Blue Planet Prize

FOR IMMEDIATE RELEASE
June 16, 2021

2021 BLUE PLANET PRIZE: ANNOUNCEMENT OF PRIZE WINNERS

This year marks the 30th awarding of the Blue Planet Prize, the international environmental award sponsored by the Asahi Glass Foundation, chaired by Takuya Shimamura. Every year, the Foundation selects two winners, individuals or organizations who have made significant contributions to the resolution of global environmental problems. The Board of Directors have selected the following 2021 Blue Planet Prize recipients.

1. Prof. Veerabhadran Ramanathan (USA) Born in India, Date of Birth: 24 November, 1944

Edward A. Frieman Endowed Presidential Chair in Climate Sustainability
Scripps Institution of Oceanography, University of California, San Diego

Professor Ramanathan has spent decades investigating the climate effects of non-CO_2 pollutants, including the role of short-lived climate pollutants (SLCPs): methane, tropospheric ozone, halocarbons (HFCs[*1]), and black carbon[*2]. His contributions include the discovery of the super greenhouse effect of halocarbons (CFCs[*3]), and clarifying the climate effects of black carbon through an international field project he led on Atmospheric Brown Clouds (ABCs). He showed that reductions in SLCPs can rapidly reduce warming and significantly improve air pollution. He later took the initiative in global actions to reduce SLCPs.

*1 Hydrofuorocarbons (CFC alternatives), no ozone depletion potential but much greater global warming potential than CO_2.

*2 Commonly known as soot; formed through the incomplete combustion of fossil fuels, biofuel, and biomass.

*3 Chlorofluorocarbons, large ozone depletion potential and much greater global warming potential than CO_2.

2. Prof. Mohan Munasinghe (Sri Lanka) Born in Sri Lanka, Date of Birth: 25 July, 1945

Founder Chairman, Munasinghe Institute for Development (MIND)

Professor Munasinghe pioneered the integrative, transdisciplinary 'Sustainomics' framework which views development issues from environmental, social, and economic perspectives. Innovative concepts like 'balanced inclusive green growth (BIGG)' and 'millennium consumption goals (MCGs)' emerged from Sustainomics. BIGG calls for each country to take a sustainable development path in accordance with its development stage, while the MCGs ask the affluent, who consume most global output, to adopt consumption goals to reduce the burden on the planet. He has been developing practical activities using environmental economics and policy to implement these concepts worldwide.

- Each recipient is presented with a certificate of merit, a commemorative trophy, and 50 million Japanese yen in prize money.
- We'd like to hold the Blue Planet Prize Award Ceremony and commemorative lectures, which could well be on a smaller scale, while taking proper measures to prevent infection with the new coronavirus. The Award Ceremony is scheduled on Wednesday, October 6, 2021 at Tokyo Kaikan. Commemorative lectures will be given on October 7 and 9, 2021, at United Nations University (Shibuya Ward, Tokyo) and at Kyoto University, respectively.
- This press release and the photo of each recipient will be published 11 a.m. on Wednesday June 16 on the website of the Asahi Glass Foundation (www.af-info.or.jp).

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Statements from the Award Recipients upon Notification of Selection

Prof. Veerabhadran Ramanathan (USA)

It is a great honor to be awarded the Blue Planet prize for short-lived climate pollutants (SLCPs) research. Reducing the planetary heat-trapping by four SLCPs is essential for quick reductions in global warming. The targeted SLCPs are: Methane; Black Carbon; tropospheric Ozone and hydrofluorocarbons (HFCs).

The science of SLCPs has been known since 1975, when I was fortunate to discover the enormous heat-trapping effect of chlorofluorocarbons (CFCs), which with HFCs belong to the halocarbons family. Warming might have already exceeded dangerous levels had CFCs not been phased out by the Montreal protocol to eliminate their ozone hole impacts.

We also have to phase-out Carbon-dioxide emissions by 2050 to stabilize long-term climate.

This prize is like the North Star for me since it will amplify my climate solution efforts – bridging gaps across political chasms and bringing science into alliance with policy and faith for climate actions.

