The Pontifical Academies' BROKEN MORAL COMPASS

Indur M. Goklany

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About the author

Indur Goklany is an independent scholar and author. He was a member of the US delegation that established the IPCC and helped develop its First Assess- ment Report. He subsequently served as a US delegate to the IPCC, and an IPCC reviewer. He is a member of the GWPF's Academic Advisory Council.

Summary

This paper is a commentary on the opening four sentences of the pontifical academies joint declaration, *Climate Change and the Common Good: A Statement of The Problem and the Demand for Transformative Solutions,* echoes of which resonate in the recent papal encyclical. The paper finds that the premise behind the academies' call for deep decarbonization and a rapid reduction in fossil-fuel use is fundamentally flawed.

The academies claim that fossil-fuel use has reduced the world's sustainability and resilience. But despite record human numbers and carbon dioxide emissions, human wellbeing has never been higher, by virtually any measure whether climate-sensitive or not. The average person has never lived longer or been healthier or wealthier. Living standards are at their highest ever; poverty, hunger, malnutrition, and mortality from vector-borne diseases and extreme events are at record lows. There is no indication that these trends are being reversed.

Prior to the Industrial Revolution virtually all of humanity's basic needs – food, fibre, fuel, energy, materials – were met by the rest of nature. Fossil fuel technologies and associated economic development increased the terrestrial biosphere's natural productivity to provide these basic needs, shifted humanity's demand for energy away from biomass and animal power, and increased its reliance on man-made fibres and materials. Consequently, the share of humanity's demand for life's basic necessities filled by the rest of nature has never been smaller despite exploding demand. Also, because of carbon dioxide fertilization, nitrogen deposition, and possibly a more equable climate, all caused by fossil-fuel use, the terrestrial biosphere's productivity now exceeds pre-industrial levels. This allows the biosphere to sustain larger biomass.

Thus greater fossil-fuel use has been accompanied by advances in both human wellbeing and terrestrial biosphere's ability to sustain biomass. That is, our reliance on fossil fuels has *increased* the world's sustainability and resilience. Another result has been that conversion of wild land to farmland has almost peaked worldwide, allowing some societies to reserve land for conservation.

Also contrary to the academies' claims, inequality, which is secondary to poverty, hunger, and malnutrition as indicators of wellbeing, has shrunk among the world's population in recent decades. Moreover, there is no empirical evidence for their claim that agriculture is 'doubtless causing' hundreds of thousands if not millions of extinctions.

The academies' assertion that fossil-fuel use poses existential risks for the poor and future generations must necessarily rest on models of future impacts of climate change. But impact models use climate models that overestimate global warming two- to four-fold. Moreover, neither climate nor impact models have been validated using external data, climate models often contradict each other regarding the direction of precipitation change at regional and local scales, and the impact models do not fully account for the increased adaptive capacity of future generations, who will

be wealthier and technologically-more sophisticated than we are.

The academies' 'transformative solutions' are based on a delusion that economic alternatives to cheap fossil fuels are widely available, a notion belied by the government mandates and subsidies that prop up these alternative energy sources. These purported solutions would therefore be counterproductive for both humanity and the rest of nature. They would slow the ongoing broad advance in human wellbeing, retard poverty reduction, and reduce the ability to adapt and cope with adversity in general and climate change in particular, especially harming the poor. They would also reduce the future productivity of the terrestrial biosphere, increasing pressure on species and ecosystems.

In exchange for reducing both humanity and the rest of nature's sustainability and resilience, the academies would solve future problems that may not even exist or, if they do, might be more easily solved by future generations who should be richer, both economically and technologically. Essentially, these policies would give up real gains in human and environmental wellbeing to solve hypothetical problems forecast by models which, if they have a track record, is for inaccuracy.

The academies are right that climate change is a moral and ethical issue. Unfortunately, they are on its wrong side. Apparently their moral compass is broken.

1 Introduction

In a joint declaration entitled *Climate Change and the Common Good: A Statement of the Problem and the Demand for Transformative Solutions* (hereafter 'the statement'), the pontifical academies – of sciences and social sciences – asserted that:

> Unsustainable consumption coupled with a record human population and the uses of inappropriate technologies are causally linked with the destruction of the world's sustainability and resilience. Widening inequalities of wealth and income, the world-wide disruption of the physical climate system and the loss of millions of species that sustain life are the grossest manifestations of unsustainability. The continued extraction of coal, oil and gas following the 'business-as-usual mode' will soon create grave existential risks for the poorest three billion, and for generations yet unborn. Climate change resulting largely from unsustainable consumption by about 15% of the world's population has become a dominant moral and ethical issue for society.[1]

Based on these assertions, the statement demanded 'transformative solutions' including, among other things, 'deep de-carbonization',[2] a reduction in worldwide carbon dioxide emissions 'without delay',[3] and a 'shift from fossil fuels to zero-carbon and low carbon sources and technologies, coupled with a reversal of deforestation, land degradation, and air pollution'.[4]

The statement was meant to serve as a major input to the latest papal encyclical, *Laudato Si*.[5] And, indeed, echoes of its text reverberate throughout the encyclical. They can be heard, for instance, in the assertions that, 'We all know that it is not possible to sustain the present level of consumption in developed countries and wealthier sectors of society...',[6] that the 'exploitation of the planet has already exceeded acceptable limits',[7] and that each year thousands of species are being lost forever.[8] They are also evident in the calls for humanity to 'recognize the need for changes of lifestyle, production and consumption, in order to combat...warming',[9] drastically reduce carbon dioxide and other emissions,[10] and redistribute wealth.[11]

But the statement is fatally flawed. It is riddled with sins of omission and commission bolstered by wishful thinking. For instance, it ignores decades of well documented empirical data that show that human wellbeing has advanced throughout the world and that the terrestrial biosphere's productivity has increased above pre-industrial levels, allowing it to support more biomass, in no small part because of carbon dioxide emissions from humanity's use of fossil fuels. The advances in human wellbeing include reductions in poverty, hunger, malnutrition, death and disease, and increases in life expectancy and the standard of living across the world. The poor have been major beneficiaries of these advances.

The statement also overlooks the fact that inequality has declined as fossil–fuel-powered economic growth has lifted billions out of poverty in developing countries, particularly in east and south Asia.

