COLLOQUIA - Accademia Nazionale dei Lincei

Colloquia on Science Diplomacy

MMXX ✦ MMXXI

Edited by
Roberto Antonelli
Giorgio Parisi
Wolfango Plastino

Foreword by
Beatrice Fihn

ISTITUTO DELLA
ENCICLOPEDIA ITALIANA
FONDATA DA GIOVANNI TRECCANI

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DEI LINCEI

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E se 'l mondo là giù ponesse mente
al fondamento che natura pone,
seguendo lui, avria buona la gente.

Dante Alighieri, *La Divina Commedia*,
Par. VIII, 142-144

But if the world below would set its mind
on the foundation Nature lays as base
to follow, it would have its people worthy.

Paradiso, in *The Divine Comedy of Dante Alighieri*,
a verse translation with introductions & commentary
by Allen Mandelbaum, Berkeley-Los Angeles,
The University of California Press, in collaboration
with the Schlesinger Foundation, 1982, p. 72.

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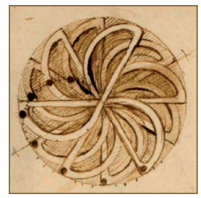
ACCADEMIA NAZIONALE DEI LINCEI

Colloquia on Science Diplomacy



Leonardo da Vinci, Codex Atlanticus (1494)

The *Colloquia* on Science Diplomacy, organized by the Accademia Nazionale dei Lincei in collaboration with the Ministry of Foreign Affairs and International Cooperation, promote the values of Diplomacy and Science in international relations as fundamental principles to be pursued in the *modus operandi* and the *modus vivendi* of modern society.

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MMXX ✦ MMXXI

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Foreword
How Science and Diplomacy Can Save the World

Beatrice Fihn

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How Science and Diplomacy Can Save the World

Over the past two years, the world has been heavily impacted by a massive crisis that has changed everything. With over 5 million people dead from the Covid-19 pandemic and with massive upheaval to the economy, mobility, and society, this catastrophe has proven that we are facing global security threats that require a multilateral and cooperative approach. For the modern protection of people, we need science and diplomacy to be at the heart of any decision-making.

The pandemic has shown us what is needed to solve these new global crises. Healthcare staff stepped up to protect people, working through incredibly challenging circumstances and at great personal sacrifice. Grocery and factory workers, delivery people and other essential workers kept us fed and supply chains going. Scientists worked frantically and coordinated across the globe to develop vaccines in record time, showing remarkable breakthroughs such as the highly efficient mRNA vaccines. Weapons were completely useless in combating this crisis. You cannot threaten a virus with weapons of mass destruction.

And this is only the beginning of this kind of new threat. The world will continue to face these complex types of challenges. We are entering a global climate crisis, with extreme weather, migration flows and instability on the horizon. Nationalism and populism are fueling anti-democratic movements and feeding conspiracy theories and distrust in each other and our institutions. And as if that wasn't enough, we're seeing the nine nuclear armed states engaging in a new nuclear arms race that could literally explode at any second.

These are the threats we're facing in the world today, and none of them will stop at borders. Today's security threats will cross borders, cultures, and continents. They will affect everyone, although the impact will always hit our most vulnerable populations hardest.

None of these threats can be solved by one country, or by nationalistic policies. They can only be solved together, through multilateral action based on scientific evidence and research.

Scientists have warned us before

Scientists started warning about climate change in the 1970s, with global climate models and studies on the impact of increased CO2 levels in the atmosphere. As the 1979 World Climate Conference concluded, "it appears plausible that an increased amount of carbon dioxide in the atmosphere can contribute to a gradual warming of the lower atmosphere, especially at higher latitudes [...]. It is possible that some effects on a regional and global scale may be detectable before the end of this century and become significant before the middle of the next century".

Yet it took decades before the issue of climate change got the attention it deserves. And still today, as people are drowning in floods, fleeing their houses to escape fires, and relocating against their will because of droughts and other climate disasters, governments are still not acting to face the urgent crisis that confronts us.

In 2018, a century after the Spanish flu raged across the world, organizations and experts like the World Health Organization and the International Federation of Red Cross and Red Crescent Societies warned the world that a new pandemic was a real threat to humanity and urged decision-makers to prepare for it, in order to reduce its impact as much as possible. Despite this widely known fact, governments appeared helpless and surprised as the Covid-19 pandemic rolled over the world in early 2020.

These two ongoing crises could have been mitigated if governments had listened to experts and acted earlier.

In 2019, United Nations climate scientists stated that 300 billion US dollars would be needed to stop the rise in greenhouse gases and to buy up to 20 years of time to fix global warming. That is a fraction of the 2 trillion US dollars that governments spend on their militaries each year.

It has been estimated that it would cost 25 billion US dollars to vaccinate the whole world. As new variants of the Covid-19 virus emerge, refraining from ensuring equal distribution of the vaccine across the globe seems like a foolish and shortsighted choice. Instead of spending 25 billion US dollars on vaccinating the whole world and ending this pandemic, world military spending rose to almost 2 trillion US dollars in just 2020. The nine nuclear-armed states spent 72.6 billion US dollars on their nuclear arsenals alone.

For example, the United States spent 37.4 billion taxpayer dollars building and maintaining its nuclear warheads and missiles, planes and submarines. What could it have bought instead? At an average cost of 37,500 US dollars a piece, the United States could

purchase 35,000 more ventilators. At 25,000 US dollars per intensive care unit bed, the United States could buy 300,000 more beds, meeting the reported nation-wide gap. Doctors and nurses across the country are overworked and exhausted. Instead of buying nuclear weapons, the United States could hire 150,000 nurses at an average salary of 75,000 US dollars and 75,000 doctors at an average salary of 200,000 US dollars, as reported by Nurse Salary Guide and Salary.com.

It is short-sighted and foolish to waste billions of dollars on weapons of mass destruction when the world is facing such massive immediate threats to global security such as the pandemic and climate change. Covid-19 is not the first and will not be the last pandemic we face; we are only confronting the beginning of an escalating climate change crisis, yet governments are not taking decisive action yet.

Why we urgently need to listen to scientists and experts about nuclear weapons

The Bulletin of the Atomic Scientists, founded in 1945 by Albert Einstein and University of Chicago scientists, created the Doomsday Clock, using the imagery of apocalypse and the contemporary idiom of nuclear explosion (countdown to zero) to convey the threats and risk to humanity and the planet. In 2021, the Board of Scientists concluded, "Accelerating nuclear programs in multiple countries moved the world into less stable and manageable territory last year. Development of hypersonic glide vehicles, ballistic missile defenses, and weapons-delivery systems that can flexibly use conventional or nuclear warheads may raise the probability of miscalculation in times of tension. Events like the deadly assault of January 6th 2021 on the US Capitol renewed legitimate concerns about national leaders who have sole control of the use of nuclear weapons. Nuclear nations, however, have ignored or undermined practical and available diplomatic and security tools for managing nuclear risks. By our estimation, the potential for the world to stumble into nuclear war – an ever-present danger over the last 75 years – increased in 2020. An extremely dangerous global failure to address existential threats – what we called 'the new abnormal' in 2019 – tightened its grip in the nuclear realm in the past year, increasing the likelihood of catastrophe".

It's hard to look back at the last years without sharing the Bulletin of Atomic Scientists' growing concern about nuclear weapons and the security situation in the world.

We've seen the unravelling of arms limitation treaties, whilst all nuclear-armed states are increasing investments in their nuclear forces to the tune of nearly 73 billion US dollars per year. The risk of nuclear use continues to grow, augmented by new developments in cyber operations and military artificial intelligence. These few governments are putting us all at risk and endangering their people in order to hold on to their weapons of mass destruction.

And experts and scientists know that the consequences of any nuclear weapon use would be devastating. After the first nuclear weapons were dropped on Hiroshima and Nagasaki, the International Committee of the Red Cross (ICRC) reported, horror-struck, on the humanitarian travesty and the decimation of the area's medical response capacity.

About 80% of hospitals were destroyed in Hiroshima and out of 300 doctors, 270 died or were injured; out of 1,780 nurses, 1,654 were killed or injured.

Reporting on the conditions at an emergency hospital in Hiroshima, the ICRC's Fritz Bilfinger wrote "Medical equipment was practically nonexistent. The place looked more like a morgue than an emergency hospital".

As the ICRC and medical associations have repeatedly warned, they cannot prepare to respond to a humanitarian catastrophe on this scale today. Because even the detonation of just one 100-kiloton nuclear weapon over a major city would leave hundreds of thousands to over a million people injured.

It takes around 10 seconds for the fireball from a nuclear explosion to reach its maximum size. A nuclear explosion releases vast amounts of energy in the form of blast, heat and radiation. An enormous shockwave reaches speeds of many hundreds of kilometres an hour. The blast kills people close to ground zero, and causes lung injuries, ear damage and internal bleeding further away. People sustain injuries from collapsing buildings and flying objects.

Thermal radiation is so intense that almost everything close to ground zero is vaporized.

The extreme heat causes severe burns and ignites fires over a large area, which coalesce into a giant firestorm. Even people in underground shelters face likely death due to a lack of oxygen and carbon monoxide poisoning.

There would be nowhere near enough hospital beds, doctors, nurses, ICU beds or burn care centres to treat all the patients from such a blast. Every remaining hospital bed and surviving doctor would suddenly have to accommodate dozens if not hundreds of badly injured patients, while coping with basic utility failures.

People within 4 kilometers in every direction from the detonation point would suffer third-degree burns, but many cities' burn beds number in the single digits. Medical infrastructure would be overwhelmed by many times more new patients in one city in one second than new Covid-19 patients in one day in the entire country at the peak of the pandemic.

A full 9 kilometers from the center of the blast, glass windows can be expected to shatter, causing additional injuries to anyone in the vicinity. How could any city respond to a health crisis of this proportion?

And yet, in many ways, this is the best-case scenario. It only measures the impact of one average-sized nuclear weapon within the first few hours of detonation.

It does not measure the impact of certain modern nuclear weapons, which are many times more destructive, nor does it consider the radiation that would sicken and kill many more over time, the long-term environmental and climate damage or the escalating nuclear war that a nuclear strike over a nuclear-armed state city would almost certainly trigger.

The trauma of overwhelmed hospitals and overburdened doctors and nurses around the world who are struggling to meet the needs of patients during the Covid-19 pandemic shows just how impossible it would be for medical infrastructure to respond to even one nuclear weapon's detonation. We have seen the overfull morgues and the refrigerated trucks of corpses in hospital parking lots.

And sadly, it is clear that a nuclear attack would be much worse. Yet, the governments of the nuclear-armed states and many nuclear-allied states continue to live in denial, ignoring this massive security threat, ignoring the warnings of experts and scientists.

A diplomatic light in the darkness

But while nuclear-armed governments are sleepwalking into disaster, something significant has changed in the last few years, which could not only provide the solution to the nuclear threat, but might also contribute to solving other global threats such as pandemics and climate change.

In stark contrast to the reckless behavior of the nuclear-armed states, the majority of governments in the world gathered in 2017 to use their most powerful weapons, multilateralism and diplomacy, to protect their people, the world and our future by negotiating and adopting the Treaty on the Prohibition of Nuclear Weapons (TPNW).

This didn't happen by mere accident, but was the result of a coordinated push by a coalition of progressive governments, international organizations, civil society, academics, experts, and impacted communities.

Ever since the atomic bombings of Hiroshima and Nagasaki, citizens the world over have petitioned and protested for a permanent ban on nuclear weapons. That ban – long imagined, long sought – entered into force in January 2021.

For the first time, the worst weapons of mass destruction – weapons so horrific that they threaten the very survival of humanity – are subject to a comprehensive, global prohibition. For the first time, a multilateral legal framework exists to eliminate nuclear-weapon programmes, verifiably and irreversibly. For the first time, an international system is in place to assist victims of the use and testing of nuclear weapons, and to remediate contaminated environments.

This treaty is a monumental accomplishment, and it is important to recognize the diverse coalition that contributed to its creation: the activists and concerned citizens, the scientists and academics, the diplomats of many governments, United Nations officials, and Red Cross humanitarians. But perhaps most of all, the *hibakusha*. We all owe a debt of gratitude to the survivors of nuclear war who have courageously and painfully spoken out, time and again, to save humanity from itself.

In many countries, the victims of nuclear weapon use or testing have struggled for the full realization of their rights. Indigenous communities, already victims of social and political marginalization, have been marginalized further still – by transgenerational cancers, by contamination of traditional lands.

Representatives of these communities spoke during the negotiation of this treaty. And what makes the TPNW so unique is that their voices were finally heard by the diplomats and representatives that participated in those negotiations. And even if some of their own governments, to their shame, ignore these voices, the TPNW is still evidence that multilateralism and international law responded to those voices in the treaty.

Developing multilateral solutions to global challenges is not an easy process, and it will often be extremely difficult – if not impossible – to bring everyone along at the same time. The TPNW has been called "divisive" by those who still ascribe value to nuclear weapons, and many of them continue to try to work against it. But over time, this treaty will stand strong – because it is based on strong foundations. It is morally right, and it is coherent with the framework of international law.

Important progress is rarely easy. Groundbreaking steps forward do not start with consensus agreements. There was a lot of resistance when slavery was abolished. There was plenty of opposition when women fought for the right to vote. The fight for civil rights and to end apartheid weren't met with unanimous support by all.

Progress doesn't happen only when everyone is ready; it must be fought for, and someone has to be brave and lead. And with this treaty, we have seen diplomatic leadership based on scientific and humanitarian arguments.

We see instruments such as the Paris Agreement or efforts to achieve a Pandemic Treaty at the World Health Organization struggle to achieve more than the lowest common denominator.

By using the model of the Treaty on the Prohibition of Nuclear Weapons, a model which allows for a group of progressive governments in collaboration with scientists and civil society to set a higher standard, we can set in motion multilateral solutions to global challenges like pandemics, climate change and more.

Beatrice Fihn
Executive Director of ICAN
Nobel Peace Laureate

The *Colloquia* on Science Diplomacy

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The *Colloquia* on Science Diplomacy

The mission of the Accademia Nazionale dei Lincei is to promote, coordinate, integrate and spread scientific knowledge in its highest expressions, in the context of cultural unity and universality. The *Colloquia* on Science Diplomacy promote the values of Diplomacy and Science in international relations as fundamental principles. At the *Colloquia*, the most important personalities of world institutions and the presidents of the most prestigious world academies discuss topics and future developments of interest for the international community.

Diplomacy and the Science have a common *modus operandi* and *modus vivendi*: *dialogue*. Galileo Galilei – *Lynceus* – the father of modern Science, the author of the *Dialogue Concerning the Two Chief World Systems*, highlighted that *dialogue* always requires new "knowledge", new "interpretations" and new "visions" beyond the contemporary horizon. The symbol of knowledge, interpretation and vision is Leonardo da Vinci. Indeed, the *Colloquia* on Science Diplomacy's logo from the *Codex Atlanticus* (folio 1062, recto) depicts the wheel as an object for the study of perpetual motion. Leonardo da Vinci stated that perpetual motion cannot exist in nature, anticipating by more than three centuries the demonstration of that principle provided by the thermodynamic studies of James Clerk Maxwell. Even dialogue is not perpetual.

The 2020-2021 edition of the *Colloquia* was affected by the Covid-19 pandemic which imposed reorganization of the Special Events starting in November 2020 only. The world has been shaken by the crisis created by the Covid-19 pandemic, and at this difficult time, which continues to change the societies in which we live, we are called to care for one another and to avoid closing in on ourselves. In this context, the *Colloquia* fully represented this perspective.

The topic on "Fraternity, Integral Ecology and Covid-19. The Role of Diplomacy and Science" was discussed with H.E. Most Rev. Msgr. Paul Richard Gallagher, Holy See Secretary for Relations with States. The theme was the importance of the concepts of fraternity and integral ecology, both outlined in the last two Encyclical Letters of Pope Francis, *Fratelli tutti* on fraternity and

social friendship, and *Laudato si'* on care for our common home. Seriously facing the causes of this crisis will require a real change of direction involving all of society, and, in particular, the scientific and diplomatic communities, in adopting an integral vision that is capable of promoting an interdisciplinary dialogue to foster trust and develop the common good.

One of the greatest tasks of the 21st century, i.e. to meet society's growing need for healthy, accessible and affordable food whilst simultaneously reducing the environmental impact of agriculture, was discussed with H.E. Qu Dongyu, Director General of the Food and Agriculture Organization of the United Nations (FAO) in his *Lectio Magistralis* "Agri-Food Systems Transformation: From Strategy to Action". Special focus was dedicated to the holistic vision and systemic approach that are required to face the global challenges of today, which are both complex and inter-related. In this analysis, food and agriculture, people's livelihoods and well-being, as well as preservation of natural resources, cannot be addressed in isolation, but rather must be perceived through the action-oriented lens of global agri-food systems transformation, in a people-centred transformative effort that is driven by innovation, technology and data as well as effective institutions and governance.

The topic on "Science and Solidarity for a Sustainable Planet" was discussed with H.E. Inger Andersen, Under-Secretary-General of the United Nations and Executive Director of the UN Environment Programme (UNEP). The UNEP *Making Peace with Nature* report laid out the gravity of Earth's three environmental emergencies – climate change, nature and biodiversity loss, and pollution and waste. These three crises are threatening to pull the rug out from beneath global efforts to create a healthy, peaceful and prosperous planet that lives in harmony with nature. But the report also laid out a blueprint for a transformation to a sustainable future. We need to take strong action in everything from the problems to their causes, focusing on how we can all play our part in addressing them with science and solidarity as guiding principles for a sustainable future.

Known both as the "International nuclear watchdog" and the world's organization promoting "Atoms for Peace and Development", the International Atomic Energy Agency (IAEA) as a centre for international cooperation in the nuclear field was introduced by H.E. Rafael Mariano Grossi, IAEA Director General, in his *Lectio Magistralis* "Atoms for Peace and Development. Science and Technology for a Better and Safer World". The IAEA deters the spread of nuclear weapons by detecting the misuse of nuclear

material and technology. At the same time, it strives to ensure that no community is left behind in benefiting from the peaceful uses of nuclear energy, and also helps them to meet their Sustainable Development Goals.

The topic on "Youth in Science Diplomacy" was discussed with H.E. Henrietta Holsman Fore, Executive Director of the United Nations Children's Fund (UNICEF). Climate change will affect today's children and future generations more than anyone. Despite being the least responsible for the devastating effects of a changing climate – for example, rising temperatures, famines and water insecurity – they are the most affected. Around the world, in the streets and online, children and young people are raising their voices and demanding urgent climate action. Yet they are consistently overlooked in the design and content of climate and water policies and related processes. This failure undermines children's right to be heard in the decisions and actions affecting them – a right codified in Article 12 of the Convention on the Rights of the Child and recognized in the Paris Agreement on Climate Change. This year, UNICEF released a new index that clearly shows the vulnerability of children to the impacts of climate change in each country on Earth. The index also highlights the urgent actions and solutions that must be adopted to avert the worst impacts of the climate crisis for children and communities and to give all children the future they deserve. Above all, these actions and solutions must be designed and delivered in collaboration with those who have the highest stakes in our planet's future: children and young people.

The challenges that the world is facing, such as the pandemic and climate change, are unprecedented in scale and complexity; this was discussed by H.E. Christine Lagarde, President of the European Central Bank (ECB) in her *Lectio Magistralis* on "Dialogue in a Changing World". The commitment to truth, the opposition to false information, as well as the ability to engage with public opinion clearly and emphatically, are the requirements of contemporary political action, which must act in tandem with Science to achieve common goals. Progress is the outcome of such joint efforts: this is why multilateral cooperation is today more important than ever.

We, the Editors, are pleased to present in this volume the remarks from each Special Event of the *Colloquia*. We thank the President of the US National Academy of Sciences, Professor Marcia McNutt, the President of the Pontifical Academy of Sciences, Professor Joachim von Braun, the President of the Royal Swedish Academy of Sciences, Professor Dan Larhammar, the

President of the Royal Society of Canada, Professor Jeremy McNeil, the President of the Norwegian Academy of Science and Letters, Professor Hans Petter Graver, and the President of the French Academy of Sciences, Professor Patrick Flandrin for their fundamental support.

We also thank the Officials of the Holy See Secretariat of State, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), the International Atomic Energy Agency (IAEA), the United Nations Children's Fund (UNICEF), and the European Central Bank (ECB) for their fruitful collaboration. Special mention goes to the Secretariat General of the Ministry of Foreign Affairs and International Cooperation, and to our partners: the Fondazione "I Lincei per la Scuola", the Fondazione Agnelli, the Collegio Carlo Alberto, and the Istituto della Enciclopedia Italiana.

We express our sincere appreciation to all Staff of the Accademia Nazionale dei Lincei for organizing the *Colloquia*.

Accademia Nazionale dei Lincei
Rome, December 10th 2021

Roberto Antonelli
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Colloquia on Science Diplomacy

Fraternity, Integral Ecology and Covid-19

The Role of Diplomacy and Science

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Introduction

Elisabetta Belloni

The title of this Special Event "Fraternity, Integral Ecology and Covid-19. The role of Diplomacy and Science" evokes the main themes of the two last encyclicals of Pope Francis. Focusing on a buffer zone where religion, ethics, science and diplomacy meet encourages us to reflect on and identify the respective role that science and diplomacy play in finding sustainable responses to challenges such as the Covid pandemic – but not only – that we have to face in today's world.

The relationship between Diplomacy and Science is a dilemma that we diplomats have faced since the beginning of our career. It is a dilemma which we used to address as almost a joke: is it better to be a diplomat who, being a diplomat, knows nothing about everything, or a scientist who, being a scientist, knows everything about nothing? Globalization and the interdependence of everything has proven that today more than ever we need a merging of diplomacy and science, a *science diplomacy*, as suggested by the title of the *Colloquia*. It is clear that the existing interrelation of crises, the need to address all their aspects and all their causes, and the unlimited consequences of different remedies introduced, require global responsibility based on a common understanding and on the knowledge, as deep as possible, of the direction we should take. I would suggest "scientific knowledge" as the background and the basis on which political decisions have to be honestly taken.

Through the lens of Aristotle, the scientist and the diplomat are both philosophers: one cultivating theoretical science, the other political science. Their activities revolve around three main objectives: dialogue, truth and the common good.

Scientists and diplomats have been able to foster dialogue between human beings coming from very different personal and national backgrounds, providing a shared language. Dialogue is the merging of two concepts. The concept of "logos" derives from the Greek verb λέγω (*légo*), which means to choose, tell, enumerate, speak, and think, as opposed to the term "mythos". In this opposition, mythos corresponds to mythical thought, based on images,

on the authority of the archaic tradition, on principles accepted and shared uncritically, while logos corresponds to critical, rational and objective thought, capable of submitting beliefs and prejudices to scrutiny. "Dia-" (from gr. διά, δια-) is a prefix that mostly means "between" or "by means of", or indicates separation, diversity.

Dialogue is the search for the logos, the truth. It is therefore a process that allows us to acquire the elements needed for the adoption of a decision after an exchange between all those that have deep knowledge of the essence of the problem in need of addressing. This process allows to reach the core of human coexistence, the identification of the common good, based on profound knowledge and respect for differences, thus overcoming any individualistic approach.

Moreover, theoretical science and political science are both seeking the truth, the logos again. For the former, truth could be an end in itself, the main goal of scientific discovery, while for the latter it is a means to change reality in order to achieve the common good of the polis, the community where the human being thrives. Only by understanding how things really are can we negotiate and find a sustainable compromise.

I think that diplomats and scientists – of course those who interpret their mission according to the highest values based on knowledge – are answering a calling in their life, a calling that requires a strong spirit of service to humankind.

Our work has become more complex than ever in the 21st century.

We are living in the age of interdependence. The phenomenon known as globalization has been at the core of the prosperity of our planet ever since Second World War and technology has widened its scope over the last twenty-five years. The boost of international trade, communication and knowledge sharing has driven one of the most impressive periods of wealth creation in the history of humankind. In 2015, an estimated 736 million people were living in conditions of extreme poverty, from a baseline of 1.9 billion in 1990. Therefore, over the course of a quarter-century, 1.1 billion people have escaped poverty and improved their standard of living.

However, this positive development was accompanied by a worrisome growth of inequality and by an unprecedented stress on the resources of our planet. We have witnessed a spike in the planet's average temperature. The loss of 20% of its biodiversity is driving the deterioration of our ecosystems to a point where, if we do not take action, desertification, lack of water and conflict over other natural resources could lead to a dangerous wave of instability.

Covid-19 has shown how this interdependence can also make the world more fragile. The pandemic has proven that we are all

equally vulnerable in our fragility, but at the same time it has deepened inequality (for instance, can everybody afford treatment for Coronavirus or for the vaccine?). It is true that, thanks to our technology, we are continuously connected to each other, even in the isolation of lockdown. But this does not necessarily make us stronger. The fragility of the individual (who is more and more isolated in spite of our technological connectivity) is actually, somehow, amplified.

The pandemic, including its socio-economic impact, is a major tragedy. But it could also open the opportunity for a new age, similar to the one we saw 75 years ago, with the end of the Second World War, the creation of the United Nations, and the rise of a new world order which granted an era of unprecedented peace and growth.

We will be confronted with serious challenges in the coming decade: post-Covid recovery; climate change; energy transition; growing inequalities and polarization within our societies; artificial intelligence; and many others.

It is clear that we need a new compass.

I truly hope that the next generation will identify a turning point in 2015, the year when Diplomacy gave us the 2030 Agenda for Sustainable Development, Science proved the unquestioned evidence upon which the Paris Agreement was negotiated, and Pope Francis offered all of us the encyclical *Laudato si'*.

The interconnection between economic, social and environmental welfare is at the core of these three documents. There is need for a multidisciplinary approach based on a profound knowledge of nature as well as on the respect for what others can offer or need. This means the revitalization of a new multilateral approach at the global level that abandons individualism in favour of a constructive solidarity. A new world order, which should establish an alliance among states and other subjects of the international community committed to safeguarding the common good.

The great challenges of our time can be tackled only if scientists and diplomats join in their efforts and are able to hold their work to the highest standards, seeking for knowledge and using it to drive toward the common good. To do this effectively, strong investment in education and culture is needed.

The time for healing and reconstruction is now. Italy will play a leading role by taking over the G20 Presidency next week and setting an agenda that will revolve around three words: People, Planet and Prosperity, to remind the world that sustainability and equality are the main objectives to protect our interests.

Lectio Magistralis

Paul Richard Gallagher

This year is characterized by the rapid and inexorable spread of Covid-19, which has put humanity to the test. The pandemic, in fact, caught us by surprise, upsetting our plans and plunging us into an unprecedented and global, "epochal" crisis. In a few months, the coronavirus has infected millions of people around the world and, with the same speed, amplified inequalities in our access to essential goods and services, with devastating consequences, especially for the most vulnerable. "In the very middle of our technological and managerial euphoria, we have found ourselves socially and technically unprepared for the spread of this contagion: it has been difficult for us to recognize and admit its impact. And now, we are rushing to limit its spread".[1] The coronavirus has exposed the radical vulnerability of everyone and everything. It is raising numerous doubts and concerns, including around our economic systems and the way we organize our societies. Our securities have collapsed; our appetite for power and our craving for control have suddenly crumbled. We find ourselves weak and full of fear.

We live in an era full of contradictions. If, on the one hand, we are witnessing unprecedented progress in various scientific fields, on the other hand, the world is facing multiple humanitarian crises in different areas of the planet, each of which are strongly interrelated.

We are facing a *health crisis* that has and will have even greater repercussions especially when considering the environment, the economy, politics, nutrition and access to food. The World Health Organization (WHO) has already recorded more than 50 million people infected by Covid-19 worldwide and well over a million people who have lost their lives due to the pandemic.[2]

[1] Pontifical Academy for Life, *Global Pandemic and Universal Brotherhood*, 30 March 2020.

[2] Cf. WHO (World Health Organization): https://www.who.int/emergencies/diseases/novel-coronavirus-2019.

A food crisis is already underway. It is and will be further exacerbated by the pandemic which has direct and indirect impacts on production, distribution and access to food, the availability of which has been compromised both in the short and long term, especially for the most vulnerable. Furthermore, the food and nutritional situation in the world was already alarming before the spread of Covid-19. According to the latest Report on *The State of Food Security and Nutrition in the World*, published last July by the United Nations agencies operating in the sphere of nutrition (FAO, IFAD, WFP, UNICEF and WHO), in 2019 almost 690 million people were undernourished.[3] Unfortunately, for a few years now, the number of people affected by hunger, which was on the decline since 2010, is increasing once again. The spectre of famine is crossing our world once more. The causes are many and partly depend on an uneven distribution of the Earth's goods. They also include a lack of investment in the agricultural sector, increasing food losses and waste, as well as the proliferation of conflicts in different areas of the planet.[4] Making matters worse, there is climate change, which especially affects small rural producers who live in countries more likely to be exposed to natural disasters and whose economy is based on the agricultural sector.

This last point recalls us back to the *environmental crisis* for which the scientific community, in the face of global warming and climate change, has provided us with countless pieces of evidence, all of which are well known and alarming. Climate change represents a multitude of threats, with the potential to push part of the world's population into extreme poverty in the coming years, nullifying the significant progress that was made in terms of development and that was achieved with great difficulty. The Special Report of the Intergovernmental Panel on Climate Change (IPCC) dedicated to "Climate Change and Land" has shown that at least half a billion people live in areas at risk of further desertification.[5] The result is inevitable: agricultural production and the security of food supplies are falling and the price will be paid by

[3] Cf. FAO, IFAD, UNICEF, WFP and WHO, *The State of Food Security and Nutrition in the World 2020. Transforming Food Systems for Affordable Healthy Diets,* 2020.

[4] Cf. Pope Francis, *Video-Message for World Food Day*, 16 October 2020.

[5] IPCC (Intergovernmental Panel on Climate Change), *Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems. Summary for Policymakers*, 7 August 2019, p. 3.

the poorest populations, many of which will be forced to flee. In October 2018, the IPCC also found that, if no firm commitment is made to the reduction of greenhouse gas emissions, by 2030 global average temperatures could exceed those recorded in the pre-industrial period by 1.5°C, with serious and widespread impacts on humanity both today and in the future.[6] "These studies show that the current commitments made by States to mitigate and adapt to climate change are far from those actually needed to achieve the goals set by the Paris Agreement".[7]

Obviously, to all of this is added the economic and social crisis. The pandemic continues to have significant economic repercussions with substantial effects on the labour market.[8] It revealed and amplified many of the vulnerabilities and injustices that were already present. Regarding its impact on health, the virus does not discriminate. But in the world of work, it is the most disadvantaged and most vulnerable who are hit the hardest and with the most cruelty. The devastating consequences of inequality can no longer be ignored. For millions of workers, no income means no food, no security and no future. The poor, especially those working in the informal sectors, were the first to see their means of survival disappear. Living outside the margins of the formal economy, they do not have access to social safety nets, including unemployment insurance and health care. Thus, as their desperation increases, they are more likely to seek other forms of income, increasing the likelihood of their exploitation, including forced labour, prostitution and human trafficking. We must never forget that "in a genuinely developed society, work is an essential dimension of social life, for it is not only a means of earning one's daily bread, but also of personal growth, the building of healthy relationships, self-expression and the exchange of gifts. Work gives us a sense of shared responsibility for the development of the world, and ultimately, for our life as a people".[9] Work also

[6] Cf. IPCC (Intergovernmental Panel on Climate Change), *Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. *Summary for Policymakers*, 6 October 2018.

[7] Pope Francis, *Message to the United Nations Framework Convention on Climate Change (COP25)*, Madrid, 2 December 2019.

[8] Cf. ILO (International Labour Organization), *ILO Monitor: Covid-19 and the World of Work*, 1st-6th edition, March/September 2020.

[9] Pope Francis, Encyclical Letter *Fratelli tutti* on Fraternity and Social Friendship, 3 October 2020, n. 162.

helps us to fulfil our duty of solidarity towards every social group and community, as well as towards future generations.

The health crisis, food crisis, environmental crisis and socio-economic crisis are all highly interrelated transversal crises, so much so that we can speak of a single and complex socio-health-environmental crisis.

Each crisis requires vision, planning and swift action, moving beyond both individualistic and more conservative approaches.

Taking up an aphorism attributed to Winston Churchill, "never waste a crisis". Every moment of difficulty contains an opportunity. The catastrophic event of the pandemic can be seen as "social remodelling", as a unifying moment in which common interests converge. As Pope Francis suggested while he presided over the extraordinary moment of prayer on March 27, this year, we must "take this time of trial as a time of *choosing*".[10]

The Covid-19 pandemic can, in fact, represent a real moment of *conversion* (and not only in a spiritual sense), a real opportunity for transformation; however, it might also be a recipe for detours from the right path, or individualistic withdrawal and exploitation.

Pope Francis, speaking to the UNGA (United Nations General Assembly), stated: "We are faced, then, with a choice between two possible paths. One path leads to the consolidation of multilateralism as the expression of a renewed sense of global co-responsibility, a solidarity grounded in justice and the attainment of peace and unity within the human family, which is God's plan for our world. The other path emphasizes self-sufficiency, nationalism, protectionism, individualism and isolation; it excludes the poor, the vulnerable and those dwelling on the peripheries of life. That path would certainly be detrimental to the whole community, causing self-inflicted wounds on everyone. It must not prevail".[11]

The response to Covid-19 can, in fact, give rise to the possibility of starting over, a second chance, animated by the hope that, while "the post-industrial period may well be remembered as one of the most irresponsible in history, nonetheless there is reason to hope that humanity at the dawn of the twenty-first century will be remembered for having generously shouldered its grave responsibilities".[12] It is a challenge to civilization in favour

[10] Pope Francis, *Extraordinary Moment of Prayer*, 27 March 2020.

[11] Pope Francis, *Video-Message to the 75th Meeting of the General Assembly of the United Nations*, 24 September 2020.

[12] Pope Francis, Encyclical Letter *Laudato si'* on Care for Our Common Home, 24 May 2015, n. 165.

of the common good and to place human dignity at the centre of all our actions.