Prof. Mohan Munasinghe (Sri Lanka)

I am deeply grateful and honoured to receive the 2021 Blue Planet Prize, the premier global environmental sustainability award, symbolizing the outstanding commitment of the Asahi Glass Foundation of Japan, to a better future. I am indebted also to many who have contributed generously to my intellectual development and emotional intelligence, including teachers, mentors, colleagues, family and friends. Social ties have been invaluable to survive the pressures of COVID-19.

It is encouraging to learn that the award committee has specifically acknowledged several key concepts I developed and their practical application worldwide, during almost 5 decades, including the Sustainomics framework, sustainable development triangle (economy, environment, society), balanced inclusive green growth (BIGG), and Millennium Consumption Goals (MCGs).

My research interests have evolved, from basic disciplines like engineering, physics and economics, to application sectors like energy, water, transport, ICT, and environmental resources, and finally to multidisciplinary topics like poverty, disasters, climate change and sustainable development. This eclectic experience helped me develop Sustainomics, as an integrative, trans-disciplinary methodology. Drawing on my past work and the global platform provided by the prestigious Blue Planet Prize, I will continue my modest efforts to make our planet more sustainable for all.

Report on the Selection Process (2021 Blue Planet Prize)

A total of 472 nominators from Japan and 748 nominators from other countries recommended a total of 127 candidates. The top three fields represented by the candidates, in order of number, were environmental economics and policy making (31), ecology (29), atmospheric and earth sciences (19). The candidates represented 38 countries; 33 nominations, 28 percent of the total, were from developing countries.

After individual evaluation of the 127 candidates by each Selection Committee member, the committee was convened to narrow down the field. The results of their deliberation were examined by the Presentation Committee. The Board of Directors formally decided to award the Prize to **Prof. Ramanathan,** and to **Prof. Munasinghe**.

Laureates (1992-2021)

1992	Dr. Syukuro Manabe (USA) International Institute for Environment and Development (UK)
1993	Dr. Charles D. Keeling (USA) IUCN—The World Conservation Union (headquartered in Switzerland)
1994	Professor Dr. Eugen Seibold (Germany) Mr. Lester R. Brown (USA)
1995	Dr. Bert Bolin (Sweden) Mr. Maurice F. Strong (Canada)
1996	Dr. Wallace S. Broecker (USA) The M.S. Swaminathan Research Foundation (India)
1997	Dr. James E. Lovelock (UK) Conservation International (head-quartered in the USA)
1998	Professor Mikhail I. Budyko (Russia) Mr. David R. Brower (USA)
1999	Dr. Paul R. Ehrlich (USA) Professor Qu Geping (China)
2000	Dr. Theo Colborn (USA) Dr. Karl-Henrik Robèrt (Sweden)
2001	Lord (Robert) May of Oxford (Australia) Dr. Norman Myers (UK)
2002	Dr. Harold A. Mooney (USA) Professor J. Gustave Speth (USA)
2003	Dr. Gene E. Likens (USA) and Dr. F. Herbert Bormann (USA) Dr. Vo Quy (Vietnam)
2004	Dr. Susan Solomon (USA) Dr. Gro Harlem Brundtland (Norway)
2005	Professor Sir Nicholas Shackleton (UK) Dr. Gordon Hisashi Sato (USA)
2006	Dr. Akira Miyawaki (Japan) Dr. Emil Salim (Indonesia)
2007	Professor Joseph L. Sax (USA) Dr. Amory B. Lovins (USA)
2008	Dr. Claude Lorius (France) Professor José Goldemberg (Brazil)
2009	Professor Hirofumi Uzawa (Japan) Lord Nicholas Stern of Brentford (UK)
2010	Dr. James Hansen (USA) Dr. Robert Watson (UK)
2011	Dr. Jane Lubchenco (USA) Barefoot College (India)
2012	Professor William E. Rees (Canada) and Dr. Mathis Wackernagel (Switzerland) Dr. Thomas E. Lovejoy (USA)
2013	Dr. Taroh Matsuno (Japan) Professor Daniel Sperling (USA)
2014	Prof. Herman Daly (USA) Prof. Daniel H. Janzen (USA) and Instituto Nacional de Biodiversidad (INBio)
2015	Professor Sir Partha Dasgupta FBA FRS (UK) Professor Jeffrey D. Sachs (USA)
2016	Mr. Pavan Sukhdev (India) Prof. Markus Borner (Switzerland)
2017	Prof. Hans J. Schellnhuber (Germany) Prof. Gretchen C. Daily (USA)
2018	Prof. Brian Walker (Australia) Prof. Malin Falkenmark (Sweden)
2019	Prof. Eric Lambin (Belgium) Prof. Jared Diamond (USA)
2020	Prof. David Tilman (USA) Dr. Simon Stuart (UK)
2021	Prof. Veerabhadran Ramanathan (USA) Prof. Mohan Munasinghe (Sri Lanka)