The statement also claims that continued use of fossil fuels poses existential risks for the poor and future generations, but neglects to inform us that these claims are suspect: they are based on results of models that have not been validated, overestimate temperature changes, give contradictory results for changes in other climatic variables, and largely ignore humanity's time-tested ability to cope with and adapt to adversity, a capacity which should increase in the future as humanity becomes technologically more sophisticated and wealthier, just as it did over the past quarter of a millennium.

In the following sections, I will elaborate on these and other defects in the statement. But because life is short and the document's flaws are numerous, I will focus only on its first four sentences.

2 First sentence

> Unsustainable consumption coupled with a record human population and the uses of inappropriate technologies are causally linked with the destruction of the world's sustainability and resilience.

This sentence implies that the world's sustainability and resilience have been diminished, but is that really so?

Humanity's sustainability and resilience

If that were the case, the world's population would be smaller today, worse off than in the past, or both. But by the academies' own admission the world's population is at a record level. Equally important, human wellbeing is at or near its peak by virtually every objective broad measure. Consider that:

- Between 1990–92 and 2014–16, despite a global population increase of 35% (or 1.9 billion), the population suffering from chronic hunger declined by 216 million.[12,13] Consequently malnutrition also declined. Since reductions in hunger and malnutrition are the first steps to better public health, age-adjusted mortality rates have declined and life expectancy has increased.[14]
- Even in low-income countries, life expectancy, probably the single best indicator of human wellbeing, increased from 25–30 years in 1900 to 42 years in 1960 and 62 years today.[15]
- People are not just living longer, they also are healthier. This is true in the richer as well as the poorer segments of the world. Healthy life expectancy – that is, life expectancy adjusted downwards to account for years spent in a less-than-healthy condition (weighted by the severity of that condition) – was 53 years in 2012 in low-income countries, far exceeding their *unadjusted* life expectancy in 1960 (42 years).[16]

- Between 1950 and 2013, the average person's standard of living, as measured by GDP per capita,[17] has increased from $2100 to $8200.[18,19] This statistic understates the relative increase in the standard of living because long-term changes in GDP per capita do not properly account for the fact that some goods and services available today – e.g. cell phones, the Internet, personal computers – were simply unavailable at any price a few decades ago. Nor do they account properly for improvements in the quality of others; compare the bulky, grainy black-and-white analogue TVs of yesteryear with the light, 80-inch HD 3-D colour models of today.
- More importantly, the global population in absolute poverty declined from 53% to 17% between 1981 and 2011.[20] There were about 847 million fewer people living in absolute poverty in 2011 than in 1981, although the population of the developing world increased by 2.5 billion.[21] Not accidentally, the most rapid reductions in poverty occurred in east and south Asia, the areas with the fastest economic growth. This was all supported by fossil fuels.
- Education and literacy, once the domain of the clergy and the wealthy, have advanced. In low-income countries between 1980 and 2012, enrolment in secondary schools increased from 18% to 44%.[22]
- The average person has never had greater and faster access to information, knowledge and technology to help them learn, adapt and solve whatever problems they face. Mobile (cell) phone subscriptions have risen from 0% of population in 1997 to 55% in 2013 in low-income countries, while Internet users rose from virtually nil to 7% of the population over the same period.[23]

These indicators reflect the very factors that enhance resilience and adaptive capacity, no matter what the threat.[24] And as humanity's vulnerability to adversity has declined, the negative consequences of climate and weather in particular have been reduced. Therefore the more narrowly focused climate-sensitive indicators have, predictably, also improved. Specifically:

- Global death rates from all extreme weather events have declined by over 98% since the 1920s.[25]
- Crop yields have improved steadily across the world. Between 1961 and 2013, cereal yields increased by 85% in the least-developed countries and by 185% worldwide, and show no sustained sign of decelerating, let alone reversing.[26]
- Despite population increases, which in theory should have made clean water less accessible, the number of people with access to a safe supply has actually increased worldwide. Between 1990 and 2012, the population with such access increased from 75.9% to 89.3%, some 2.3 billion additional people.[27] Concurrently, an additional 2.0 billion people got access to improved sanitation.[28]

- The global mortality rate for malaria, which accounts for about 80% of the burden of vector-borne diseases that may pose an increased risk due to global warming,[29] declined from 194 per 100,000 in 1900 to 9 per 100,000 in 2012, an overall decline of 95.4%.[30,31]

Thus trends in both the broad indicators of human wellbeing and the narrower climate-sensitive indicators show that, despite population growth, both sustainability and resilience have advanced markedly, in direct contrast to the claims made by the pontifical academies. Figure 1 shows that, globally, both life expectancy and real GDP per capita – representing public health and the standard of living, and perhaps the two most important measures of human wellbeing – have been increasing in parallel with carbon dioxide emissions. Similar graphs can be produced showing improvements in the various indicators of human wellbeing with economic development.[32,33]

But these are no mere correlations. The improvement in human wellbeing have been enabled directly or indirectly through the use of fossil fuels or fossil-fuel powered technologies and economic growth.[34,35,36,37] This is because every human activity –whether it is growing crops, cooking food, building a home, making and transporting goods, delivering services, using electrical equipment for any purpose, studying under a light or going on holiday – depends directly or indirectly on the availability of energy (see below) and, in today's world, energy is virtually synonymous with fossil fuels; they supply 82% of global energy used.[38] Even human inactivity cannot be maintained for any length of time without energy consumption. A human being who is merely lying around needs to replenish their energy just to maintain basic bodily functions. The amount of energy needed to sustain inactivity is called the basal metabolic rate (BMR). It takes food – a carbon product – to replace this energy. Insufficient food, which is defined in terms of the BMR, leads to starvation, stunting, and a host of other physical and medical problems, and, possibly, death.[39]

Nature's sustainability and resilience

It may be argued that the increase in humanity's sustainability and resilience has come at the expense of the rest of nature. Indeed, this *was* the case for millennia, with an approximately linear relationship existing between land clearance on the one hand and human population and standard of living on the other. This was because virtually everything humanity needed and used – food, fuel, clothing, medicine, mechanical power, and much of its housing, shelter, material goods, energy and transportation – was obtained directly or indirectly via the services or products of living nature. The slow rate of technological change meant that if living standards had to improve or the population increased then, barring favourable weather, the increase in demand for food, fuel or any other good would have to be met mostly through addi-