This requires a clear vision of what kind of society and economy we want to build and an accurate "reflection on the meaning of the economy and its goals, as well as a profound and far-sighted revision of the current model of development, so as to correct its dysfunctions and deviations. This is demanded, in any case, by the Earth's state of ecological health; above all it is required by the cultural and moral crisis of man, the symptoms of which have been evident for some time all over the world".[13]

This clear vision cannot fail to call for a careful evaluation and re-proposal of the concept of *security*. In 2019, global military spending continued to rise, reaching more than 1.9 trillion US dollars and equalling 2.2% of world GDP (Gross Domestic Product), the highest since 1988.[14] The picture that emerges from this data is a world economy committed to spending more and more to arm itself. The paradox is that its ever-growing expenditure on arms does not contribute to reducing insecurity, but increases it. It confirms the logic of the classic "security dilemma", according to which the search for a balance of forces pushes each State to try to secure some margin of superiority out of fear of finding itself at a disadvantage. However, weapons and armies will not guarantee greater security. This is particularly evident if we consider the fight against Covid-19, a non-military threat, which has shown the total ineffectiveness of military spending in guaranteeing integral security and which can only be resolved with increased global cooperation.

In fact, the current crisis has revealed that this model too, is unsustainable. Despite enormous military investments, the crisis has highlighted the inadequacy of the concept of "security" understood only from a military perspective. An alternative to this unsustainable model is to strengthen multilateralism, while insisting on the commitment to disarmament and arms control, not as an end in itself, but with a view to contributing to common security and peace. This should not be understood as the absence of war, but the absence of fear, and therefore the promotion of social well-being in the common good. Indeed, it is necessary to combine our efforts to inspire dialogue, diplomatic initiatives and common

[13] Benedict XVI, Encyclical Letter *Caritas in veritate* on Integral Human Development in Charity and Truth, 29 June 2009, n. 32.

[14] Cf. SIPRI (Stockholm International Peace Research Institute), *SIPRI Yearbook 2020: Armaments, Disarmament and International Security*, 2020.

security policies. "The international community is called upon to adopt forward-looking strategies to promote the goal of peace and stability and avoid short-sighted approaches to national and international security problems".[15]

"Everything is related", "everything is connected" – this is one of the main threads running through the Encyclical *Laudato si'*. The Holy Father uses it in the awareness that the whole world is intimately connected. The defence of ecosystems, the preservation of biodiversity and the management of the global commons[16] will never be effective if it is not considered together with politics and economics, migration and social relations. "Strategies for a solution demand an integrated approach to combating poverty, restoring dignity to the excluded, and at the same time protecting nature".[17]

From this perspective emerges the need "to convert the model of global development"[18] into an approach that is more respectful of the common good, of creation and of the integral human development of peoples, including present and future generations. We need to adopt a new vision of the world, anchored in an integral ecology. This implies that we promote a more complete understanding of our common home that brings together the scientific, environmental, economic and ethical dimension, and that is open to an "integral vision of life that can inspire better policies, indicators, research and development processes and criteria for evaluation, while avoiding distorted concepts of development and

[15] Pope Francis, *Message to the United Nations Conference to Negotiate a Legally Binding Instrument to Prohibit Nuclear Weapons, Leading Towards their Total Elimination*, New York, 27 March 2017.

[16] *Global commons* have been traditionally defined as those parts of the planet that fall outside national jurisdictions and to which all nations have access. Stewardship of the global commons cannot be carried out without global governance. Global commons include the Earth's shared natural resources, such as the high oceans, the atmosphere and outer space and the Antarctic in particular. Cyberspace may also meet the definition of a global commons. Due to the impossibility to manage effectively global commons at national level, the key challenge of the global commons is the design of governance structures and management systems capable of addressing the complexity through multiple public and private interests. The management of the global commons requires pluralistic legal entities, usually international and supranational, structured to match the diversity of interests and the type of resource to be managed, and stringent enough with adequate incentives to ensure compliance. Such management systems are necessary to avoid, at the global level, the classic tragedy of the commons, in which common resources become overexploited.

[17] Pope Francis, *Laudato si'*, n. 139.

[18] Benedict XVI, *Angelus*, 12 November 2006.

growth".[19] Here the image of the "polyhedron whose different sides form a variegated unity, in which 'the whole is greater than the part'"[20] is very effective.

The development of a polyhedric and interdisciplinary approach to integral ecology has, as its pivot point, the centrality of the human person. The consequence is the promotion of a culture of *care*.[21] This is in contrast to the culture of waste, so widespread in our society today, whose object "is not only food and dispensable objects, but often human beings themselves".[22]

It is therefore essential to adopt an integral point of view that favours an intimate knowledge of nature and its processes. This is a fundamental prerequisite for a better understanding of the current crisis and for the development of effective solutions aimed at correcting the dysfunctions of the current model of development, which has negative impacts on people's lives and on the environment. "A technological and economic development which does not leave in its wake a better world and an integrally higher quality of life cannot be considered progress".[23] The ethical and social dimensions of development must be adequately considered.

All of this implies the education and training of new generations. Indeed, when it comes to integral ecology, particular attention must be paid to the importance of the education process. The transforming power of education in integral ecology requires the patience to generate long-term processes, aimed at shaping genuinely sustainable policies and economies which promote quality of life, in favour of all peoples and the planet, especially the disadvantaged and those in situations of greater risk. Spaces for education and formation are central to this model. They should become more than simply places for the transmission of knowledge; they should be poles for the promotion of integral human development, working with new generations to adopt more sober and responsible lifestyles.

The fact that in an increasingly globalized world everything is interconnected, requires that our centres of education address our

[19] Interdicasterial Working Group of the Holy See on Integral Ecology, *Journeying Towards Care for Our Common Home: Five Years After* Laudato si', LEV, 31 May 2020, p. 9.

[20] Pope Francis, *Fratelli tutti*, n. 215.

[21] Pope Francis, *Laudato si'*, n. 231; Pope Francis, *Fratelli tutti*, nos. 17, 79, 96, 117, 143, 188.

[22] Pope Francis, *Address to the Members of the Diplomatic Corps Accredited to the Holy See*, 13 January 2014.

[23] Pope Francis, *Laudato si'*, n. 194.

interdependence not only at the commercial, economic and technological level but, even more importantly, at the level of our interpersonal, intergenerational and social relationships.

The Covid-19 pandemic revealed problems that had already existed for years and that can no longer be avoided, "The world was relentlessly moving towards an economy that, thanks to technological progress, sought to reduce 'human costs'; there were those who would have had us believe that freedom of the market was sufficient to keep everything secure. Yet the brutal and unforeseen blow of this uncontrolled pandemic forced us to recover our concern for human beings, for everyone, rather than for the benefit of a few".[24] The current situation requires us to reflect on the need for a new solidarity, a conversion of mentality and gaze. It requires the promotion of an ethic of change that is capable of preparing the way for personal and social rebirth. We have experienced both uncertainty and fragility as collective, constitutive dimensions of the human condition. We need to respect these limits and to keep them in mind in every development project, while also caring for the most vulnerable.

After all, "solidarity is not a feeling of vague compassion or shallow distress at the misfortunes of so many people, both near and far. On the contrary, it is a firm and persevering determination to commit oneself to the common good; that is to say to the good of all and of each individual, because we are all really responsible for all. It is above all a question of interdependence, sensed as a system determining relationships in the contemporary world, in its economic, cultural, political and religious elements, and accepted as a moral category".[25] The most important lesson that this pandemic has left us with is that, whatever the emergency we face, it is only by being united, only by showing solidarity, that we can overcome the most trying of circumstances.

The various global problems that we have to face in the 21st century, and of which the Covid-19 pandemic is only the latest clear expression, call for a new ethics and a new kind of international relations. Both must be capable of facing the fact that, as "a society becomes ever more globalized, it makes us neighbours but does not make us brothers".[26]

[24] Pope Francis, *Fratelli tutti*, n. 33.

[25] St. John Paul II, Encyclical Letter *Sollicitudo rei socialis*, 30 December 1987, n. 38.

[26] Benedict XVI, *Caritas in veritate*, n. 19.

For this reason, the process of strengthening international co-operation is even more important and can no longer be postponed, nor can anyone avoid being implicated or remove themselves from it. It is necessary to build it together because no borders, barriers, or political walls can hide or protect anyone from the effects of this socio-environmental-health crisis. There is no room for the globalization of indifference, for an economy of exclusion, or for the throwaway culture so often denounced by Pope Francis. "Today, no State can ensure the common good of its population if it remains isolated."[27] The current circumstances clearly show that goods such as health, the environment, the climate, and security are not just individual or national goods, but public and collective goods. They require an integral and collective approach, both at a substantive and geographical level. This approach depends on responsible behaviour, that is, a behaviour that is aware of others and that is oriented towards "us" and "we". Internationally this approach takes the name of "multilateralism".

Building together presupposes a commitment to pursue constructive dialogue that is interdisciplinary and genuinely oriented towards the universal common good.

Therefore, we cannot overcome an emergency such as that of Covid-19 if we do not combine technical solutions with a vision that places the common good at its centre. Political decisions must take scientific data into account, but interpreting human phenomena solely through a scientific lens would mean producing answers at a purely technical level.

This pandemic has helped us discover that we must start again to think and plan together the future of the planet.

For this reason, a new alliance between science and humanism is indispensable. They must be integrated and not separated and should not be opposed to one another. The health and the economic and social development of our community depend on them. Concerning the latter, "the development of a global community of fraternity based on the practice of social friendship on the part of peoples and nations calls for a better kind of politics, one truly at the service of the common good. Sadly, politics today often takes forms that hinder progress towards a different world".[28]

Better politics means an inclusive politics that is at the service of everyone, where the health of the political system is determined

[27] Pope Francis, *Fratelli tutti*, n. 153.
[28] Pope Francis, *Fratelli tutti*, n. 154.

precisely by the kind of care received by the most vulnerable, because it is the way in which they are treated that reflects the true health of society as a whole and, therefore, of each one of us that makes up the community.

In the current globalized world, such policies cannot be limited to any one nation or region. Instead, it is necessary to have better policies at the international level, bearing in mind, as has already been said, that no country can go forward alone.

While today's problems must be solved by taking into account the entire international community and all of humanity, the world is larger than a single country. The right solutions must also take into account the many complexities that exist. This requires that we engage in scientific collaboration that is truly interdisciplinary and that does not ignore any type of knowledge. "Given the complexity of the ecological crisis and its multiple causes, we need to realize that the solutions will not emerge from just one way of interpreting and transforming reality. Respect must also be shown for the various cultural riches of different peoples, their art and poetry, their interior life and spirituality. If we are truly concerned to develop an ecology capable of remedying the damage we have done, no branch of the sciences and no form of wisdom can be left out, and that includes religion and the language particular to it".[29] Let's make the world great again!

Often, in our technologically advanced world, there is the temptation to seek solutions to problems through science and technology alone. The sciences equip the human intellectual with power that can be used for the common good, or that can be used in a selfish way, leaving others behind. For this reason, the sciences must be guided and oriented by ethical principles, as well as grounded in human nature, in all of its richness. An approach disconnected from the human person cannot reach a solid, just and human solution. It risks being partial, relative and ideological. In recent years, technological development has made it possible to achieve incredible progress for our societies; however, it has also led to the belief that technology itself can predict all human activity using only data and algorithms. Instead, in order to face the consequences of the pandemic, I would argue that we must engage in innovative scientific and institutional models based on the sharing of knowledge and cooperation between different disciplines.

[29] Pope Francis, *Laudato si'*, n. 63.

Life is bigger than science. The study of the laws of nature and wide-ranging scientific investigations can benefit significantly from in-depth and interdisciplinary dialogue. For example, this could include engaging with philosophers and theologians with the aim of building an ethical framework that encourages each of us, with our different skills, to take more responsibility in caring for and cultivating creation[30], building an economic system that will improve, rather than destroy, our world.[31] I am thinking, for example, of the various circular models of production and consumption,[32] capable of contrasting and reversing the perverse dynamics set in motion by the current throwaway culture.

In this time of uncertainty and anguish, the pandemic has amplified the injustices and inequalities in our world, many of which stem from unequal economic growth that disregards fundamental human values and that is indifferent to the damage inflicted on our common home. No country has been spared, no population has come out unscathed and no one is immune to its impact. The spread of the virus has shown us that human health is intimately connected with the health of the environment in which we live.

This chance to start over should be founded in a complex vision and a systemic approach that relies on a renewed sense of solidarity, and respect for the common good and the environment. The international community can no longer pursue a market-based logic, seeking profit at any cost. Instead, it has the moral duty to promote measures and decisions that are ethically founded and that put the human person at the centre. It is necessary to create a fraternal society that promotes education in dialogue and that allows everyone to give their best. The appeal not to leave anyone behind must be a warning, that human dignity should never be neglected and that the hope to build a better future should never be denied to anyone.

I would like to conclude with the words that the Holy Father addressed to the participants of the 75th session of the General Assembly of the United Nations, "We never emerge from a crisis just as we were. We come out either better or worse. This is why, at this critical juncture, it is our duty to rethink the future of our common home and our common project. A complex task lies before us, one that requires a frank and coherent dialogue aimed at strengthening multilateralism and cooperation between states.

[30] *Genesis*, Ch. 2, Verse 15.
[31] Pope Francis, *Laudato si'*, n. 129.
[32] Cf. Pope Francis, *Laudato si'*, n. 22.

The present crisis has further demonstrated the limits of our self-sufficiency as well as our common vulnerability. It has forced us to think clearly about how we want to emerge from this: either better or worse. The pandemic has shown us that we cannot live without one another, or worse still, pitted against one another. The United Nations was established to bring nations together, to be a bridge between peoples. Let us make good use of this institution in order to transform the challenge that lies before us into an opportunity to build together, once more, the future we all desire".[33]

[33] Pope Francis, *Video-Message to the 75th Meeting of the General Assembly of the United Nations*, 24 September 2020.

Discussion*

Paul Richard Gallagher, Marcia McNutt, Giorgio Parisi,
and Wolfango Plastino

Wolfango Plastino: *The current health emergency has underscored the need for more integrated international cooperation. How will a stronger multilateralism help us face the global crisis caused by Covid-19 and more specifically, its political, economic and social consequences?*

Marcia McNutt: First of all, this was a fabulous opening statement, and I would like to elaborate on some of the themes that we've already heard. I think multinationalism is essential on a number of fronts, and let me enumerate a few of them from my perspective as a scientist. The first is epidemiology. We find unfolding before us an unintended scientific experiment. Populations around the globe, with different age and genetic demographics, who are under different public health systems, with different degrees of exposure to pre-existing conditions, and different cultural norms that determine their willingness or resistance to adopt public safety precautions, are all experiencing the very same health emergency. This is a classic example of a multivariate problem for which we have the hope of actually having an overdetermined system. As scientists, we owe it to the public to make national statistics freely available from all our countries on infection rates, on deaths, who is dying, who is getting infected, how badly are they being impacted, and to analyse them globally, in order to understand how best to confront this global scourge. We can't do this on an individual nation basis, but we can do this multinationally.

The second example I want to cite is medicine. Vaccines, treatments, and other therapies are being developed all over the world. We understand deep in our hearts that the ideal humanitarian

* The text below is the full transcript of the Round Table that followed the *Lectio Magistralis* by H.E. Paul Richard Gallagher, Holy See Secretary for Relations with States.

solution is to use these treatments to protect the most vulnerable first. But that's going to require international cooperation.

The third example I want to give is ecology. Zoonotic diseases are becoming more common, they're becoming more deadly, and they're becoming more global in their impact. International cooperation, and understanding the factors that lead to diseases crossing boundaries and acquiring remarkable virulence, is absolutely essential. What are the relative roles of habitat destruction, humans encroaching on the urban-wildland interface, the practice of consuming wild as opposed to farm animals and other factors in leading to the rise of these zoonotic diseases? We have to cooperate internationally if we are going to become more resilient to these kinds of crises.

And then the last example I want to give, which is quite different from the others, is supply chains. Let me start with just a personal story. During the early days of the pandemic, when the US was suffering from shortages of all sorts of personal protective equipment, a scientific colleague of mine from Hong Kong, Zhao Wutang, sent me a large crate filled with thousands of surgical masks. Those masks supplied my local hospital, my entire extended family, and all of my neighbours with the protection we all needed to stay safe during the first few months of the pandemic, until supplies could be established here in the US. But I know that not everyone was so fortunate. We learned, sadly, from the Covid-19 crisis that the just-in-time efficiency of global supply chains was badly suited to global emergencies. We need new paradigms. Engineering works very differently from science. Science is all about discovery. Engineering knows that there are many solutions to problems, and so they optimize which solutions they take depending on the needs of the user. If the user wants the safest solution, that's the one they get. If they want the most cost-efficient solution, that's the one they get. Right now, we don't have supply chain solutions that are suited to crises. And we need to prioritize that.

Now although I've focused on the role of science, engineering and medicine, these challenges benefit cooperation and collaboration across governments, non-governments and communities. And I'd like to acknowledge the role of international scientific organizations in all this, such as the G20 Science Summit 2021, which Italy will host next year, the International Science Council, and the InterAcademy Partnership. They all help to coordinate international science efforts. In fact, the InterAcademy Partnership has a secretariat hosted in Trieste with support from Italy, and I want to thank the Italian government for that. There's also a secretariat in the US which is hosted by our academy. They

have all provided resources to help governments decide on policies regarding Covid-19 and many other issues, and so these organizations have remained strong and vital.

Paul Richard Gallagher: I'd just add a few thoughts onto what I've already said. This mask that I've just taken off – you talk about international cooperation – was actually provided to the Vatican by the Korean Embassy to the Holy See. They've been very attentive, like many other embassies have been, to our well-being. They want to keep us alive, which is not a bad thing.

I think we have to be quite honest, and say that the state of relations between countries and regions of the world, continents of the world, is not that great. It's true that we've had an unprecedented period of peace following on the Second World War. But even today there are many, many, many conflicts taking a very high price for humankind. And so I think that this is an opportunity to renew some of our structures and our organizations; there is urgent need for this, because some of the problems we are facing today could exacerbate those situations. Environmental considerations do not respect borders, nor do pandemics. And there is always the danger, then, that people, if they feel that their neighbours are not taking these problems seriously or are not acting in an appropriate way, might take matters into their own hands.

So it is urgent that relations improve, not only with dialogue but with the use of the multilateral system, and we are very much in favour of reform of the multinational system as well. Many things need to be changed at every level. But at the same time, its very existence is vital at this time. And as I said, this needs to be based on a renewed appreciation of our humanity and renewed commitment to solidarity amidst peoples and cultures and countries to face the common problems that we are facing. And in all of this, I think that diplomacy has its role, that it is more necessary than ever; there needs to be as much "jaw, jaw," and as little "war, war," as possible, and we move forward in that way. I think it's a way of also generating a certain optimism and combatting the pessimism to which I referred, and which is undoubtedly present amongst many of us before the enormity of the problems we are facing. But if we do get people working together, we do get people talking together, and talking about the things that matter most, then I think that we can move forward with a certain degree of confidence.

Giorgio Parisi: Multilateralism is the future. We live in a world with finite resources, and we are bound to work together. It is dramatically true that with the global crisis weaker countries become

poorer, and inequalities increase. During Covid-19, some countries have been touched in a very heavy way, and I'm very sorry to hear about Peru, where the number of deaths this year has nearly doubled with respect to the previous year. This is a real humanitarian disaster, like the Spanish flu, but I have the feeling that other countries don't care about what is happening in Peru.

The Covid-19 crisis will not end if the virus is not eliminated in every country, as was done with smallpox. Vaccination should be a fundamental human right, for this and other illnesses, and this aim, as has been stressed by the international Gavi organization, may be reached only by a strong international combined effort. International collaboration is ultra-fundamental, in order to construct a global pandemic preparedness for future pandemics, and this can be done only within a multilateral approach. We know that there will be a new pandemic in the future, and we must be prepared. The role of the WHO should be strongly increased; for example, we need a global reserve of personal protective equipment, ventilators, tools for sanitizing, whatever may be useful. We cannot let any country be left alone, without these extremely useful objects to help save lives. I wish to add that a global institute of health, something that is organized like the NIH, the National Institute of Health of the United States, would be a crucial step to address all the scientific problems that are related to pandemics and preparedness.

Wolfango Plastino: *What does the coronavirus emergency teach about dealing with environmental threats?*

Giorgio Parisi: The environment is crucial to us in many, many respects. As has already been said by His Excellency Gallagher, global warming is a terrible crisis, and unfortunately we have only started to face it. For the moment, we have only the most feeble signals, but in the future things will become much, much worse. I hope that the Covid-19 crisis has taught all of us that global problems should be solved at the global level. No country (as His Excellency also said) can be saved by its lone efforts.

Let me just mention two of the many ways in which the present environmental threats have influenced the Covid crisis: air pollution strongly increases pulmonary and circulatory illnesses. These illnesses played a crucial role as co-morbidities and increased the death toll of Covid. We also have to remember that animals are a crucial part of the environment; not only is respect for animals our moral duty, but disrespect of animals also has serious health

consequences, as we saw already long ago during the MERS-CoV disease. We know that Covid emerged from a market, where the animals were kept in an unhealthy way. We have just heard, in the recent news, that Covid has been transmitted from humans to minks, and back from minks to humans. This is an extremely worrying phenomenon, because we should avoid the formation of a mammal reservoir of the virus. There are so many points of connection between the environmental aspect and the Covid crisis, that I will leave them to other people to go into greater detail.

Marcia McNutt: I will try not to repeat any of the points that President Parisi has made, which are of course so very important. Let me just say that environmental threats, whether it's Covid-19 or climate change, clearly know no boundaries. We can't close our borders to them. We can't call up our military and tell them to shoot the virus out of the sky. We can't negotiate with them diplomatically. We can't legislate them out of existence. And most importantly, we can't solve them anywhere until we solve them everywhere. My own nation is now leading in cases and deaths per capita – not a record we are proud to claim. Despite strong interventions by some nations to control infection rates, no one is going to be safe as long as the US remains a reservoir for the disease. These ubiquitous problems demonstrate that we have to work together, that facts and science matter.

We can see the consequences of ignoring science and facts daily with Covid-19. We are seeing the consequences of ignoring science and facts also regarding climate change, too, unfortunately, especially here in the US. But let me say this. Shame on us as scientists for too long having assumed that all of society would automatically embrace the benefits of science technology and innovation. We must remake the case each and every day for the benefits of science, and be more mindful about how we can anticipate and mitigate the negative impacts of innovation on some components of society, particularly those who are most vulnerable. We have to recommit to that, and decide how we are going to do that consistently and every day.

Paul Richard Gallagher: These two crises have an awful lot in common. We all know that we're going to be incredibly indebted to the teams of scientists who are working on the vaccines which will hopefully save so many lives in the years to come. But if I look at the other element which is indispensable in this situation, I think it is personal responsibility. The scientists can do so much, but if we are not going to contribute to that, it will not be successful.

So I think that when it comes to the environment – and we see many, many initiatives, and certainly as a result of *Laudato si'* five years ago and the Paris Agreement – many, many people have experienced a kind of ecological conversion, an environmental conversion, and are more aware of the world in which they live and its vulnerability. It's the same thing now with Covid-19. We have to be prudent, we have to be responsible in our actions, and in following the leadership. We can't just leave it up to governments and authorities, or to scientists. Everybody has to do their bit here.

And I think that then underlies the need for recommitment to education; we need to help people who do not appreciate these things, or the young as they are moving into their maturity in the world which is environmentally fragile, and which is affected by Covid-19. We need to help them through education, through our programmes, and to help them to assume the responsibilities which will be theirs in the future for themselves and for their loved ones.

Wolfango Plastino: *The key role of dialogue in our society has been stressed several times, along with the need to encourage interdisciplinary debate between scientists, philosophers and theologians. What is the link between science, religious freedom and the common good?*

Paul Richard Gallagher: I think the principal point that I'd like to make here would be that the benefits that science can bring are many and great, but science and scientists need to work in an ethical and a principled environment. There's an old principle going back to the New Testament, where it says that not everything that we can do is necessarily good, just because we can do it. We have to have that dimension to it: the thing must be ethically sound, in order to produce something good. I think that there is this need for interdisciplinary scientific cooperation, and I think that religious freedom is very fundamental because it draws us to consider what are the fundamental rights of the person, the right to life, the right to other things, the fundamental things. But the right to religious freedom is really that inner, interior freedom that all people should benefit from. And I think it therefore provides an element of a litmus test also for the capacities of science as well.

Giorgio Parisi: Roughly speaking, scientists try to understand world as it is, philosophers ask how we understand the world, and theologians try to relate the world with something that transcends

the world. Of course, this may be a caricature of what happens, but just to summarize the situation.

Now, what I would like to stress, is that all these people have different viewpoints on the same world in which we live, and an interdisciplinary dialogue is very important. It has often been said that scientists and philosophers speak to the mind of people, while religion speaks to the heart of the people. As has been stressed by other participants, in the past scientists have forgotten to address many of the problems of many people, and that is something which brings shame on us. We have to remember that we are all men, that we all have the same ethical principles, and that we should work only in the same direction of the common good. Scientific freedom and religious freedom are fundamental human rights, and in the past their suppression has been the source of many events; I sincerely hope that this kind of suppression of human rights will stop in the future.

Marcia McNutt: Scientists can certainly advise citizens on steps that they should take to protect themselves, for example in the case of the Covid-19 pandemic, or steps they could take to mitigate climate change – how they can protect themselves, their loved ones, their neighbours and all others. But sadly, science cannot make people care about how their actions affect strangers, generations yet to be born, citizens of other nations, or people who do not look or think like they do. And yet we do know that we share a common journey with all of them, and our futures are intertwined, intertwined in a way that means that we're all in this together. Religion has always been one of the most powerful forces for motivating people to think beyond their own personal welfare. Science and religion working together for the benefit of preserving a sustainable future for humanity, for us now, for our children, for our grandchildren, for the unforeseeable future is likely our one, our only, and our best hope.

Wolfango Plastino: *Given its disruptive power, artificial intelligence (AI) is one of many emerging technologies at the centre of many debates due to its ethical and social impacts. What are the challenges, opportunities and risks associated with the use of artificial intelligence?*

Marcia McNutt: Artificial intelligence shares so many aspects of many of the things that we've already been discussing. It offers the promise of multiplying our abilities, of taking over routine tasks, doing them much more rapidly and accurately, and replacing

mind-numbing jobs that no one really wants to do, and even of finding possible answers to questions that were not possible to solve before. AI in my view is neither intrinsically good nor bad. And that's true with most science. Science isn't good or bad, science just is. It's knowledge. But how it is applied can either be a benefit overall to society, or it can have negative impact. And because AI is a disruptive technology, it is essential for researchers to work with civil society to encourage the beneficial applications and mitigate possible problems. As H.E. Gallagher already stated earlier, if we leave it only up to market forces to decide how science and technology are to be used, then shame on us for accepting that negative outcomes can happen.

So, examples of some of the questions that scientists working with civil society need to consider in how AI is applied are: How will we confront the issue of finding gainful employment for those whose jobs are lost to AI? This can't be a situation where those who know how to benefit from it do, and those who don't are simply left behind and become unemployed and destitute. How do we protect personal privacy, which may no longer be guaranteed when independent large datasets are combined using AI, thus circumventing the protections that each database had individually, but no longer hold once they are put together? How do we create an ethical framework for when and how AI can replace humans in decision-making, and how can errors be eliminated? This has been discussed extensively, for example, in drones being used in warfare. And as a fourth example, how can we establish a continuing framework within which we can re-examine the social and ethical implications for AI that involves conversations of scientists, engineers, and civil society all working together? Because, honestly, science and technology change our ethics as it permeates society, and we have to keep up with the pace of that change and constantly look at the new applications, and how they are disrupting our society, and make sure that we are building the society we want, not the society that we are being driven into.

Paul Richard Gallagher: I think I can be really quite brief here, because I want to reinforce some of the things President McNutt has just mentioned. I think that in recent years, maybe even recent decades, the question of AI is the issue broached by more engineers and companies of engineers involved in the development of artificial intelligence approaching the Vatican, asking us for guidance, holding dialogues about the ethical and moral questions associated with this technology. That's been very encouraging, and it does show that the very engineers who are responsible for this development

are aware of both the negative and the positive dimensions, and are to some extent fearful of the misuse of AI.

I'd like to reinforce the question that is certainly of concern to us: the whole question of AI in the matter of autonomous weapons, and where decisions are made during conflicts. And we've seen already increasingly the use of drones, which for the most part are still controlled by generals and other people, but there is the prospect that they could be so programmed as to make their own decisions about targets, etc. The other thing is the whole question of employment, the impact of AI on the employment markets, the danger of technological unemployment, and the impact then that that would have on human dignity, and also on security and the development of our societies. In many parts of the world there are already endemic problems of unemployment. When I was a young priest in the city of Liverpool, there were already then – and we're talking about the late 1970s – families in their third generation of unemployment in the parish that I cared for. Now, forty-odd years later, one shudders to think what the situation may be.

But we certainly do have to make this one of our priorities, because work is not just a way of earning a living, or providing for your loved ones. It is also part of what it means to be a human being, and we shouldn't allow that to be forgotten.

Giorgio Parisi: My colleagues have been very clear and have mostly said everything that I want to say. It is clear that we cannot leave the control of AI in the invisible hand of profit. We should carefully design measures that are needed to share the benefits of AI across society. It is clear that when we have an automatic car, or a self-driving car, there will be the problem that taxi drivers are going to disappear. Taxi drivers will lose their jobs very, very rapidly, and this will be a painful process which should be controlled in some way or other.

We need insight from many fields to maximize the social benefit of artificial intelligence and with interdisciplinary research which involves not only hard scientists but soft scientists, psychologists, economists and so on. We have to give opportunities to education, artificial intelligence and information in schools, and generally speak with citizens in order to give them end-to-end control over what's happening. The issue of military use of AI is extremely important and I think it will be extremely urgent to organize an international conference, discussing what steps could be taken to limit the risks of autonomous weapons, and to arrive at full international agreement on this point for all the countries in our world.

Agri-Food Systems Transformation

From Strategy to Action

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Introduction

Giorgio Marrapodi

I would like to begin on a very serious point – namely, with an overview of the data that tell us that while enough food is currently produced to feed the entire world population, about 821 million people suffer from hunger or malnutrition and about 45% of infant deaths are linked to malnutrition.

Among these people, in 2019 alone, 123 million experienced food insecurity caused by crises: humanitarian, environmental, military and, very often, interconnected crises. In 2020, with the health crisis induced by Covid-19, the food supply chains failed in many countries where they are unintegrated and unable to survive external shocks, worsening the whole picture.

At the same time, 1.9 billion people – more than a quarter of the world population – are overweight, costing the global economy the equivalent of 3.5 trillion US dollars a year, and carrying an even more serious cost in human lives.

About 80% of extreme poverty in the world is concentrated in rural areas where climate change and the delay in resilience and mitigation policies aggravate the effects of food insecurity. For years now, a large literature has described the harmful effects of malnutrition on immune responses, which are unable to adequately cope with pathogens and infections, underlining how serious the problem is especially in low-income countries. And, as I have already noted, in 2020, faced with the health crisis, this situation worsened still more.

To tackle such a complex and systemic problem, the Italian Development Cooperation has been trying for years to identify the strategies and actions necessary to put an end to these dramatic numbers: for this reason, food security, proper nutrition and sustainable agricultural development are the traditional priorities of our commitment.

We employ our response in emergencies, working together with efforts by the international community to defeat the food crises in progress, which affect especially some African countries, acting urgently to save the hardest-hit populations.

However, responding to the emergency is not enough; the goal remains to create the conditions for sustainable agricultural and rural development beyond the emergency, to produce systems which are able to endure and react to future shocks, increasing the resilience of more vulnerable populations.

Italy's efforts in this sector have always been a national priority, but alone, as we well know, we can achieve only limited objectives. The synergies that we put into place in this field with the three Rome-based agencies of the United Nations, which together constitute the main global reference point for the fight against hunger and the promotion of sustainable agricultural development, permit us to amplify our range of action.

We are important financial partners of the Food and Agriculture Organization of the United Nations (FAO) and of all the agencies of the Rome-based UN hub. Ours is a strong and necessary support, but our effort goes beyond it: we take the role of a leading country in the food and nutrition sector, and export our models, which are based on significant experience in Italian agro-industrial development and are linked to the protection of the territory, to organic production, to the enhancement of local peculiarities, to the system of cooperatives, to the added value in processing and to the quality of food, which today makes for the excellence of the sector.

There is always occasion to strengthen our partnership with FAO, thanks to the leadership of Director General Qu, in order to reinforce our view of an agricultural model based on crop diversification – one which promotes biodiversity and restores ecosystems, achieving a balance that ensures long-term soil fertility.

In our work, we dedicate the utmost commitment to the promotion of sustainable agricultural supply chains, through support across the spectrum: with solid roots in science, but with a solid grounding as well in the human rights that characterize our approach to development, supporting small producers, cooperatives, the involvement of local communities and, last but not least, the enhancement of female entrepreneurship and their trade associations. I left this last point for last – but not because, as Fermat writes, "it is not contained in the narrow margin of the page".[1] I assure you, it is for us an essential part of our own "theorem": until everyone acts like human rights are women's rights and

[1] *J'en ai découvert une démonstration véritablement merveilleuse que cette marge est trop étroite pour contenir* (Pierre de Fermat, in a handwritten margin note to his personal copy of Diophantus of Alexandria's *Arithmetica*, in 1637).

women's rights are human rights, once and for all, we will not be free from poverty and hunger, either. 25 years after Hillary Clinton's assertive speech in Beijing, we must unfortunately point out that gender equality has not yet been achieved. Yet until there is true equality, which we must strive to achieve with all the tools available, our work will not be completed.

The Covid-19 emergency has once again shown the importance of resilient food chains, which are capable of reacting to external shocks and continuing their indispensable function of supplying the population.