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Supplementary Information
Profiles of the 2021 Blue Planet Prize Recipients

Prof. Veerabhadran Ramanathan (USA)

Major research achievements and activities

In a 1975 paper in *Science*, Professor Ramanathan showed that chlorofluorocarbons (CFCs)[1] are about 5000 to 10000 times more potent than CO_2 in warming the planet. This discovery subsequently led to the identification of numerous other non-CO_2 gases as major contributors to global warming.

In 1985, Ramanathan led a World Meteorological Organization study group and published a UN report which concluded that increases in non-CO_2 greenhouse gases were contributing as much as CO_2 increase to global warming. The short-lived climate pollutants (SLCPs)[2], methane, tropospheric ozone and HFCs, in addition to CFCs and nitrous oxide are the principal non-CO_2 gases. This conclusion led to the inclusion of non-CO_2 greenhouse gases along with CO_2 in the Kyoto Protocol[3].

Professor Ramanathan broadened his attention to aerosol[4]-derived atmospheric brown clouds (ABCs)[5]. He was the American chief-scientist for the Indian Ocean Experiment (INDOEX) conducted during 1997 to 1999 with 200 scientists from around the world to study ABCs. INDOEX gathered observations of ABCs with a constellation of satellites, surface stations, aircraft. Ramanathan continued ABC observations beyond INDOEX with light-weight drones. The massive data revealed a 3-km thick brown clouds with large amounts of sulfate and nitrate particles as well as black carbon and organic carbon particles. He and his team linked the black carbon with substantive dimming of solar radiation at the surface, heating of the atmosphere, melting of the Himalayan-Tibetan glaciers, weakened monsoon circulation and large reductions in wheat and rice yields. He made the first observationally based estimate of the global heating effect of black carbon thus clarifying the role of SLCPs in global warming.

His studies on the warming effects of non-CO_2 greenhouse gases and black carbon in ABCs, led him to the conclusion that targeting mitigation of four SLCPs would be the most effective way for bending the warming curve quickly. The four SLCPs they targeted were: Methane, HFCs, Tropospheric Ozone and black carbon. His projection was that drastic reductions of the SLCPs with available technologies would reduce the warming by 0.6°C before 2050 and thus cut down the near-term (decade) to medium-term (few decades) rate of warming by half. Through these studies, he argued effective ways to meet the Paris Agreement[6] target of *well below* 2.0°C which relied on pulling on three levers: The CO_2 lever to achieve zero net emissions by 2050; The SLCPs lever to reduce, within 20 years, emissions of methane by 40%, black carbon by 90% and HFCs by 100%; and the Atmospheric Carbon Extraction (ACE) lever to extract more than 500 billion tons of CO_2 by 2100.

In response to these findings, the UN asked Ramanathan to co-lead a scientific assessment of SLCPs, which led to the formation of the Climate and Clean Air Coalition (CCAC)[7]. SLCPs were also included for mitigation actions in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC)[8].

Ramanathan's work persuaded California to pass a climate action bill to drastically reduce emissions of SLCPs. In 2016, the Montreal protocol was amended by the Kigali amendment which proposed large reductions in HFCs. In 2021 April, the EPA (USA) proposed a rule to phase down HFCs.

Beginning 2013, he teamed up with his daughters, Nithya Ramanathan and Tara Ramanathan, and created Project Surya which conducted demonstration projects with unique sensors to cut down emissions of black carbon from cooking with solid fuels (firewood and dung).

More recently, he has been working to engage globally influential people in building public consensus for action to curb climate change. Professor Ramanathan, who is not a Catholic but has been a member of the Pontifical Academy of Sciences[9] since 2004, met Pope Francis in person in 2014 and informed him: "The poorest three billion in the world, who had very little to do with CO_2 emissions, will suffer the worst consequences of climate change." Since then, the Pope has often made statements calling for action on global warming including the need for protecting the poor. He also appointed Ramanathan as science advisor for his Holy See delegation to the 2015 UN Paris climate summit. Ramanathan was also responsible for persuading American evangelical leaders to join him in discussions at the Vatican on global warming. Professor Ramanathan also advised the 14th Dalai Lama on global warming and its impact on the poorest three billion people.