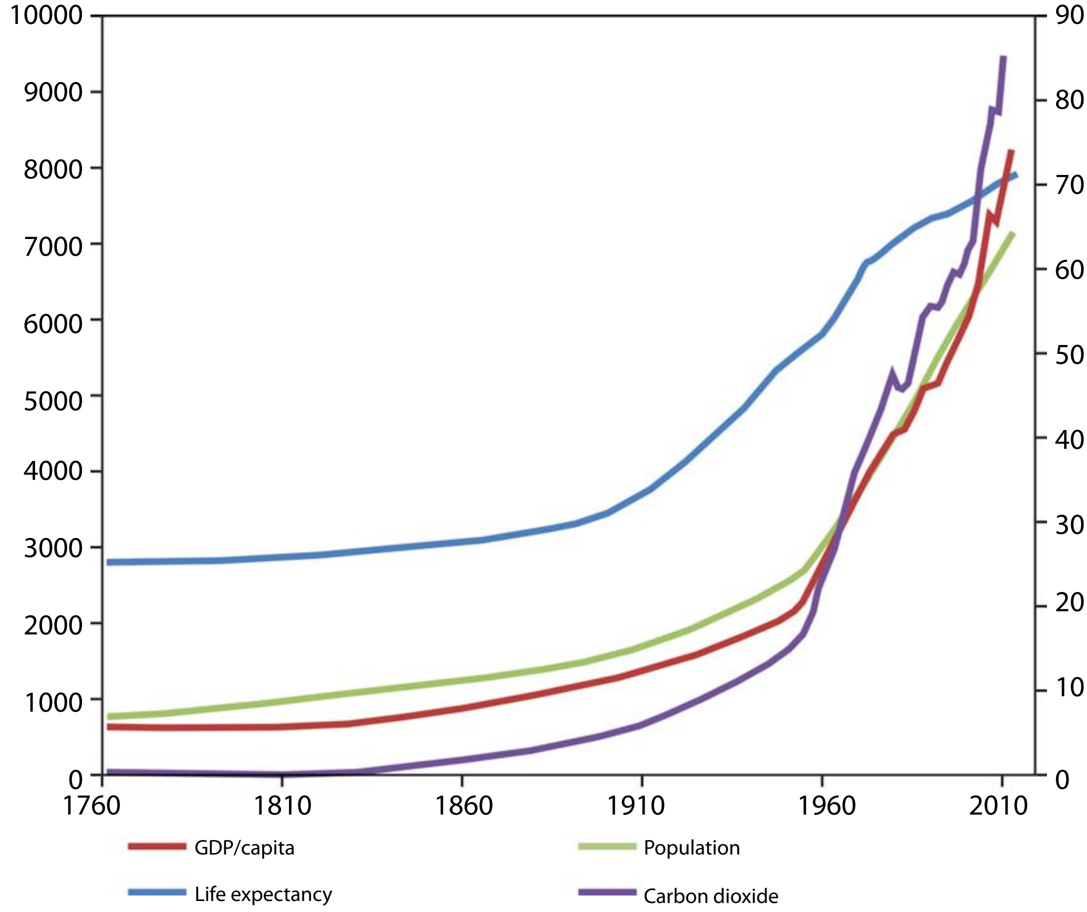

Figure 1: Carbon dioxide and improving human wellbeing

Long-term trends in population, standard of living, health, and carbon dioxide emissions, 1760–2013. GDP (1990 PPP-adjusted dollars), population (millions) and carbon dioxide emissions (MMT) are per the left-hand scale. Life expectancy (years) is on the right-hand scale. Source: Updated from Goklany (2011).

tional land clearance. Thus initially the Industrial Revolution saw population increases accompanied by higher conversion of land per capita to agricultural use. However, this trend was eventually reversed due to a host of fossil-fuel-based technologies. Firstly, these technologies increased the productivity of land to provide the needed goods and services. Secondly, they began to displace the goods and services that humanity traditionally obtained from nature.The following paragraphs list specific examples.[40,41]

Food Synthetic fertilizers and pesticides derived from fossil fuels, both of which were unknown in 1900, increased crop yields during the 20th century. Together they are responsible for at least 60% of today's global food supply.[42] Crop yields have also been augmented by other fossil-fuel powered technological advances, such as the drilling, pumping and distribution of irrigation water. The amount of food produced (or consumed) per acre of cultivated land has been further stretched by reductions in post-harvest and end-use losses, also enabled by fossil-fuel-derived technologies such as refrigeration, faster transportation, plastic packaging and storage, and more efficient processing methods.

Fibre About 63% of the world's fibre production is of synthetic fibres, which are made from fossil fuels. Of the remainder 79% comes from cotton, which is also substantially dependent on synthetic fertilizers and pesticides.[43] Synthetic fibres were little more than curiosities until the 1900s, but since that time have diminished the need to hunt and trap for furs and skins, helping defuse a major threat to biodiversity.[44]

Fuel and energy Biofuels (mainly wood) provided 52% of global energy in 1900. Today their share is down to 11%, while the share of fossil fuels has increased from 42% to 82%.[45,46] Along the way, fossil fuels displaced animal power for transporting goods, people, and doing other work on and off the farm. Feeding these animals used to consume a substantial share of agricultural produce. In the US, for instance, 27% of the land harvested for crops in 1910 was devoted to feeding the 27.5 million horses and mules. Thus displacing animal power with fossil fuels freed up land to feed people and limit habitat loss.[47] Habitat loss is generally considered to be the single largest threat to biodiversity.

Materials Biomass was responsible for 74% of material use in 1900 but only 30% in 2009.[48] This was enabled by the invention of new materials (e.g. plastics and new alloys) and the application of new, often energy-intensive processes to old and not-so-old materials (cement, iron, steel, engineered woods) to extract, manufacture, fabricate and transport them.