In a year as difficult as this past one, we have promoted the Food Coalition with FAO to share with other countries our good practices of sustainable agriculture and food supply chains that can be used to create resilient and sustainable food systems and prevent serious crises, like the one we are still experiencing, from interrupting even our most basic needs, such as nutrition.

This model, which entails our view of the humanitarian/development nexus, can save millions of lives which are currently exposed to systemic crises, when they are not tragically lost due to the effects of food insecurity, and we will carry it forward in the main global events of 2020, from the G20 Italian Presidency to the Food Systems Summit in Rome and New York.

I would like to conclude by recalling that often the solutions are at hand, but we are not able to fully grasp them. So this too must be our effort: in carrying out the European *farm to fork* strategy, let us rely on science and nature, which, as the Lincei teach us, do not contradict one another. Let's work with the aim of putting an end to chronic food insecurity for almost a billion people, without moving away from the earth, from agriculture, from food linked to our culture. Most importantly, let's not uncritically turn to the production of food at scale, according to the latest fashion of *lab to fork*.

Lectio Magistralis

Qu Dongyu

The Food and Agriculture Organization of the United Nations (FAO) was established on 16 October 1945 at the first session of the newly created UN in Quebec City, Canada, with 44 nations formally joining the organization. It was the fruit of two years of hard work, which began at the Hot Springs Conference organized by US President Franklin D. Roosevelt. During the conference, the countries decided to establish a specialized agency focused on food and agriculture.

FAO took over the mandate of the Rome-based International Institute of Agriculture, whose mission was to help farmers share their knowledge and establish rural credit unions. The appointment of John Boyd Orr, a prominent British nutritionist, whose research showed the link between poverty and malnutrition, as the first Director General spoke to the mission of the organization. Specifically, the FAO charter stipulates the organization's mandate to reduce extreme poverty, eliminate hunger, improve nutrition, increase agricultural productivity and rural living standards, and contribute to global economic growth.[1]

FAO made an enormous contribution to the Green Revolution through capacity building and technology transfer. New high-yielding wheat and rice varieties developed by Norman Borlaug enabled farmers to double or triple their yields from the 1970s through mid-1990s, especially in Asia, and the Green Revolution helped save hundreds of millions of lives.[2] But it also decayed the environment through the excessive use of fertilizers and pesticides, damaging biodiversity and depleting water resources.

FAO is now working to complete the unfinished agenda of the Green Revolution to reform policies and institutions guided by

[1] FAO Charter, in *Basic Texts of the Food and Agricultural Organization*, 2017, http://www.fao.org/3/K8024E/K8024E.pdf.

[2] University of California – San Diego, "Green Revolution Saved over 100 Million Infant Lives in Developing World: Increased Global Agricultural Production Had Large and Positive Effects on Child Health", *ScienceDaily*, 17 December 2020. https://www.sciencedaily.com/releases/2020/12/201217145235.htm.

science and in line with the 2030 Agenda for Sustainable Development – a collective effort made possible only through partnerships and the generosity of the host government Italy.

A strategic foresight exercise at FAO (CSFE, Corporate Strategic Foresight Exercise) identified key current and emerging socio-economic and environmental drivers and related trends which impact agri-food systems and are in turn impacted by them through feedback effects. Some drivers (systemic [overarching] drivers) directly affect the entire agri-food systems given their high interconnectedness with both supply and demand sides, and their linkages with the global socio-economic context within which food and agricultural activities occur. Other drivers directly impact food access (food demand) and livelihoods, production and distribution processes, or the environment natural resource base supporting food and agricultural activities.

Systemic (overarching) drivers

Population dynamics and urbanization are expected to keep increasing and changing food demand. Sub-Saharan Africa and South Asia are leading these changes. In addition to population growth, other factors relative to different locations are also important (e.g. ageing in rural areas and high-income countries). Other social aspects, such as spatial location and/or gender balances, change also as a consequence of internal and international migration. A recent UN report[3] on megatrends affecting global societies and economies notes that between 2020 and 2050, the portion of people living in urban areas will shift from 53% to 70% globally. These population dynamics present interconnected implications for agri-food systems because population growth and changing structure, urbanization and food demand are closely linked. Urbanization is seen as a challenge for food and agriculture, for instance in its encroaching on fertile land. In addition, the growth of young cohorts, particularly in sub-Saharan Africa and in South Asia, raises serious concerns regarding employment opportunities and the risks of degrading the quality of jobs (remunerations, exploitation, safety) within and outside agri-food systems.

[3] UN (United Nations), *Report of the UN Economist Network for the UN 75th Anniversary: Shaping the Trends of Our Time*, 2020.

Economic growth, structural transformation and macro-economic stability are not always delivering the expected results in the inclusive economic transformation of societies. The transformation of agri-food systems is closely tied to the structural transformation of socio-economic systems at large and their macro-economic stability. Economic growth and economy-wide structural transformation are results and drivers of food and agriculture transformation processes. The World Bank[4] suggested that stronger economic growth is an important driver of poverty reduction; however, poverty reduction is only realized when the gains of economic growth are shared across social strata. Sub-Saharan Africa, for instance, despite its very high economic growth in the last two decades, still awaits substantive economic transformation. The outbreak of Covid-19 is expected to add to the already existing macro-economic imbalances of several countries, where "if the current policy stances continue, the global economy from here to 2030 will face slower growth and higher instability. As labour shares across the world continue on their decreasing path, household spending will weaken, further reducing the incentive to invest in productive activities".[5]

Cross-country interdependencies tie together agri-food systems globally, but low-income food-deficit countries (LIFDCs), Small Island developing States (SIDS) and landlocked developing countries (LLDCs) heavily depend on imports for their food needs. Other countries depend on a small number of export commodities in order to import technology, energy, financial services or healthcare equipment. This commodity-dependence makes economic systems fragile and leads to negative impacts on the lives of people. *The State of Food Security and Nutrition in the World (SOFI) 2019*[6] reports that "eighty percent of the countries (52 out of 65) with a rise in hunger during recent economic slowdowns and downturns are countries whose economies are highly dependent on primary commodities for export and/or import." Furthermore, commodity-dependency may increase the difficulty of addressing environmental and social concerns *inter alia*, because multilateral

[4] World Bank, *Poverty and Shared Prosperity 2018. Piecing Together the Poverty Puzzle,* 2018.

[5] UNCTAD, *Trade and Development Report 2019. Financing a Global Green New Deal,* 2019.

[6] FAO, IFAD, UNICEF, WFP and WHO, *The State of Food Security and Nutrition in the World (SOFI) 2019. Safeguarding against Economic Slowdowns and Downturns*, 2019.

trade agreements create uncertainties,[7] as well as potentially lead to illicit financial flows that draw resources from low-income towards high-income countries, due to weak institutions.[8] The conditions under which these interdependencies increase the resilience and sustainability of agri-food systems and economic systems in general, or force them towards commodity-dependency or other forms of dependency (technological, energy, financial, cultural, geo-political and strategic etc.), is an issue that requires further consideration, while it is hoped that as a reaction to Covid-19, selected countries and communities may move towards self-sufficiency.

Big data generation, control, use and ownership enable real-time decision-making in agriculture and food systems. However, due to the large economies of scale that exist in digital industries, digitalization of many aspects of human life, social interactions and production, including agri-food value chain processes, has resulted in a digital divide, raising concerns also about the economic benefits of big data platforms that are able to amass extraordinary amounts of information on consumer behaviour and preferences.[9] Capacities in National Statistical Systems and awareness of consumers and civil society need to be built on data harvesting, storage, management and control, to ensure country-driven independent, transparent and accountable data generation, validation and utilization processes, as well as their conversion into statistics – and this is particularly important for small countries.

Geopolitical instability and increasing impacts of conflicts, including those relating to competition over resources and energy, are a major driver of food insecurity and malnutrition.[10] SOFI 2017[11] highlights that the vast majority of chronically food-insecure and malnourished people live in countries affected by conflicts. Furthermore, research suggests that 40-60% of intrastate armed

[7] For instance, "Since carbon footprint is not in essence a physical part of products [...] the implications of the TBT [Technical Barriers to Trade] Agreement requirement for the equal treatment for imports of 'like' products remain untested", FAO (Food and Agriculture Organization), *The State of Agricultural Commodity Markets (SOCO): Agricultural Trade, Climate Change and Food Security,* 2018.

[8] Cf. SDG 16, target 4, and Joint African Union Commission (AUC), United Nations Economic Commission (ECA), *Illicit Financial Flows: why Africa Needs to "Track It! Stop It! Get It!". High Level Panel on Illicit Financial Flows*, 2014.

[9] UN Chief Executives Board for Coordination, CEB/2019/1/Add.2.

[10] The number of forcibly displaced persons in 2019 reached almost 80 million people: UNHCR, *Global Trends. Forced Displacement in 2019,* 2019.

[11] FAO, IFAD, UNICEF, WFP and WHO, *The State of Food Security and Nutrition in the World (SOFI) 2017. Building Resilience for Peace and Food Security,* 2017.

conflicts over the past 60 years have been triggered, funded, or sustained by natural resources. Conflicts reduce food availability, disrupt access to food and health care, and undermine social protection systems, and the majority of food-insecure people in many parts of the world result from conflicts. This driver, interacting with climate change, the degradation of renewable natural resources and desertification, is disrupting agricultural livelihoods and food systems. Extractive activities tend to be concentrated in rural areas that include indigenous territories and have been a recurrent reason for socio-economic and ethno-territorial conflicts. A "world in disorder", where international and national conflicts emerge and persist, is among the possible future scenarios. Agriculture and food systems would be affected by disruptions in various parts of socio-economic and environmental systems and would affect people according to their social features (gender, age, ethnicity, socio-economic status, etc.).

Uncertainties. All drivers affecting agri-food systems are subject to multiple systemic risks of hazards carrying uncertainties that often materialize in sudden occurrences. *The Future of Food and Agriculture*[12] (FOFA) highlights that the future of food and agriculture faces uncertainties that give rise to serious questions and concerns, and that these uncertainties revolve around different factors, including population growth, dietary choices, technological progress, income distribution, the state of natural resources, climate change, and the sustainability of peace. The timing, speed, geographic spread and magnitude of the outbreak of Covid-19 and its impacts is a case in point.[13] Multiple risks of disasters and crises, often combined with conflicts and other shocks, generate damage and losses. Extreme climate events such as drought, floods and storms, seasonal variabilities in weather and slow onset events such as sea-level rise are also unfolding emergencies. The 2020 desert locust upsurge together with other high-impact and transboundary food chain crises are also threatening agriculture and food systems. Uncertainties, and more specifically, their impacts on agri-food systems, are difficult to predict and measure, but prevention with risk management and anticipation, including emergency preparedness and capacity to face them, may reduce their impacts.

[12] FAO (Food and Agriculture Organization), *The Future of Food and Agriculture. Alternative Pathways to 2050*, 2018, https://www.fao.org/3/I8429EN/i8429en.pdf.

[13] FAO (Food and Agriculture Organization), *Protecting People and Animals from Disease Threats,* 2018.

Drivers directly affecting food access and livelihoods

Rural and urban poverty. Rural areas are lagging behind. Despite great potential in many instances, a high proportion of rural inhabitants live in poverty or extreme poverty. Labour income in the agricultural sector is lower than the average income of other sectors and is characterized by higher gender imbalances. Many rural territories face severe deficits in infrastructure, institutional weakness, limited access to basic services and natural resources, and an eroded social fabric. Overall, the number of food-insecure people is increasing and malnourishment is widespread, as stated in *SOFI 2020*, because the cost of a healthy diet is much higher than the international (extreme) poverty line, established at 1.90 US dollars purchasing power parity (PPP) per day,[14] and there are significant risks for the most vulnerable of falling into poverty. While the whole of Agenda 2030 is grounded on the 'Leave no one behind' principle, still certain groups within society such as the elderly, children and youth, women, as well as indigenous people, in many instances risk discrimination and marginalization. Moreover, in some instances these groups face conditions such as insecurity, violence and/or involvement in illegal economic activities which aggravate their situation. An additional issue brought about by the outbreak of Covid-19 is the disparity of access to public healthcare services, as well as other public services, within societies and across countries, topped by exacerbated pre-existing gender inequalities along many dimensions, including the increase of care and domestic work that limit women's participation in the labour market. These often unmeasured disparities may provide a more severe picture of current poverty levels, with resulting worsening of purchasing power, and consequent resorting to mere calorie consumption, thus worsening their nutritional status.

Inequalities. Societies are characterized by high inequalities in income, job opportunities, access to assets including natural resources, basic services, and fiscal burden. There are large segments of populations that are living either below the threshold, or at the edge of, poverty, while a few make very significant profits, within and outside the food and agriculture sectors. Women, girls, youth, small producers and indigenous groups suffer the most, and in ways that are not always measured because they go very far beyond

[14] FAO, IFAD, UNICEF, WFP and WHO, *The State of Food Security and Nutrition in the World (SOFI) 2020. Transforming Food Systems for Affordable Healthy Diets,* 2020.

mere economic inequalities. Increased inequality can erode social cohesion, lead to political polarization and ultimately lower economic growth.[15] Worryingly, inequality of income is growing. In Asia, for instance, despite high economic growth over the past few decades (an average annual gross domestic product, GDP, per capita growth rate of 5% from 2000 to 2016), income inequality has risen, thus slowing progress in poverty reduction, with further exacerbating inequalities due to the impact of Covid-19.

Food prices are significantly higher in recent years than they were 20-30 years ago. Indeed, food is around 30% more expensive than in the '90s, even without considering the price spikes of 2008 and 2011.[16] This occurred despite the fact that current pricing mechanisms fail to capture the whole cost of food, including social and environmental externalities at all levels (full cost accounting). FOFA 2050 highlights that if environmental costs were accounted for, food prices might significantly increase, all things being equal, by 30-35% in the next decades. While political and media attention is sensitive to the price of food, and policy makers raise concerns on the efficiency of food and agricultural systems, cheap, unhealthy, and socially and environmentally unsustainable food cannot be the solution.

Drivers directly affecting food and agricultural production and distribution processes

Innovation and science. Several technologies currently applied in agri-food systems contribute to degradation of natural resources. This is due to intensive production systems focusing on profitability over environmental aspects. Technical progress including the emergence of more "systemic" technologies, digitalization, biotechnologies and all other innovative approaches raise opportunities[17] to

[15] IMF (International Monetary Fund), *Fiscal Monitor: Tackling Inequality*, 2017.

[16] As measured by the real FAO Food Price Index (FFPI). The FFPI is a measure of the monthly change in international prices of a basket of food commodities. It consists of the average of five commodity group price indices weighted by the average export shares of each of the groups over 2014-2016.

[17] FAO advocates leveraging ecosystem services to complement these external inputs. The overuse of external inputs increases the environmental footprint of food production – too much irrigation exerts more pressure on an already scarce resource, just as too many pesticides and herbicides damage the environment, reduce biodiversity (which generate ecosystem services) and potentially are prejudicial to human health.

achieve, in concert, the dual aims of producing sufficient food and safeguarding the environment, while remaining mindful of challenges.[18] Research is ongoing into their development, limits and potential drawbacks to ensure that their safety and acceptability aspects are properly addressed, providing gender-balanced access and bringing low-income countries onboard to avoid technological divides.

Public investment in agri-food systems decreased significantly in the last 15 years, as shown by the FAO Agriculture Orientation Index (AOI) for Government Expenditures (SDG Indicator 2.a.1). In many instances, priorities set by governments, particularly those of low-income countries, including LIFDCs, SIDS, and LLDCs, are not implemented due to insufficient public investment and/or the low priority they attribute to local food systems. Thus, those countries that are currently heavily dependent on imports to cover their food needs are likely to remain such, unless they shift their priorities. In addition, adequate regulatory and legal frameworks to secure financing are limited and not conducive to attract private sector investments.

Capital/information intensity of production is increasing due to the mechanization and digitalization of production in almost all sectors, including in food and agriculture. While these trends contribute to augmenting the overall productivity, they also raise concerns for the levels of employment, both in rural and urban areas.[19] Increasing capital intensity in the downstream segments of food value chains limits labour demand in processing and distribution, all things being equal. In addition, the mechanization/digitalization of primary production lowers profits for farmers who do not or cannot appropriate new capital assets. Young farmers, possibly more inclined to adopt digital technologies and other innovations, can increase their capital ownership only if they have access to finance, training and capacity development. However, despite the fact that the progressive spread of advanced technologies is likely to increase the profitability of food-related livelihoods and create new job opportunities, the net job balance is most likely to be

[18] UN (United Nations), *UN Secretary-General's Strategy on New Technologies,* 2018.

[19] UN Economic and Social Council, E/CN.9/2020/2, *Population, Food Security, Nutrition and Sustainable Development*, 2020: "[…] the manufacturing, agrifood and service sectors are themselves undergoing capital intensification through the adoption of information technologies (robotics, digitalization and artificial intelligence) that reduce the need for workers".

negative. Thus, increasing capital/information intensity of food production, associated with ageing, may further contribute to urban migration and the emptiness of rural areas, and if employment and other earning opportunities cannot be found in urban areas, poverty and food insecurity may increase.

Market concentration of food and of agricultural inputs and outputs represents a challenge for the resilience, equitability and sustainability of agri-food systems. Unprecedented levels of market concentration throughout the global agri-food systems[20] spanning from crop seeds, agricultural chemicals, veterinary pharmaceuticals, agricultural machinery, fertilizers, livestock genetics, fishing rights, food processing and commodity trading deserve attention. Furthermore, land concentration associated to the lack of land-use regulations also affects access to resources. This puts rural, local and low-income economies at risk and increases their dependency on external actors. The Covid-19 pandemic is showing the weaknesses of such concentrations, which may require in some circumstances relying more on locally produced goods.

Consumption and nutrition patterns, resulting from a behavioural change in consumers, are key factors affecting food and agriculture systems. Consumers are increasingly making complex choices about the sustainability, nutritional content and safety of what they eat. Shifting consumer demand in the direction of sustainable and healthier eating patterns is important. Recognizing that consumers are ready to change their behaviour if correctly informed may lead to deep changes in production systems. For instance, carbon labelling could help shape consumer preferences, contributing to the transition to a low-emissions economy. This would require an internationally recognized approach in setting the related standards (FAO SOCO, 2018) and, as recalled in the *Global Sustainable Development Report*, building sustainable food systems and healthy nutrition patterns to accelerate progress towards the SDGs (Sustainable Development Goals) requires collaborative action by various stakeholders, including consumers.[21]

[20] IPES-Food, *Too Big to Feed: Exploring the Impacts of Mega-Mergers, Concentration, Concentration of Power in the Agrifood Sector*, 2017, https://www.ipes-food.org/_img/upload/files/Concentration_FullReport.pdf; UNCTAD (United Nations Conference on Trade and Development), *Trade and Development Report 2018: Power, Platforms and the Free Trade Delusion*, 2018.

[21] UN (United Nations), *Global Sustainable Development Report 2019: The Future is Now: Science for Achieving Sustainable Development*, 2019.

Drivers regarding environmental systems

Scarcity and degradation of natural resources. Land, water, soil and biodiversity are progressively degrading. Water scarcity, land degradation, soil nutrient depletion, large-scale deforestation, overexploitation of marine resources and pasture, and pollution at all levels raise serious concerns, not only for the entire agriculture and food systems, but also for the achievements of the SDGs. "Inefficient or unsustainable farming systems are often associated with environmental and soil degradation and biodiversity loss and an increase in crop specialization and distribution can raise the risk of poor harvests."[22] Availability and accessibility of natural resources per capita, including land and water, are one of the most important bottlenecks for agri-food systems. For instance, although the Asian and the Pacific region account for more than half (56%) of the world population, the region covers less than one-quarter of the global land area. Population growth, urbanization and industrialization are increasing pressure on natural resources used by the agricultural sector. In Latin America, the natural resources of the region have been degraded by the development of intensive productive activities related to agriculture and food systems. Sub-Saharan Africa is experiencing the same situation of severe degradation of natural resources, water scarcity in dryland areas of the Sahel and the Horn of Africa, as well as in Southern Africa. Massive deforestation is also occurring, linked to the extension of agricultural land, to the exploitation of mining, to infrastructure works such as hydroelectric dams or roads, to urbanization, and even to excessive logging. Competition over progressively scarce natural resources contribute to conflicts, and likewise, the agricultural sector across many regions is increasingly deeply affected by the frequency and intensity of extreme weather events.[23]

Epidemics and degradation of ecosystems, beyond Covid-19, may increase in the future due to rising trends in transboundary animal and plant diseases and pests, agriculture encroaching on wild areas and forests, antimicrobial resistance and the increasing production and consumption of animal products. According to a UNEP-ILRI

[22] UNEP (United Nations Environment Programme), *Global Environment Outlook – GEO-6: Healthy Planet, Healthy People*, 2019.

[23] Full-cost accounting of natural resource use and degradation, mentioned above, while engendering shifts in prices may have impacts on natural resource use, GHG (Greenhouse Gas) emissions and biodiversity.

report,[24] "the pathogens originate in animals, and the emergence or spillover of the diseases they cause in humans is usually the result of human actions, such as intensifying livestock production or degrading and fragmenting ecosystems, or exploiting wildlife unsustainably." All this adds to the increasing occurrences of events that threatens food safety, aggravated by climate change, and calls for a One Health approach.[25]

Climate change, due to agricultural and economy-wide greenhouse gas (GHG) emissions, is already affecting food systems, food safety and natural resources, and is expected to accelerate hunger and poverty in rural areas.[26] In Latin America, for instance, food systems will be impacted, both currently and in the medium- and long-term, by climate change. It is estimated that rain-fed production in selected areas (e.g. in the Southern Cone of Latin America) will be reduced by seasonal water stress. In addition, fisheries and aquaculture production will be affected. SIDS and coastal areas will face sea level rise, increased hurricane frequency and intensity, saline intrusion, ocean acidification and warming and increased incidence of coral bleaching. On the other hand, "an estimated 23% of total anthropogenic greenhouse gas emissions (2007-2016) derive from agriculture, forestry and other land use".[27] Not only agri-food systems contribute a large share of total global CO2-equivalent emissions, including through deforestation and other land use changes, but almost all prevailing economy-wide development paradigms are based on fossil fuels and huge GHG emissions.[28] Overall, there are no risk-informed measures to tackle a warming planet

[24] UNEP (United Nations Environment Programme) and ILRI (International Livestock Research Institute), *Preventing the Next Pandemic: Zoonotic Diseases and how to Break the Chain of Transmission,* 2020.

[25] WHO (World Health Organization) One Health approach to designing and implementing programmes, policies, legislation and research requires that multiple sectors work together to achieve better public health outcomes such as food safety, the control of zoonoses (diseases that can spread between animals and humans, such as flu, rabies and Rift Valley Fever), and combatting antibiotic resistance of bacteria.

[26] Regarding the impact on food safety, see for instance: FAO (Food and Agriculture Organization), *Climate Change: Unpacking the Burden of Food Safety*, Rome, 2020, https://www.fao.org/3/ ca8185en/CA8185EN.pdf.

[27] IPCC (Intergovernmental Panel on Climate Change), *Special Report on Climate Change, Desertification, land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems,* 2019.

[28] This also applies to some activities that are increasingly portrayed as complementary to agricultural activities in rural areas such as tourism, whose GHG footprint has largely to be investigated.

beyond a 1.5 degree scenario, and there is limited understanding of the implications of deep decarbonization. Vision and knowledge about these issues is particularly important for the post-Covid recovery process that, it is assumed, will "build back better".

The "Blue Economy", that is the development of economic activities related to oceans and coastal areas, is increasing globally, and increasingly the concept around which countries (particularly SIDS and other states that enjoy large Exclusive Economic Zones, or EEZ) build their economic development policies. A recent IPCC report[29] highlights an important role for sustainable ocean industries to reduce GHG emissions and adapt to climate change. At the same time, while aquaculture is expected to provide the necessary increase in aquatic products globally, its regional development is uneven and hampered by constraints which need to be adequately addressed through better governance, increased investment, and targeted support of environmentally friendly production systems such as integrated multi-trophic aquaculture in coastal areas and integrated agriculture-aquaculture in inland regions, with a special focus on Africa which is the only region foreseen to have declining "apparent consumption".[30] Aquatic food production systems are nested in the larger development framework. However, many "blue economy" policies favour large projects such as oil/gas and shipping/ports or even tourism, which bring economic benefits, but also environmental degradation, with impacts on food from the ocean and ocean biodiversity. Arising trade-offs require further investigation for risk-informed, sound policy-making and investments for resilient and sustainable development.

Current agri-food systems are failing. They are not delivering the food security and nutrition outcomes that countries aim to achieve by 2030. They are also creating vicious feedback loops that are harmful to health, the economy and the planet.

For starters, the world is not on track to ending hunger.[31] The number of hungry people in the world has continued to rise. Almost 690 million people went hungry around the world in 2019,

[29] IPCC (Intergovernmental Panel on Climate Change), *Special Report on the Ocean and Cryosphere in a Changing Climate,* 2019.

[30] Apparent consumption is a proxy measure for consumption of a product or material defined as production plus imports minus exports of the product or material (UN Stats Glossary).

[31] FAO, IFAD, UNICEF, WFP and WHO, *The State of Food Security and Nutrition in the World (SOFI) 2020*, *Key Messages*, 2020, https://www.fao.org/3/ca9692en/online/ca9692en.html#chapter-Key_message.

an increase of 10 million over 2018. During the five years before that, the ranks of the hungry swelled by 60 million. The coronavirus pandemic is estimated to have pushed an additional 83-132 million into chronic hunger in 2020. Additionally, 2 billion people globally don't have regular access to safe, nutritious and sufficient food. If recent trends continue, the number of people affected by hunger will surpass 840 million by 2030.

The world is also not on track to defeating malnutrition.[32] Despite some progress, child stunting remains unacceptably high. In 2019, over 21% (144 million) of children under 5 years of age were stunted, and almost 7% (47 million) were wasted. Child overweight is also not improving, with about 38 million, or 5.6%, of children being overweight. Adult overweight and obesity are also on the rise in rich and poor countries alike. The number of people living with obesity exceeded that of people in hunger in 2012. And more than 3 billion people globally cannot afford a healthy diet.

Our dietary choices and agri-food systems have dire consequences not only on health. They inflict significant environmental damage, including staggering levels of food loss and food waste, air pollution, greenhouse gas emissions, and loss of biodiversity. They are also a growing source of inequality.

Understanding these hidden costs is critical for making progress in other Sustainable Development Goals.[33]

By 2030, undernourishment must fall everywhere to a maximum of 5%. Healthy diets must be affordable for all. Overweight has to be cut everywhere to 15% or lower, similar to what it was in the 1980s. In every country, obesity needs to fall to no more than 5%. Stunting among children must be reduced significantly. The lost decade in rural poverty reduction needs to be recovered. In order to cut rural poverty, inequality must be addressed. Finally, the world has to meet the Paris agreement target of limiting global warming to less than 2°C.

Agri-food systems are the largest economic system, measured in terms of employment, livelihoods and planetary impact. They employ 4 billion people, directly and indirectly. Poverty and inequality are endemic in agri-food systems. As stated earlier, 690 million people go to bed hungry every night, even though the world produces enough food for everyone. About 80% of the extreme poor live in rural areas, working in agri-food systems.

[32] Ibid.
[33] Ibid.

To achieve our food security and nutrition goals, it is important to approach the challenges in a systems-based way, adopting a holistic view. That means recognizing the interconnectedness of the economic, social and environmental impacts of our agri-food systems, looking for synergies and trade-offs in policy solutions. Evidence must guide how to prioritize policy actions and investments.

The pay-off of doing this can be tremendous, including an array of solutions to reduce our carbon foodprint and ensure environmental sustainability, while making healthy foods more affordable for everyone and addressing inequality. A systems-based approach could also help policymakers manage trade-offs. For example, some low- and lower-middle income countries may need to increase their carbon footprints in order to meet the dietary needs of their populations, particularly to prevent malnutrition.

Making agri-food systems more inclusive, sustainable and resilient will go a long way toward ending hunger and malnutrition.

Agri-food systems are the major driver of climate change and the planet's unfolding environmental crisis.[34] Agriculture uses about 40% of the Earth's land and emits more greenhouse gases than all cars, trucks, trains, and aeroplanes combined. Runoff from fertilizers pollutes waterways and coastal ecosystems. Agriculture also consumes 70% of all freshwater on Earth. And it causes approximately 80% of forest loss.

The coronavirus pandemic is a wake-up call on the urgent need to transform agri-food systems. This is because Covid-19 and climate change are intimately linked. Covid-19 and other diseases are rooted in environmental change. 60% of all infectious diseases are zoonotic, and 75% of all emerging diseases are zoonotic.[35]

Food systems have contributed to substantial biodiversity loss, even though biodiversity is indispensable to food security. It supplies many vital ecosystem services, such as maintaining healthy soils, pollinating plants, controlling pests and providing habitat for wildlife – for fish and other species that are vital to food production.[36]

[34] UN (United Nations), *Policy Brief: The Impact of COVID-19 on Food Security and Nutrition*, June 2020, https://www.un.org/sites/un2.un.org/files/sg_policy_brief_on_covid_impact_on_food_security.pdf.

[35] UNDP (UN Development Programme), *Coinciding Crises: how COVID-19 and Climate Change Are Putting Pressure on Health Systems Worldwide – and How we Can Prepare for the Future*, 2020, https://reliefweb.int/report/world/coinciding-crises-how-covid-19-and-climate-change-are-putting-pressure-health-systems.

[36] FAO (Food and Agriculture Organization), *The State of the World's Biodiversity for Food and Agriculture*, 2019, http://www.fao.org/state-of-biodiversity-for-food-agriculture/en/.

It should raise the alarm that key components of biodiversity for food and agriculture are declining. Humans have fundamentally altered 75% of the Earth's land surface.[37] Around 1 million animal and plant species are threatened with extinction.[38] About 66% of the ocean area is experiencing multiple impacts from people, including from fisheries, pollution, and chemical changes from acidification. Nearly a third of fish stocks are overfished.

Deforestation and forest degradation continue to take place at alarming rates.[39] This is of course resulting in significant loss of biodiversity. Forests cover 31% of the global land area. And the proportion of land covered by forests is decreasing. In the last 30 years, the world lost 178 million hectares of forest, an area about the size of Libya. Since 1990, an estimated 420 million hectares of forest has been lost through deforestation. While the rate of deforestation is going down, the world is still losing an area of forest the size of Italy every 3 years.

Forests remove about one third of the fossil fuel emissions every year. So the loss of forests means not only a loss of resources and products forests provide for humans, plants and animals, but also not being able to meet the global climate goals. If deforestation is halted and degraded forests are restored, it can provide up to one third of climate mitigation needed between now and 2030 to stabilize global warming to below 2°C.[40]

Agricultural expansion is the main driver of deforestation and the associated loss of forest biodiversity. So to stop deforestation and the loss of biodiversity, agri-food systems must change.

FAO's Strategic Framework seeks to support the 2030 Agenda through sustainable, inclusive and resilient agri-food systems for better production, better nutrition, a better environment, and a better life.

The four "betters" represent an organizing principle for how FAO intends to contribute directly to SDG 1 (no poverty), SDG 2

[37] UN (United Nations), *First Person: COVID-19 is not a Silver Lining for the Climate, Says UN Environment Chief*, 5 April 2020, https://news.un.org/en/story/2020/04/1061082.

[38] IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services), *The Global Assessment Report on Biodiversity and Ecosystem Services. Summary for Policymakers*, 2019, https://ipbes.net/sites/default/files/2020-02/ipbes_global_assessment_report_summary_for_policymakers_en.pdf.

[39] FAO (Food and Agriculture Organization), *The State of the World's Forests*, 2020, *Key Messages*, https://www.fao.org/3/ca8642en/online/ca8642en. html#chapter-Key_message.

[40] Ibid.

(zero hunger), SDG 10 (reduced inequalities), and to achieve the broader SDG agenda, which is crucial for achieving FAO's overall vision. The "betters" reflect the interconnected economic, social and environmental dimensions of agri-food systems. As such, they also encourage a strategic and systems-oriented approach within all FAO interventions.

In order to maximize efforts in meeting the SDGs and to accomplish the organization's aspirations – the four betters – FAO will apply four cross-cutting/cross-sectional "accelerators": technology, innovation, data and complements (governance, human capital, and institutions) in all of its programmatic interventions.

Emerging technologies are already changing the food and agriculture sector. Helping farmers take full advantage of new technologies such as digital agriculture, biotechnologies, precision agriculture, innovations in agroecology, 5G, and Artificial Intelligence can increase food production, while minimizing the environmental footprint. For example, accelerators can help reduce physical inputs and improve or optimize their use. Digital tools – from e-commerce and blockchain transaction ledge to improved pest control and crop genetics using AI – can optimize natural resources and enhance food security.

Innovation in agriculture is a driving force for achieving a world free from hunger and malnutrition. Social innovations, policy innovations, institutional innovations, financial innovations, and technological innovations are important drivers affecting food and agricultural production and distribution processes.

FAO's geospatial platform and the big data lab exemplify how data on food, agriculture, socio-economics, and natural resources can come together to help strengthen evidence-based decision-making in the food and agriculture sectors. Data can enable monitoring of agricultural water productivity, allowing the design of targeted agricultural interventions and investment plans through a territorial approach which fosters inclusion and sustainable food and nutrition security.

Complements refer to the needed governance, human capital and institutions that can ensure agri-food systems transformation is inclusive and equitable. It is critical that technology, innovations and data are inclusive and gender-sensitive, and are used to spur development. Transformative processes require as a precondition much stronger, more transparent and accountable institutions and governance, including adaptive and effective regulatory governance.

As technologies revolutionize, the risks of unequal access and exclusion loom. Investments in human capital by building capacities, as well as policy and regulations minimizing such risks are

required. It is imperative that the labour supply respond to the new labour demand that will result from the new technologies and innovation to make the process more inclusive. Technologies have to be affordable, so that everyone can access them. Other structural barriers, including lack of education and training, must be identified and addressed.