Thus, for more than 45 years, Professor Ramanathan has been perceiving, measuring, and explaining climate change in terms of both reducing air pollution and global warming, and thus contributing to mitigation of climate change through rapid action to reduce SLCPs.

Academic and Career Background

1965 Annamalai University, India（BA, Engineering）
1970 Indian Institute of Science, India（MS, Engineering）
1974 State University of New York at Stony Brook (Ph.D., Planetary Atmosphere)
1974-76 Post Doctoral Fellow, NASA Langley Research center, USA
1976-82 Scientist, National Center for Atmospheric Research, USA
1979- Principal Investigator, NASA
1986-90 Professor, Department of Geophysical Sciences, University of Chicago
1990- Professor, Scripps Institution of Oceanography, University of California at San Diego
2002- Academician, National Academy of Sciences, USA
2004- Academician and council member (since 2014) of the Pontifical Academy of Sciences
2011- Academician (Foreign Member), Royal Swedish Academy of Sciences
2014- Champion of Earth for Science and innovation, UN Environment

Notes

***1 Chlorofluorocarbons (CFCs)**

Chlorofluorocarbons (CFCs), also known by the brand name Freon, are compounds containing atoms of carbon, fluorine, and chlorine. They have been widely used as cleaning agents, refrigerants, foaming agents, propellants for aerosol sprays, etc. Since CFCs are chemically stable substances, when released into the atmosphere, they, for the most part, don't decompose in the troposphere and eventually reach the stratosphere. In the stratosphere, CFCs are decomposed by strong ultraviolet radiation from the sun, releasing chlorine atoms. These atoms catalyze a chain reaction that decomposes ozone.

***2 Short-lived climate pollutants (SLCP)**

These are air pollutants with a relatively short lifetime (a few months or less), such as tropospheric ozone, aerosols, and black carbon (soot) emitted by human activity. Also known as short-lived climate forcers (SLCF), they are drawing attention for their effects on regional climate as well as regional pollution.

***3 Kyoto Protocol**

The Kyoto Protocol is a treaty adopted at the Third Conference of the Parties (COP 3) to the United Nations Framework Convention on Climate Change (UNFCCC), held in Kyoto in 1997, stipulating international efforts to combat climate change. The Protocol set a goal to reduce greenhouse gas emissions in industrialized countries as a whole by 5% from the 1990 levels.

***4 Aerosol**

A mixture of minute liquid or solid particles suspended in a gas and the gas surrounding such particles. Aerosol particles are also called dust, fume, or mist according to their formation process, and are sometimes called fog, mist, haze, or smog in meteorological terms depending on their visibility and color.

***5 Atmospheric brown clouds (ABCs)**

An artificial form of air pollution caused by aerosols, such as sand and dust generated by fossil fuel combustion and desertification. The presence of ABCs was perceived in 1999. Being smog that contains soot and chemicals and absorbs sunlight, ABCs have the effect of increasing respiratory disease and heart disease. In contrast to the increase in atmospheric temperature in the vicinity of ABCs, the temperature on the earth's surface decreases, which can reduce the yield of crops. It has also been pointed out that ABCs are linked to climate change, such as monsoon anomalies in Asia. The United Nations Environment Programme (UNEP), which has been working on ABCs since 2003 as a new environmental pollution problem, announced in a report released on November 13, 2008 that ABCs three kilometers in thickness were spreading from the Arabian Peninsula to China and the western Pacific Ocean. The report warned of global warming that would cause the snow and ice in the Himalayas to melt and of negative health effects.

***6 Paris Agreement**

The Paris Agreement is an equitable and effective legal framework for the global action against the threat of climate change in the year of 2020 and beyond, in which signatories—regardless of whether they are from developed or developing countries—joined. Unlike the Kyoto Protocol of 1997, which sets GHG emission reduction targets only for developed economies, the Paris Agreement applies to all signatories. It calls for

holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. Adopted at the 21st Conference by the Parties (COP 21) at the United Nations Framework Convention on Climate Change, held in Paris in December 2015, the Paris Agreement took effect in November 2016 and Japan became a signatory later in the month.