Thus the use of fossil fuels has allowed humanity to vastly increase the quantity of goods and services that it obtains from the rest of nature while limiting land conversion. The trend towards greater land productivity is reinforced by the fact that higher carbon dioxide concentrations in the atmosphere increase the rate of vegetation growth, and the efficiency with which plants use water. Nitrogen deposition from fossil-fuel and fertilizer use further increases the biosphere's productivity. Together, these factors have enabled humanity to meet its growing needs without adding proportionately to its already considerable burden on the rest of nature. Consequently, as shown by Figure 2, the amount of land used for humanity's needs per capita had peaked by the second half of the twentieth century: between 1990 and 2012, although global population increased 33%, the increases in global cropland (3%) and agricultural area (2%) were ten-fold smaller.[49] That is, habitat conversion to crops and other agricultural land has almost plateaued globally. Agricultural uses, since time

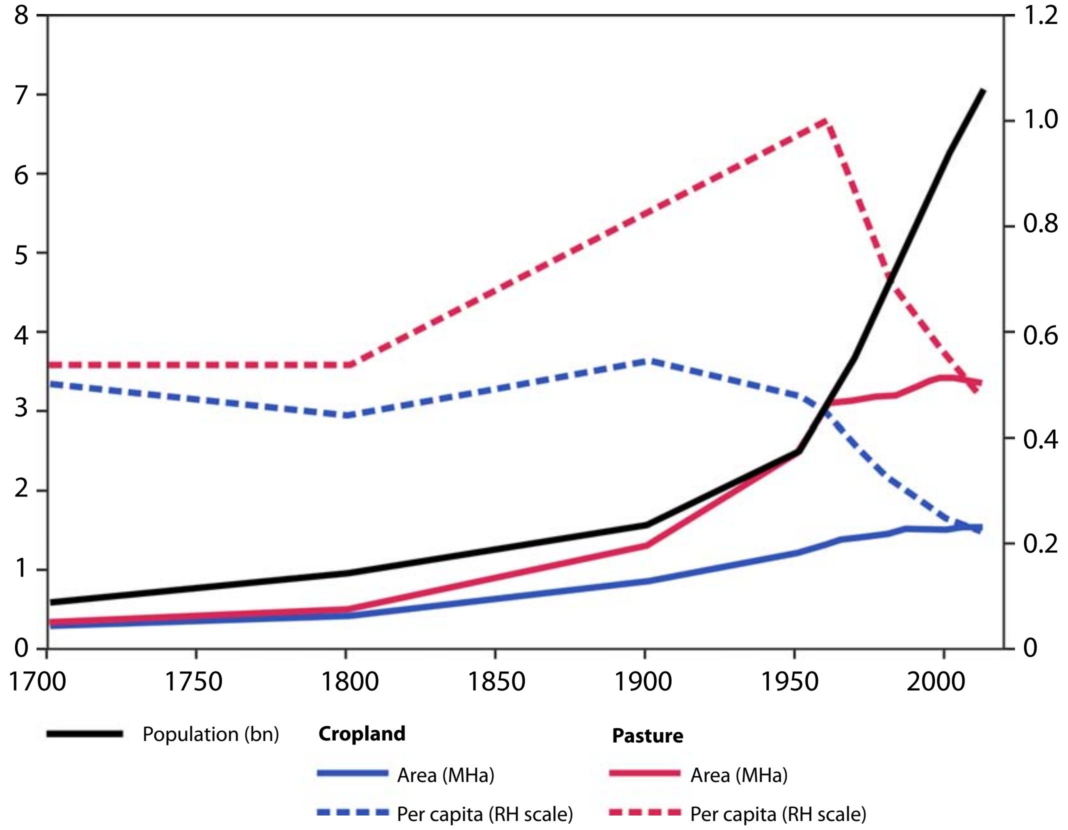

Figure 2: Global habitat conversion to agricultural uses, 1760–2012.

Left-hand scale: population in billions and area in MHa. Right-hand scale, hectares per capita. Sources: Kees Klein Goldewijk et al.,[50] FAO.[51]

immemorial, have been the major cause of habitat conversion.

Equally important, despite a 52% population growth[52] and any land clearance and degradation, satellite data indicate that the productivity of global ecosystems *increased* by 14% from 1982 to 2011.[53] They also show that 31% of the global vegetated area has become greener while 3% has become less green. All vegetation types – tropical rain forests, deciduous and evergreen boreal forests, scrubland, semi-deserts, grasslands and all other wild ecosystems – have increased their productivity. The IPCC Working Group II's Fifth Assessment notes (with emphasis added) that:

> '[d]uring the decade 2000 to 2009, global land net primary productivity was approximately *5% above the preindustrial level*, contributing to a net carbon sink on land…*despite ongoing deforestation'* [and land-use change] .[54]

These increases have been attributed to higher carbon dioxide levels; nitrogen deposition from fossil-fuel combustion and fossil-fuel-derived fertilizer use, and possibly a more favourable climate.[55,56] Thus, at least over the past thirty years, fossil fuels have helped the planet increase its productivity above its pre-industrial level; that is, the ability of the planet to sustain plant and animal biomass[57] has increased.

To appreciate the scale of the positive effect of fossil-fuel technologies in limiting and reversing habitat loss, consider that fossil fuels currently are 'directly or indirectly responsible for at least 60% of humanity's food and fibre. Thus, absent fossil fuels, global cropland alone would have to increase by *at least* 150% (or 2.3 billion hectares) just to meet current demand. This is equivalent to the combined land area of South America and the European Union.[58,59] Such action would have further exacerbated the greatest threat to biodiversity, namely, the conversion of habitat. To put into context the land saved by fossil fuels in this way, consider that the area concerned exceeds the total amount of land set aside worldwide in any kind of protected status (2.1 billion hectares).[60]

So contrary to the pontifical academies' claim, empirical trends show that sustainability and resilience – both of humanity and of rest of nature – have *advanced* rather than diminished. Moreover fossil fuels have been an integral reason for these advances. Curiously, the pontifical academies also claim to have demonstrated a causal link between this alleged decline and 'unsustainable consumption coupled with a record human population and the uses of inappropriate technologies'. This claim is obviously risible, given that one cannot establish such a link when the phenomenon concerned, namely the alleged reduction in the world's sustainability and resilience, has not been observed.

The divergence between the academies' claims and empirical reality is due to their omission, for whatever reason, of any examination of a host of indicators of human wellbeing and global biological productivity. Less charitable souls may note that these indicators are not arcane, and that their favourable trends have persisted for decades and have also been repeatedly noted by researchers.[61,62,63] They may therefore wonder if the academies' oversight is wilful: a sin of commission. But it could also be due to wishful thinking rooted in confirmation bias, or to plain ignorance, although the latter seems implausible given the qualifications of the members of the academies.

