	0.8901	0.8771	0.86
14	USA	0.92	0.797	0.9162	0.9124	0.901	0.8861	0.8823	0.847
15	Belgium	0.919	0.849	0.9088	0.8986	0.868	0.8829	0.8727	0.839
16	Japan	0.915	0.882	0.9066	0.8982	0.873	0.8778	0.8694	0.833
17	Austria	0.914	0.843	0.9063	0.8986	0.8755	0.8827	0.875	0.851
18	Luxemburg	0.909	0.822	0.9027	0.8964	0.8775	0.8805	0.8742	0.856
19	Israel	0.906	0.809	0.8977	0.8894	0.8645	0.8724	0.8641	0.838
20	Korea	0.906	0.777	0.8825	0.859	0.7885	0.8685	0.845	0.826
21	Slovenia	0.902	0.858	0.8915	0.881	0.8495	0.8681	0.8576	0.835
22	Spain	0.893	0.765	0.8817	0.8704	0.8365	0.8622	0.8509	0.838
23	Czechia	0.891	0.85	0.877	0.863	0.821	0.86	0.846	0.836
24	France	0.891	0.809	0.8836	0.8762	0.854	0.8614	0.854	0.84
25	Malta	0.885	0.815	0.8751	0.8652	0.8355	0.8494	0.8395	0.817
26	Italy	0.883	0.776	0.866	0.849	0.798	0.851	0.834	0.827
27	Estonia	0.882	0.818	0.8765	0.871	0.8545	0.8444	0.8389	0.809
28	Cyprus	0.873	0.788	0.8619	0.8508	0.8175	0.837	0.8259	0.808
29	Greece	0.872	0.766	0.8453	0.8186	0.7385	0.8374	0.8107	0.811
30	Poland	0.872	0.801	0.8557	0.8394	0.7905	0.8396	0.8233	0.818
31	Lithuania	0.869	0.775	0.8595	0.85	0.8215	0.8302	0.8207	0.796
32	Slovakia	0.857	0.804	0.845	0.833	0.797	0.8206	0.8086	0.795
33	Latvia	0.854	0.776	0.8461	0.8382	0.8145	0.8147	0.8068	0.784
34	Portugal	0.85	0.742	0.8377	0.8254	0.7885	0.8153	0.803	0.796
35	Chile	0.847	0.696	0.8229	0.7988	0.7265	0.8125	0.7884	0.794
36	Hungary	0.845	0.777	0.8393	0.8336	0.8165	0.8085	0.8028	0.787
37	Croatia	0.837	0.768	0.8294	0.8218	0.799	0.7983	0.7907	0.774
38	Argentina	0.83	0.714	0.8085	0.787	0.7225	0.7932	0.7717	0.775
39	Russia	0.824	0.743	0.8187	0.8134	0.7975	0.7905	0.7852	0.781
40	Belarus	0.817	0.765	0.8136	0.8102	0.8	0.7828	0.7794	0.774
41	Kazakh	0.817	0.759	0.7912	0.7654	0.688	0.7834	0.7576	0.776
42	Bulgaria	0.816	0.714	0.8077	0.7994	0.7745	0.7816	0.7733	0.773
43	Montenegro	0.816	0.746	0.8027	0.7894	0.7495	0.7772	0.7639	0.759
44	Romania	0.816	0.725	0.7908	0.7656	0.69	0.7749	0.7497	0.752
45	Uruguay	0.808	0.703	0.784	0.76	0.688	0.7697	0.7457	0.755
46	Turkey	0.806	0.675	0.778	0.75	0.666	0.7722	0.7442	0.767
47	Malaysia	0.804	0.66	0.7822	0.7604	0.695	0.7663	0.7445	0.754
48	Serbia	0.799	0.685	0.7719	0.7448	0.6635	0.7581	0.731	0.741
49	Iran	0.797	0.706	0.7557	0.7144	0.5905	0.7583	0.717	0.746
50	Mauritius	0.796	0.688	0.7797	0.7634	0.7145	0.7522	0.7359	0.73
51	Costa Ric	0.794	0.645	0.7739	0.7538	0.6935	0.7551	0.735	0.744
52	Albania	0.791	0.705	0.7361	0.6812	0.5165	0.7487	0.6938	0.731