***7 Climate and Clean Air Coalition (CCAC)**

The CCAC, officially, Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants, was established in 2012 with the objective of reducing emissions of SLCPs. The CCAC supports countries in their efforts to achieve the UN Sustainable Development Goals (SDGs) and the global warming control targets in the Paris Agreement by taking an integrated approach to improving both climate change and air quality. (Ref. Climate & Clean Air Coalition https://ccacoalition.org/en)

***8 Intergovernmental Panel on Climate Change (IPCC)**

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) with the objective of conducting comprehensive assessments of human-caused climate change and its implications as well as adaptation and mitigation measures from scientific, technological, and socioeconomic perspectives.

***9 Pontifical Academy of Sciences**

The history of the Pontifical Academy of Sciences began as the Academy of the Lynxes, founded in Rome in 1603 by Federico Cesi and others. In 1847, Blessed Pope Pius IX reorganized it as the Pontifical Academy of the New Lynxes; and in 1936, during the reign of Pope Pius XI, it took on its current name and organization. The Academy welcomes, as members, researchers of any nationality or religion who have made outstanding contributions to the world through scientific research.
(Ref. http://www.pas.va/content/accademia/en/about/history.html)

Prof. Mohan Munasinghe (Sri Lanka)

Major research achievements and activities

Having earned a PhD in solid state physics and a Master's degree in development economics in the 1970s, Professor Munasinghe researched optimal management of environment and natural resources such as energy and water. He was the Division Chief for Environmental Policy at the World Bank from 1990 to 1995, where he played a key role shaping policy on environmental economics, climate change and ozone, while developing the World Bank environmental assessment guidelines. At the 1992 United Nations Rio Earth Summit[1], he presented the sustainable development triangle that formed the basis for the transdisciplinary Sustainomics[2] framework. Sustainomics is a practical, step-by-step approach to make development more sustainable, in which relevant issues are addressed from three perspectives—the economy, society, and the environment—in a balanced and harmonized manner. In creating practical strategies for sustainable development, he also stressed the importance of managing natural resources prudently and effectively, and of successfully integrating climate change countermeasures into national development strategies by using methods such as the Action Impact Matrix (AIM)[3]. In the 1990s, his model of green growth was applied in several countries. Based on his experiences in conducting and implementing policy research, he published seminal research[4] on environmental economics, sustainable energy, water resources, digital technology, disasters, urban environment, and climate change – all contributing to the transdisciplinary approach of Sustainomics and ultimately to achieving sustainable development.

After establishing the Munasinghe Institute for Development in 2000, Professor Munasinghe further pursued his study of the environment, economy and society, and published the basic concept of balanced inclusive green growth (BIGG)[5] in 2012, based on the Sustainomics framework. One outcome of BIGG is that each country should follow the sustainable development path suited to its own level of development -- developed countries would restrain future natural resource use by making their consumption and production more sustainable without sacrificing their quality of life, while developing countries could grow and reduce poverty by sustainably increasing consumption and production. Earlier in 2010, at the United Nations, Professor Munasinghe proposed the idea of Millennium Consumption Goals (MCGs)[6], which aims to reduce the burden on the earth's natural resources by encouraging voluntary goals for consumption in wealthy countries, while addressing the problems of global poverty and inequality by meeting basic consumption needs in poor countries. After being discussed at the UN Rio+20 Earth Summit in 2012, the MCG concept was incorporated into Goal 12 (Responsible consumption and production) of the Sustainable Development Goals (SDGs)[7] and adopted by the United Nations General Assembly in 2015. During 2017-19, he chaired the Presidents Expert Committee on Sustainable Sri Lanka 2030 Vision – the national sustainable development strategy based on BIGG. His paper "Covid19 and sustainable development" in 2020, received much attention for proposing a practical BIGG-based approach to recovery from the pandemic.