FAO has prioritized 20 programme priority areas around the *four betters* of the new strategic narrative.

• *Better Production* means ensuring efficient, sustainable consumption and production patterns through sustainable and inclusive supply chains to boost food systems resilience. Priority areas include green innovation, blue transformation, one health, small-scale producers' equitable access to resources and digital agriculture.

• *Better Nutrition* means ending hunger, achieving food security and improving nutrition. Priority areas include healthy diets for all, nutrition for the most vulnerable, safe food for everyone, reducing food loss and waste and transparent markets and trade.

• *Better Environment* means protecting, restoring and promoting sustainable use of terrestrial and marine ecosystems, promoting a good environment for farming systems, and combating climate change through sustainable, inclusive and resilient agri-food systems. Priority areas include climate mitigating and adapted agri-food systems, bio-economy for sustainable food and agriculture, and biodiversity and ecosystem services for food and agriculture.

• All of the above contribute to *Better Life*. This means promoting inclusive economic growth by eliminating hunger, improving the life of vulnerable people, reducing inequalities, and improving quality of life in urban and rural areas. Priority areas include gender equality and rural women's empowerment, inclusive rural transformation, sustainable urban food systems, agriculture and food emergencies, and resilient agri-food systems. Scaling-up investment and the Hand-in-Hand Initiative focus on ensuring that collective action towards SDG achievement can be scaled to trigger transformational change in agri-food systems.

Cross-cutting themes around gender, youth and inclusion will ensure that FAO does not lose sight of vulnerable and marginalized groups in its work. FAO is deeply committed to leaving no one behind and contributing to the attainment of SDGs 1, 2 and 10.

Finally, as previously mentioned, FAO will apply the accelerators – technology, innovation, data and complements (governance, human capital and institutions) – in all its programmatic interventions to speed up progress and minimize trade-offs.

The following showcases FAO's programme priority areas around the betters.

Digitalization

FAO proposes the development of "1,000 Digital Villages", focusing on digital technologies to improve production and agribusiness management as well as market-oriented agricultural processes.

• From the perspective of agricultural production, it refers to "e-Agriculture." It focuses on improving productivity by using Information and Communications Technologies, as well as other digital solutions. Examples: climate-smart agriculture, precision agriculture, intelligent facility agriculture.

• From the perspective of farmer's livelihood, it refers to "Digital Farmer Services". It focuses on enhancing farmers' access to financial services, social protection and insurance. Examples: digital finance, fintech, digital agricultural insurance schemes and farm registries.

• From the perspective of the village, it refers to digital services that can support "Rural transformation". It focuses on enhancing the delivery of public services in health, education, jobs, welfare, eco-tourism and agri-tourism.

Transformation through aquaculture

Capture fisheries peaked in the mid-1990s. They have since remained remarkably constant, regional variations notwithstanding. At the same time, aquaculture – an old production industry – started to grow, and it now matches capture fisheries in volume.

FAO has projected three future scenarios for both sectors: a high-road scenario, a low-road scenario, and business-as-usual scenario. There is a difference of 110 metric tonnes between a high-road and a low-road scenario. "Blue transformation" can take fishermen to the high-road scenario. There is a gap between sustainable intensification of aquaculture (where food is needed most) and transformative fisheries management (where sustainability is under threat). Blue transformation can fill this gap by 2050.

Fish are more efficient at converting protein than terrestrial livestock. This is because they expend less energy on maintaining bodily processes than terrestrial livestock do. So they outpace chicken, pork and beef in their efficiency. One kg of fish will provide 1 kg of feed; with beef, it would be 150 g of feed, with pork 280 g of feed. Even though fish is an excellent source of food to address micronutrient deficiencies, especially in pregnant women and children under 5 years of age, it wasn't until 2014 that the

role fish can play in eliminating hunger and malnutrition was recognized by the Committee on World Food Security.

Sustainable urban and rural development

FAO launched the Green Cities Initiative to improve the urban environment, strengthen urban-rural linkages and boost cities' resilience, services and populations against shocks, like climate change and the coronavirus pandemic. The initiative builds on FAO experience of integrating agriculture, forestry, fisheries, and sustainable food systems in urban and peri-urban settings. The main objective is to increase people's well-being through better access to improved products and services provided by urban and peri-urban forestry, agriculture and food systems. The initiative will be implemented in at least 100 cities around the globe in the next three years; 1,000 cities are expected to join by 2030.

FAO launched the Hand-in-Hand Initiative to accelerate agricultural transformation and sustainable rural development to end poverty, hunger and all forms of malnutrition. It is a country-led, country-owned programme to eradicate poverty and end hunger and malnutrition. It uses integrated geospatial, bio-physical and socio-economic analysis to identify territories where agricultural and rural transformation can have maximum impact within a 6- to 8-year timeframe. The programme supports countries that have limited capacities for sustaining such processes on their own, including those facing serious food crises. Currently, 34 countries have signed on.

Discussion*

Qu Dongyu, Joachim von Braun, Giorgio Parisi,
and Wolfango Plastino

Wolfango Plastino: *According to State of Food Security and Nutrition in the World (SOFI) Report 2020, three billion people can't afford healthy diets today; what changes are needed to increase access to healthy diets and to assure at the same time sustainable agri-food systems?*

Joachim von Braun: Before answering this question, first let me define healthy diet. It is a diet that is human-health promoting and disease-preventing by providing adequacy of nutrients, without excess, from foods that are nutritious and healthy, and avoiding the introduction of health-harming substances anywhere in the value chain. Healthy diets must also be accessible and affordable and culturally acceptable.

So what changes are needed to increase access to healthy diets and to ensure at the same time a sustainable agri-food system? This is a complex modelling issue. We are addressing it for the Food Systems Summit in cooperation with FAO, because we need to assess synergies and trade-offs. I have four quick points to make. People need to have the purchasing power to buy a healthy diet. The poverty line postulated by the World Bank needs to be higher. 1.90 US dollars a day does not buy a healthy diet. Poorer people need social safety nets to ensure their access. Secondly, the food industry needs to be part of this, and it needs to produce healthy food. Governments need to regulate for safe and healthy food. Consumer information needs to be sound and labelling understandable. Third, there needs to be direct action for children to have access to healthy diets. School lunches and early childhood feeding at health and nutrition centres need to be expanded and better funded to have broader coverage of lower-income children, especially under Covid-19 conditions. And fourth, for sustainable food systems, food prices must

* The text below is the full transcript of the Round Table that followed the *Lectio Magistralis* by H.E. Qu Dongyu, Director General of the Food and Agriculture Organization of the United Nations.

reflect the true cost of healthy food. So-called externalities must be internalized, farming needs the incentives to become climate-neutral and shift to more sustainable land use. Food losses must be cut by means of technologies, and food waste by incentives and behavioural change targetted at consumers.

So your simple question requires a complex answer. We need to follow up on it.

Giorgio Parisi: Producing a healthy diet is not simple. So many different aspects must be considered, aspects which are not only scientific but also socio-economic, because it is one thing to know what should be done, and it is another to have other people do it, and to implement it on the field. Many aspects should be considered, but I would like to stress one, which I believe is very important, and that is biodiversity.

Biodiversity is crucial, because it has many different positive effects. Biodiversity is an insurance against bad harvests. I mean that one food crop may be destroyed by a pest, while another one may survive. Other crops can compensate for the one that is destroyed by adversity. Biodiversity also allows for food diversity, both daily and seasonally. For technical reasons, the diversity of crops allows the soil to regenerate, and micro-organisms can adapt to the great difference of compounds over time, making it more difficult for pests and other organisms to multiply. Agriculture and related land use, of course, accounts for something like 17% or 19% of the total CO2 emissions, and the transport costs may also be very high for easily degradable goods like fruit and vegetables. I think that while monocultures seem to be economically viable, they must be strongly discouraged.

Qu Dongyu: I fully agree with Professor von Braun and President Parisi, but I just want to highlight Professor von Braun's points. I respect him because, you know, we need a developed economy. If you don't develop a country which is neither big nor rich, you will create a lot of social problems in time. So, we need development and the creation of jobs, decent jobs for the farmers and the people, so they have money to buy their homes. That's the incentive. No matter whether it's food-intensive agriculture or fashion shows, fashion design or industry, or something else, we need to create jobs for development.

Second, we need innovation to improve efficiency, productivity. It doesn't matter whether it's a biotic or an abiotic approach or an engineering approach, because we're talking about biological sectors, biotechnological sectors. And so we need engineering, too. I

visited some Italian factories many years ago. You have very good machines for horticulture, for trimming the garden and so on. All these agricultural sectors are related to technology and innovations. We need innovation to improve jobs and incomes. And last but not least, we need an enabling policy to look at all the issues, like those that President Parisi mentioned, such as how to have farmers and local communities make use of biodiversity and transform biodiversity into food diversity. You can only protect your food, your biodiversity, through food diversities *in situ*. We even have a professional word for this: *in situ*. So you have one village protecting its native flowers, vegetables, fruit. I visited some small villages in Italy many years ago. Each has its special fruit, its special vegetables. And that's your national gene bank, your national germplasm.

So you can let your farmers grow, making food for other consumers for generations to come. Otherwise you're only talking about biodiversity protection. That's not very relevant to our daily life; it's only relevant to the experts. It's not good enough. So I think of these three aspects – enabling policy by putting the durables first, decent jobs in bio-agriculture, and the food industry and so on – and I think of the digital also. In China, we have 60 million new digital jobs created in e-commerce. So you lose jobs from the department store, from supermarkets, but at the same time you create new jobs in e-commerce. Direct service. These are real transformations through innovation. And that is the final point: innovation. Innovation in all things, not only technology, but business models, policy and so on.

Wolfango Plastino: *How do we use science and innovation to transform agri-food systems to achieve the 2030 Agenda for Sustainable Development Goal 2: Zero Hunger?*

Qu Dongyu: First, zero hunger: what does zero hunger mean? For different regions, for different peoples, there are different interpretations. I would say that the staple food in Africa is cassava. In Asia, South Asia, it's rice. In the South Pacific islands, it is taro, and in the Caribbean region it is a legume, or pulses. So we have the first thing to focus on: first, there are major commodities of the zero-hunger staple food. Second, we have to look at how to improve the nutritiousness of food. In Italy, you like to eat different vegetables than those that we like to eat. You like to eat eggplant, but not many countries like to eat eggplant. So you have to focus on your specific commodities. Third, to end global hunger, you have to establish a good supply chain, because in the culture of

perishable products, you need both the culture and the supply chain running. So you need to invest in the infrastructure surrounding agriculture. And fourth, you need innovation again, because, as I've said, innovation is needed in each commodity, each sector, each sub-sector. You need a different specific innovation for each of these. Otherwise, you can't feed the populace.

Joachim von Braun: Science in all key components of the food system is needed. The primary production system in the market and processing system, in consumption and nutrition, and addressing the income and resiliency issues related to climate stress. And science is needed that embraces the system as a whole – system science.

Current investment in public science for the food system is not sufficient to achieve the 2030 Agenda for hunger and nutrition. The ratio of science investment per capita in high-income countries versus low-income countries is about one hundred to one. That is one of the biggest inequalities on Earth. And we need more sharing of science – more investments and more sharing of relevant science between North and South. Investment in agricultural research for innovations is one of the highest pay-offs in terms of sustainable hunger reduction. When we scientists call for more investment in science, and more science, and so on, policy makers don't immediately believe that there is need for this. So we need to prove it. Research shows that with investment costs per person of 30-40 US dollars, about three hundred million people can be brought out of hunger productively and sustainably, if well targeted.

We need in addition better science and policy interface. Climate policy and climate science were helped forward by the international Intergovernmental Panel on Climate Change, the IPCC. We need something like that for food also, an IP on food. Maybe FAO can host it.

Giorgio Parisi: I fully agree with Director Qu and Professor von Braun. I think that science has a great responsibility here. Of course, it's not only science. We have to organize things on a global level. I think that there should be some global investment made by the rich countries in such a way that the investments of rich countries go to third-world countries, to the poorest countries, in order to help them. The total budget of FAO is something less than one billion dollars, which is not a lot if we consider the incredible kinds of problems our world is facing. It is clear that multilateralism and collaboration of countries are required to provide the possibility of having science, and innovation coming from

science, go and work in the field – to work *in situ* as Director Qu was saying. And science of course can only say to politicians what should be done; their answer on all levels, or their decision to adopt specific suggested courses, depends very much on their prior political commitments. The Green Revolution that Director Qu has spoken of before, of the fifties and the sixties, piloted new varieties of wheat, rice and maize. There were various successes in Mexico, in many Asian countries, as in India, the Philippines and China, where politicians committed to their widespread adoption, but there were fewer in Africa.

And there is another point that is quite important, one where science could be very relevant, and that is protection from pests, from all kinds of pests. For example, we know that a long time ago, I mean thirty years ago, science was quite useful in blocking the case of the cassava mealybug, which could potentially have destroyed agriculture almost completely in many African countries. The very important introduction of a parasitoid, *Apoanagyrus lopezi*, enabled control of the pest, and avoided widespread famine across sub-Saharan Africa, practically saving the lives of twenty million people. It is clear that this was a very successful intervention, but science should be very careful in monitoring this type of new parasite that could destroy agriculture, also because in some cases it could be extremely difficult to find a way to biologically control new parasites.

Wolfango Plastino: *Do we have to choose between agro-ecology and biotechnology?*

Giorgio Parisi: Well, no. I don't think we have to choose. I think that agro-ecology and biotechnology are complementary to one another. I would say that the main aim of agro-ecology is to reduce the use of synthetic chemicals, which in the long run have harmful consequences for human health, and even more importantly, we should make agricultural production sustainable, and chemical use may sometimes take us in the wrong direction. Biotechnology allows us to take fundamental steps in the same direction as agro-ecology, and there are many ways in which biotechnologies may help.

I will give only one example. Soil, which is of course the basis of any crop, is quite a complex system containing many organic and inorganic components, which coexist in close interaction with the living biomass. Of course, the system is complex because the number of different species, the number of different substances and so on, is so high that their interactions are not so easily understood, in the same way that we don't understand what happens

in our guts, where we have a hundred thousand different microbiota. Now, there are many bacteria that promote cell growth, and among these bacteria, the role of rhizobacteria is fundamental – for example, Rhizobia, which are very important because they can establish a symbiosis with leguminous plants for nitrogen fixation in the soil. It is clear that nitrogen fixation is crucial, because this is the basis of all agriculture, and all types of crop rotation. It is clear that if we succeed in certain interventions in the composition of soil micro-organisms in such a way that we can improve nitrogen fixation and other types of beneficial processes, this kind of scientific intervention, which could be done in such a way that it could be easily used, could have a dramatic effect on the productivity, and also on the sustainability, of agriculture.What is important is what happens in the long run; we should not only succeed in eradicating hunger in 2030, but we should also find a way of maintaining a world free of hunger; the sustainability of agriculture is crucial here. Now, these kinds of interventions on bacteria and other kinds of interventions of the same type are absolutely compatible with the agro-ecological vision, so I do not see any kind of contradiction between these two ideas.

Qu Dongyu: I fully agree with President Parisi, but I want to make two short comments. You know, every technology, every approach, has a main purpose, a main function. So first, I want to be clear: there is no contradiction between agro-ecology and biotechnology. They should play complementary roles. I agree with President Parisi.

Second, what kind of agro-ecological tradition are we talking about? In China, in Roman times, two thousand, three thousand years ago, in Egypt, they already had agro-ecology. But that's a low-level tradition. Now we need more innovation in agro-ecology. Innovation should come in all ideas, not only the technological stuff, but also management, and also in our marketing approach. And then we have to look out for bad technology, also. We need to minimize negative fossil fuel impact before these technologies come to the field. So there's no contradiction here.

But how can we put all of this together to make one plus one larger than two? Or even two times two makes four, or three times three makes nine. It's simple. Different countries have different priorities. Some countries may put more priority on agriculture, some maybe put more on agro-ecology or other technologies. So let's be flexible, and differentiate the priorities and the choices of the member countries, because they are in different development stages in their economies and agri-food systems.

Joachim von Braun: I want to follow up on President Parisi's point regarding soils. I very much agree that this is critical. Land and soil degradation is a big global problem. In our research, my institute together with our partners estimate that three hundred billion dollars is the annual cost of land and soil degradation. And most of this cost is lost in ecosystems functions, in water and biodiversity and so on, and also a large part is lost in production. The cost of inaction, of our accepting this high cost, is much higher than the cost of action. There are solutions, and agro-ecological approaches are part of the solutions. All agricultural systems must consider ecology; that was also highlighted by Ambassador Marrapodi. However, we must start by improving from where the systems are, that is from the realities of farming in the highly diverse farming systems around the world, and identify best-fit approaches, not idealizing approaches across the board.

Many agro-ecology approaches exist alongside many biotechnology approaches; so best fit is what we need to look for. With the exception of low-input low-output, farming will waste land resources, and we need to watch that. For instance, most smaller farmers in Africa would benefit from improved seed breeding. That breeding should be done much more locally and can be enhanced by bioscience. So the two approaches belong together.

Wolfango Plastino: *Is there one game changer solution or should we be thinking on bundling solutions to achieve the needed agri-food systems transformation?*

Joachim von Braun: There is no silver bullet to end the problems of the food systems. We have analyzed a whole range of options and concluded that a bundle of about twenty interventions in combination could go a long way towards optimally and sustainably ending hunger by 2030, or bringing it close to or below 3% from the current about 10%. That is not free of charge. At an additional cost per annum of about forty to fifty billion US dollars, we can collectively partnership between the global North and the global South, and, with a lot of actions by public and private players, achieve a world coming close to ending hunger.

For the Food Systems Summit, we are carefully modelling scenarios adapted to local circumstances, and considering options that quickly achieve both improve food and nutrition security, and protect and rebuild the agro-environment. Where should this additional annual investment of forty to fifty billion US dollars to end hunger come from? Through broad-based investment, not a

single game-changer; these resources should not only come from development aid and public investment, but also from creative financing, which needs to be mobilized. Trillions of dollars of funds are looking for investment in the low-interest-rate context currently, while there is a huge need to invest in hungry people, people with potential. This is an economic market failure and an ethical failure that the Food Systems Summit must address.

Giorgio Parisi: I agree with Professor von Braun. I also think that there is not only one game-changing solution. We actually need a bundling solution, because the transformation that we face is a slow but continuous process that requires time, but also perseverance and balance. There can be no single answer, but rather a range of answers to be adapted to different situations in different regions of the world and in different areas within the same country. There are great differences between agrifood systems in both food security, which is extremely important, and nutritional status. There are major differences in nutrition even between population strata within the same country, and eating habits change as per capita income rises. There is no one-size-fits-all solution to achieve a healthy diet and exploit the potential of the environment.

Many factors also need to be considered, such as food prices, the income of farmers, especially small farmers, the distance between production and consumption sites, and the priorities of governmental objectives in the agricultural system (because it is also important what local governments want to do); and one also has to consider finally the availability of products in local supermarkets and markets. So all kinds of economic factors have to be taken into consideration in order to go in this direction, but always recalling that the process is slow and cannot be solved with a silver bullet.

Qu Dongyu: First of all, I agree with my colleagues. But I just wanted to remind our audience that the agri-food system is not as simple as you might imagine. You eat food; every day you eat it. But this food is composed of chemistry, physics, mathematics, biology – you name it – from the soil to the water to the air. So it's not that simple, if you are not an expert in food systems. And agrifood is important not only for the time being, but for generations and generations to come, because this is part of civilization.

That's why I would like to look at the complexity of agri-food systems. We need to look at the level of scientific innovation, we need to look at the economic level, we need to look at the environmental level, we need to look at the educational aspect, we need to look even at the family level, the individual level. It's like a big

player playing a piano. You are each one of the fingers; you can play your specific role. So you may not work in the agri-food system, but you still can play a role, starting with your family, for instance by educating your grandchildren to waste less food, or by building good habits – how to purchase the hard work of farmers, and from producers and traders and so on.

But I have an idea which is a little different from the others'; we can use one stone to hit three birds. That is a government policy-maker's thinking, to use one stone to hit three birds, instead of one bird or two birds. That's the beauty of enabling policies. That's also a big potential internationally, with FAO working for one hundred and ninety four countries. I forgot to mention investing in farming development not only in Germany or China or the United States or Europe; you should go to the field. So we need more agents that understand this within the market, via market-oriented scientists in developing nations. Not only by talking in Rome; we also need to go to Africa, to the Caribbean, Latin America, and other developing nations. So let's work together, let's think together, and, by learning together, walk together and contribute together to a safe, peaceful world.

Wolfango Plastino: *What do you expect to be the role of digital technologies in the agri-food system transformation by 2030?*

Qu Dongyu: You know, in the history of the Roman times, or ancient Chinese or Asian times, we have faced three or four different stages of civilization, from traditional wild life, to the traditional home life, then you come to industrial life. Now comes digital life. You can see that the pandemic has forced us to be placeless. Placeless life, virtual life, is really green life. Of course we need face-to-face talks in the future. Still, this will be a good adjustment for us: digital culture, no matter if you're a big farmer in Brazil or in North America, or a small one in the Far East, Japan, South Korea, China (some parts of China). As I said, the digital approach will be one stone hitting three birds, or four birds, at the same time. You can force a reversal in over-production processes and supplies, and food loss or waste.

And then there is food diversity. If you come to Beijing, I don't know how to make the typical Italian spaghetti or pizza. But I can order it. If you arrive at 6:00 pm, I'll order it for half an hour later. So that's sharing cost, sharing economy, from farm production to consumption. And it also ritualizes all the small components of the process. That's what I wanted to make clear.

Every small-hold farmers in Italy can directly sell your olive oil to the market in the Far East, in Japan or in China, and there you can benefit. Through the traditional wholesaler-retailer systems, there is a lot of food and environmental waste, and also less efficiency, and farmers don't benefit from that. But it's different if you have a direct e-commerce, C2C, C2B, you name it. And also you really improve quality, because you don't need the long-term go-between. Everything is synced. We unleash potentials for the economy, for the shared economy in the world – especially for agricultural commodities.

Joachim von Braun: Director General Qu Dongyu already addressed an excellent set of issues in his lecture. The future of digital technologies in the agri-food system looks bright, but we're not there yet. Inequalities are large. Rural people and farmers need digital access. This becomes very obvious under the current Covid-19 situation. We had a conference in the Pontificate Academy of Science a couple of years ago with a distinguished Italian policy-maker, Romano Prodi, on connectivity as a human right. A human right. Some people were wondering what we were up to. Today it has become clear, thanks to Covid-19, that if rural areas don't have connectivity, their human rights are being violated.

But we don't only need connectivity, we also need the capability to use digital access, and the content needs to be useful. Digital technologies will be great for monitoring fields and animals, and the market platforms just mentioned by Qu Dongyu. Field robots can facilitate crop diversity in fields and help overcome monocultures and mechanically assist in weed control. These are things that will happen in the future; they're currently in an advanced experimental stage. The food processing industry in emerging economies, too, will become more automated, because that leads to safer food production. But that will impact labour markets. We need to consider the labour market effects of digitalization, and invest more, a lot more, in training the youth.

In conclusion, in the future, digital innovations and artificial intelligence will increasingly interact with bioscience, so the digital and the bio will come together. That can revolutionize farming on the fields and indoor farming in megacities, say for vegetables, and it will facilitate a more sustainable food system in a circular sustainable bio-economy.

Giorgio Parisi: I fully agree with the previous two distinguished speakers. One must be careful, because the introduction of digital technology is in some sense an on-going revolution, and if we do

not pay enough attention, we risk seeing only the tip of this revolution. In this sector, there is a danger that the technology will be ahead of planning, because there are things that happen that we do not control. There are a very high number of possible innovations in the agricultural system. Some of them which might be extremely interesting include the feeding of each animal according to the quantity and quality of the meat produced, of its daily weight gain; irrigation with different quantities of agro-pharmaceuticals for different areas in the cultivated fields; and semi-automatic tractor driving.

But another aspect which is very important is food quality, food safety, and this is essentially to trace products along the food supply chain, documenting where they come from, how they were grown and treated after harvesting. However, the massive use of digital technology can be achieved only if it can be used in a user-friendly way by farmers. Of course, this requires the ability to understand technology and use technology, and this might be not very easy at all in many different regions.

Also, there are some cultural and economic aspects that have to be considered; for example, special attention must be paid to small farmers who, with a few exceptions, may not have the technical and financial capacities to invest in digital technologies. It is imperative that the diffusion of these technologies does not merely strengthen large estates, depriving small farmers and small producers of economic value. The measures that one has to take, also in this case, may vary considerably from country to country.

However, I would suggest that cooperative solutions are likely to be needed, where small farmers join forces to use advanced technologies, together with technicians who can help them control this new technology. Now, the local governments need to intervene energetically to finance this initiative, even if necessary on a non-repayable basis. Public authorities need to be sensitized; the public governmental authorities need to act as a catalyser for the use of digital technologies. In this problem, as in the others, it is clear we need a whole panoply of initiatives, that go from the scientific side to the development of user-friendly interface to transfer this knowledge from one country to another; and we need to adopt this new technology locally in such a way that it goes to benefit everybody, not a small minority. And that is a very complex system, and we need everyone's help to go in the right direction.

Science and Solidarity for a Sustainable Planet

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Introduction

Luca Sabbatucci

It is now clear that we are in a condition of planetary emergency: the interconnected crises of biodiversity loss, pollution, resource depletion, degradation of ecosystems and climate change – caused to a great extent by unsustainable production and consumption – require immediate global action.

The acceleration and interaction of these phenomena, as indicated by science, is causing irreversible damage, with economic and social consequences and aggravation of poverty and inequalities, since the poor have fewer opportunities and economic resources to cope with and adapt to environmental shocks. However, together with efforts towards sustainable production and consumption patterns, nature-based solutions can deliver multiple benefits across these challenges, and are integral to tackling these issues.

The scientific community has confirmed that the past decade was the hottest ever recorded globally, underlining that there is still time to tackle the threat, if actions are taken swiftly and decisively.

The actions taken collectively in 2021 will very likely shape at least the next decade of climate actions. Since "the next decade" is all that is left to stop the climate crisis and to promote the energy transition, the stakes could not be higher.

I would like to emphasize the importance of science in our shared efforts towards achieving internationally agreed climate and environment targets. It is in effect crucial to raise awareness and understanding through scientific investigation in order to find proper solutions to major economic, social and environmental challenges and to ensure sustainable development. Since no country can reach these goals on its own, international scientific cooperation contributes not only to scientific knowledge but also to create peaceful relations and solidarity.

In this regard, the key role of the Intergovernmental Panel on Climate Change (IPCC) in assessing the science related to climate change comes to mind. As we know, its establishment stemmed from the need to improve the understanding of climate change and related phenomena. Acting as an interface between the scientific world and politics, it provides policy-makers with invaluable

scientific assessments on climate change, as well as its implications, impacts and potential future risks: key elements that help politicians to take accurate decisions at national and international level.

It is thanks to the latest scientific reports that we know for a fact that 2021 will be a key year in the fight against climate change, and Italy, as G20 Presidency and partner of the UK for COP26, intends to work strenuously to ensure the success of the negotiation processes, reaffirming and strengthening its role as a virtuous, ambitious and supportive country. This will be a testing ground for multilateralism, as well as for our country's ability to lead by promoting a recovery based on the ecological transition, conscious of its great potential to generate wealth, well-being and employment.

We believe indeed that recovery offers a unique opportunity for transformative change as a global community: while restoring the health of our economies, we need to invest in the health of our planet and to put people and nature at the heart of our political leadership.

This is why with our G20 agenda, we focus on the enhancement of those public goods – People, Planet, Prosperity, which are a condition for preventing and addressing shocks like the ones we are experiencing.

We have to imagine a new development model, and tackling climate change will be the core of these efforts.

The nexus between climate and energy is crucial to advance towards these three priorities. Building back better requires advancing towards universal clean energy access and centring all our policy actions on people.

This is why we are holding, for the first time ever, a Joint Energy and Climate Ministerial meeting. The Ministerial focuses on series of common priorities, seizing the opportunities offered by innovative technological solutions, the role of sustainable cities and the alignment of global financial flows towards a green, sustainable recovery that will be key in ensuring prosperity and environmental sustainability while eradicating energy poverty.

Moreover, the G20 Environment Ministers Meeting offers the opportunity to tackle issues regarding the protection of biodiversity, ecosystems and oceans and seas.

Specifically, the Environment Ministerial is an important moment to facilitate negotiations and push for ambitious positions for the new post-2020 Biodiversity framework that could be defined at the 15th Biodiversity (CBD) COP in Kunming. The Ministerial has a specific focus on protected areas, oceans and seas, which are fundamental to life on our planet and to our future, as well as being an important source of biodiversity and playing a vital role in the climate system and in carbon and water cycles.

As we know, oceans and seas supply us with oxygen to breathe, they absorb over a quarter of the total carbon dioxide that we produce and they contribute to food security and to the creation of decent jobs and livelihoods. With this in mind, Italy will step up effective actions to expand the Marine Protected Areas by as much as 30%, responding to the challenges arising from climate change and pollution, and supporting a sustainable blue economy. We will also promote commitments aimed at the reduction of emissions deriving from the maritime sector, focusing not only on greenhouse gases, but also on other air-polluting substances, which are harmful to the environment and to our health.

As the leading global voice on the environment, UNEP (United Nations Environment Programme) plays a key role by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations. Its commitment to facilitating the transition to low-carbon societies, improving the understanding of climate science, facilitating the development of renewable energy and raising public awareness is crucial in combating climate change.

As mentioned, this year we have an important role in view of COP26, which the UK chair in partnership with Italy. With COP26, we hope that 2021 will be the year that sees the full and effective implementation of the Paris Agreement, as well as a driver for countries to elaborate and implement ambitious national climate commitments in the short term and the successful transition to climate neutrality in the long term, anchored in concrete instruments for reducing emissions.

As partner for COP26, Italy is hosting a series of significant preparatory events to the Conference, including the Pre-COP in Milan, the preparatory meeting of ministers traditionally held about a month before the COP, with the aim of offering those ministers who represent the main negotiating parties an opportunity to informally discuss key political aspects, thus providing a very relevant step on the path to a successful COP.

Italy is also hosting an event in Milan called *Youth4Climate: Driving Ambition*, which will be linked to the Pre-COP. The event will give young people from around the world the opportunity to draw up concrete proposals, which will be taken into account in the pre-COP and COP26. We have decided to unite the two events, as we deem it crucial to promote the engagement of young generations in order to channel youth mobilization in positive ways.

Furthermore, in October we are hosting a high-level ministerial outreach event in Rome on environmental and climate challenges in Africa, *Incontri con l'Africa*.

In our vision, these events are an opportunity to broaden the perspective of the theme of ambition to all the actors involved in the global climate action: in addition to young people, civil society, the business world, the academy, local authorities and regional institutions.

This holistic approach is indeed a factor behind the recent establishment in Italy of the Ministry of Ecological Transition, which was created in order to promote an integral ecological transition of the Country. Merging the competences for the environment, climate and energy sectors further strengthens the centrality of the energy-climate nexus as a qualifying aspect of Italy's foreign policy, in a pivotal year for Italy at the international level with regards to climate change.

These developments at the national and EU level, with the ongoing work on the Recovery and Resilience Plans, reinforce our resolve at the international level, as G20 Presidency and partner of the UK in the COP26, to make this year a real turning point for all countries towards more sustainable, green and inclusive economies and societies.

Lectio Magistralis

Inger Andersen

More than a year since the emergence of Covid-19, the pandemic continues to devastate lives and economies. There is hope in vaccination programmes, but we have a long way to go. Our sympathies lie with those struggling with physical and mental health, grief and financial problems.

We must overcome this pandemic, for all of our sakes. But as we do so, we must understand that Covid-19 is not something we can fix and forget, so as to return to normal. And by normal, I mean our high-carbon and resource-intensive economic models. Normal helped to cause the pandemic. Normal is warming the planet. Normal is destroying nature and biodiversity, and therefore the foundations of human existence. Normal is polluting the air, land and sea. Normal is a world of inequality in which those least responsible for the three planetary crises – climate change, biodiversity and nature loss, and pollution and waste – are the ones who suffer the most from them.

Normal, my friends, is our and the planet's enemy.

Humanity now faces two paths. The first path leads back to normal and a world in which these crises slowly destroy our future. The other path transforms our economies and societies so that we can live in harmony with nature, on a planet that aspires for peace and prosperity.

Today, obviously, I would like to focus on how we can walk the latter path. I will outline the steps, guided by the principles of science and solidarity, that we must take. And the path that I will describe is outlined in significant detail in UNEP's recent report, entitled *Making Peace with Nature*. We consider this report a blueprint for a sustainable future.

But before I get to the blueprint, and the positive vision it presents, allow me to provide the darkness to counterpoint the light: what science tells us about the scale and threat of the three planetary crises.

Concentrations of all greenhouse gases in the atmosphere are higher than at any time in the past 800,000 years. As a result, the Earth's mean near-surface temperature has risen by over 1°C as

compared to pre-industrial times. 2020 was the second-hottest year on record. The top ten hottest years have all come since 2015.

We are living with the consequences. In 2018, damages from climate-related natural disasters cost about 155 billion US dollars. Two billion currently people live in water stress. Wildfires, floods and droughts are so commonplace they often do not even make the news.

And we are approaching tipping points. Warming oceans are melting ice, which means less reflected sunlight and more heating. Permafrost is disappearing, releasing methane into the atmosphere. Burning forests deprive us of carbon sinks, again sending emissions up. We face a system cascade that will send global temperatures through the roof.

Nature is declining at an unprecedented rate. Around 1 million out of 7.8 million species face extinction. Humans have altered 75 per cent of the terrestrial surface and 66% of marine areas. Only 15% of wetlands remain. Around 10% of forests have been lost since 1990.

As we degrade our ecosystems, we chip away at the foundations of what makes well-being possible – food, water, temperature regulation, economic growth, the roofs over our heads and the clothes we wear, to name only some of nature's services. This loss is a threat to our survival.