3 Second sentence

> Widening inequalities of wealth and income, the world-wide disruption of the physical climate system and the loss of millions of species that sustain life are the grossest manifestations of unsustainability.

This sentence implies that inequalities of wealth and incomes are not only valid – but also significant – measures of human wellbeing.

Firstly, it is not clear that inequality is, by itself, a legitimate public policy issue unless the wealthy have stolen from the less wealthy directly, or indirectly through public policies that sanction crony capitalism or interventions in the marketplace that increase burdens disproportionately on the less wealthy. Examples include subsidies for low- or no-carbon energy sources such as wind, solar, biomass and biofuels, which are paid to landowners and politically-connected middlemen from fees and taxes extracted legally from the rest of the population. Such subsidies increase the cost of energy, fuel and food for all of society. But because these are basic necessities, increases in their cost have a greater impact on the poorer segments of society. They effectively increase poverty (by reducing consumption among the poor).

Secondly, the focus on increasing inequality does not take into account that the marginal utility of an extra dollar of consumption declines as consumption increases. What this suggests is that the marginal utility of an extra dollar for a relatively poor person outweighs the marginal utility of several extra dollars for a much wealthier person.

Thirdly, and most importantly, is inequality more significant than increases in life expectancy or decreases in the numbers living in poverty which, as we have seen, have improved markedly? Prior to the Industrial Revolution the average person lived between 25 and 30 years and GDP per capita was $900.[64] Today, the average person worldwide lives 71 years and even in low-income countries the figure is 62 years . Global GDP per capita is above $11,600.[65] Similarly, there are far fewer people living in absolute poverty today than probably any time since at least 1950. These advances are owed in large part directly or indirectly to economic development, which in turn relied largely on the use of fossil fuels.

This begs the question of whether the average person is better off today than previously. Are the vast gains in health and life expectancy and the standard of living overridden by any increase in inequality? By what moral calculus is inequality a superior measure to either the population living in absolute poverty or improvements in life expectancy? Is it morally acceptable to have more poverty so long as fewer are really wealthy?

It is ironic that the academies should dwell on inequality as if it were a measure of wellbeing, despite it being rooted in one of the seven cardinal sins: envy. Regardless, such data as exists (see Figure 3) shows that while inequality between *countries* may have increased for much of the period following the start of the Industrial Revolution, inequality in the *global population* – a much more important criterion – has declined at least since the 1990s, chiefly due to higher incomes in China and India. On some measures the effects may have been felt even earlier.

The statement's second sentence also suggests that millions of species have been or are being lost. Page 8 provides additional information on this claim:

> Over the 10,000 years that humans have depended on agriculture… doubtless

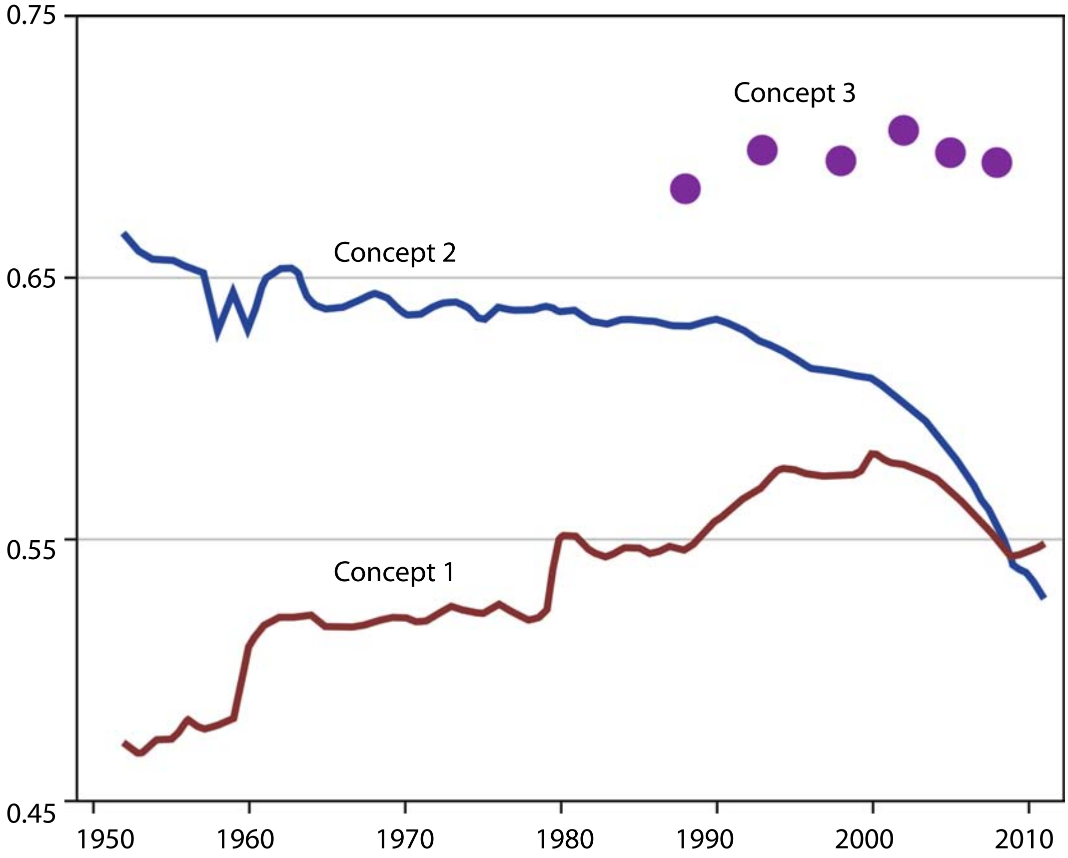

Figure 3: Trends in global inequality

Gini coefficients representing three different concepts of inequality are shown. Concept 1 is based on inequalities between average incomes of countries; Concept 2 on average incomes of countries *considering their population sizes*; and Concept 3 on inequalities between countries and populations within the countries. The major decreases in inequality in all three measures during the 1990s and 2000s were the result of higher incomes in China and India, in large part because of fossil fuel driven industrialization. Source: Milanovic B (2012).[66]

> causing the extinction of at least hundreds of thousands and perhaps millions of species of organisms in the process.