Professor Munasinghe was also active in the Intergovernmental Panel on Climate Change (IPCC)[8] in the areas of sustainable development and climate change -- serving as lead author in Working Group III (WGIII) of the Second Assessment Report (1990–1995), Vice Chair and lead author of WGIII in the Third Report (1996–2001), and finally as IPCC Vice Chair of the Fourth Report (2001-2008). He led the IPCC effort to integrate sustainable development into climate change strategy, coordinating the work of multidisciplinary expert teams,

who studied and compiled relevant scientific findings. He also led the provision of scientific information for preparing global agreements, including the 1997 COP 3 Kyoto Protocol[9], the 2009 COP 15 Copenhagen Accord, and the 2015 COP 21 Paris Agreement[9]. The IPCC was a co-winner of the Nobel Peace Prize[10] in 2007 "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change." He has received many other international awards for his work, including decorations and honours from the heads of government of five countries: Bangladesh, Brazil, Dominican Republic, France, and Sri Lanka.

In summary, Professor Munasinghe conducted innovative, comprehensive and transdisciplinary research. Further, he showed leadership in putting those research results into action worldwide for over 40 years in many fields, including environmental science, environmental economics and policy, sustainable energy and water, climate change and sustainable development.

Academic and career background

1967 Cambridge University, England (BA, MA, Engineering)
1969 Massachusetts Institute of Technology, USA (MS, EE, Electrical Engineering)
1973 McGill University, Canada (PhD Solid State Physics)
1975 Concordia University, Canada (MA, Development Economics)
1982- Honorary Senior Advisor to the Government of Sri Lanka
1991-95 Division Chief for Environment Economics and Policy, World Bank, USA
1996-02 Senior Advisor for Sustainable Development, World Bank, USA
2000- Founder Chairman, Munasinghe Institute for Development (MIND), Sri Lanka
2001-08 Vice Chair, Intergovernmental Panel on Climate Change (IPCC)
2017-19 Chairman, Presidential Expert Commission on Sustainable Sri Lanka 2030 Vision report

Notes:

***1 United Nations Rio Earth Summit**

The United Nations Conference on Environment and Development (UNCED) was a UN conference held in Rio de Janeiro, Brazil in 1992 on the themes of environment and development. It is also known as the Earth Summit. At this conference, the Framework Convention on Climate Change and the Convention on Biological Diversity became open for signature.

***2 Sustainomics**

Sustainomics is a framework for making development more sustainable, characterized by being transdisciplinary, integrative, comprehensive, heuristic, balanced, and practical. The basic principle is to make ongoing or future development efforts more sustainable in practical ways, by harmonizing the economy, environment and society. Sustainomics is a term that Professor Munasinghe has popularized since 1992.

(Source: MIND website, http://www.mohanmunasinghe.com/default.cfm)

***3 Action Impact Matrix (AIM)**

The AIM is a method to better understand the inter-linkages that exist among seemingly independent elements such as, macro-economic policies, key vulnerability and adaptation areas, and climate change. As shown in the example matrix, usually, the row headings include development goals and policies, while column headings include the areas most vulnerable to climate change. This method has been in use since the early 1990s, linking macroeconomic policies to the environment.

(Source: MIND Technical Report, May 2005)

Example of Active Impact Matrix

		Vulnerable & Adaptation (VA) Areas			
		Economic		Environmental	Social
		(1) Agricultural Output	(2) Industrial Activity	(3) Water Resources	(4) Health
Dev. Goals/Policies					
(A)	Growth				
(B)	Poverty alleviation				
(C)	Food Security				
(D)	Employment				

Source: MIND Technical Report, May 2005

***4 Seminal Research**

Among 100+ books and 350+ articles published over 40 years, selected seminal monographs in key areas contributing to the multidisciplinary approach of Sustainomics, include:

1979 *The Economics of Power System Reliability and Planning* (John Hopkins Univ. Press, Baltimore)
1983 *Energy Economics, Demand Management and Conservation Policy* (Van Nostrand Reinhold, NY)
1989 *Computers and Informatics in Developing Countries* (Butterworths, London – Third World Academy of Science, Italy)
1992 *Water Supply and Environmental Management* (Westview Press, Boulder, CO)
1992 *Environmental Management and Urban Vulnerability* (World Bank, Wash. DC)
1993 *Environmental Economics and Sustainable Development* (World Bank Env. Paper 3, Wash.DC)
1995 *Disaster Prevention for Sustainable Development* (UN Int. Decade for Disaster Reduction, NY, and World Bank, Wash,DC)
1995 *Property Rights in a Social and Ecological Context* (Beijer International Inst. Stockholm and World Bank, Wash, DC)
2002 *Macroeconomics and the Environment* (Elgar Ref. Collection, Edward Elgar Pub. Cheltenham, UK)
2005 *Primer on Climate Change & Sustainable Development* (Cambridge Univ. Press, Cambridge, UK)
2019 *Sustainability in the 21st Century: Applying Sustainomics to Implement the SDG* (Cambridge Univ. Press, Cambridge, UK)