Every year, pollution causes about 9 million premature deaths, primarily from dirty air. Marine plastic pollution has increased tenfold since 1980, swirling in ocean currents and in the guts of fish and seabirds. Cities produce 1.3 billion tonnes of solid waste per year and we throw away 50 million tonnes of e-waste every year – roughly equal to the weight of all commercial airliners ever made. And the pandemic is worsening the waste problem, with tens of millions of pieces of disposable protective equipment thrown away every day.

Our current development model was based on the idea that the planet would never stop giving, no matter how we treated it. We grew reliant on fossil fuels. We rushed to convert land for agriculture, infrastructure and urban expansion. We emptied the waters of fish, giving back only plastic and toxic sludge. Since 1970, trade has grown tenfold, the global economy has grown nearly fivefold, extraction of natural resources and energy has tripled, and the world population has grown by a factor of two.

As a result, we are altering the Earth systems that have provided relative climatological stability for the past 3 million years. The systems that enable regular rainfall, seasonal shifts, the hydrological cycle and predictable ocean currents. That predictable world,

where season follows season, where harvest follows harvest, is no longer a given.

Governments and businesses have made promises to deal with these problems: through sustainable development goals, through the Paris Agreement, through international goals on biodiversity and so much more. But the world has not acted strongly enough on the science nor on its own promises. Let us look at climate change as an example.

Nearly six years ago, nations arrived at the Paris Agreement to limit global warming this century to well below 2°C and pursue 1.5°C. Many nations stepped up with pledges. Many are now committing to transition their economies to net-zero emissions by mid-century. But pledges – and the action to back them – must still become stronger. If nothing changes, we will hit a global temperature rise of over 3°C this century. To get back on track for a 2°C world, we have to cut one-third of emissions by 2030. For 1.5°C, we must halve emissions.

The pandemic-linked economic slowdown will not help. The CO2 bathtub was already full, so turning off the tap for a couple of seconds does not mean it is now empty. Worryingly, greenhouse gas emissions have already rebounded to pre-pandemic levels. The light at the end of pandemic tunnel is looking increasingly like a fire.

Just as importantly, we have to catch up on solidarity. Strong financial support for nations that need help to adapt to the impacts of climate change is baked into the Paris Agreement. But we have failed to deliver.

We are in a similar position with biodiversity. In 2010, we agreed on a series of biodiversity targets to be reached by 2020. We met none of them. I could go on to talk about inadequate progress on chemicals, on waste, on sustainable development. But I have talked enough about the problems, about what we have not done. Now I will turn to what we can, and must, do.

As UNEP's *Making Peace with Nature* report lays out, to address the climate crisis, the biodiversity and nature crisis, and the pollution and waste crisis, we need urgent transformations in three areas:

- First, we must tackle the Earth's environmental emergencies and human well-being as one integrated and indivisible challenge.
- Second, we must transform our economic and financial systems to power and enable the shift to sustainability. Easy to say, harder to do, but essential for our long-term survival.

- Third, since we all need food, water and energy, we must transform the systems that provide them to meet growing human needs in an equitable, resilient and environmentally friendly manner.

Let us look at each transformative area in turn. Planetary health and human health are the same thing. The three planetary crises – the climate crisis, the nature and biodiversity crisis and the pollution and waste crisis – are, in essence, one crisis: that of humanity's dysfunctional relationship with the natural world. No one sector on its own is entirely responsible for, or can fix, these crises.

There are many examples to illustrate the interconnectedness of the crises, human health and their solutions.

A cooler climate will protect biodiversity and slow down desertification, conserving nature, while healthier nature will help to store carbon and create natural buffers to the impacts of climate change. Nature-based solutions – such as ecosystem restoration – could provide between 35 and 40% of the effort needed until 2030 to limit warming to 2°C. This buys us time to decarbonize our economies. Quickly reducing greenhouse gas emissions will also make it easier and cheaper for vulnerable countries to adapt to climate change – essential for solidarity.

The sources of climate change and air pollution are often the same, from coal-fired power plants to polluting vehicles, so moving to clean energy will address both crises. Meanwhile, by fully implementing international conventions that touch on chemicals, waste and climate change, we can save millions of lives each year and protect fragile ecosystems.

The destruction of nature and over-exploitation of species is a contributing factor to zoonotic diseases such as Covid-19, so restoring nature will increase human health by reducing pandemic risks, while boosting food security and the services nature provides.

In each of these examples, action in one area impacts another.

This is why it is so essential for nations, this year, to incorporate new net-zero commitments into strengthened pledges at the climate summit, COP26, in Glasgow. In fact, every country, city, financial institution and company should adopt plans for net-zero by 2050 and make them a reality. And this last bit matters: make them a reality, with clear time-bound plans, and start implementing them immediately.

Right now, countries need to take strong action on energy systems, land use, agriculture, forest protection, urban development, infrastructure and lifestyles – all through the lens of resource efficiency and circularity. And right now, we are pouring public finance

into the economy to recover from the pandemic slowdown. We must use these resources wisely – to create a more sustainable and green future, instead of going back to the "old normal". Let us not forget that we are borrowing these monies from the next generation. We do not want to leave them with both a broken planet and an insurmountable debt.

This is why we must pass an ambitious post-2020 biodiversity framework at the next Conference of Parties – COP15 – in Kunming, China. Here, it is vital to target biodiversity-positive agriculture and fisheries, an end to harmful subsidies, promotion of larger and better-managed conservation areas, and movement to patterns of sustainable consumption and production.

This is why we must ensure a strong post-2020 framework for the sound management of chemicals. We require a framework that prevents harmful chemicals from entering the environment and moves nations and businesses towards effective, safe and green alternatives.

This is why we must push hard on the UN Decade on Ecosystem Restoration, which gets underway in June, to restore hundreds of millions of hectares of degraded land.

We need to establish more mechanisms and approaches for cross-sectoral coordination so that solutions addressing all three crises together become the norm. Here, I must draw your attention to the One Health approach. A One Health approach integrates action across sectors and disciplines to protect the health of people, animals and the environment. We must use it.

Integration also applies to science. We have a separate body on climate, in the IPCC. On biodiversity, in IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services). On resources, in the IRP (International Resource Panel). And many more. They are all needed. But if they can work together on joint assessments that demonstrate common solutions, we will have a stronger case to take to the world. This, in fact, is the central tenet of our report, *Making Peace with Nature*.

We must also move outside of the environmental and science bubbles to engage the sectors – public and private – that are essential for human survival, but in their current form undermine long-term sustainability and drive environmental damage. Here I refer to infrastructure. Agriculture. Energy. Transport. Cities. Consumers. There is no point in setting targets for, say, biodiversity loss, unless we engage with and support these key sectors to shift to more nature-positive models.

We need to integrate nature into built infrastructure. Build infrastructure that has a smaller footprint by deploying circular

models in construction. Support and incentivize farmers to use agricultural practices that support and underpin nature. Electrify our transport and invest in public mobility.

And as consumers we have choices too. We can eat a plant-rich diet. Control how we travel and move and what we buy. And when we select who represents us in government, we should demand that they set the policy guardrails for greater sustainability through incentives, through regulations, through laws and through trade rules.

We need trillions of dollars each year to meet the Sustainable Development Goals. To unlock this investment, we need to move entire markets and financial systems. How do we do this? The answers are manifold, but key actions are incorporating accounting for nature into our economic and financial systems, shifting subsidies and investing in the right places.

The starting point is to recognize the true value of nature. Over half of global Gross Domestic Product (GDP) depends on nature – never mind the services nature provides free of charge, such as climate regulation, water filtering and protection against natural disasters.

We are eating into these natural assets faster than they can regenerate because we do not reflect the true value of nature's goods and services in market prices. We have not created wealth if, in the process, we have polluted our waterways, our soil, our oceans or our air. We have not created wealth if we have fished the oceans empty or cut the forests down for timber or agriculture. And yet today, that is our measure of wealth.

When we apply inclusive wealth accounting, as UNEP has done, we can clearly see that our prosperity has come at a price. Produced capital and human capital – such as roads and skills – have increased by 13% since the early 1990s. At the same time, natural capital – the planet's stock of renewable and non-renewable natural resources – has declined nearly 40%. This is not a viable road to follow.

The good news is that there is now a growing understanding that we must replace GDP with an inclusive wealth index that values all forms of capital. This is not in any way to deny the intrinsic value of nature. Nor is it about hanging a price tag on every bee and tree. It is about understanding that intact ecosystems are worth more to humanity than when they are destroyed.

So, the days when environmental impact was treated as an externality must end. We must legislate against and tax the environmental "bads", as opposed to merely targeting labour and goods. Governments, businesses and financial institutions should

mainstream natural capital accounting to help shift behaviour to a more sustainable path.

Even without such measures, we know that backing industries that harm the environment is a bad idea. Many subsidies do just that. I am not suggesting a blanket end to subsidies – particularly those that keep food affordable for many people in difficulty. Nonetheless, trillions of dollars of subsidies go to fossil fuels each year. These could be redirected to underfunded biodiversity and climate goals. Carbon taxes, carbon pricing, markets for carbon trading and payments for ecosystem services are other ways to start moving markets.

Both accounting for nature and shifting subsidies would start investments flowing to where they are needed. But we must invest regardless. Pandemic recovery stimulus packages are a massive opportunity to accelerate action. The UNEP Emissions Gap Report, for example, found that a green recovery could cut 25% off of 2030 emissions.

So, as mentioned, governments must use pandemic stimulus packages to create a more sustainable future. This means putting recovery money into decarbonization, into nature-positive agriculture, into sustainable infrastructure, into climate change adaptation measures that protect vulnerable communities and reduce poverty, and so much more.

The same goes for businesses and investors – for their own bottom lines as well as the planet. Renewables are a great investment. But other figures show that the business opportunities from transforming the food, land and ocean use system could generate 3.6 trillion US dollars of additional revenues or cost savings by 2030, while creating 191 million new jobs.

Investing in sustainability is the smartest move any of us can make.

The world we live in is profoundly inequitable. Almost 700 million people go hungry every day, while we waste almost one billion tonnes of food each year. Hundreds of millions of people struggle with energy poverty, while others leave lights on in every room. Some people leave their taps running without blinking an eye, while others struggle to find water to drink or tend their crops.

If we are serious about solidarity, we need to ensure that everybody has enough to eat. That we provide energy equity and connectivity for all. That water resources are used wisely and shared. We must do all of this while ensuring that the environmental impact of the food, water and energy systems shrinks instead of growing.

On energy, we obviously have to prioritize clean, renewable sources. But this must be accompanied with huge improvements

in the energy efficiency of every appliance, vehicle and building that draws power – including through regulations. We also need incentives and infrastructure for electric vehicles and sustainable bioenergy strategies.

There is a price tag: investments of 0.8-2.9 trillion US dollars are needed per year until 2050 to deliver a low-carbon system consistent with the Paris Agreement. But energy efficiency alone can deliver costs savings of 2.9-3.7 trillion US dollars per year by 2030.

Meanwhile, our food systems need serious reform. The global food system, as a whole, emits 21-37% of greenhouse gases. Then we have the stripping of forests and other ecosystems to meet growing demand for food, feed and fibre. This is why the UN Secretary-General is hosting the Food Systems Summit later this year.

We need to move to food systems that work with nature. Make agriculture, forestry, fisheries and aquaculture biodiversity positive. Integrate sustainable production and management of food and water within terrestrial, freshwater and marine ecosystems. Promote sustainable agricultural intensification, agroecological practices and conservation of genetic resources. Stop overfishing. Empower small-scale farmers, especially women.

I would like to give a special mention here to methane, a greenhouse gas that emanates both from energy and agriculture. Methane is 28 times more powerful at trapping heat than CO2, but it lingers in the atmosphere for far less time. So, efforts such as capturing methane from the oil and gas industry and improving the health of livestock can have rapid effects.

In fact, a new report from UNEP and the Climate and Clean Air Coalition to be released in a few weeks, shows that reducing human-caused methane by 40-45% by 2030 would avoid nearly 0.3°C of global warming by the 2040s. It would also prevent over 250,000 premature deaths and more than 25 million tonnes of crop losses globally each year.

Here, I would like to touch again on the role of personal responsibility. Some 17% of food is wasted at the household, retail and food service level, while meat-heavy diets are big drivers of environmental damage. Relatively minor changes in our diets, cutting waste and reducing meat intake, can make a big difference, including to the methane emissions just mentioned. The same idea of personal responsibility applies in everything from how we travel to the packaging we chose.

Yes, it can be difficult to make choices that are good for the planet. Our societies depend heavily on fossil fuels, monoculture

crops and wasteful packaging. The system must change. Until it does, we must do what we can – within the constraints of our circumstances, and no matter how small – to change our lifestyles.

I have barely scratched the surface of the huge and complex task we face. This task may seem overwhelming. It would be overwhelming, if it were the task of just one person. But it is not. It is the task of over seven billion people. If each of us does our part, we can make rapid progress.

We are seeing this process of change. We have more commitments and solutions than ever. Businesses and investors are stepping up. Renewable energy is more widespread, and cheaper. Public awareness of the issues is at an all-time high. And Covid-19 has shown how quickly we can change, when we have to. Well, we have to change.

We have the science, the knowledge and the tools for transformation. We have the opportunities, in a green pandemic recovery and in the many international processes unfolding over the coming months and years.

We now need to let science lead us, and principles of solidarity guide us, as we get to work making peace with nature, and building a world in which we can all live, peacefully and prosperously, together.

Discussion*

Inger Andersen, Dan Larhammar, Giorgio Parisi,
and Wolfango Plastino

Wolfango Plastino: *How do we bring everyone together to unite the action agendas of the three planetary crises and amplify impact?*

Dan Larhammar: To deal with this on a global scale, as you pointed out, we really need to work together. And I think the only way to accomplish that is through information and education about the situation and what needs to be done, and what ideas we have to do something about it.

Now, these are very beautiful words: information and education. It's easier said than done. But, we should also remember that we have better opportunities than ever before to do this. More people than ever before – a higher proportion, I should say, of the population, than ever before – have reasonably long school educations nowadays. And we have the internet with connections that allow us to convey information to many parts of the world. So I think those tools should be used as much as possible.

The internet is a blessing if we want to transmit information. But it can also be used for opposing purposes; and as you pointed out Dr. Andersen, there are financial interests that go against our efforts to save the planet. There are efforts against vaccination programmes to improve human health, and so on. So we need to be prepared to deal with this anti-science lobbying, the propaganda from certain interest groups, where the financial sector as a whole is probably the largest. And I think it's most important to transmit information about the situation to those with the power to take global decisions. And those are the financial experts, the economists and policy-makers. It's not really the scientists who take those decisive decisions. But the scientists need to provide all the evidence for wise decisions.

* The text below is the full transcript of the Round Table that followed the *Lectio Magistralis* by H.E. Inger Andersen, Under-Secretary-General of the United Nations and Executive Director of the UN Environment Programme.

In fact, I'm presently chairing a working group in the organization of ALLEA (All European Academies), and the title of the report that we will deliver is "Fact or Fake?" We are dealing specifically – as are several other working groups in different combinations – with the problem of false information, disinformation, or even misinformation, deliberately untrue statements. We are looking specifically at how both scientists and science communicators can respond to that, and we are also trying to make policy-makers aware of such interest groups that transmit false information for commercial or ideological purposes. So it's certainly no easy task, but we're striving to increase awareness of those challenges.

Giorgio Parisi: I agree with you that a unifying agenda is crucial. The point is that we very often have a confluence of agreement between states that are devoted to one single crisis, which is addressed separately from the other ones. And there is no widespread awareness that the three crises that you have so clearly spoken about are intertwined, and that you can take measures that are synergic with one another to address the challenges posed by any one of them. All efforts should be done to put the whole problem of the environment at the centre of this line, by emphasizing the advantage of a global vision, so that the problem can be addressed in an effective way.

Now, in the case of climate change, it is clear that the problem is global. But for the other two crises, the problems are seen more by people as local problems that individual governments have to manage, not as global problems. We do not often realize that biodiversity is a huge asset, not only for all of humanity, but for all life on the planet, and it's not the problem of a single country which is losing its biodiversity. Pollution is seen as something which does damage only locally. But for example there has been a recent study that shows that microplastics enter into the global atmospheric cycle, and they are deposited around the world even fifteen years after they've been produced and emitted into the atmosphere. We need to undertake a great work, and I agree with the president about the need to reflect scientifically on this point and to make the public aware. We need to increase scientific conferences and opportunities for debate, such as the one we have had today, but where the three crises we are considering are addressed in a simultaneous way.

Inger Andersen: If I could just comment ever so briefly – as I think that I've done a lot of speaking already – I entirely agree with you: education and awareness is critical, and I also agree with what you said, Professor Parisi, about ensuring that there is

awareness of the integrated nature of these crises. I also very much agree that climate is to some extent seen as global, whereas other things such as pollution and biodiversity might be seen as more local.

I'm so happy that we've heard about the youth summit that Italy will host prior to the COP, because young people actually give me a great amount of hope. Because they get it – in a deeper way, I'm afraid, than my generation does. And so they are also seeing what the situation is for the world that we are leaving them. And they're demanding something in a different way than my generation did when we were young. They get these planetary crises nearly instinctively.

Now, that means that the responsibility that we have is to make their voices heard – not as a "nota bene", not as a small point that we just allow into the "adult" conversation, but we have to begin to give them an equal voice, since it is their future. And I think that here with the transformation that the Green Recovery offers, it would be inconceivable if we were to use these moneys in the wrong way. And that might very well help drive our approach to these crises in a more integrated way.

Wolfango Plastino: *How do we increase international solidarity to ensure fairness and equity for developing nations and vulnerable communities?*

Inger Andersen: I think as things now stand we have vaccine *haves* and vaccine *have-nots*, and even with the vaccine *haves* there is a little bit of jostling at the front line of the queue between a few nations; but I think that we should understand that for the rest of the world, it's a reality of vaccine *have-not*. And we have to ask ourselves if we really believe that that's a viable future – if we really do believe that not driving equity at the global level is going to be good for those who are at the front of the queue, whether it's for vaccines or for anything else.

Surely it can't be. Because if I have Covid, and I'm in a poor country, we all have Covid. And if I have climate change, we all have climate change. It's as simple as that. So if we just want to talk self-interest for a moment, it is in our distinct interest, even if we are at the front of the queue, to think about those at the back.

Now, that is hard for a politician who is elected for four years, and short-termism will drive what they need to supply to the nation and what the nation will demand. But it's also incumbent upon leaders to talk about the fact that if one person has Covid we

all have Covid, so to speak, if one person has climate change we all have climate change. The inequity and the unfairness that we are seeing, and the wealth divide that has grown, is simply not a viable option for long-term stability on this good planet. And we need to look no further than people going into boats and people striving for a better life, etc. to understand that the reason is that the land cannot sustain them, that the rains are not coming, that climate change has hit, that crises are there. There are of course always many aspects to any crisis. It's like peeling an onion. There is politics, and religion, and ethnicity, and many other things – but invariably within that onion, there is a piece called environmental sustainability. And that piece, we have to understand, is more important than we might comprehend. If the land is nutritious and will support people, likelihood of movement is less. If the land is nutritious and the climate is stable, the likelihood of stable society is higher.

So we should understand that investing in solidarity is good from a basic value and ethical point of view, but even if we have to drive it home through self-interest, it's absolutely also in self-interested terms.

Dan Larhammar: That is so excellently said, I cannot possibly add much further. I was also thinking of the example of the Covid-19 pandemic. I think this shows excellently how important global solidarity is, because unless we can reduce the number of infected individuals across the world, there will be new variants popping up, and they will spread. So a pandemic probably shows more than most other things how crucial global solidarity is, because this solidarity will lead to benefits for everyone, or avoid a crisis for everyone.

Now, since conditions differ so much for people across the world, there are different meanings of the word "solidarity". People in highly developed countries, with highly developed economies, do the most damage per capita overall. So they can produce the most changes in the situation. We cannot expect the people who are forced to worry about food and healthcare for themselves and their families for the next few days or weeks to be concerned about consequences for the planet years or decades ahead. And I think we must realize that conditions differ so much, but that should not take away the need for solidarity between regions with different levels of economic and social development.

Giorgio Parisi: I agree with both of you, but there are some distinctions that I would like to make.

I fully agree that fairness and equity for developing nations are a fundamental part of the approach that aim to really solve problems on a global scale. Unfortunately, I am very pessimistic about international solidarity. The vaccine is a very good example. What you have said is fully evident – if other people get Covid, then your chance of getting Covid is much higher. However, there is a programme, the COVAX programme, which is supposed to vaccinate two billion people in countries which are not really rich, and this programme has been financed in a completely inadequate way. They have money to buy 10 or 15% of the needed amounts of vaccines. Of course, there are certain countries in Northern Europe that are helping this action, but aid is certainly not coming from other countries.

This is an example of how the egoistic behaviour of countries – of many countries, not all countries, as I said before – obstructs realizing the clear interests that we all have to vaccinate everybody. The amount of money put toward vaccinating everybody on the whole planet is so ridiculously small compared to the trillions that are spent on the crisis that it's difficult to believe that it's going to happen.

And I think that in the past, too, the rich nations have been able to transfer only marginal amounts of their resources to developing nations. Here we need a much bigger amount. So although I would also like to call it "solidarity", maybe "solidarity" is not the best word to convince politicians. Because if a nation needs economic compensation in order not to destroy its forests – which is a typical situation that happens in developing countries where a nation wants to destroy its forests to improve its economic situation – then compensation should not be regarded as an act of solidarity, but as an action to avoid global disaster. Providing clean energy sources to developing countries should not be considered as a gift, but as something that reduces CO2 impact in the atmosphere, letting us avoid other actions like sequestration of CO2 and so on. Increasing the economic level of developing countries is not an act of simple solidarity, because it leads to a decrease in demographic pressure, and we all know that demographic pressure is one of the sources of all the troubles that we have.

Therefore, my suggestion is that, although we know that this is truly a question of solidarity in some sense, it's important to convince politicians and to convince the public that it's not only solidarity – which is an extremely important thing on the human scale, because we all are humans – but that it is also in the self-interest of everybody to help other countries in this direction.

Wolfango Plastino: *How do we persuade businesses and governments to start including the value of nature in all of their decision-making?*

Giorgio Parisi: Let me say that if business people were obliged to compensate public finance for the damage they do to the environment, the situation would be very different. However, it is of course clear, as the Director also said, that this kind of compensation should be not be taken as a licence to pollute. Strict regulation should be added to enforce the limit, and governments should push for this type of accountability. Accountability is very important. I can remember a famous speech of Robert Kennedy's, which I think was given about fifty-three years ago, in which he was speaking of the gross national product. He was saying that the gross national product contains a lot of information, but not all the things that are important. For example, selling guns increases the gross national product, car crashes that kill people increase the gross national product, and the gross national product does not include many of the things that make life worthwhile.

It is clear that we have to reflect on the gross national product, and if a country is going to destroy its environment, using up its national resources, this must be accounted as a negative factor for the gross national product because the richness of the country is going to decrease. However, in the way that we do the computation, we see that the gross national product is increased if we destroy the country, which is something that does not make sense when we realize that the country's resources are limited. And of course, the important and interesting part is how to persuade the government to start to reach this conclusion.

Now, let me say that if someone asked, two centuries ago, "How do we persuade businesses and governments to start including the value of the well-being of workers in all their decision-making?" – well, we know all the struggles that have occurred over the last two centuries, and we know how things finally worked out. And we also know that this issue is still at the centre of political debates. Adding the value of nature to decision-making may seem simple, but not too simple. As has been said, we need public opinion if we are going to make changes; we need to make convincing arguments. But we have other people who are pushing in the other direction. After the public opinion has been convinced, we need to bring this issue to the centre of the political arena, to the centre of the political agenda. And we should add that it's sometimes possible to find a bipartisan approach to this problem, but this is not easy, nor always possible.

However, we have to do our best to see to it that the people, when they go to vote, have in their minds also the values of the environment, and that they decide in consideration of these things too, which will be crucial for the future.

Inger Andersen: I was enjoying listening to Professor Parisi so much. I just want to say that I think it has to be about setting the regulatory guardrails, as well as driving public understanding and information. But when we began to make new rules – you know, you couldn't smoke in offices, you couldn't smoke in aeroplanes, I'm old enough to remember that – there was a heightened understanding of the public health impact. Some people still choose to smoke, but the number has been reduced, and there is a greater understanding of the impact.

So it is about informing, but also setting regulatory guardrails for what you can and cannot do. Today we have privatized the goods, the profits, and we are externalizing and putting the bads on the public purse. All the environmental clean-up in the oceans, for instance – well, it's *nobody's* business, except *everybody's*. It's yours and mine. So we need to ensure that we use subsidies, and we use regulatory setting, and we use taxation in the right way. As an example, let's put a price on carbon – finish Article Six in the Climate Convention, please, in the Paris Agreement, so that we can get to carbon trading! Let's redirect harmful subsidies, subsidies which up to today have undermined long-term sustainability – not those that support the poor, etc., but those that support over-investments in certain sectors, including obviously the hydro-carbon sector – and support, via smart subsidies, sustainable agriculture, sustainable transport, green transport, public transport, electrification of the motor vehicle fleet.

All of these things don't happen at the speed that we need them to happen, unless we help them through regulatory requirements. So on the one hand it is about GDP, as I mentioned, but it is also about that regulatory setting. And most of the CEOs that I speak to, and most of the financing houses I speak to, are asking for a level playing field. If there is a level playing field, which means at the international level, they don't feel that if they're in one country where the guardrails are set, while in another country they are not, then they have to compete with someone that has a competitive advantage, because of lower regulatory settings. That's why multilateralism has to be part and parcel of the answer.

But I will say, I'm seeing that more and more companies get this. These are especially companies that are reliant on nature

services. And, another big sector is for example the reinsurance industry. They *get* that they have to pay out huge amounts for climate impacts. They are on the front lines, saying, "Can we invest in coral reefs that break the waves, ensuring that they are protected? Can we ensure that sand dunes are there, that mangroves are there?" And so on. Because they understand that these things will buffer high winds. "Can we be sure that we have wetlands, so that the infrastructure won't be flooded – which we then have to pay out?" So I think it is also about increasing awareness.

And finally I would say that this is one of our problems: ensuring there's enough understanding and awareness there amongst the general population that this is not against them, it's in their favour, and ensuring that we put a safety net under those that could potentially be left behind. We have coal miners, who work in mines for coal, and they should not be left high and dry. They should be supported in new opportunities, and it's very important that we understand who are the potential short-term winners and losers, and leave no one behind in that regard.

Dan Larhammar: I totally agree. Encouraging responsibility is something we must strive to achieve, but it is a difficult thing because some people just don't care. But of course, explaining evolution, explaining that nature is precious – that it doesn't regenerate in a few years, that evolution is the result of millions or hundreds of millions of years – will probably make at least some people more aware. And the catch-phrase used recently by David Attenborough and several people before him – "Extinction is forever" – should make everybody think.

Let me add to what you have already said that maybe we can hope a little bit also for consumer power, especially in markets where consumers have a choice. Then they can choose the products, or methods, or whatever else, that show a greater awareness of the situation we're in. It's perhaps difficult in markets where there is no choice, and in less developed areas where people cannot afford to choose, but have to go for the cheapest option all the time.

Then finally, on a very much smaller scale, but nevertheless important for certain ecosystems, tourism can focus on what is sometimes called "luxury tourism" – but it's luxury for nature as well: namely, to restrict the number of individuals that are allowed to visit certain very vulnerable areas. One of the most beautiful examples of that are the limited visitations allowed to the mountain gorillas, and we have also the Serengeti as a whole, where tourism

is restricted, as in many other regions. That's a way to protect some areas of our planet. And this also helps increase awareness.

So we have to work on multiple fronts, here as everywhere else.

Wolfango Plastino: *How do we democratize science so that it becomes more accessible, diverse, understandable and actionable for the general public?*

Dan Larhammar: I think I can be very brief here, because we have already touched upon this to some extent. Again, it's a matter of information and education to make science more accessible and understandable for the general population. And again, the internet is a tool to reach that. But we also need to have help from professional communicators, science writers, who can help explain both the situation that we face, and what possible solutions there are to it, so that this information becomes more comprehensible for the general populations.

Giorgio Parisi: I fully agree with Professor Larhammar, because I think communication, information and education are important. The point is that scientists are very often not good communicators, because they usually speak with other scientists, and other scientists understand their jargon; and very often scientists that I know, when they speak publicly, start to use jargon and say some words which I understand, but which I am sure that no one in the public is going to understand.

Now, all that – communication, information and education – can be done, it should be done. The point is that we scientists have somewhat neglected our duty to communicate to the public, and we should do that in a more serious way. And also, education in school is very important. We have seen during the pandemic that there were simple ideas, like exponential growth, that were very difficult for people to grasp, in part because they could not read, for example, plots on a semi-logarithmic scale. Education should be done in such a way, not only to learn something, but to learn the ability to understand new arguments which one is not familiar with – of course, if it is explained in a reasonable way.

Inger Andersen: Being the non-scientist on the panel, I think I can only endorse what the scientists on the panel are saying. But I'll say that the more we can aggregate, the better. I mean, we understand that science has to be deep; for it to be scientific, it has to be deep. But the more science also aggregates and laterally integrates

across disciplines, the more it will be understood, I think. And the more science is, as you said, explained in language that is accessible, and the more it comes with real-life applied implications, the more it will be understood.

And finally, I think we need to understand that there are things – I'm old enough to have been at earlier COPs, I mean COP2 or 3 or something, for climate – that science has been telling us for a long time. It's just gotten ever more precise for twenty-seven years, plus. But the world hasn't reacted. So we have to ask ourselves, what is it then that science has failed to do? And it is that we need to hit the heart, as well as people's well-being. And unfortunately, we've taken science very purely, and we haven't understood how politicians need to own this in a different way.

I think we're getting there, and lectures such as this, which are open and engaged, are very, very important. I'm deeply honoured to have had the opportunity to participate.

Atoms for Peace and Development

Science and Technology for a Better and Safer World

Pasquale Ferrara
Rafael Mariano Grossi
Jeremy McNeil
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Introduction

Pasquale Ferrara

The international scenario currently before our eyes is deeply concerning, with heightened international and regional tensions, and with the proliferation of nuclear weapons representing a major threat to international security.

In this respect, the system of safeguards represents a fundamental guarantee for our common security. Director Grossi can rest assured that in all relevant international fora, Italy will continue to promote the universalization of the Comprehensive Safeguards Agreements together with an Additional Protocol as the verification standard. Indeed, I wonder whether it would be possible to make the principles of the Additional Protocol a general norm of the international order: although this would now be very hard to accomplish, it is important that all responsible states continue to uphold this cornerstone of the non-proliferation architecture.

The non-proliferation and disarmament community is currently engaged in the preparation of the next Review Conference of the Non Proliferation Treaty (NPT), scheduled in 2020 and postponed due to the Covid-19 pandemic. In this regard, let me emphasize the importance that Italy attaches to the NPT: it remains the cornerstone of the global non-proliferation regime and the essential foundation for the pursuit of nuclear disarmament, as well as the basis for further development of nuclear applications for peaceful purposes. In our view, these three mutually reinforcing pillars are still perfectly valid today. We should use the remaining time in preparation of the Review Conference as an opportunity to build bridges between the State Parties and to assess the substantial progress achieved so far in the framework of this historic Treaty.

Our desire for a safer world for future generations underpins our efforts for effective progress on nuclear disarmament and non-proliferation. I am convinced that Article VI of the NPT provides a realistic legal framework to attain a world without nuclear weapons in a way that promotes international stability.

Our approach is based on the idea that the goal of a nuclear-weapons-free world can be reached gradually, with the involvement

of all relevant actors, through a series of concrete and progressive steps, and based on the principle of undiminished security for all.

In terms of concrete and effective measures towards this goal, Italy has always been a staunch supporter of the entry into force of the Comprehensive Test Ban Treaty and has always strongly promoted the start of negotiations for a treaty prohibiting the further production of fissile material for nuclear weapons or other explosive devices.

I would also like to stress the relevance of risk reduction, which can contribute to alleviating tensions and building the necessary trust and confidence, such as transparency and dialogue on nuclear doctrines and postures, military-to-military dialogues, hotline, "accident measures agreements" and notification of exercises, missile launch notifications and other data exchange agreements, consistently with the 2010 NPT Review Conference Action Plan.

This reflection on the NPT brings me to the current state of the Joint Comprehensive Plan of Action (JCPOA) on the Iranian nuclear programme. We believe that this agreement is an important element of global non-proliferation efforts and achievement of multi-party diplomacy, as endorsed by UNSCR 2231.

The JCPOA was agreed on to ensure that Iran's nuclear programme remained exclusively peaceful, in return for the comprehensive lifting of related UN, multilateral and national sanctions.

Preserving the JCPOA is therefore crucial, not only in terms of nuclear non-proliferation, but also for the security environment of the region. Therefore, the intention to return to the deal and to its full compliance stated respectively by the Biden administration and Iran are both highly welcomed. The new US approach marks also an extremely positive realignment between the two sides of the Atlantic on this crucial topic.

With the substantive discussions that will take place in Vienna, we are now on the right track, as this testifies that the only solution lies in diplomacy. Nevertheless, the road ahead is long and the end goal far from secured: at this critical juncture, all sides should refrain from any action that could increase tensions and derail this positive process.

In terms of challenges to the global non-proliferation regime, North Korea's nuclear and ballistic missile programmes remain an issue of serious concern. Pyongyang should undertake concrete steps towards a complete, verifiable and irreversible denuclearization, in view of a return to the NPT.

The global non-proliferation regime is under pressure also in relation to the threat posed by the proliferation of weapons of

mass destruction and their means of delivery to – and through – non-state actors.

Let me finally recall the need to recognize the changing nature of the existing threats, to react, adapt and step up our efforts at reinforcing the global non-proliferation regime. Risks may indeed arise from a variety of sources: states aspiring to possess nuclear weapons; non-state actors in search of "dirty bombs"; poor national legislation in place to prevent illicit trafficking of materials and dismantle proliferation networks, as well as from mismanagement and misuse of rapid development of science and technology.