This suggests an average extinction rate of tens or hundreds of species per year since the start of agriculture. Actual data on documented and confirmed extinctions do not support such fanciful rates.[67,68] Moreover, there is no record of mass extinctions since the start of the Industrial Revolution. And with respect to the role of climate change on the number of extinctions, even the IPCC's latest assessment report notes, not without some skepticism:

> Climate change may have already contributed to the extinction of a small num-

> ber of species, such as frogs and toads in Central America, but the role of climate change in these recent extinctions is the subject of considerable debate.[69]

More importantly, as we have seen, fossil fuels have, if anything, diminished the threat to mass extinction because they have reduced land conversion while enhancing the terrestrial biosphere's productivity. Thus it would be counterproductive to implement the academies' primary solution:

> Reduce worldwide carbon dioxide emissions without delay, using all means possible to meet ambitious international targets for reducing global warming and ensuring the long-term stability of the climate system.[70]

Reducing global warming without delay would halt, if not roll back, the increase in the productivity of agriculture and farming. Since food demand is not about to diminish any time soon, this would raise food prices everywhere, increase habitat conversion to make up for the loss in production, or both. To the extent that food prices increase, the very poorest will be priced out of the food market, increasing hunger and disease among the very population for which the academies profess concern. Thus their solution would actually exacerbate the 'existential risks for the poorest three billion, and for generations yet unborn'.[71]

We have had a preview of this. In an attempt to reduce the use of fossil fuels for transport, subsidies were offered for biofuels, resulting in crops being diverted from the production of food. According to one estimate, in developing countries an additional 32 million people were pushed into absolute poverty in 2010 as a result. This is estimated to have led to 192,000 premature deaths worldwide in 2010 alone.[72]

Perhaps the academies are victims of wishful thinking, namely that good intentions rooted in the desire to increase sustainability cannot have unintended negative consequences. This, of course, is enabled by a sin of omission, namely failing to explore the negative consequences of the proposed 'transformative solutions'. But in fact there will always be unintended consequences, at least some of which are negative and foreseeable.

4 Third sentence

> The continued extraction of coal, oil and gas following the 'business-as-usual mode' will soon create grave existential risks for the poorest three billion, and for generations yet unborn.[73]

The claim that business-as-usual 'will soon create grave existential risks for the poorest three billions' is presumably based on modelling exercises that purport to estimate the future impacts of climate change. But the extent of these impacts and the alleged rapidity of their occurrence are vastly exaggerated.

Firstly, these exercises use the results of global climate models to drive various downstream biophysical and socioeconomic models and thus to estimate the future impacts of changes in climatic variables. However, the climate models run too hot. An analysis of the performance of 117 simulations using 37 models indicates that the average global temperature would increase 0.30±0.02°C per decade for 1993–2012 but empirical data from HadCRUT4 surface temperature data set show that global temperature increased at half that rate (0.14±0.06°C per decade).[74,75] For the more recent 15-year period of 1998–2012, the average modelled trend was *quadruple* the observed trend (0.21±0.03°C per decade vs 0.05±0.08°C). However, the academies omitted any mention of how model results compare with reality.

Secondly, most climate impact assessment models, in addition to downplaying positive effects of carbon dioxide, assume little or no endogenous (or autonomous) adaptation. For example, most studies of the impacts of climate change on water resources assume, contrary to what actually happens in the real world, that no adaptive measures will be taken individually or collectively to reduce adverse impacts from floods, droughts or reductions in water availability. This is despite the fact that such measures – dams, reservoirs, and water conservation for example – are among the oldest and best-tested climate adaptations known to humanity.[76,77] Similarly, 63% of the studies used by the IPCC to estimate future impacts on crop yields did not consider improvements in the agricultural sector's adaptive capacity.[78] Moreover, some studies that did only considered technologies that were available as of the 1990s or early 2000s. But because of secular technological change, one should expect even newer and more effective technologies to be on hand by whatever date the impacts are being projected (usually in the 2050–2100 period, or beyond). Neglecting adaptive capacity in impact assessments results in a double exaggeration: it both overstates the negative effects while understating the positive ones.

Historical experience shows that failure to account for increases in adaptive capacity can lead to overestimating negative impacts by an order of magnitude or more. For example, if one assumed no improvement in adaptive capacity from 1900 onward, the global mortality rate for malaria would have been frozen at 194 per 100,000.[79] In fact, it dropped by 95.4% to 9 per 100,000 in 2012.[80] This improvement can be attributed to an increase in adaptive capacity. Similarly, long-term increases in adaptive capacity have reduced the global mortality rate from all extreme weather events by over 98% since the 1920s.[81] The poorest segments of society have been the overwhelming beneficiaries of these advances in adaptive capacity, many of which were facilitated by fossil fuels.

Thirdly, most assessments of species range and distribution ignore the positive impacts of carbon dioxide on plant photosynthesis and water-use efficiency, as well as the productivity enhancements from nitrogen deposition, although these have both contributed to a more productive biosphere.[82,83] For example, Thomas et al. (2004), in their paper, 'Extinction risk from climate change', cited over 4000 times according to Google Scholar,[84] ignored these direct carbon dioxide and nitrogen effects on plants. This is not an exception.

In addition, the academies omit any discussion of the confidence, if any, that can be placed on climate impact assessments. While climate models are able to hindcast *globally averaged temperatures* with some skill (mainly because they are adjusted or tuned to reproduce those temperatures), their results become progressively less accurate as one progresses from the global to the continental, regional, national and local scales.[85]

Even in hindcast, no matter the geographic scale, their ability to reproduce precipitation is even worse.[86,87] But for humanity and the rest of nature, precipitation may be a more critical climatic variable than temperature. However, because the geographical features that determine precipitation are spatially heterogeneous, as are other variables, such as soil composition, that affect the distribution and composition of species, the ecological impacts of climate change must necessarily be modelled at the local scale. However, precipitation projections at less-than-global scales from different models often contradict each other. For example, a recent study of annual precipitation changes in California indicates that, '12 projections show drier annual conditions by the 2060s and 13 show wetter'.[88] Similarly, a study of climate change impacts on hydrology in the American Midwest found that some models predicted drier soil conditions, while others predicted wetter conditions.[89] Thus, impact assessments that use the outputs of these climate models are good for speculation, but little else. They cannot and should not be relied upon to develop policies, particularly if they are consequential in terms of costs or benefits.