53	Georgia	0.786	0.692	0.7368	0.6876	0.54	0.745	0.6958	0.732
54	Srilanka	0.78	0.686	0.7411	0.7022	0.5855	0.733	0.6941	0.708
55	Mexico	0.767	0.595	0.7401	0.7132	0.6325	0.7288	0.7019	0.727
56	Thailand	0.765	0.635	0.7177	0.6704	0.5285	0.7241	0.6768	0.717
57	Brazil	0.761	0.574	0.7334	0.7058	0.623	0.7229	0.6953	0.723
58	Colombia	0.761	0.585	0.7142	0.6674	0.527	0.7222	0.6754	0.721
59	Armenia	0.76	0.685	0.7198	0.6796	0.559	0.7186	0.6784	0.712
60	Algeria	0.759	0.604	0.7322	0.7054	0.625	0.7219	0.6951	0.724
61	Macedon	0.759	0.66	0.7399	0.7208	0.6635	0.7224	0.7033	0.726
62	Peru	0.759	0.612	0.7081	0.6572	0.5045	0.7164	0.6655	0.708
63	China	0.758	0.636	0.7142	0.6704	0.539	0.7191	0.6753	0.718
64	Ecuador	0.758	0.607	0.7118	0.6656	0.527	0.7134	0.6672	0.701
65	Ukraine	0.75	0.701	0.7351	0.7202	0.6755	0.7133	0.6984	0.719
66	Dom Rep	0.745	0.584	0.7048	0.6646	0.544	0.7018	0.6616	0.696
67	Tunisia	0.739	0.585	0.7184	0.6978	0.636	0.6996	0.679	0.703
68	Mongolia	0.735	0.635	0.6861	0.6372	0.4905	0.6943	0.6454	0.697
69	Lebanon	0.73	0.6	0.7024	0.6748	0.592	0.6892	0.6616	0.693
70	Jamaica	0.726	0.604	0.6903	0.6546	0.5475	0.6827	0.647	0.682
71	Paraguay	0.724	0.545	0.6855	0.647	0.5315	0.6855	0.647	0.695
72	Surinam	0.724	0.557	0.7119	0.6998	0.6635	0.6836	0.6715	0.69
73	Philippines	0.712	0.582	0.6782	0.6444	0.543	0.6661	0.6323	0.665
74	Uzbek	0.71	0.579	0.6699	0.6298	0.5095	0.6712	0.6311	0.684
75	Turkmen	0.71	0.579	0.6864	0.6628	0.592	0.6675	0.6439	0.674
76	Indonesia	0.707	0.584	0.6597	0.6124	0.4705	0.6625	0.6152	0.665
77	S. Africa	0.705	0.463	0.6953	0.6856	0.6565	0.6652	0.6555	0.678
78	Bolivia	0.703	0.533	0.6449	0.5868	0.4125	0.657	0.5989	0.658
79	Egypt	0.7	0.492	0.6787	0.6574	0.5935	0.6574	0.6361	0.666
80	Morocco	0.676	0.47	0.6272	0.5784	0.432	0.6382	0.5894	0.662
81	Kyrgyzstan	0.674	0.61	0.6401	0.6062	0.5045	0.6349	0.601	0.657
82	El Salvador	0.667	0.521	0.6309	0.5948	0.4865	0.6222	0.5861	0.636
83	Tajik	0.656	0.574	0.6108	0.5656	0.43	0.6122	0.567	0.631
84	Guatemala	0.651	0.472	0.6222	0.5934	0.507	0.6053	0.5765	0.622
85	Nicaragua	0.651	0.501	0.6116	0.5722	0.454	0.6057	0.5663	0.623
86	India	0.647	0.477	0.5703	0.4936	0.2635	0.5968	0.5201	0.606
87	Honduras	0.623	0.454	0.5825	0.542	0.4205	0.5768	0.5363	0.601
88	Bhutan	0.617	0.45	0.5457	0.4744	0.2605	0.5677	0.4964	0.587
89	Bangla	0.614	0.465	0.5585	0.503	0.3365	0.5597	0.5042	0.57
90	Congo	0.608	0.456	0.5311	0.4542	0.2235	0.5562	0.4793	0.574
91	Ghana	0.596	0.427	0.5271	0.4582	0.2515	0.5492	0.4803	0.579
92	Myanmar	0.584	0.448	0.5245	0.465	0.2865	0.5298	0.4703	0.55
93	Cambodia	0.581	0.465	0.5302	0.4794	0.327	0.5293	0.4785	0.555
94	Kenya	0.579	0.426	0.5255	0.472	0.3115	0.5244	0.4709	0.545
95	Nepal	0.579	0.43	0.4996	0.4202	0.182	0.5274	0.448	0.554
96	Cameroon	0.563	0.371	0.4892	0.4154	0.194	0.5147	0.4409	0.551
97	Pakistan	0.56	0.386	0.5007	0.4414	0.2635	0.5093	0.45	0.542
98	Nigeria	0.534	0.349	0.4556	0.3772	0.142	0.4851	0.4067	0.528
99	Tanzania	0.528	0.397	0.4453	0.3626	0.1145	0.4729	0.3902	0.507
100	Cote Ivoire	0.516	0.331	0.4436	0.3712	0.154	0.4646	0.3922	0.508
101	Senegal	0.514	0.347	0.4489	0.3838	0.1885	0.4605	0.3954	0.502
102	Malawi	0.485	0.346	0.4255	0.366	0.1875	0.43	0.3705	0.476

This table uses data for 102 countries that appear in all indices in the paper. The economic vulnerability-adjusted HDI at 1 percent (HDI1), 2 percent (HDI3) and 5 percent (HDI3) shock probability uses the share of vulnerable employment as a measure of vulnerability from a scale of 0 to 1. The ecology vulnerability-adjusted HDI4 uses a 1 percent probability of shocks from the Notre Dame Vulnerability Index. HDI5 combines economic and ecological vulnerability at a 1 percent probability of shocks to create a combined vulnerability-adjusted HDI. In the last column, for illustration, 1 minus the Notre Dame Vulnerability Index is added to the HDI with equal weights given to income, health, education and vulnerability, using geometric means.

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