I would like therefore to conclude this presentation by highlighting the importance of further analysis and research in the field of nuclear technology. In this respect, this event is an excellent opportunity for debate and analysis among international high-level experts and officials.

Technology and scientific innovation are essential for development. Nuclear applications offer enormous benefits in many areas of our lives, including health, agriculture, food production and energy generation, as well as in many sectors of industry.

In this respect, we commend the International Atomic Energy Agency's further advance along its pattern of "Atoms for Peace and Development" and its impressive work to ensure security and safety of nuclear activities around the globe, including to help countries achieve the goals of the 2030 Agenda for Sustainable Development.

Along this path, Italy is proud of its contribution to the technical cooperation fund of the Agency. Let me recall in particular the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, which is a driving force behind global efforts to advance scientific expertise in the developing world.

Finally, let me mention that each year a number of foreign researchers are hosted in our laboratories and medical facilities in the framework of fellowships financed under the Agency's technical cooperation fund. I believe that this research and academic aspect is a crucial component in confidence-building within the international system: compliance relies – *inter alia* – on the "human dimension", and we should learn to consider individuals involved in nuclear activities and their connected responsibilities as structural elements of the overall picture.

Lectio Magistralis

Rafael Mariano Grossi

In December 1942, on an old squash court beneath the stands of an abandoned American football stadium, an Italian scientist became the first person to light an atomic fire. In that moment, humankind harnessed the vast cosmic reservoir of energy in our sun and our stars.

The pioneering scientist was of course Accademia Nazionale dei Lincei's very own Enrico Fermi. Fermi laid the foundations of his famous experiment with the "ragazzi di via Panisperna" here in Rome.

As the inventor of the nuclear reactor and among the first to warn of its potential military use, Fermi knew that the energy he had unleashed could both harm and benefit us.

Towards the end of his life, he gave a lecture to a group of physicists. He told them: "What we all fervently hope, is that man will soon grow sufficiently adult to make good use of the powers that he acquires over nature".

In 1957, five years after Fermi made that statement, the International Atomic Energy Agency (IAEA) was founded and given a mandate to turn his "hope" into reality.

I have spent much of my adult life in the orbit of the IAEA. This has given me the privilege of seeing the Agency from several different angles: as an Argentinian diplomat; as a staff member, and now as its Director General.

The IAEA is a unique international organization, steeped in technical and scientific knowledge. Our hallways and laboratories echo with the conversations of scientists and public servants from every continent. We are a member of the United Nations family and partner with many of its Agencies. At the same time, we are autonomous. Ultimately, the IAEA answers to its 173 Member States.

Some of these states operate nuclear power plants, others do not; some are rich and others less so. Two wishes unite everyone we serve: the wish to live in peace, and the wish to benefit from the many life-enhancing applications of nuclear science and technology.

It is in meeting these wishes that the IAEA finds its mandate: "Atoms for Peace and Development".

Like a coin, the IAEA has two sides. On one side, we are the world's nuclear watchdog. We verify that states do not develop nuclear weapons. On the other, we are the facilitators of scientific and technical progress. We work to ensure that no community is left behind when it comes to benefiting from the safe, secure and peaceful uses of nuclear technology. We assist countries in healing their sick, boosting their crop yields, finding sources of fresh water, making oceans cleaner, and mitigating the consequences of climate change. The uses of nuclear are so wide ranging, that the IAEA alone helps countries achieve 9 of the UN's 17 Sustainable Development Goals.

To better understand where we are today and imagine what tomorrow might hold, I would like to take you on a journey back to the 1950s.

In Vienna, the wounds of war are still etched into the buildings. It is 1957, and the new home of the IAEA is just emerging from a decade of occupation by the war's victorious powers.

Here in Italy, things are looking up. The industrial miracle is producing everything from the most desired fashions to the Vespa. Federico Fellini and Sofia Loren are bringing Italian cinema to the world.

In Africa and Asia, countries are forging a new future, independent of colonial rule.

Technology is advancing. A new transatlantic cable enables better communication; the first computer comes to market; and jet aeroplanes herald intercontinental travel. In the Soviet Union and in the UK, the first nuclear power stations are producing electricity, and among nuclear scientists there is a sense of promise of further applications.

But, with the shock of the atomic bomb still fresh in people's hearts and minds, the spectre of nuclear conflict is casting a dark shadow over all this post-war potential.

To move confidently into the future, the world needs to find a way to prevent the destructive power of nuclear weapons while nurturing the technology's benefits for peaceful use.

It is in this context that the IAEA is founded, and 13 years later the Treaty on the Non-Proliferation of Nuclear Weapons, known as the NPT, will come into force.

For the past six decades, the IAEA and the NPT have made immense contributions to the safety and well-being of billions of people.

Were it not for this powerful international legal framework and the indispensable role of our inspections, we might well be living in the world the leaders of the 1950s and 60s feared would come to pass.

That the world is not permeated by nuclear weapons states, is a remarkable achievement. We should not take it for granted. As with other treaties and international institutions, the NPT and the IAEA rely on nations respecting international laws and norms. Today, the undermining of international laws and institutions; the closing of borders and the disregard for scientific and other facts, are serious challenges to peace.

Amid these obstacles, it is critical that the IAEA maintain its high level of credibility. To do this, we must remain steadfast in being firm and fair, especially in difficult situations.

Iran's nuclear programme is one of these challenges.

My team and I have maintained an open dialogue with Iran to verify, without bias, its nuclear programme. In the past months, we have worked tirelessly with Iran to ensure there is no break in the IAEA's collection of data while diplomatic negotiations towards an agreement between Iran and the five permanent members of the UN Security Council, plus Germany and the EU, continue.

This constructive and respectful approach does not mean we have shied, or will shy, away from telling the truth. We have made it clear that Iran has not yet answered our questions. And I have publicly stated my concern regarding this lack of clarity, especially as this ambiguity comes amid the backdrop of a continuously growing level of nuclear activity.

Also deeply concerning is the situation in North Korea. Satellite imagery indicates a reprocessing campaign may be underway. The situation is a cautionary tale of what happens when a country turns its back on established norms and its cooperation with the IAEA.

Even though inspectors cannot enter North Korea, the IAEA continues to monitor its programme and we stand ready to reengage. Every day we are reminded that diplomacy requires patience. This is true also in the IAEA's role in establishing a nuclear-weapons-free zone in the Middle East.

The process of establishing such a zone is, of course, led by the states in the region, and it is not easy. We will continue our consultations and engagement.

Over the past sixty years, our long-term goals of peace and prosperity have not changed. However, the political interests of nations have fluctuated amid constant geopolitical shifts, from the dawn and dusk of the Cold War, to terrorism and regional conflicts.

In coming decades, the pace of geopolitical and technological change is unlikely to slow. It will be vital that the IAEA remains strong throughout.

Member states are wise to keep supporting our work, financially, by helping strengthen safeguards, security and safety norms, and by furthering the scientific collaborations that help us support peace and prosperity around the world.

A robust regime of safeguards, including Additional Protocols, is essential. The Additional Protocol strengthens the IAEA's safeguards mandate. Without it, what inspectors can do is limited. A little like a man looking for his keys under a lamp post, not because he dropped them there, but because this is the only illuminated place on the street, it is not good enough for the IAEA to look for nuclear activity only where a member state declares it is. The Additional Protocol gives inspectors the authority to search thoroughly, thereby more confidently being able to reassure the world that no nuclear materials are unaccounted for, nor have any been diverted. The international community granted the IAEA this authority after the revelation in 1991 of the extent of Iraq's hidden weapons programme.

A similarly important lesson came a decade later amid the September 11 terrorist attacks in the United States. These made clear to the world that the threat of nuclear proliferation had changed since the 1950s. With the spread of nuclear material across all continents and the rise of non-state actors, it was high time to sharpen the international focus on security.

The Convention on the Physical Protection of Nuclear Material and its 2005 Amendment make it legally binding for countries to protect a wide range of peaceful nuclear material wherever it is located, whether in facilities, in transit or in storage. Through peer reviews, shared databases, and training, the IAEA assists countries across the world in meeting that obligation. We help them understand how to keep their nuclear material safe and secure, whether it is located in a hospital treatment room, at a power plant, or in a university laboratory. The amendment also provides for strengthened international cooperation. Italy plays an important role in this. For example, it funds the International School of Nuclear Security, organized by the IAEA and the International Centre for Theoretical Physics in Trieste. Our 10th session was held last month, updating early-career professionals from developing countries on the latest in nuclear security.

Nuclear safety and nuclear security are closely related. Without them, nuclear will not be able to deliver on its beneficial potential. Today, we have a strong international safety culture in no small

measure because of the lessons we learned from the Chernobyl accident. International conventions and a robust network of cross-border cooperation exists, with the IAEA at their centre. Principles to guide countries in their implementation of these objectives, further strengthened that safety culture following Fukushima. This is important, not only for those countries pursuing nuclear power programmes, but also for those, like Italy, that have decided to decommission their nuclear power reactors.

Globally, nuclear power plants provide around a third of our low-carbon electricity. Nuclear energy is here to stay. Countries in Asia and even in the oil-rich Middle East are looking to it to meet their growing energy needs. More than 50 reactors are under construction and 27 countries are actively considering, planning or embarking on a nuclear power programme. The IAEA is helping many of them lay the legal, organizational, human and technical foundations that will allow them to fulfil their ambitions in a safe, secure and efficient way.

Because every time a nuclear power plant replaces a coal mine, the world can breathe more easily – quite literally. Today, 8 million people a year die because of the health effects of fossil fuel emissions.

With the technical challenge of long-term nuclear waste disposal having been overcome by sites like Finland's Onkalo repository, experts have concluded there is no science-based evidence to suggest nuclear does more harm to human health or the environment than other green technologies backed by the European Union.

Of course, each country has its own unique circumstances, and each chooses its own energy mix. But if we are to reach net-zero emissions anywhere close to 2050, the world will need to harness all available low-carbon energy sources. The Intergovernmental Panel on Climate Change models four pathways to achieving our critical 1.5°C degree goal. These require nuclear power generation to increase between 59% and 501%. This projection by leading international environmental scientists is higher even than the IAEA's top estimates.

It is clear that we will have to come up with new technologies across all low-carbon solutions. In nuclear, for example, Small Modular Reactors (SMR) could offer an option for smaller electricity grids, including those in developing countries. If SMRs are used to produce hydrogen, we could reach tough-to-decarbonize sectors, including transport and industry. Further in the future, tangible progress in fusion will bring with it the prospect of safe, reliable and abundant carbon-free energy. In all of these cases, the IAEA is laying the groundwork to contribute to their safe development and deployment.

If we are to hand this world to the next generations better than we found it, we must invest in science.

Newspaper headlines may tend to focus on our safeguard work, but many countries join the IAEA because they want our help in safely applying nuclear science and technology to a myriad of peaceful endeavours. The following specific examples illustrate the IAEA's unique mandate.

The SESAME international research centre in Allan, Jordan is a notable achievement in which the IAEA is involved. Countries in the Middle East with deep political differences came together to build the facility at whose heart is a synchrotron light source allowing scientists from across the Middle East and beyond to collaborate, teach and advance nuclear science. These days, as the conflict in Gaza rages on, this example reminds us of what can be done when scientists work together.

Whereas the SESAME project was a long time coming, my next example shows just how quickly the IAEA can move in a crisis. Over the past year, we have done our part to help fight the Covid-19 pandemic. To date, the agency has sent RT-PCR testing kits to 128 countries, enabling the testing of more than 28 million people.

While we were mounting the largest emergency response operation in our history, we were also devising a coordinated, long-term initiative to combat the reoccurring challenge of viral outbreaks like that of Covid-19. Zoonotic Disease Integrated Action, the IAEA initiative we call ZODIAC, is nuclear's contribution to helping developing countries spot zoonotic diseases and stop them from spreading. The programme builds on decades of experience and is an example of the IAEA joining partners, such as the World Health Organization, the United Nations Food and Agricultural Organization, and the World Organization for Animal Health, under the "One Health" approach to soothe and to cure, and to rebuild communities.

There are many medical uses of nuclear technology beyond combating zoonotic diseases. Cancer is a big one. Through nuclear medicine and therapy, the IAEA has been working hard to open access to life-saving pharmaceuticals, equipment and knowledge to countries that lack them. The projected increase in cancer cases over the coming decade will be distributed unevenly. The number of new cases is forecast to rise more than 80% in low-income countries, double the rate richer countries will experience. Today, cervical cancer kills more than 300,000 women every year – nine out of ten of them in low- and middle-income countries. Many of these deaths would be preventable if it weren't for the fact that

people living in nearly 70 countries, 28 of them in Africa, still do not have access to radiotherapy. Setting up a cancer centre is not an easy task, which is why the IAEA has helped countries such as Zambia on their journey to do so. For many public professionals and policy-makers, the agency serves as a key resource for learning and sharing best practices, and to ensuring these life-saving treatments are available and carried out safely and effectively.

The next examples I would like to give are of nuclear science offering solutions to the challenges of climate change and pollution that go well beyond decarbonizing electricity production.

For farmers in Vietnam, for example, radiation processing turns casava root starch polymers into water-absorbent pellets, which are used to help irrigate rubber plantations. In Latin America, Asia and Africa, IAEA experts help countries use ionizing radiation to breed new crop varieties so famers reap harvests that can better survive droughts and disease and offer higher nutritional value. This not only boosts yields, but also conserves water and reduces the need for pesticides and fertilizer. From Afghanistan to Argentina, the IAEA helps communities use isotopes to trace and assess the availability of fresh water, allowing them to use this precious resource prudently. Isotopes also allow scientists to trace microplastics across the oceans, and through the food chain from the bellies of shrimp to those of fish to ours. This means governments can rely on accurate information as they seek to overcome an increasingly global problem. Of all the plastic we have used to date, 70% is already waste. Less than 10% has been recycled, with much of the rest eventually landing in our waterways. One of the problems is that plastic is difficult to recycle, and here too, nuclear techniques can help, in this case by breaking down long and complex polymers. Like a discarded plastic bottle washed onto a distant shore, many challenges do not respect national borders. The IAEA enables scientists and professionals to reach across their borders to share their experiences and data. A powerful example of this comes in a rather small body – that of the Mediterranean fruit fly, one of the world's most destructive agricultural pests. The IAEA helps many countries eradicate the medfly by using radiation to sterilize males. In the Middle East, this little insect flies without challenge across borders and through military no-fly zones. But it met its match when Israeli, Palestinian and Jordanian policy-makers, scientists, farmers and technicians came together and – aided by the IAEA – used the sterile insect technique to eradicate them. The agency has adopted the same approach to help Senegal and other countries combat the deadly tsetse fly.

In these endeavours, member states receive our assistance on the ground, at our laboratories near Vienna and in Monaco, and at the conferences and training events we host and facilitate. Knowledge like this is shared through our virtual platforms and reports, and through our partnerships with research facilities around the globe.

In all we do, we seek to empower the people we serve, and this is especially true of women. I am determined we do our part to boost the number of women benefiting from and participating in nuclear science.

The American physicist, Leona Woods, was the only woman in Fermi's team that built and experimented with the world's first nuclear reactor. There are far too many women scientists who have received far too little credit for their important work.

I opened my remarks with Enrico Fermi, and as I approach the end of them, I want to name some of the women scientists who worked around Fermi's time. Their contributions in many cases were not only important to science, but also to him.

- Tatiana Ehrenfest-Afanaseva, who together with her husband laid the foundations of statistical mechanics and statistical thermodynamics.
- Emmy Noether, who solved problems key to the theory of relativity and whose mathematical formulations, including those surrounding the principle of the conservation of energy, contributed to our understanding of physics.
- Marietta Blau, the first physicist to show that proton tracks could be separated from alpha-particle tracks in emulsion.
- Irène Joliot-Curie, whose work offered an important clue for the discovery of the neutron, and who discovered induced radioactivity.
- Lise Meitner, who discovered radiationless atomic transitions and later discovered nuclear fission. Her mastery of experimental physics underpinned and facilitated some of the most important scientific advances made by her fellow scientists, including Fermi's nuclear reactor.
- Ida Tacke Noddack, a chemist, who suggested that the radioactivity Fermi observed resulting from neutron bombardment of uranium might be caused by disintegration of the uranium nucleus into several heavy fragments. Had Fermi taken note, he would have sooner understood the process we now know as fission.
- Maria Goeppert Mayer, who proposed the nuclear shell model of the atomic nucleus.

My hope is that young scientists will research these great scientists' discoveries and take inspiration from their perseverance and determination. And that we more senior leaders will remember the equally vital contribution women and men make in helping us achieve our goals.

Today, it is our job to clear the path of women scientists of their historical and current obstacles. This is why I launched the Marie Skłodowska-Curie Fellowship, whose inaugural group of 100 women fellows is already receiving financial support to study for their Master's degrees in nuclear subjects around the world.

We have come a long way since the hopes and fears of the mid-1900s led to the IAEA's founding. As you can perhaps tell, I am fiercely proud of this unique organization's accomplishments and of the work its women and men continue to do every day. But we cannot do it alone. In closing, I want to thank the Accademia Nazionale dei Lincei for the great honour of being with you in this magnificent setting today. And I want to thank Italy, its policy makers and its scientists, for helping the IAEA to make Fermi's hope a reality. I call on all of us to redouble our efforts to use wisely, justly and always peacefully the incredible power he and the women and men who worked alongside him unleashed 80 years ago.

Discussion*

Rafael Mariano Grossi, Jeremy McNeil, Giorgio Parisi, and Wolfango Plastino

Wolfango Plastino: *Should nuclear energy be a part of the energy mix that moves us onto a more environmentally sustainable path? If so, what are the kind of activities that would move nuclear power higher on the climate change agenda?*

Jeremy McNeil: I am an ecologist who works on the effect of climate change on agricultural and natural ecosystems, and obviously any form of energy that will reduce the production of greenhouse gases, such as nuclear energy, is in my mind something that we should seriously investigate. Like everything else, though, it comes at a cost, and there are benefits and there are disadvantages, and we have to look at those. And while nuclear plants do not produce greenhouse gases, there is the whole question of radioactive waste that we have to deal with. In Canada, of course, this has been a very active area of debate, and there are two possible approaches: one is the deep geological disposal, whereby the waste is put very deep into the ground in areas that are extremely solid, and thus the probability of leakage is reduced, particularly as they have developed multi-barrier approaches. There is always the question, as this waste lasts for thousands and thousands of years, of what might happen: could they leak? And as a result, there is another group that is taking an above-ground approach, and it has basically been called "rolling stewardship", whereby the responsibility passes from one generation to the other; the argument for that is that science and technology might develop a means by which we can actually reduce the dangers of radioactive waste with future development.

In my mind, to be honest, it's extremely important that we look at alternatives. Of great importance for us as scientists is the

* The text below is the full transcript of the Round Table that followed the *Lectio Magistralis* by H.E. Rafael Mariano Grossi, Director General of the International Atomic Energy Agency.

question of education. We have the data, we mustn't just believe that because we believe something, everybody else will, as well. We must have an open dialogue between scientists and politicians; we must work with agencies such as Professor Grossi's. We really need to make sure that the public understands. And I think that this is an important role that academics and academies can play. We have serious problems with climate change, and nuclear energy is obviously one of the potential solutions that we must investigate at great length, but with transparency, and by presenting both the benefits and the disadvantages.

Giorgio Parisi: The use of nuclear energy in the future is a highly controversial point. I have discussed it with many friends and with many fellows of the Academy, and the viewpoints are quite different. The difficulties in finding a common viewpoint also arise because there are many different issues which are interwoven here. There are not only environmental issues, but there are economic issues and societal issues; we also have problems with the import/export of developing countries that should be taken care of. And then, as President McNeil was also saying, we have the problem of the relation between science and society in education, which should be taken into account.

Let me present some personal considerations, since it's clear that I certainly can't speak here in the name of all academics, because there are many different opinions. I am very convinced that, as we know, from what we have seen from Chernobyl and also from the Japanese accident, most of the damage that is done by nuclear plant reactor incidents happens in the vicinity of the reactors. They say up to one hundred kilometres – certainly, more than one hundred kilometres, the damage is very minimal. But the regions that might be at twenty, thirty kilometres are also the most likely to be evacuated, at least in a very serious accident. Therefore, this type of damage, which is very serious, is proportionate to the population around the centre.

We have been very lucky in the past; the populations around Chernobyl and also around the Fukushima reactor were not as high-density as the Val Padana. Therefore, as far as the possible damage in proportion to the population, we can say more or less that the benefits do not strongly depend on the region where they are constructed – especially if you think of it from the ecological point of view; for carbon reduction, it is region-independent. Of course, if you want to transport energy, it is clear that you would like to have reactors near to populated regions, but of course this includes very high costs. I think that in countries like Italy, Belgium,

the Netherlands and some regions also of China and India, the construction of reactors should be avoided, because these are the worst places to construct reactors if you look at the ratio between benefit and risk.

As Professor McNeil was saying, there is a serious problem in the whole world regarding long-term management of radioactive waste. There are so many unsolved problems. For example, there is no final decision for the long-term, permanent deposit of waste in the United States. The Yucca Mountain Project failed, a similar project in salt mines in Germany failed, and so of course we can have nuclear waste for hundreds of years, for thousands of years. We know how to control it. But it is unclear where we can put it, in a place where we can forget it – not for the rest of the universe, but at least for ten or a hundred or a thousand years, or something like that.

One other problem that makes difficult large-scale construction of nuclear plants – and I am not discussing a single or a few cases, but large-scale construction, since if you don't have large-scale construction, it will impact very little, in a marginal way on CO2 – is that nuclear energy is an extremely complex technology to import from abroad. Many developing countries may not be able to construct safe reactors themselves – I don't mean reactors in general, which is easy, but latest-generation safe and stable reactors – the reason being that the technology must be imported from abroad. And this is something that would have some weight in the technological independence of the country; for it's clear that if a country becomes dependent on outside intervention, this goes in the wrong direction, because it is very important that developing countries become, as far as possible, economically independent from others.

Even developed countries should become independent, in some cases. I remember there was a shortage of masks in Italy and in many other countries, because we were dependent in the same way on other countries for the construction of masks and similar individual protection. So it's clear that economic independence is very important.

And I think that one kind of action that should have the highest priority is energy-saving actions. Energy-saving actions are very important. One of the places where you can save an incredible amount of energy is in ecologically friendly building. We have a huge amount of energy that goes into heating – this depends on the country, of course; not so much in Africa; but even in Africa, if you want to have the same level of life as in the developed countries, you will have a certain amount of air conditioning in

the future. Now if you start to put air conditioning in a place with bad insulation, it will bring a lot of waste, so I think that improving insulation of buildings will be extremely important. And insulation technology made by local development will strongly contribute to the local economy.

Rafael Mariano Grossi: This is a fascinating debate. What we hear from President Parisi, and especially from certain comments by Dr. McNeil, is that what's really important here is to have a debate with full transparency, where the discussion is based on scientific fact and information, and not on ideological aspects. One feels sometimes that around the issue of nuclear energy – in particular in some parts of the world, in Europe for example – there is a lot of emotion, and a lot of positions that are based on beliefs, but sometimes not so much on scientific information.

As I said, I do not consider myself a nuclear lobbyist, but the reality of the world is that nuclear energy in the world is growing. It's not diminishing. So I think we should talk about things as they are. And why is this happening? Are people jumping irresponsibly into activities that they should not be doing? I don't think so. What we see is that for many, many countries – for a number of reasons, including some relating to energy independence, for example in Eastern Europe; for diversification of energy matrices, like in the Arab world; the necessity of facing the ambitious goals of decarbonization, in countries which are consumers of coal, like China or India – for a variety of reasons, what we see is an increasing trend. And I would quote, not the representative of a nuclear utility, but the Intergovernmental Panel on Climate Change, which, as many of you must know, is a group of distinguished scientists from all over the world. Having studied the current trends and evolution in terms of decarbonization and energy in all of their projections and the different models that they have established to get to a decarbonized global economy, nuclear is part of it. The issue is how much nuclear you have, or if you have any. There are some countries that are not going for it; as I was saying, forty-two countries at the moment have embraced it. And by the end of the decade, there might be around fifty. So what we are saying is that this is a growing trend.

What's important here – and I think that Professor Parisi was mentioning some of these issues – is that we have adequate answers to the safety operation of nuclear power plants, including waste, where, from our perspective, the problem is more of social acceptance than of technical lack of answers. Because the answers are

there. A few months ago I was on the island of Onkalo in Finland, where half a mile underground you have an incredible feat of engineering, and a deep geological nuclear repository is ready for licensing. So the issues of waste are also there, and the cases that we know are of course debated. And rightly so. In democracies, these things should be debated, and all the information should be set before the public to reach an informed decision.

So, from the perspective of the IAEA, what are we trying to do, how are we trying to contribute? In two ways. First of all, by ensuring through the safety standards that we administer all over the world that there is a lowest common denominator. There are some countries that have highly developed and sophisticated safety structures. Some others, less so. What we want is to make sure through the IAEA that everybody has at least the minimum required levels.

This is one thing. And the other thing is, when working with countries – especially those newly acceding to nuclear energy – to make sure that they do everything as they should, and work within and with the international community through the commissions and committees on safety standards that we have, in order to ensure that whatever they do, it is done in a way that is beneficial, and beneficial to all.

Wolfango Plastino: *There are regional concerns regarding the water disposal from the Fukushima Daiichi nuclear power plant as it may affect the water environment in that part of the Pacific Ocean. Are those concerns well founded?*

Rafael Mariano Grossi: It's an excellent question, because this is one of the topical issues of the day. As many of you know, around the stricken nuclear power plant, the water that has been used to cool off the stricken reactors has been accumulating, and the Japanese government has arrived at a decision to dispose of it through controlled discharges of treated, processed water. And there are concerns, mainly expressed by some regional, coastal countries: China, the Republic of Korea, some other South-East Asian countries, and even by Japanese people. I was myself in Fukushima; I was talking to the fishing associations and groupings and journalists, and of course there are concerns. You ask in your question, Wolfango, whether these concerns are justified. I would say these concerns are legitimate. Every concern has to be taken seriously and with due respect. Because these people need to be

reassured that if anything is done, it will be done in a way which will not be harmful to the environment.

In terms of what we do, the IAEA has been working with Japan ever since the accident took place. And in particular, in this case, I discussed these matters in Japan with the then Prime Minister, Shinzo Abe, a year and a half ago, and I proposed to him that whatever was to be done, could be done with the IAEA. And I took the liberty, as head of an international organization, to suggest to him that they should avail themselves of our assistance – not because Japan needs any assistance in undertaking this, but simply because the international community needs a neutral, third-party with the technological ability to monitor whatever is going to be done there, through a process – a process that will take place before, during, and after the discharge of this water.

Of course, the water can be made acceptable to the environment, and, as those who are knowledgeable say – and I suppose Dr. McNeil, you are an environmentalist, you must know this – there are methodologies to get rid of the radionuclides, in particular the caesium and strontium, and also a number of other radionuclides that are present in this water before it is released, so that whatever is released is not contaminated, radioactive water. It's water that may contain some tritium. People have also been asking, why can't we do this only after tritium has been taken out of these volumes of water? And we also have been looking into this, to give people an idea – because again we have to inform, we have a responsibility to inform. In this 1.2 million tonnes of water, there are sixteen grammes of tritium; and this tritium will be disposed of after treatment, and in volumes that are reduced, because this water is not going to be released all of a sudden, as if one opened the floodgates; it's going to be done over the course of decades. You heard me well: decades. Maybe thirty years, or maybe even more. So it's going to be done in such a way that you have a function of volume of water, an amount of tritium, and the comparison with activities that are being carried out.

You know, effluents are a reality of industry, let alone nuclear industry. In any activity, there are effluents. So what we do is try to ensure that whatever we put back into our environment is not harmful, is not doing any damage to the fish, to the marine sediment, or to the water itself. This is what we are going to do. It's going to be a complex operation – one of the most complex operations that the IAEA is going to be undertaking – but we have started already. And also let me say – because this is also about acceptability, this is also about taking the right political decisions – I have set up a task

force at the IAEA where our experts will be joined by a select group of top scientists, like the Accademia Nazionale dei Lincei, coming especially from the countries that are expressing concerns, so that we will show, as far as possible, that we have an operation that is scientifically sound, politically honest and transparent.

Jeremy McNeil: I think the most important point, as Director General Grossi indicated, is transparency. People have concerns, and their concerns should be addressed, and in a very transparent way.

Obviously, he addressed the question of removing contaminants. As an ecologist, there's one other thing that we need to think about: what is the temperature of the water that is being released, and what is the relative volume and the area that might be affected? Now, that might sound silly, but as water doesn't change temperature as rapidly as air does, if you're releasing water at a much higher temperature – and that could be two or three degrees – than the ambient temperature, this can have an effect on the food chains, and as a result it could have a local or a broader effect. It may affect the growth of algae blooms; a slightly higher temperature may cause the proliferation of diseases that are present, like viruses that might be present in seafood. Now, the relative importance of that is going to be, as I said, decided by the temperature difference, and the amount of water being released relative to the volume that it's being released in.

Much of this can actually be mitigated by previous experience, because, as was mentioned earlier, this whole idea of effluents being put out into water systems is not new. I remember, a number of years ago, there was a very large factory that was producing aluminium, and they were taking water out of the lake, using it in the factory, and then putting it back in at a much higher temperature, which then caused problems with the ecosystem. Well, they said, "We have to control this", so what they ended up doing was actually building a series of greenhouses, and the hot water was pushed through, the heat was taken out, allowing them to grow vegetables during the winter, in an area where this normally couldn't happen, so they were available locally. And only then the water, at a temperature which was very close to the normal temperature, was returned. In that way they mitigated the problem.

So again, the science is available to address the questions that are being raised. We as scientists must work with politicians, we must work with the general public, and make sure that everything is presented in such a way that they understand that their concerns have been listened to and that there is science that can be applied to help mitigate problems.

Giorgio Parisi: What has been said is very important. It's very important that all these kinds of concerns are addressed. There are concerns related to radioactivity, there are problems related to the temperature of the water. But I believe that the fact that the IAEA is going to monitor all these activities is extremely important, because transparency is unusually important in this situation, since people often do not trust governments. I don't say that they have any reason to mistrust governments, but it's a fact that many people do not trust even their own governments, or the governments nearby; so, to have an international agency that is going to monitor this situation, to check that all the radioactive heavy nuclei have been filtered out, that only a small amount of tritium will remain, is extremely important. Because if only tritium remains in a small amount, it's clear that there is no environmental danger, except as far as water temperature is concerned and so on. And this can be addressed. If there were heavy nuclei insertion, that would be a completely different story, and it is crucial that an independent observer – not only an observer, but an independent team of scientists, led by the IAEA – is overseeing the situation. If IAEA is overseeing this activity, I am completely confident that everything will go well.

Wolfango Plastino: *Can you please highlight the initiatives to promote peaceful uses of nuclear science and technology to extend their reach across the globe, especially to developing countries?*

Giorgio Parisi: This is an extremely important issue, and as has already been said by Ambassador Grossi, one big issue is the treatment of cancer. Cancer has to be treated. There are many things that can be done with cancer, and one thing that is extremely important with cancer is some kind of radiation therapy. Radiation therapy is something that may completely change the outcomes of some kinds of cancer from negative to positive, or it might allow patients to gain many years, and it's clear that it's missing in many countries. So this is something that must be seen to. And also another important programme – of course, it is only for a small minority of people – is proton therapy. This therapy is an extremely sophisticated way to cure cancer, and it should be used only for a small number of cancers that are resistant to radiotherapy, or in some regions near the brain, or other regions where you can't use radiotherapy. And it's clear that even people in developing countries must have access to this type of therapy. Proton therapies are very expensive, but they include the construction of a small

accelerator, and this will be very important also at an educational level, since you have to train people on site that are able to do these kinds of things.

The other problem that I think is also as important as the treating of cancer is cancer diagnostics. Something like positron emission tomography. This can be done only if you produce, on the spot, a few kilometres away from the place where you implement this type of diagnostic tool, various types of reactive elements. Also scintigraphy, since all these types of diagnostic tools, which are crucial to see whether or not you have metastases, where they are and so on, have to be done with a very short half-life. You can have a combat bomb or some long-life radioactive elements for standard radiotherapy, but if you want to use positron emission tomography, you must produce the elements on the spot, and this is also very important. This is a very sophisticated technology that must be imported, and people in the country must learn to use it.

Rafael Mariano Grossi: I'll try to be brief, because I think you brilliantly explained things that we're actively working on: nuclear medicine, radiotherapy, diagnostics, theranostics, and the new trends. The agency is not only trying to give the hardware, but we are also working on capacity building. We are training the people. This is what needs to happen. The same applies as well to some of the areas I mentioned before, like plastic pollution, like food security with crops, with plant breeding and genetics.

We have a technical cooperation programme which is at the moment helping more than one hundred and forty countries. One hundred and forty countries are benefitting in one way or another from the work we are doing, which we are carrying out in the IAEA.

There is one thing I want to say. We more or less know the scientific areas, as we have mentioned. The problem is of course the vastness of the needs, and the expectations that are there, which require redoubled effort. And it is obvious that the meagre budgets of international organizations – for example, I have the budget of a small police force in a medium-sized city in Europe or even in Latin America, and we are doing non-proliferation work, we are doing a variety of things – is a fact of life. So this is why we are trying to reach out also to the private sector. We are reaching out to regional development banks, because these needs are there. And funding is not going to be reaching those who need it just because of the force of the market. We will have to be active and proactive in doing these things.

Jeremy McNeil: Obviously, one has heard all of the related issues for medicine. Because of my own field in entomology and working with insects within the context of food security, I would bring a little more detail into the whole idea of insect control.

We were very reliant on pesticides for many, many years; the idea was basically, if we have a problem, spray. And more and more we became aware of the ecological impact, which was very negative in many cases. So we've been working for more than half a century in the area of developing a much more integrated approach, called "integrated pest management", where one uses natural enemies, one uses resistant plants, and one of the other areas is what's called the "sterile male technique" that Director General Grossi actually mentioned in his plenary lecture.