Nevertheless, these uncertain results serve as inputs for the bioclimatic models that are used to estimate the impact of climate change on species, ecosystems and biodiversity. But as a rule, species and ecological impacts models, like global climate models, have not been validated with external data. Among other things, they ignore species' adaptability, evolutionary changes, species persistence, species competition, predator–prey relationships and the long-term ecological history of the species under consideration.[90,91,92,93,94,95]

To summarize, climate models exaggerate the rate of temperature change; one cannot rely on them to even get the direction of precipitation change right; and even if they were able to get climate change right, climate impact models vastly inflate their net negative socioeconomic impacts by downplaying the adaptive capacity of future populations who will be wealthier and more technologically advanced than today. The uncertainties in climate models are compounded by those associated with bioclimatic and other models used to estimate the impacts of climate change on species and ecosystems.

Even if these shortcomings are ignored, some cost-benefit analyses indicate that that some additional warming are not necessarily net harmful.[96] It is possible to use impacts estimates to calculate a lower bound for the 'net' GDP per capita for future generations by adjusting the future GDP downward to account for the equivalent welfare loss due to damages from global warming. One of the largest estimates for global warming damages was provided by the Stern Review. It provided a 95th percentile estimate for damages from warming due to market, health, and environmental impacts,[97] putting the figures for the total welfare loss at 7.5% and 35.2% of global GDP by 2100 and 2200, respectively. Based on these estimates, for both developing and industrialized countries, net GDP per capita – albeit an imperfect surrogate for human wellbeing–should be:

- double the current US level by 2100 under the warmest scenario
- lowest under the poorest IPCC scenario but highest under the warmest scenario through 2200.[98]

That is, whatever problems global warming may bring, the average person should be better off in the future than they are today. This is a very robust finding considering the Stern Review's *central* estimate itself was an outlier– beyond the 95th percentile of other estimates according to a review article.[99] Other cost-benefit analyses indicate that that an additional warming of 1–1.2°C relative to today should be a net benefit for the world.[100] One may argue that it does not matter that some warming will be a net benefit or that climate models exaggerate the warming rate because all that means is that the world will get warmer – and reach any tipping point – later rather than sooner. Therefore, this argument would go, we still need to shift out of fossil fuels. But this case overlooks the fact that the observed low rate of warming is important because it indicates a relatively low sensitivity of temperature (and climate) to a doubling of atmospheric carbon dioxide. If the equilibrium temperature sensitivity is, say, 1.5°C per doubling of carbon dioxide concentrations as opposed to 3.0°C, it suggests that an octupling of carbon dioxide from the pre-industrial level of 275 ppm to 2200 ppm – a level that exceeds the projections using the IPCC's hottest scenario[101] – would raise the equilibrium temperature by 4.5°C instead of 9.0°C, since the temperature increase is logarithmic in carbon dioxide.[102]

Moreover, the evidence for any tipping point is, at best, weak. Table 1 is a summary of the IPCC's most recent assessment of the likelihood of various proposed tipping points occurring in the 21st century based on modelled climatic changes under various IPCC scenarios which, as noted, have substantially overestimated the rate of warming. All in all, very little confidence can be placed in their occurrence.

Perhaps more importantly climate change's impact on both humanity and the rest of nature depends critically on the rate of change. The faster the change, the greater the negative impact because it gives less time for new and improved technologies to be developed and/or deployed for adaptation. If one assumes that the globe warms at the rate of 0.5–1.4°C per century, as per Fyfe et al.'s analysis,[103] the net impacts of global warming will be in positive territory at least through the foreseeable future.

Given the credibility of the models involved, it would be foolhardy, if not immoral to spend scarce resources on problems derived from models that so far have failed to track reality, particularly since those resources can be put to better use solving problems we *know* exist here and now, and are amenable to solution.[104,105] Nor should it be overlooked that limiting the use of fossil fuels would slow not only the increase in the terrestrial biosphere's productivity but also the progress toward reducing poverty and solving real (though mundane) problems – hunger, malaria and other vector-borne diseases, access to cleaner water, sanitation, education – and otherwise enhancing human wellbeing.

5 Fourth sentence

> Climate change resulting largely from unsustainable consumption by about 15% of the world's population has become a dominant moral and ethical issue for society.

By this statement, the academies imply that their 'transformative solutions' such as 'deep decarbonization' are driven by an ethical and moral calculus. Let us examine the consequences of their solutions.

Firstly, as noted above, for the last quarter of a millennium the global increase in carbon dioxide emissions has been accompanied by economic development and improvements in virtually every indicator of human wellbeing, including those affected by climatic factors (see, for example, Figure 1). The increases in income and reductions in poverty have also enabled households and societies in the more developed parts of the world to shift from biomass and coal for cooking and heating to cleaner fuels, and to gain access to electricity. Despite these improvements, poverty, hunger and their associated problems still persist, mainly in populations that lack access to affordable and reliable energy. The academies' solution – a shift away from fossil fuels – could, by limiting access to cheaper energy, impede economic development worldwide and hinder this progress. In particular it would perpetuate poverty for the three billion the academies claim to champion, and slow their transition from biomass and coal to cleaner fuels.