***5 Balanced inclusive green growth (BIGG)**

The BIGG concept was presented by Professor Munasinghe at the 2012 UN Earth Summit. In the figure, rich nations at point C (who exceed safe limits) should reduce environmental burdens by decarbonization and other measures to reach point E. Emerging nations at point B should learn from the past, innovate and avoid exceeding safe limits, going through the Green Growth (GG) tunnel to reach point E, without passing point C. The BIGG path is also pro-poor and inclusive, thus harmonizing the sustainable development triangle: economy, environment and society.

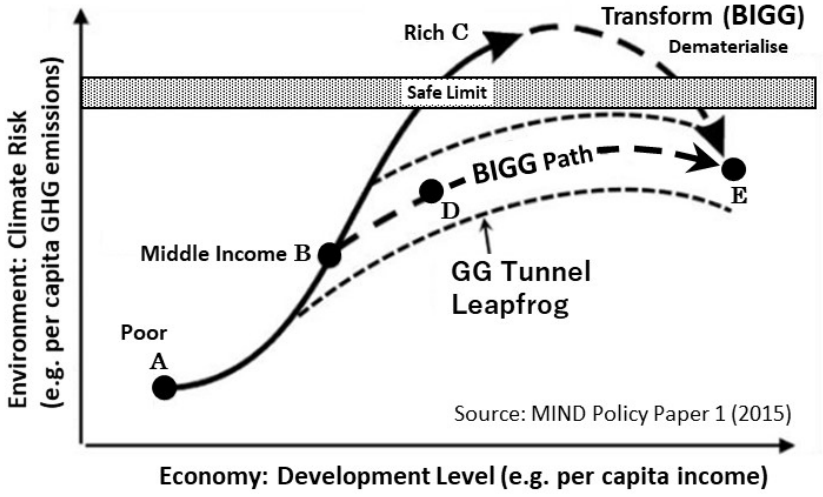

Figure Environmental risk vs. development level

***6 Millennium Consumption Goals (MCGs)**

The MCGs make the path of development more sustainable, by calling for responsible behaviour from the world's richest 1.4 billion people who consume almost 85% of global output. The MCGs are not obligatory targets, but are standards to be achieved through voluntary actions of consumers and producers, supported by government policies.

***7 Sustainable Development Goals (SDGs)**

The SDG are international goals for the period from 2016-2030 stated in the 2030 Agenda for Sustainable Development, adopted at the 2015 UN Summit. They consist of 17 comprehensive goals and 169 specific targets to achieve a sustainable world, and are characterized by a pledge to leave no one on earth behind.

***8 Intergovernmental Panel on Climate Change (IPCC)**

The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) with the objective of conducting comprehensive assessments of human-caused climate change and its implications as well as adaptation and mitigation measures from scientific, technological, and socioeconomic perspectives.

***9 Kyoto Protocol and Paris Agreement**

The Kyoto Protocol established concrete rules based on the Framework Convention on Climate Change, developed at the 1992 Rio Earth Summit. The Kyoto Protocol set targets, until 2020, for measures to combat global warming and mandated that developed countries (excluding the United States) meet their greenhouse gas emissions targets, but it did not regulate emissions in developing countries. The Paris Agreement is a new international framework for reducing greenhouse gas emissions in the post-2020 period. Although all countries, including both developed and developing countries, are required to submit targets under the Agreement, they are not obliged to achieve the targets.

***10 Nobel Peace Prize**

The 2007 Nobel Peace Prize was jointly awarded to the Intergovernmental Panel on Climate Change (IPCC), and Albert Gore, former Vice President of the United States. The IPCC issued its Fourth Assessment Report on climate change in 2007, the year when it was awarded the Nobel Peace Prize. It took six years to prepare the report, with contributions from over 130 countries: including 450 lead authors, 800 contributing authors, and 2,500 expert reviewers.