In this case, there's a mass-rearing facility where you rear millions and millions of a given pest, and the males are sterilized using radiation, and then are released into the natural population, at a density that is way higher than the natural population – let's imagine, a hundred to one. So the probability of the female mating with a sterile male is much higher than with a regular male. And in doing this over several generations, you will end up decreasing the population.

Now, that requires an infrastructure, large facilities where you can do the radiation under proper controlled conditions. It has to be a species which is easily reared, which is not always the case with major pests. And so for use particularly in developing countries it will be absolutely necessary that we provide the needed infrastructure to help, and also the capacity building, even on the basis of science. There are a number of stellar examples of where this actually worked, but there are failures, as always, and it will only work under certain conditions. If you have an enormous, enormous population you won't be able to physically rear that many insects, to produce the overabundance of sterile individuals. In species that move over very large distances, you can have a problem, so you need to know that. Another is, do the females mate more than once? And in that case, this is very different from species that only mate once, because if they mate with a sterile male, physiologically females may be able to recognize this, and then re-mate multiple times.

So there is the potential there, we can use it; but again, it is the surveillance and transparency as it relates to the actual utilization, and the education so that people can move forward on this. But it has potential, and given the whole question of food security under the conditions of climate change, this is something that we really do have to work on.

Wolfango Plastino: *How can the main international actors, including international organizations, contribute to addressing the challenges related to nuclear proliferation posed by North Korea, and how can they manage the situation in the context of safeguard activities in Iran?*

Jeremy McNeil: The Director General has very much covered this, and this is really a major question of diplomacy. Along with IAEA, there are many other organizations that are working in the direction of inhibiting, and preferably stopping, nuclear proliferation. I think at the level of organizations like national academies, we need to work together with umbrella organizations, for example both the Accademia Nazionale dei Lincei and the Royal Society of Canada are members of IAP (Interacademy Partnership), we are both members of the Science 7 Group and the Science 20 Group, and it is through collaborations like this that we should be working, developing dialogues, and providing evidence-based information. We need to be building bridges rather than walls. And in this case – through transparency, providing information, talking with the other organizations that have the same goals as us – we will be able to educate and work with those other organizations that can help locally educate the general public. Because the whole question, as all of us have repeated before, comes down to transparency, and providing evidence-based and at-arms-length information, as we move forward to try to limit or eliminate these possibilities.

Giorgio Parisi: I fully agree with Professor McNeil, and I believe that education is a very important issue in this game. Collaboration between academies is very important, and I think that what is crucial, both in the case of North Korea and also with Iran, is to develop scientific ties with these two countries.

One major success story, for example, is the SESAME electron accelerator which is being constructed in Jordan, if I am correct, to which many regional countries are contributing. Among them are certainly Israel and Iran, and I remember that Italy also made some kind of contributions. Of course, this may be more difficult to do with North Korea, but I think that one should perhaps start with scientific collaborations, scientific exchange with people from North Korea, with the rest of the world – maybe on biology if they don't want to collaborate on nuclear facilities – and I think that would also be something that we should do, that we should not suppose that a student coming from North Korea or Iran to Italy to study is a dangerous terrorist.

I think that we should open up to scientific exchange, and academics may play a very important role in facilitating a scientific exchange with these countries, because scientists tend to trust one another. This is the meaning of the title of this series, Science Diplomacy, which Wolfango Plastino suggested. And I think that this starts also with scientific exchange among countries. This is something that should be strongly developed.

With Iran, this is somewhat possible; North Korea, not. But one may start to do something of this kind, maybe start to have exchanges regarding ecology with North Korea, or something else if they don't want to share certain things that may be too sensitive.

Rafael Mariano Grossi: I think there's (of course not surprisingly) a lot of wisdom in what Professor McNeil and President Parisi have just said.

I would retain two ideas from this. First of all, when it comes to non-proliferation, we have to recognize first that this is a reality, that it can happen; secondly, that you can best tackle this kind of thing through a family of efforts, rather than unilaterally applying certain restrictive measures. Limitations are necessary, and there are treaties and conventions, and the safeguards which we carry out work. This has to be, and is, constantly improved, because technology evolves, because the proliferator may be looking for alternative ways to do what they want to do.

There is also the very important point of intangible proliferation, in the sense of the passage of knowledge. And of course, we need, as an international community, cooperation in science, and academies of course are at the heart of this work. So, as I was saying, what we need to do is something that, at the end of the day, and when we are talking from a place of humanity like this, is quite simple to understand, and it's something at which human beings can and should excel: dialogue. Listen to each other. Cooperate. Do it with eyes wide open, but with a good disposition.

And I think that with this kind of approach, the chances that we catch whatever should be caught, but at the same time we allow the flow of knowledge and good will without problems, is possible. It's not impossible, certainly.

Youth in Science Diplomacy

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Introduction

Gianluca Alberini

Over the last few years, youth issues have gained increasing relevance within the main international fora, and the United Nations have been strongly engaged in promoting youth empowerment.

Italy, which firmly believes that investing in youth means investing in the future, has immediately embraced the turn of pace brought about by Secretary-General António Guterres.

Our country supported from the outset the Youth 2030 initiative, which the same Guterres launched in September 2018 with the goal of strengthening UN action in favor of young people, promoting greater integration between the activities carried out by Funds, Programmes, Agencies and departments of the UN Secretariat. This initiative reflects the United Nations' growing attention to young people, in line with the 2030 Agenda for Sustainable Development, which recognized young people for the first time as agents of change and progress. Italy was also the first Member State to provide financial support to the Office of the Secretary General's Envoy on Youth, Jayathma Wickramanayake, after her appointment in 2017. Over the last few years, Italy has constantly endeavoured to empower young people and to enable them to make their voices heard. Starting from 2017, Italy has appointed two Youth Delegates who, through a nation-wide advocacy action as well as participation at meetings here at the UN, are helping promote the active participation of the youngest generations in peacebuilding and reconciliation processes. The Italian Youth Delegates had an active role in the negotiations of the last UN General Assembly resolution "Policies and programmes involving youth", contributing to reaching significant results, in particular by successfully introducing a reference in the text to respect for their reciprocal different cultural backgrounds as a tool for peaceful integration.

In September 2018, we started funding a multi-country initiative in partnership with UNDESA for "Promoting sustainable peace through national youth policies in the Framework of 2030 Agenda". This project is currently under implementation in three countries and includes the constitution of national and local youth-led "Youth, Peace and Security Civil Society Coalitions".

In April 2019, we co-created and financed the SDG 16 – 16x16 Young Leaders Programme, a global initiative launched during the ECOSOC Youth Forum and implemented by UNDP's Youth Global Programme. This initiative aimed to recognize, value and support the positive role that 16 young women and men play as leaders of youth organisations, movements and networks.

In May 2019, our Ministry invited these 16 young leaders to the preparatory conference on SDG16 it organized in Rome, and enabled them to meaningfully engage in the discussions.

As the Chair of the G20 in 2021, last July we hosted the Y20 Summit in Milan, which enabled young people to entrust the G20 leaders with their recommendations on the matters they value the most, such as sustainability, climate change, innovation, digitization and inclusion. Beginning tomorrow, as co-Chair of the COP26, Italy will host the 3-days event "YOUTH4Climate: Driving Ambition". Around 400 young people from 197 countries that have ratified the United Nations Convention on Climate Change will take part in the event and will have the opportunity to elaborate and present concrete proposals for the Pre-COP26 in Milan and the COP26 in Glasgow.

Italy is especially committed to the implementation of the Youth, Peace and Security Agenda. During our mandate on the United Nations Security Council, in 2017, we promoted the systematic inclusion of provisions on the protection of civilians, especially the most vulnerable categories, including youth, in the mandates of peacekeeping operations. More recently, last year we duly co-sponsored Security Council Resolution 2535, which encouraged member states to ensure the full, effective and meaningful participation of youth in peace processes, recognizing that their marginalization is detrimental to building sustainable peace.

Italy firmly believes that young people are a vital driver for peace, change, and prosperity. Their specific sensitiveness and forward-looking approach, their desire for justice and inclusion, as well as their capacities, idealism, enthusiasm and energy, can meaningfully contribute to promoting awareness about the importance of human rights and fundamental freedoms, building and sustaining peace, providing long-term sustainable solutions and fostering conflict prevention and reconciliation.

Young people contribute to peace processes in multiple ways, from monitoring ceasefires to resolving local-level disputes, building relationships across social divisions and shaping peace agreements. However, in spite of a growing awareness of young people's role for peace and security, young people continue to be excluded from decisions that will directly impact their present and future

prospects for peace. Young people continue facing significant structural barriers to participation in decision-making, and many young peacebuilders report that their participation is not welcomed by the public or by those in positions of power, pointing to an overall disregard for their work.

Nevertheless, it is essential to ensure that young people have a say in peace discussions, as they account for many of those adversely affected by armed conflict. Actually, we must not forget that over two billion of the world population are under 24, 90% of whom live in developing and vulnerable countries, and one in four young people are affected by violence or armed conflict.

Italy has been very active in creating spaces for the participation of young people in discussions and in creating a dialogue with policy-makers, other than in raising awareness on the value that youth can bring to peace processes. In December 2019, we invited several representatives of youth organizations to the High-Level Seminar on "Strengthening Women's Participation in Peace Processes: What Roles and Responsibilities for Member States?", which we organized in Rome in collaboration with UN Women. Furthermore, within the implementation of our Third National Plan on Women Peace and Security, we funded the "2020 Torino Forum for Sustaining Peace: Women and Girls at the Frontlines of Peace". This event, which has been organized by the United Nations System Staff College (UNSSC), focused on the meaningful participation of women and girls in conflict prevention.

Let me conclude by reaffirming that Italy will continue to spare no effort in promoting youth empowerment, as investing in youth is the wisest way to build a more sustainable future.

Lectio Magistralis

Henrietta Holsman Fore

The climate crisis is a child and young person's rights crisis. It poses an unprecedented threat to the health, education, development, and survival of all young children and adolescents. Urgent action is needed.

Just this summer, we saw evidence of the devastating environmental impacts linked to the climate crisis. Wildfires so vast in Canada and the western United States that the air quality all the way across the continent in New York was the worst it had been in fifteen years. Historic flooding in Germany that devastated entire towns and killed hundreds. Landslides in India. Heatwaves in North Africa.

We see the climate crisis, the nature and biodiversity loss crisis, and the pollution and waste crisis all around us.

The devastation wrought by climate change does not discriminate or stay within borders. It is disrupting lives and livelihoods regardless of income, race, or region. Yet it is the poorest and most vulnerable people who suffer the most. And those least responsible for the climate crisis are bearing its greatest impacts. There is an inherent injustice in this.

Sadly, we are extending this injustice to the next generation – all of whom were born into a world aware of the consequences of inaction, yet unable to agree on measures to stop it.

We still have time to act, but we must do so urgently. According to the latest research from the Intergovernmental Panel on Climate Change, the world has less than nine years to make the transformation necessary to avoid the worst impacts of climate change.

No one suffers more from a changing climate than a child. Children are more susceptible to deadly diseases, which are on the rise due to climate change. Nearly 90% of the global burden of disease associated with climate change is borne by children under five.

Disasters and environmental stress also increase children's likelihood of living in poverty, being displaced from their homes, and suffering from toxic stress. Flood and drought zones often overlap with areas of high poverty and little access to essential services

such as safe water and sanitation. This means that children and families with the fewest resources face some of the most immediate dangers of climate change.

Water scarcity threatens every aspect of a child's life including their survival and future. The climate crisis is limiting children's access to safe water and is contributing to increasing water scarcity. Currently 1.4 billion people, including 450 million children, live in areas of high or extremely high water vulnerability.

Extreme weather events and changes in water recharge patterns are making it more difficult to access safe drinking water, especially for the most vulnerable children. Around 74% of natural disasters between 2001 and 2018 were water-related, including droughts and floods. With climate change, their frequency and intensity are expected to increase.

To avert the worst impacts of the climate crisis, comprehensive and urgent action is required to reduce greenhouse gas emissions. We need to reduce emissions by at least 45% compared to 2010 levels by 2030. And total emissions must be cut to as close to zero as possible by 2050 to avoid the worst impacts of global warming.

At the same time, more investment is urgently needed to protect children by adapting critical services to the changing climate. Out of an average of 410 billion US dollars in climate finance per year, only 22 billion US dollars goes to adaptation while 382 billion US dollars goes to mitigation. We must invest heavily in making essential services like water and sanitation, health, nutrition, education and social protection resilient to climate shocks. We need to look at preventing damage to critical basic services.

The young people who have joined us today can tell you this. They have experienced the impacts of climate change firsthand. They are living in and inheriting an increasingly unrecognizable world. And they are pleading with us to do something about it.

Young people are demanding action. A recent analysis of feedback received by UNICEF in 21 countries with more than 270,000 responses from young people showed that 92% of respondents have heard about climate change. When asked if climate change is caused by human activity, 88% said yes, and 78% of young people said that they were worried about climate change.

All over the world, young people are not just demanding action – they are acting themselves. Standing up for their futures. Inspiring and enlisting others in their cause. Leading by example and showing that change is possible. Starting community projects, being volunteers, and dreaming of and fashioning solutions. They are coming up with ideas and innovations that make a difference,

and they are putting into practice actions that reduce CO2 emissions in their own lives and communities.

At UNICEF, it is our responsibility to make sure these voices and solutions are heard.

Children and young people must be included in all climate-related decision-making. They are consistently overlooked in climate and water policies. This undermines their right to be heard and participate, and for their best interests to be a primary consideration in decision-making and actions that concern them.

That is why UNICEF has been collaborating with Fridays For Future to amplify the voices of children and young people on the frontlines of the climate crisis. On August 20th, following an amazing panel with Greta Thunberg and other youth climate activists, we launched the Children's Climate Risk Index. It was the third anniversary of the youth-led climate protests that have grown into a global movement.

The Risk Index and its report are the result of over a year of work by dedicated colleagues at UNICEF and our partners and represents a compilation of evidence that we have generated over the last few years. Its stark findings validate the message we have been hearing from young people: We are in a crisis of crises. A pollution crisis. A climate crisis. A child rights crisis.

According to the report, almost every child on Earth is exposed to at least one climate and environmental hazard, shock or stress. Almost every single young life will have to cope with heatwaves, cyclones, air pollution, flooding or water scarcity. A startling 850 million – approximately one-third of all children – are exposed to four or more of these stresses, creating incredibly challenging environments for children to live, play and thrive.

Globally, about 1 billion children – nearly half of the world's children – live in countries that are at an "extremely high-risk" from the impacts of climate change. These children face a deadly combination of exposure to multiple shocks with high vulnerability resulting from a lack of essential services.

The survival of these children is at imminent threat from the impacts of climate change.

Until now, no climate index has focused solely on child climate risk in a global context. This groundbreaking report provides the first comprehensive view of children's exposure and vulnerability, because understanding where and how children are uniquely vulnerable to this crisis is crucial in responding to it.

Without ambitious, comprehensive, urgent action on climate change, children will suffer now, and in the decades to come.

But addressing the climate crisis requires every part of society to act. There are a range of solutions in front of us.

By improving children's access to essential services, we can significantly increase their ability to survive these climate hazards.

Protecting children now and in the future requires climate adaptation. Governments must increase their adaptation investment to 100 billion US dollars a year, prioritizing water and sanitation, health, education, social protection and disaster risk reduction.

Water scarcity is a major – but overlooked – threat that will continue to get worse in many countries. Governments must prioritize water and sanitation systems in adaptation plans, ensure existing water and sanitation systems are climate resilient and prioritize the most vulnerable communities and countries to protect life.

For children to survive and thrive, every child must have access to the facts about climate change, and the skills to respond and prepare for its impacts. Every child must have access to education on climate change, resilience and adaptation, as well as an education and training in green skills. One exciting example of green skills development is the new partnership between Generation Unlimited and the IKEA Foundation on the Green Entrepreneurship Initiative. The initiative aims to support young entrepreneurs as they turn environmental challenges into green growth and business opportunities that benefit families and protect the planet for future generations.

Young people must also be given a full part in all national, regional and international climate negotiations and decisions, including COP26.

The Covid-19 recovery must respond to the climate crisis to deliver a just, healthy and sustainable future for children and future generations.

UNICEF urges governments and businesses to listen to children and prioritise actions that protect them from impacts, while accelerating work to dramatically reduce greenhouse gas emissions.

Governments must also ensure environmental policies are child-sensitive. Schools need to be educating for green skills in both the first and second decade of children's lives. These are skills necessary to help children manage climate risks, as well as those that are relevant for the future of work, including in the growing green economy.

So, in closing, to the world's children, we need your voices. We need your actions. And we need your influence as world leaders make the decisions and investments that will affect the future that you will inherit.

Children and young people need to be recognized and listened to as the rightful family and heirs of this planet we share. Theirs is the most important perspective in this crisis.

Discussion*

Henrietta Holsman Fore, Hans Petter Graver, Giorgio Parisi, and Wolfango Plastino

Wolfango Plastino: *How can we direct economic development to not only promote environmental sustainability, but also to promote young people's rights during an era of climate catastrophe?*

Hans Petter Graver: I think that you ask a most crucial question, and I would like to say that we may have the technology and knowledge on the natural science side – at least to define the problem and to describe the problem – and we have many of the technologies necessary to solve the problem, but I think where we are lacking in knowledge is on the social science and humanities part. That is: how do we actually go about reforming the economic system in a way that is more sustainable, and how do we reform our institutions so that we can combine the capacity to take the necessary decisions, both on a national and an international level, with democratic influence? I think that's a very pressing question. And also, thirdly, how do we ensure that the necessary changes that are implemented are both just and fair, in the way that responsibilities are allocated in a fair way; and also, given the costs and the negative impacts that will certainly affect (at the very least) the way that people are used to living their lives, how can we ensure that all this is also allocated in a fair way? We know that the disadvantages are – as Ms. Fore so eloquently described – shouldered by those that have not actually contributed to or benefited from the way of life that we have lived, which has led to these problems.

So these are profound and pressing questions, and I think that we need both a huge amount of research into these fields, into social science and economy and the humanities side. We need research, we need a concentrated effort at the international level to be able to cope with these issues. The alternative, of course, is

* The text below is the full transcript of the Round Table that followed the *Lectio Magistralis* by H.E. Henrietta Holsman Fore, Executive Director of the United Nations Children's Fund.

that solutions will force themselves on society, but in a way that society won't be able to cope with, and that may lead to a breakdown of our democratic institutions. So these are important questions.

Giorgio Parisi: I appreciate, Wolfango, that in your question you used the words "economic development", and not the words "economic growth". As was noted long ago also by Robert Kennedy, among many other people, the gross national product is not a good measure of the economy. It captures the quantity of economics but it does not capture the quality of growth. Many different indices have been proposed, among them the Human Development Index and the Index of Sustainable Economic Welfare. If the gross national product remains the centre of political and media attention, our future is grim.

When politicians, journalists, and economists plan our future and monitor the progress that has been made, they should use an index that also considers human rights, along with young people's rights. It is not easy to quantify these, but it has to be done. Otherwise, we have in front of us, on the one hand, the thought that we have to defend human rights, that we have to defend young people's rights, that we have to defend our future and so on; and, on the other hand, we have the other representation that says that the gross national product has increased 2.5%, and the situation is perfect. We should have a different way of measuring what we are doing, not only in conferences and discussions, but in everyday life, from newspapers to the political arena.

Also, we have to realize an important point, in a concrete way: that people of different ages have different interests. This is particularly important in countries that are very near to being gerontocracies, like maybe in some ways Italy.

Henrietta Holsman Fore: I think President Graver's point about democracy, and President Parisi's comment about growth are pulled together by two things that the Y20 had asked us for. So Y20 said, number one, we want to be involved in the G20 negotiations, and that's the democracy point. And then they said, we want more investment, and that's the growth point. But our world is often segmented between humanitarian assistance versus development assistance, and as a result, we don't think long-term enough when we are addressing a crisis – let's say it's a cyclone that's coming through Mozambique. We often don't plant the seeds of economic development at that moment, and thus the growth that President Parisi talks about does not take place, because we're just addressing one problem at a time.

So one issue for our world is to try to weave together humanitarian and development response to the world's problems and challenges. And young people would like to help with this. So the second one that I would suggest is, as we've seen with Covid-19, how important public private partnerships are. We could not have addressed Covid-19 with vaccines without private businesses and their research and development. The more that our academic research and our commercial business research blend together and find good long-term solutions to many of our problems, the more will aid economic development. Those are my suggestions.

Wolfango Plastino: *How can it be ensured that young girls are empowered to make a contribution to this sector?*

Henrietta Holsman Fore: I of course love the idea of girls getting an education, and it's something that we believe in so strongly. I have had the benefit of an education, so I know how much it means. We really have to involve the girls.

At the United Nations, as you know, there is a step-up pledge. This means that if you can "step up" to really connect with the rights of young people, this entails the right to an education for girls. We do not get this in every part of the world. But we have to make it seem something that girls can do, so that they have the confidence to do it, that they see other women who are doing it, so that they say, "I can study in the sciences and the maths and technology. This is going to be a brave new world, an exciting one, and I want to be a part of it." Part of it is just inspiring them, so they are curious and interested; and I know that both presidents today would agree with that.

But we're behind as a world. Women and girls do not use digital technology enough. We have half of the world which is not connected. I think of the digital-based education – what we're thinking of the ed-tech revolution; we're at the beginning of it in our world, and if by 2030 we can connect every school in the world, every teacher, every learner, I think it means that girls will get a chance.

Hans Petter Graver: I agree that education and role models are crucial. I think that when it comes to education, of course the challenges are different in different parts of the world. In some parts of the world, access to education as such is the main problem. In other parts of the world – in my part of the world, or in our part of the world – I think the challenge is to inspire young girls

to a greater extent to enter the natural sciences, education, science and technology, maths, physics and so on; because that's where girls are under-represented. And of course, those are important subjects when developing just solutions for the problem.

I also think that access to institutions is important, access to public ministries and agencies, to educational institutions, and ensuring that women are inspired to choose such careers, and to be given positions in them. And also of course, fairness in the relationship between the genders – that is also very important.

These are of course general issues when it comes to equality between men and women, and they are also of great importance in this field.

Giorgio Parisi: I definitely agree with both of you. I believe that the employment of young girls is very important for our future. It has been recognized by OECD that different socio-cultural constructions of the role of men and women can result in different vulnerabilities and different impacts of the environment on the two sexes. Women may have a more long-term vision than men, as an effect of their maternal role.

How to empower women? The first point will be to construct a real equality between the different genders, starting from school, and aiming to reach equality in power and influence in our society. We've just seen that in Iceland, women have gained a slight majority in the parliament, and this is the first time this has happened in a democracy. Unfortunately, most countries are far from this goal. Schools are crucial, because they give children the tools to understand the future and to construct their roles in society. Empowerment without understanding is meaningless. Giving different access to education for children depending on their sex should considered a high crime, or at least an act of discrimination that has life-long consequences.

Wolfango Plastino: *What do you see as the global gaps in climate change response, especially as regards children?*

Giorgio Parisi: One very important point is that knowledge is power. Children must be able to understand the general situation, and to form their own ideas. And education in school is crucial. We must give children a scientific education starting from kindergarten. Like all of us, children must lean on what others have discovered. They must learn to stand on the shoulders of giants. But that said, they must first learn the scientific method, to be able to

make deductions from their own experience. It was stressed long ago by the great Italian educator Maria Montessori that education is a natural process carried out by human individuals, and you acquire education, not by listening to others, but by having your own experience. The task of teachers becomes, in this vision, that of preparing serious motivations, and refraining from obtrusive interference.

Human teachers can only help the work that is done by the children. If people are going to unfold their human selves in such a way that they are able to have a particular vision, they will not be the victims of events, but they will have the planetary vision to direct and shape the future of humanity. This vision of education is particularly important if you are looking to empower children to listen to their, not to our, viewpoints.

Henrietta Holsman Fore: I certainly agree that knowledge is power, and the consistent suggestion from all of us who advise and guide children and young people needs to be that getting deep into a subject, to really understand the subject, is important. And I think that is part of the problem of climate change, because there is often a division between children that are following the letters and children that are following science, and as a result those who are advocating might not have as much depth in the subject matter.

So it's important to look at the educational systems to make sure that children and young people are getting an education in climate in all of its aspects, as President Graver mentioned. It's the number one issue. Then, from the the perspective of the United Nations, one of the things that we ask for is something called a "Nationally Determined Contribution", what we affectionately call NDCs. And in them, we see how a nation views its priorities. And right now, only 20% of these NDCs mention children and young people. So if we don't get governments to think of the world through their youngest citizens' eyes, and what they need as an investment, then we won't get the education systems, their involvement and engagement in science and in the solutions that we see on climate change, to the extent that they need to be. I'm hoping for that from a member-state perspective.

Hans Petter Graver: Yes, of course, it all comes back to knowledge and education, which we have been circling around, and which is of profound importance.

But when we talk about gaps, I think that the greatest gap is between knowledge and action – putting the knowledge that we

have into effective action to solve the problems. And I think that where we are really lacking on a global scale, and on a national scale, is in developing and implementing effective actions to solve the problems. We have some plans, of course; we have some international agreements, we have regional arrangements and we have policies at the national level. But they're not in any way sufficient. And they're not effectively implemented in the way that is necessary to solve the climate crisis, and also the crisis of biodiversity, I would say, which is of an equally profound importance.

I think one of the basic reasons for this – and this also applies particularly to children and to the coming generations – is that our democratic institutions are highly advanced when it comes to democratic influence by citizens on the decisions taken by national assemblies and governments; but when it comes to climate change and biodiversity, the effects of the policies are much wider than the electorate. So those who are mostly affected are not represented in our democratic decision-making processes. They're future generations, and very often also people who live in other parts of the world, since the consequences of policies that are pursued, particularly in the developed world, affect people in other countries. And of course people in other countries and children don't vote.

This leads to a mismatch between the interests and the incentives for our politicians and decision-makers, because the ones who are really affected are not the ones that they have to take into account when they're up for new elections. So I think that this is one reason for the gap, and then there's also the gap in our institutional build-up. And we need then to empower the young and children, not necessarily by lowering the voting age – that's not what I'm advocating for – but in some way, as Ms. Fore is also talking about, by including children and young people in the decision-making, in a way that is also important to decision-makers.

Wolfango Plastino: *What do you see as the role for young people and how are you, UNICEF and Academies, championing their efforts, particularly to build green skills?*

Hans Petter Graver: We, as an academy, are quite a small institution in Norway. We don't have our own research institutions, as academies in many countries do. What we did a few years ago was to initiate the forming of a Young Academy. So we have a Young Academy, which is developing also in many countries, and now there is developing also a network of young academies around the world. And I think this is one important step, because, by

their structure, academies are often institutions where the average age is quite high, because the qualification needed to become a member of the academy means that people normally don't qualify before they're beyond the peak of their life, so to speak. So it's important then to encourage and to cooperate with young, excellent researchers in the young academies.

I think that's one important contribution. And then of course in the outreach that we do and in our cooperation with the academic institutions and the political institutions. But I'm afraid most of our work in that field is directed toward the established institutions; so not that much toward the young as such, I'm afraid, on our side.

Giorgio Parisi: The Accademia Nazionale dei Lincei is looking for a better scientific understanding of climate change. Especially as Professor Antonelli has already stressed, these months we have organized an international conference of current issues on climate change; its proceedings are already available.

The most important action in this respect happens through our foundation, the *Lincei per la scuola*, the "Lincei for Schooling", which is devoted to training teachers on many issues, including climate change.

Recently, we have started a new project in this direction. In the last two years, we have realized a course aimed at teachers, but also at high-school students, entitled the "Lincei for Climate". Over four days, each comprising four half-hour talks, followed by real-time discussions, about a dozen students from Italian schools were connected via live streaming, and were involved in this way, asking many questions at the end of the talks, in addition to a small number of students and teachers, who were physically present. The lessons were recorded and broadcast periodically by state television channels, and we also record these lessons, making them available two days after the discussion on the Lincei website. In response to the questions that were posed in the meetings, we received answers in writing, which are also available on the Lincei website. Finally, in this action we are providing an award to the school which submits the best paper, and it will consist in a small sum of money as well as a prize trip for a small group of students to come to a discussion event.

These events, as I have said, have been organized by the Lincei for Schooling, with financial support that was offered by the Foundation Compagnia di San Paolo of Turin. In a nutshell, we are trying to act both in an indirect way on teachers, by training teachers – which is very important because this gives us very big leverage

– and also directly on students, both in person and connected remotely. We are reflecting on whether we can somehow extend these kinds of actions in the future.

Henrietta Holsman Fore: Given the interesting comments from both President Graver and President Parisi, two thoughts come to mind. UNICEF has a platform called U-Report; we have millions of children in a number of countries who respond to questions or could do research or could do observations of nature. So let us assume that all of us feel that in climate change, we want climate change addressed, we want nature and biodiversity loss addressed, and we want waste and the recycling economy addressed. And young people would love to be part of that research. So may I just say that it's a platform that's available; if either of you could possibly use it, and ask them to measure or to observe something, I think they would love to do it.

And then the second thought is this. President Parisi, you mentioned your groups of young people; we have a number of countries now in the climate risk index, where we know what the risks are, and we are trying to focus on prevention and on resilience. Perhaps some of those young people could come help us talk about what the solutions might be in those countries. It will be, to President Graver's earlier point, a very different environment than what they are seeing in Italy, but it will teach them both something about the world. So may I just put those two out there as possibilities that we can engage on after this discussion.

And then I would just point out that UNICEF has a number of programmes in countries that I think could be useful models for others: in Bangladesh, a children's climate declaration, which raises visibility within the country; in India, a world children's day, and thus you get to talk about everything that's on your mind; in China, they've been developing new modules to put into classes about environmental education; in Zimbabwe, there are now programmes for innovation and entrepreneurs in waste management, sustainable energy, sustainable agriculture, everything you could wish. We're looking at water services, and how water can affect these, since UNICEF works often in water; so if anyone would like to pair with us, and work with water, we're open globally for that.

Dialogue in a Changing World

Ettore Francesco Sequi
Christine Lagarde
Patrick Flandrin
Alberto Quadrio Curzio
and Wolfango Plastino

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Introduction

Ettore Francesco Sequi

In November 2014, Christian Noyer, then Governor of the Banque de France, welcomed participants to the International Symposium of France's Central Bank acknowledging that "Central Banks have been considered the only game in town" and wondering whether "the very high expectations placed on them might backfire in the future".

The participants had no way of knowing that, five years after, a global pandemic would shake the world's economy once again.

Are Central Banks still "the only game in town"? In the European Union, not anymore, I would say.

The rebound we are experiencing in Europe is the result of an unprecedented and coordinated policy response that we have been adopting together, combining fiscal and monetary policies.

The activation of the general escape clause of the Stability and Growth Pact, the settlement on the State Aid Temporary Framework, the set-up of emergency instruments such as SURE (Support to mitigate Unemployment Risks in an Emergency), and the historic agreement on the Recovery and Resilience Facility, happened quickly.

We thank the ECB (European Central Bank), and the Eurosystem of Central Banks, for engaging in a broad set of monetary policy instruments, which supported the transmission of fiscal policy impulses. The mutually reinforcing effects of fiscal and monetary policies have been crucial for alleviating the impact of the crisis. Now they are supporting the recovery.

So, may we say: "Mission accomplished"? No. A series of downside risks and of legacy challenges is looming over our future.

Global value chain bottlenecks, surging energy and fuel bills, and strategic dependencies are affecting relative prices and competitiveness.

Some internal imbalances have increased. The correction of large and persistent current account surpluses has stalled.

Additional investment requirements in the green and digital transitions are set to soar to nearly 650 billion euros per year until 2030, according to the European Commission.

We are trying to shoot a moving target, and the financial effort is getting bigger, as our ambition is on the rise.

The international community cannot afford anymore to seek just a rebound towards pre-pandemic growth paths.

We need to lay the foundations for a new and more resilient economic paradigm, which is digital, sustainable and inclusive. This is one of the key messages from the G20 under the Italian presidency and the COP26 in Glasgow.

We are living in an era of change, or perhaps a change of era, as I like to say. Changes are necessary. Technology and innovation will be their drivers. We all want the European Union to live up to these epochal challenges and the expectations of its citizens.

The recovery has now taken hold, but we need to turn it into sustainable, inclusive long-term growth. To do so, we must embed the lessons learned from the successful EU policy response to the crisis into the EU economic governance framework.

80 years after the Ventotene Manifesto, let's finish what we started.

Lectio Magistralis

Christine Lagarde

The task of separating truth from falsehood has plagued policy-making for centuries. During the Roman civil war following the death of Julius Caesar, Octavian famously prevailed over Mark Antony by spreading "fake news" about his fitness for office. He did so via slogans forged on specially commissioned coins – an early version of a tweet.[1]

Today, this task of distilling the truth is more urgent than ever.

We have seen during the pandemic how quickly misinformation can spread – be it about possible treatments, such as drinking chlorine, or about the safety of vaccines. Indeed, falsehoods on Twitter are found to spread about 10 to 20 times faster than facts.[2]

At the same time, the nature of the challenges we face are increasingly global, complex and fast-moving. This means that establishing the facts and understanding how they are interconnected is a precondition for charting a course through a shifting, uncertain world. In this context, good policy-making has to rest on two foundations.

First, policymakers have to be committed to searching for the truth, as best they can, through robust analysis and evidence-based policy-making. And because we can never have perfect knowledge, they must be prepared to adjust their views as the facts change.

Second, they need to explain their analysis to the public in a way that reduces complexity and unites people around the case for action. We will not solve the challenges of today, in a world of "fake news", unless we can bring the public on board.

In my remarks this evening, I would like to explain why today's challenges are different, why they can only be addressed by integrating

[1] I. Kaminska, "A Lesson in Fake News from the Info-Wars of Ancient Rome", *Financial Times*, 17 January 2017, https://www.ft.com/content/aaf2bb08-dca2-11e6-86ac-f253db7791c6.