Secondly, poverty, for practical purposes, is an independent risk factor for death and disease. Retarding the rate of poverty reduction would therefore increase mortality rates and lower life expectancies. A WHO analysis of the difference in the burden of disease per capita for 24 risk factors between low-income countries and low-middle-income countries indicates that at least ten risk factors are higher in the former; that is, they are exacerbated by poverty or the conditions associated with it.[106,107] Ironically, the risk factor that is the most sensitive to poverty is global warming. The other nine risk factors were:

- underweight (largely synonymous with chronic hunger)

Table 1: Confidence in the occurrence of various tipping points

Change in climate system component	**Potentially abrupt** (AR5 definition)	**Irreversibility if forcing reversed**	**Projected likelihood of 21st century change in scenarios considered**
Atlantic MOC collapse	Yes	Unknown	Very unlikely that the AMOC will undergo a rapid transition (high confidence)
Ice sheet collapse	No	Irreversible for millennia	Exceptionally unlikely that either Greenland or West Antarctic Ice sheets will suffer near-complete disintegration (high confidence)
Permafrost carbon release	No	Irreversible for millennia	Possible that permafrost will become a net source of atmospheric greenhouse gases (low confidence)
Clathrate methane release	Yes	Irreversible for millennia	Very unlikely that methane from clathrates will undergo catastrophic release (high confidence)
Tropical forests dieback	Yes	Reversible within centuries	Low confidence in projections of the collapse of large areas of tropical forest
Boreal forests dieback	Yes	Reversible within centuries	Low confidence in projections of the collapse of large areas of boreal forest
Disappearance of summer Arctic sea ice	Yes	Reversible within years to decades	Likely that the Arctic Ocean becomes nearly ice-free in September before mid-century under high forcing scenarios such as RCP8.5 (medium confidence)
Long-term droughts	Yes	Reversible within years to decades	Low confidence in projections of changes in the frequency and duration of megadroughts
Monsoonal circulation	Yes	Reversible within years to decades	Low confidence in projections of a collapse in monsoon circulations

- zinc deficiency
- Vitamin A deficiency
- unsafe sex
- unsafe water
- sanitation and hygiene
- unmet contraceptive needs
- indoor smoke from solid fuels
- sub-optimal breast feeding
- iron deficiency.

In 2004, the cumulative toll for these factors was estimated to be 11.3 million deaths and 384 million lost disability-adjusted life years. Thus, any actions that perpetuate poverty also increase death and disease on this planet.

Thirdly, decreasing warming will itself lead to a host of perverse outcomes. Examples are described below.

Higher death rates The optimum temperature for many locations lies between the 60th and 90th percentiles of its annual range.[108,109] That is, human beings are better adapted to warmth.[110] A recent study based on an analysis of 74 million deaths from 384 locations in 13 countries estimates that 17 times more deaths are attributable to colder-than-optimum temperatures than warmer-than-optimum temperatures.[111] Many of these locations are in tropical and sub-tropical locales in Brazil, Thailand, Taiwan and China. The study estimated that 7.29% of deaths were attributable to cold versus 0.42% for heat. If this estimate applies to all deaths worldwide, then 3.8 million more deaths per year can be attributed to cold than heat.

Water shortages Both the net global population at risk of water shortage and the demand for irrigation water may increase.[112,113,114,115,116]

Reductions in the terrestrial biosphere's productivity Moving away from fossil fuels would slow, if not halt, the increase in the planet's productivity and increase pressure on the rest of nature.

Reductions in adaptive and mitigative capacity A reduction in economic development would reduce both adaptive and mitigative capacities to address climate change, especially for low-income countries and their inhabitants.[117]

Fourthly, and as noted above, the inordinate emphasis on deep decarbonization will divert resources from more critical priorities, which are also more easily amenable to solution and can be addressed more cost-effectively.[118,119] With respect to public health, results from WHO's study of 24 risk factors for 2004 indicated that global warming ranked 23rd based on mortality, and last in terms of the burden of disease.[120]

Nor is its significance expected to increase dramatically in the foreseeable future. Projections based on a 4°C increase in global warming by 2100, which seems unlikely given the current rate of temperature increase, indicate that in 2085 global warming will add only fractionally (13%) to cumulative mortality from hunger, extreme events, and malaria.[121]

Finally, asking today's relatively poorer generations to reduce greenhouse gas emissions now for the benefit of future generations will essentially transfer wealth from today's poorer generations to tomorrow's wealthier and technologically better endowed populations. In effect, it would exacerbate intergenerational inequality in wealth – a perverse outcome considering the academies' articulated concern for 'widening inequality'.[122,123,124]

Deep decarbonization and a shift from fossil fuels would, therefore, retard humanity's progress in advancing its wellbeing and reduce the planet's productivity, while depriving today's poorer generations of resources to solve today's real problems on the off chance that this will allow tomorrow's wealthier and technologically better equipped generations to avoid problems from climate change that may never materialize.

6 Conclusion

Despite its many sins of omission and commission, the academies did get one thing right: climate change is a moral and ethical issue. But it is a strange moral calculus that endorses policies that would reduce existing gains in human wellbeing, increase the cost of humanity's basic necessities, increase poverty, and reduce the terrestrial biosphere's future productivity and ability to support biomass, all in order to solve future problems that may not even exist or, if they do, are probably more easily solved by future generations who should be richer both economically and technologically. Moreover, because food, fibre, fuel and energy – basic necessities – consume a disproportionately large share of the income of the poorest, they would also pay the highest price for these policies. So much for the academies' concern for inequality.

Today's world may not be perfect, but without access to cheaper energy alternatives – fossil fuels, like it or not, are usually the cheapest available option – it would be more imperfect. Someday it may be possible to meet humanity's basic necessities without fossil fuels. But we are not there yet. As the academies note, three billion people still have unmet energy needs. Insisting on doing 'the right thing', but at the wrong time, could make matters worse. Even if one is confident that a child nearing adulthood could leap across a ten-foot chasm, it would be lethal to insist that a three-year old do the same thing. Similarly, there may be a fossil-fuel-free world in the future, but now is not the future. Insisting on a fossil-fuel-free world now would only prolong poverty and limit the terrestrial biosphere's productivity.

Notes

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3. Ibid., p. 9.
4. Ibid., p. 2.
5. Encyclical Letter '*Laudato Si*' of the Holy Father Francis on care for our common home, available at http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco\protect_20150524\protect_enciclica-laudato-si.html.
6. *Laudato Si*, paragraph 27, p. 9.
7. *Laudato Si*, paragraph 27, p. 9.
8. *Laudato Si*, paragraph 33, p. 10.
9. *Laudato Si*, paragraph 23, p. 7.
10. *Laudato Si*, paragraph 26, p. 9.
11. *Laudato Si*, paragraph 109, p. 32.
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2	Philipp Mueller	The Greening of the Sahel
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For further information about GWPF or a print copy of this report, please contact:

The Global Warming Policy Foundation
10 Upper Bank Street, London E14 5NP.
T 020 7006 5827
M 07553 361717

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