[2] P. Dizikes, "Study: On Twitter, False News Travels Faster than True Stories", *MIT News*, March 2018, https://news.mit.edu/2018/study-twitter-false-news-travels-faster-true-stories-0308.

scientific analysis deeply into policy-making, and why the public has to be mobilized in a new way to bring about change.

Ultimately, we need to be guided by Leonardo da Vinci words: "learn how to see [and] realise that everything connects to everything else."

The nature of today's global challenges

So what is it that makes the challenges we face now so difficult?

Many of today's challenges are not new. Environmental threats such as smog and acid rain plagued the developed world in the 19th and 20th centuries. Pandemics have ravaged many parts of the world. And global economic crises have been a feature of the world economy for as long as globalization has existed.

But what makes the contemporary challenges unique is their sheer scale – and their potential to change the world profoundly. The challenges have intensified in at least three ways: their scope, their complexity and their potential to amplify.

First, the scope of today's challenges is genuinely global. A century ago, the Spanish flu spread like wildfire across the globe, infecting around a third of the world's population at the time.[3] But even in the highly globalized world that existed at that time, there were parts of the world the disease did not reach.

Covid-19, on the other hand, has been the first truly global pandemic. In less than six months, no region of the world was left untouched (save for a few Pacific islands) and virtually no aspect of our lives was unaffected. Unprecedented containment measures, in turn, triggered one of the most severe economic slumps since the Second World War.[4]

Second, global challenges are now highly complex and require unprecedented levels of multilateral coordination. For example, when countries set out to close the hole in the ozone layer in the mid-1980s, the solution essentially required only a handful of the largest chemical companies to stop producing CFCs (Chlorofluo-

[3] R.J. Barro, J.F. Ursúa, J. Weng, "The Coronavirus and the Great Influenza Pandemic: Lessons from the 'Spanish Flu' for the Coronavirus's Potential Effects on Mortality and Economic Activity", *NBER Working Paper Series*, 2020, No 26866, National Bureau of Economic Research, https://www.nber.org/system/files/working_papers/w26866/w26866.pdf.

[4] IMF (International Monetary Fund), "World Economic Outlook: Recovery during a Pandemic. Health Concerns, Supply Disruptions, Price Pressures", Washington, D.C., 2021, https://www.imf.org/en/Publications/WEO/Issues/2021/10/12/world-economic-outlook-october-2021.

rocarbons) and find alternatives. This in turn laid the ground for major economies to agree to the Montreal Protocol in 1987.

But addressing climate change is orders of magnitude more difficult. Not only do we have to contend with the multiple faces of climate change – more extreme weather patterns, rising sea levels, loss of ecosystems and biodiversity – but regions are also affected in different ways and at different speeds.[5] This makes devising timely and appropriate mitigation measures across countries exceptionally complex.

Third, global shocks tend to amplify in the face of a more integrated global economy. The OECD (Organization for Economic Cooperation ans Development) estimates that, in advanced economies, the contribution of global factors to changes in GDP growth has risen from around 35% in the 1980s to almost 70% today.[6]

The internet also amplifies the spread of misinformation, which in certain situations can make global shocks worse. For instance, research suggests that in the first three months of 2020, nearly 6,000 people worldwide were hospitalized because of coronavirus misinformation.[7] At a minimum, the spread of "fake news" leads to greater cynicism among the public about who is telling the truth and what sources to trust.

The upshot is that we are operating in a world of much higher uncertainty – about the nature of the shocks we are facing, how they will propagate, and what the public will believe about them. And policy-makers have to change the way they approach problems and the way they communicate to adapt to this world.

Integrating science into policy

First of all, when faced with rising uncertainty, policy-makers have an even greater responsibility to commit themselves to a rigorous search for the truth.

[5] IPCC (Intergovernmental Panel on Climate Change), "Climate Change Widespread, Rapid, and Intensifying", press release, 9 August 2021, https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/.

[6] OECD (Organization for Economic Co-operation and Development) (2018), *OECD Economic Outlook 2018*, Issue 1, OECD Publishing, Paris, 2018, https://www.oecd-ilibrary.org/sites/eco_outlook-v2018-1-3-en/index.html? itemId=/content/component/eco_outlook-v2018-1-3-en.

[7] WHO (World Health Organization), "Fighting Misinformation in the Time of COVID-19, One Click at a Time", 27 April, 2021, https://www.who.int/news-room/feature-stories/detail/fighting-misinformation-in-the-time-of-covid-19-one-click-at-a-time.

To that end, their analysis has to be grounded in deep analysis, expert knowledge and the scientific method – which means constantly testing hypotheses and adjusting decisions in the light of new evidence. The public would be ill-served if policy-makers mirrored what they believed to be the public mood and based their decisions purely on instinct rather than on objective reason.

We have had a striking demonstration of the need to integrate scientific analysis into policy-making during the pandemic. This has been a fast-moving crisis that could not be addressed through hunches or preconceived notions. The only way to fight it has been to act on the basis of the emerging evidence.

It is now clear that governments which chose to draw on the evolving science to inform the trade-offs lying before them have performed better – in terms of both protecting lives and shielding the economy – than those that did not.[8] And this has produced a virtuous circle of increasing demand for policy-relevant research. In the first half of 2020, publications on Covid-19 doubled every 20 days.[9]

Yet the search for truth does not only apply to governments. In fact, for independent institutions such as central banks, the responsibility is even greater. We are entrusted with narrow mandates precisely to ensure that our decisions are based on facts rather than political influences. We therefore face an even stronger burden of proof to show that our decisions are guided by the weight of evidence alone.

This is a key reason why we invest so heavily in research and analysis. The ECB is ranked first among central banks worldwide for the quality of its research, it is ranked first in the field of monetary economics, and 15 of its economists are among the top 10% of authors globally.[10] That knowledge base – which involves constantly studying the effects of our own policies – gives us the foundation to act in the face of new challenges.

[8] A. Deaton, "COVID-19 and Global Income Inequality", *NBER Working Paper Series*, 2021, No 28392, January, National Bureau of Economic Research, https://www.nber.org/papers/w28392.

[9] J. Brainard, "Scientists are Drowning in COVID-19 Papers. Can New Tools Keep them Afloat?", *Science*, 13 May 2020, https://www.science.org/content/article/scientists-are-drowning-covid-19-papers-can-new-tools-keep-them-afloat.

[10] ECB (European Central Bank), "Introducing Directorate General Research 2019-2020", 2020, https://www.ecb.europa.eu/pub/economic-research/programmes/shared/pdf/Introducting_DG_Research.pdf.

The benefits of that foundation were clearly visible in our own response to the pandemic. The shock to the economy was unprecedented, but we were able to draw on our past experience of financial disturbances in the euro area, on our analyses of how self-fulfilling destabilizing dynamics could emerge, and on our research into the effects of our previous asset purchase programmes, to deliver a rapid and effective response.

Indeed, our pandemic emergency purchase programme and long-term lending operations were able to rapidly remove tail risks in financial markets and avert a liquidity and credit crunch. Coupled with the actions of our banking supervision arm, our researchers estimate that these measures saved more than one million jobs.[11]

Overall, the exceptional level of evidence-based policy-making in our societies during the pandemic has taken place because we have faced an existential threat, leading to the type of relentless focus on results that we usually only see in times of war.

It is simply remarkable that, within weeks, the genome of the coronavirus had been sequenced. Within a few months, tests for infection had been made available. And within a year, highly effective vaccines had been developed.

Having seen the incredible progress we can make when science and policy are united behind a common goal, in my view we should not now slide back into the pre-pandemic status quo. We must strive to continue this joined-up approach if we are to tackle the challenges we face today – and this applies perhaps most of all to climate change.

It is not by chance that the international architecture set up to tackle climate change has placed the science-policy nexus firmly at its core. Over the years, the Intergovernmental Panel on Climate Change has acted as an anchor for the understanding of climate science, helping ground policy agreements in knowledge and evidence.[12]

Without this institutional anchoring, we would now be facing even more dangerous and irreversible levels of climate change. Absent global measures, the world would be at or over the 1.5°C warming threshold and heading towards a projected 4.4°C. That

[11] C. Altavilla, F. Barbiero, M. Boucinha, L. Burlon, "The Great Lockdown: Pandemic Response Policies and Bank Lending Conditions", *Working Paper Series*, 2020, No 2465, September, ECB, Frankfurt am Main, https://www.ecb.europa. eu/pub/pdf/scpwps/ecb.wp2465~c0502b9e88.en.pdf.

[12] UN (United Nations), "Report on the Structured Expert Dialogue on the 2013-2015 Review", 4 May 2015, https://unfccc.int/resource/docs/2015/sb/eng/inf01.pdf.

would translate into a 30% loss of global GDP by the end of this century.[13]

But clearly the work is not yet done. The drawn-out negotiations at the COP26 summit illustrate the difficulties in reaching global political consensus, despite solid scientific evidence and the buy-in of large parts of the private sector. And an important reason for this is that, to achieve sustained progress, the public must be brought on board as well.

Engaging the public

Indeed, the job of policy-makers is not only to make decisions based on the best assessment of available evidence, but also to explain that assessment in a way that reduces complexity and underpins the case for action.

Today, faced with challenges that require far-reaching and unprecedented changes in all segments of society, the premium on effective communication has never been higher. To bring about change with the necessary speed and in line with democratic principles, we need a critical mass of people who are willing to overhaul many aspects of their daily lives.

Yet the barriers we face are high. In a world where "fake news" can spread rapidly and people no longer know which sources they can trust, it is increasingly hard to centre public opinion around a broadly agreed course of action. However, it is not impossible.

The pandemic has proven that societies can be mobilized by scientific evidence to make profound changes, if that evidence is communicated in an effective way. People have accepted sweeping restrictions on their usual freedoms in order to contribute to the common goal of saving lives and preventing an uncontrolled spread of the disease.

So what are the elements that can help bring the public on board? To my mind, there are three: simplicity, framing and empathy.

Starting with simplicity, we should not underestimate the ability of the public to evaluate and absorb factual evidence – but it has to be presented in an accessible way.[14]

[13] E. Williams, D. Steven, N. Mabey et al., "The Value of Climate Cooperation", Climate Analytics, 21 September 2021, https://climateanalytics.org/media/the-value-of-climate-cooperation.pdf.

[14] A. Burni, F. Domgörgen, "The Verbal Fight against COVID-19. Why Female Leaders Stand out on their Political Communication during the Pandemic",

We have seen this in the area of climate. In an experiment where US citizens who knew little about the scientific consensus on climate change were shown a simple pie chart illustrating the overwhelming consensus in favour of its man-made origins, their estimates of the climate consensus increased by nearly 20% – and that was with just one exposure.[15]

We know that simplicity works for monetary policy communication, too. Research finds that providing households with simple statistics about inflation, such as the central bank's inflation target or forecast, has large and immediate effects on their inflation expectations. Providing more detailed statements and arguments, however, has no additional effect.[16]

This is an important reason why one of the cornerstones of our strategy review was to make our inflation target clearer. Our new, symmetric 2% target is clear-cut and unambiguous.

But the challenge is not only to present the facts simply. It is also incumbent on policymakers to find ways of framing those facts so they resonate broadly with the values of the people they are speaking to. This is the second element.

It is well-known, for example, that framing climate change as a difficult trade-off between environmental benefits and economic costs tends to reduce support for mitigation measures, even for those who generally support action.[17] However, messages linked to healthier and more sustainable lifestyles – cleaner air, less waste – tend to meet with a positive response across a broad cross-section of the public.[18]

The Current Column, German Development Institute, 10 March 2021, https://www.die-gdi.de/uploads/media/German_Development_Institute_Burni_Domgoergens_10.03.2021.pdf.

[15] S.L. Van der Linden, A.A. Leiserowitz, G.D. Feinberg, et al., "How to Communicate the Scientific Consensus on Climate Change: Plain Facts, Pie Charts or Metaphors?", *Climatic Change*, 126, 2014, pp. 255-262, https://link.springer. com/article/10.1007/s10584-014-1190-4.

[16] O. Coibion, Y. Gorodnichenko, M. Weber, "Monetary Policy Communications and their Effects on Household Inflation Expectations", VoxEU, 22 February 2019, https://voxeu.org/article/monetary-policy-communications-and-household-inflation-expectations.

[17] M. Bertolotti, P. Catellani, T. Nelson, "Framing Messages on the Economic Impact of Climate Change Policies: Effects on Climate Believers and Climate Skeptics", *Environmental Communication*, 16 April 2021, https://www.patriziacatellani.com/images/2021/4.%20Bertolotti_Catellani_Nelson_framing_economic_impact_climate_change_EC_2021.pdf.

[18] T.A. Myers, M.C. Nisbet, E.W. Maibach et al., "A Public Health Frame Arouses Hopeful Emotions about Climate Change", *Climatic Change,* 113, 2012,

Even the words we use matter. Studies from the United States find that conservatives are more likely to support preparing for environmental disasters when climate change is framed as "extreme weather".[19] And people across the political spectrum feel more negatively about natural gas as a source of energy when it is termed "methane gas".[20]

Finally, we have to consider how the message is given and by whom. It has been clearly established that, when shaping people's perceptions of a crisis, empathy and compassion are critical elements of leadership communication.[21]

For instance, there is some evidence that female leaders have performed better during the pandemic,[22] in part because their communication approach has balanced science and empathy. Female leaders have often sought to share common experience, engage with the public and reach out and speak to vulnerable groups.[23]

We also understand the importance of empathy at the ECB. Trust in the ECB is found to hinge not just on our competence in delivering our mandate, but also on whether we are perceived to care about citizens and act responsibly. So, communicating

pp. 1105-1112, https://link.springer.com/article/10.1007/s10584-012-0513-6; L. Whitmarsh, A. Corner, "Tools for a New Climate Conversation: A Mixed-Methods Study of Language for Public Engagement across the Political Spectrum", *Global Environmental Change*, 42, 2017, pp. 122-135, https://www.sciencedirect. com/science/article/abs/pii/S0959378016306318.

[19] J. Carman, K. Lacroix, M. Goldberg et al., "Americans' Willingness to Prepare for 'Climate Change' vs. 'Extreme Weather'", New Haven, CT, Yale Program on Climate Change Communication, September 2021, https://climatecommunication.yale.edu/publications/americans-willingness-to-prepare-for-climate-change-vs-extreme-weather/.

[20] K. Lacroix, M. Goldberg, A. Gustafson et al., "Different Names for 'Natural Gas' Influence Public Perception of It", *Journal of Environmental Psychology*, 2021, 77, September, https://climatecommunication.yale.edu/publications/testing-other-names-for-natural-gas/.

[21] L.P. Wooten, E.H. James, "Linking Crisis Management and Leadership Competencies: The Role of Human Resource Development", *Advances in Developing Human Resources*, 2008, 10, 3, pp. 352-379, https://journals.sagepub.com/doi/10.1177/1523422308316450.

[22] S. Garikipati, U. Kambhampati, "Leading the Fight Against the Pandemic, Does Gender "Really" Matter?" *Discussion Paper Series,* No 2020-13, Department of Economics, University of Reading, 2020, http://www.reading.ac.uk/web/files/economics/emdp202013.pdf.

[23] A. Burni, F. Domgörgen, "The Verbal Fight against COVID-19. Why Female Leaders Stand out on their Political Communication during the Pandemic", cit.

how responsible ECB policy benefits people's welfare can foster greater trust.[24]

This is why, as ECB President, I have set out to overhaul our approach to communications. Among other initiatives, we have made our monetary policy communication more accessible and we now convey our decisions in a "layered" way that makes them more relatable for people. The aim is to be simple – but not simplistic.

Conclusion

The challenges facing the world today are truly unprecedented. They have immense scale, complexity and potential to amplify through our extensive economic and digital links. This places extraordinary demands on humanity to solve them.

The coronavirus pandemic has demonstrated the speed with which risks can spread across the globe. And it may only be a dress rehearsal for the type of threat to our livelihoods that an overheating planet will pose to all its inhabitants.

But crucially, our joint response to the pandemic holds important lessons for the future. It can provide, perhaps, an emerging template for dealing with the complexity and uncertainty of the global challenges ahead.

In many ways, this response stands out for the considerable efforts made by all policy areas and the unprecedented policy measures taken. However, our ultimate success in tackling this crisis has stemmed from recognizing that we have all had to act together.

Indeed, joint action from different policy areas has proved hugely beneficial in coping with the breadth of the shock. Intensive dialogue between scientists and policy-makers has been fundamental in dealing with complexity and uncertainty. And broad coordination across countries has proved crucial in managing the pace with which the virus has spread.

Without this intensive cooperation, we would not have progressed nearly as fast with the economic recovery and the introduction of vaccines.

So, the fundamental lesson to be learnt here is that we cannot afford to operate with a setup that confines our work to distinct

[24] M. Gardt, S. Angino, S. Mee, G. Glöckler, "ECB Communication with the Wider Public", *ECB Economic Bulletin*, Issue 8, pp. 122-142.

spheres. In a more interconnected global economy, intersectoral and multilateral cooperation is more important than ever to face complex challenges that transcend national borders.

As John Donne wrote, "no man is an island entire of itself; every man is a piece of the continent, a part of the main." This is the reality that we face in a world where our common challenges bind us closely together.

The benefits of science, policy and the public joining forces to realise our full potential are overwhelming. Only by working together in all areas can we draw on our strengths and build hope for a brighter future.

Discussion*

Christine Lagarde, Patrick Flandrin,
Alberto Quadrio Curzio, and Wolfango Plastino

Wolfango Plastino: *In the Corona crisis, Europe and the EU governments reacted with fiscal and monetary policy responses. With the benefit of hindsight, do you think these responses were appropriate, and what can we learn from them for the future?*

Patrick Flandrin: The Corona crisis broke out extremely suddenly. This created an unprecedented, worldwide situation of emergency, calling for immediate actions from governments. This absolute priority led Europe to adopt rapid responses in terms of fiscal and monetary policy, with the added advantage of relying on community reactions to complement national initiatives. This proved effective but it also raises issues for the mid- and long-term, depending on whether the crisis will soon be terminated or, on the contrary, will only be the first of a series. It is therefore of the utmost importance for us to be prepared for possible future pandemics. This was precisely the topic addressed this year by the (S20) group of the Academies of the G20 nations, under the leadership of Italy via the Accademia Nazionale dei Lincei.

This resulted in statements submitted to political leaders, promoting the importance of anticipation and swift reactions at the international level. It was first proposed to promote the creation of a global network of surveillance. One further recommendation was to promote a fair distributed manufacture and delivery of diagnostics, drugs, vaccines, and medical supplies. It was finally proposed to launch an intergovernmental convention to pave the way to an international agreement on pandemic preparedness and management.

Two remarks about the way of thinking about pandemic preparedness. The first is that, while science has a key role to play –

* The text below is the full transcript of the Round Table that followed the *Lectio Magistralis* by H.E. Christine Lagarde, President of the European Central Bank.

that has been discussed as such within the S20 – economic and societal issues are equally important and cannot be separated from it. Acknowledging this necessity led the Accademia Nazionale dei Lincei to launch in parallel a discussion within the G20 Academies concerned with social sciences and humanities (SSH20), resulting in a companion statement. This initiative has definitely to be pursued and enforced in the future. The second remark is that, in terms of science, preparation for the future is deeply rooted in the capacity of engaging long-term, innovative research programmes, and not only of reacting to emergency situations. What we witnessed with vaccines for Covid-19 is particularly exemplary. If the development of mRNA vaccines has been so fast, it did not wait for the outbreak of the epidemics to be envisioned, nor did it appear from nowhere: it resulted from at least 15 years of discoveries and innovations. We cannot predict what will happen in the future, but being prepared for tomorrow means supporting today research efforts that are not necessarily driven by short-term objectives.

Alberto Quadrio Curzio: First of all, before answering the question, I'd like to thank the President of the European Central Bank (ECB), Mme Christine Lagarde, for her excellent speech and all those who made this session on "Science Diplomacy" possible, especially Professors Plastino and Barba Navaretti. Before turning to the questions, let me mention Luigi Einaudi (1874-1961), a crucial figure in Italian and European History. He was "un Piemontese" who died 60 years ago. His many contributions include those as President of the Italian Republic (1948-1955), as a scholar of Institutional Political Economy and as an "architect of a Federal Europe." When he was 23 years old, he wrote his first article on Europe, which is our main topic today.

I shall start by quoting Mario Draghi's Editorial on "Fiscal policy and the pandemic" which came out in *Economia Politica. Journal of Analytical and Institutional economics* in 2021[1]. He states: "The economy is recovering, and schools have reopened." He

[1] The Editorial, (*Economia Politica. Journal of Analytical and Institutional Economics*, 2021, 38, 3, pp. 797–802), is the English translation of Prime Minister Mario Draghi's *Lectio Magistralis* delivered on 1 July 2021 when he, in the presence of the President of the Italian Republic, received the International Feltrinelli Prize 2020 for "Monetary Institutions", given by Roberto Antonelli, President of the Accademia Nazionale dei Lincei, in Rome. As Editor-in-Chief of the journal, I was quite pleased to have the privilege of publishing Draghi's enlightened *Lectio* on this crucial period.

chose to talk immediately about schools! Then he goes on: "But we must be realistic. The pandemic is not over. Even when it will be, we will have to deal with the consequences for a long time." Draghi stressed two points at the beginning of his article: "The economic crisis that began a year ago is unprecedented in recent history" and, as you said, President Lagarde, the global nature and the timespan of this pandemic is yet unknown. Secondly – here Draghi is speaking as an economist, past President of the ECB and President of the Italian Council of Ministers. At the stage when the pandemic broke out, there were two choices: either fight a recession or accept a long and terrible depression. The first choice was the right one, otherwise it would have been a disaster with bankruptcies, breakdown of the supply chains, and massive unemployment. The necessary choice had the side-effect of producing a surge in the debt.

Draghi goes on to explain that the timing of policies is crucial in order to converge on a path of sustainable development. This brings me to the Next Generation EU (NGEU) and the Recovery and Resilience Facility (RRF) that the EU started in 2020, and which exists mainly due to Ursula von der Leyen and Angela Merkel. Thanks to this crucial innovation, for the first time ever, the EU will issue Eurobonds (EuroB) to finance reforms, investments and structural changes precisely for a greener, more digital, civil, social and scientifically oriented Europe. Close to 1 trillion euros will be raised to finance this path of innovation in the 27 European countries.

Christine Lagarde: The pronounced impact of the pandemic on the economy and the protracted weakness in inflation clearly called for a very accommodative monetary policy stance and a very supportive fiscal policy. Our monetary policy response has evolved in line with the economic situation. When the pandemic hit the world in early 2020, it was crucial to contain and stamp out the risk of a self-reinforcing spiral of uncertainty on financial markets. We also needed to ensure sufficient liquidity at attractive conditions to help firms and households get through the crisis. Gradually, our focus shifted towards putting the recovery on solid ground. First and foremost, we sought to preserve favourable financing conditions for all sectors in the economy to offset the negative impact of the pandemic on the inflation outlook. Closing the gap to the pre-pandemic inflation outlook is only the first step. Our policy measures are key to helping the economy shift to a sustained recovery which will ultimately bring inflation to our 2% target over the medium term.

Two policy measures have been crucial for achieving those goals: the pandemic emergency purchase programme (PEPP) and the targeted longer-term refinancing operations (TLTROs). The PEPP has been effective in reducing financing costs from their initial highs at the onset of the pandemic back to pre-pandemic levels. Our TLTROs – as a powerful complement to PEPP – have supported favourable bank lending conditions. Without our measures, we would have faced a much worse growth and inflation outlook.

What did we learn? First, monetary policy needs to be responsive and flexible. History has taught us that unpredictable events will challenge financial markets from time to time. Responding to those new circumstances will require the development of novel approaches and tools. The positive experience with non-standard measures implies they will continue to be a key tool in times of market dysfunction and when inflation falls short of target in conditions that constrain our traditional instrument. Overall, the low level of the natural rate of interest implies that encounters with the effective lower bound are likely to be more frequent than in the past. As a result, non-standard tools are also likely to remain part of our regular toolkit. This was clearly recognized in our strategy review.

Second, diversification of the policy toolkit is essential. Deploying a package of complementary tools enhances the overall effectiveness of monetary policy because instruments can be mutually reinforcing. For example, negative interest rates reinforce the effects of our forward guidance, i.e. the indications that we issue about the likely path of our policy rates. Marrying these two policies has proved extremely effective in making credit more affordable for households and firms.

Fiscal policy very effectively mitigated the fallout from the pandemic by channelling support to where it was most needed. Governments supported the health system and provided aid to the unemployed and other vulnerable groups through various social transfers. Fiscal emergency packages limited the economic fallout from containment measures through direct steps to protect firms and workers in the affected industries. Short-time work schemes proved effective in preserving employment. Extensive liquidity support-measures in the form of tax deferrals and state guarantees helped firms particularly affected by the containment policies to avoid liquidity shortages. The EU's response to the coronavirus (Covid-19) crisis – e.g. through Next Generation EU and SURE – has been unprecedented and significantly complements the fiscal measures taken at the national level.

Fiscal and monetary policy measures taken during the pandemic have been highly effective, and have complemented each other in their respective fields of responsibility: the European Central Bank's (ECB) monetary policy has stabilized markets and eased the monetary stance, in line with its price stability objective. Our monetary toolkit has proved large and flexible.

Fiscal policy measures were instrumental in setting the euro-area economy back on a sustainable growth path. They helped to limit scarring of economies. Fiscal policies are important for macroeconomic stabilization, especially in the proximity of the effective lower bound on interest rates. In such circumstances, fiscal policy can complement monetary policy effectively. Importantly, this requires that debt sustainability is ensured and that sufficient fiscal buffers are built in times when the economy runs smoothly.

Temporary European tools have been created to counter the pandemic crisis. If they work well, this could provide lessons for the Economic and Monetary Union architecture, which would benefit from a permanent stabilization facility to enhance the macro-economic policy mix during severe downturns.

Wolfango Plastino: *Recently, the ECB and other central banks have started to pay much more attention to environmental and climate policy considerations. Is this really covered by the ECB`s mandate or is this rather an example of mission creep, as some critics claim?*

Christine Lagarde: Exploring how the ECB – within its mandate – can support the public goal of mitigating climate change is not only our responsibility as a public European institution, but is also what we need to do in order to fulfil our mandate. First, climate change and the transition towards a more sustainable economy affect the outlook for our primary objective, price stability, through their impact on macro-economic indicators – such as inflation, output, employment, investment and productivity – and on natural interest rates, the transmission of monetary policy and financial stability. Second, climate change and the carbon transition affect the value and the risk profile of the assets held on the Eurosystem's balance sheet, potentially leading to an undesirable accumulation of climate-related financial risks. Furthermore, the Treaty on the Functioning of the EU not only allows, but arguably requires, the ECB to take climate change into account. The ECB has a duty, based on the secondary objective, to support general economic policies in the EU. And environmental protection and

climate mitigation figure prominently among these policies which the ECB is required to support. In doing so, we have to find the right balance between exploring what is feasible within our mandate and ensuring that our actions never interfere with our primary objective of price stability.

Patrick Flandrin: It becomes every day more obvious that climate change must be the major concern when considering the future of humankind. Its reality has been amply documented by scientists and recognized as unambiguously attached to human activities. Global warming has dramatic effects on our environment, modifying ecosystems, impacting biodiversity, and creating new inequalities between populations. Consequences affect all aspects of our lives and profound transformations are to be undertaken in order to mitigate them. Energy production and consumption are to be reconsidered with respect to their environmental and climatic impact, many economic sectors have to be reshaped, and now is the time for action. This certainly justifies the ECB and other central banks to take such aspects in consideration, though at the expense of raising novel issues. One question concerns for instance taxonomy, with the issue of agreeing upon what is "green" or not (an classic example of the controversy that this may generate is the place to be given to nuclear energy, which should be included in view of its excellent carbon footprint, but which might be obstructed by other kinds of reticence). A companion question is related to the economic models on which central banks may rely, in which environmental issues or externalities due to climate are seldom taken into account while they should be, possibly by including specifically related costs when optimizing utility functions of economic agents.

Alberto Quadrio Curzio: The ECB could buy Euro Green Bonds from the European Commission and from the single states, as well as other types of green bonds. It has already been purchasing green bonds since 2016 in compliance with the Environmental, Social and Governance (ESG) criteria. Moreover, the ECB has many other ways of purchasing green bonds (directly and indirectly).

It is important to note that the European Commission (EC) within NGEU and RRF has adopted a broader sectoral strategy by also issuing "SureBonds" to alleviate unemployment. When it issued its first green bonds, it raised 30 billion euros (with a demand 10 times the availability!), while by the end of 2026 the total amount raised should be 250 billion euros, that is 30% of the total NGEU.

The EU, with NGEU, will become the world's largest issuer of green bonds.

More generally, the NGEU's EuroB and Green strategies must be evaluated from the technical and political perspectives. From a technical stance, NGEU has been developed according to the green bond principles (GBP) of the International Capital Market Association, which is a market standard reviewed by Moody's. Politically, the programme follows the protocol developed by the EC and approved by the European Parliament and Council. Furthermore, the effective compliance and use of the funds allocated to member states under the NRPs will be monitored. At least 37% must be earmarked for the green transition (from energy to transport).

As for the ECB's compliance with its mandate, the problem is more complex for multiple reasons; and the risk of infringing its statutes is always present. Now, the risk that the ECB might be brought before the European Court of Justice is notable. Over the past decade, Mario Draghi faced, with wisdom, courage and success, the financial crisis. However, a complaint was filed with the European Court of Justice (ECJ) against "his" ECB monetary policy and the massive purchases of state bonds. The ECJ ruled that the statutes had not been infringed. Nonetheless, the degree of ECB intervention since the pandemic has increased significantly and the total amount of state bonds in its vaults has soared.

The ECB's mandate must remain within the scope of the European Treaties. It is not as broad as that of the Federal Reserve for many reasons. One crucial difference is that the Fed buys US Treasury bonds without the problem of different rates of interests, which characterize the state bonds of the 19 EMU countries. This is one of the reasons why I have argued for 20 years (more or less, since the birth of the euro) that Eurobonds should be issued like Treasury Bonds for European federal economic policies, while state bonds should be issued for the national questions specific to the EMU members. If the ECB were to buy only Eurobonds, its policies would be simpler. To date, the ECB has been capable of solving the EU's challenges, but in the future, it might become much more difficult.

Wolfango Plastino: *What is your assessment of the current inflation developments? Is it a temporary phenomenon or, given the increase of primary commodities prices, might it be long-term?*

Alberto Quadrio Curzio: Inflation is a real danger for current EU policies and for worldwide economic recovery. Factors to consider

include commodities, money and debt. While these aspects impact EU and EMU structural policies and the EU's stability, I will not address all of them here. I mentioned earlier that the ECB has a 2% (medium term) inflation target. The Fed does not have a target ceiling and so its expansionary policy also led to significant speculation.

However, let us consider other factors that could cause inflation.

The pandemic is changing the geo-economy and production chains. Many new combinations are being introduced, and there is a crucial return to commodities. At the beginning of 2020, commodity prices in euros, according to various indices, had fallen sharply, accentuating the decline that had begun in 2018. From a significant low around April, prices spiked violently, taking some indices in euros to all-time highs. This was due to factors such as a strong recovery in demand, a lag in adjusting supply, problems with logistics and maritime transport. In short, a supply chain disruption.

There are also other structural, long-term, problems to consider. One is global and concerns dematerialization and the transition to clean energies, which requires many rare and scarce raw materials. Commodities like lithium and copper – used for semiconductors – or gas are indispensable in most production processes. Another concerns the EU's scarcity of these materials and its lack of common stocks. The worsening EUR-USD exchange rate, which is the currency of commodity prices, has heightened the EU's vulnerability in this geo-economic and geopolitical area in contrast to the USA and China.

I've already mentioned that the ECB injected extraordinary amounts of liquidity into the EMU area. Now, various countries with solid public accounts are calling for a return to orthodox fiscal policy to avoid going from a "covid pandemic" to a "debt pandemic". This stance, in particular by a German institutional figure, was expressed in May and June also in the *Financial Times*, with the suggestion of introducing a "physically gold-backed rescue fund" in some countries (like Italy). However, this is a simplistic way of looking at these very difficult issues.

In fact, three aspects must be considered. The first is that the EU's public expenditure is 1% of its annual GDP, while for other federal states it's at least 20%. That is why the EuroBs prescribed in the NGEU and RRF should become permanent, solid, with long maturities, and why they should be issued regularly by the EU and EMU. The second is to provide a structure, for what should become "GoldEuroUnionBonds" beyond the issuances of EuroBs currently planned until 2026. These should have a long duration, most near to 30 years. Gold-backed bonds would provide

the euro and EMU with extraordinary strength, since the EMU members have the largest official gold reserves in the world, around 10 thousand tonnes. I have been proposing this for more than 20 years and condensed it into an essay, "Eurobonds for EMU stability and structural growth", published with Cambridge University Press (2017). Third, it will be impossible to implement the Stability and Growth Pact, which has been suspended to the end of 2022, with a target of 60% public debt to GDP ratio for individual states, when the average ratio in the EMU is currently over 100%. It is time to move from decentralized prescriptive fiscal policies to structural economic policies that are truly federal and functional.

Christine Lagarde: Inflation has been surprising to the upside for a while. In October, euro-area inflation rose to 4.1% from 3.4% in September. We see this inflation upswing largely reflecting three factors, which will fade over time. First, a broad-based surge in energy prices. Energy inflation alone accounted for just over half of the overall inflation in the euro area in October. It was also responsible for a large share of the recent upward surprises. The second factor is recovering demand, due to the reopening of the economy, which is outpacing constrained supply. The increase in HICP services inflation mainly reflected an increase in prices for high-contact services reopening after pandemic restrictions. Non-energy industrial goods (NEIG) inflation remained well above its historical average, reflecting high demand for durable goods in conjunction with global supply chain disruptions. The pipeline price pressures for NEIG inflation are visible in historically high rates of producer price inflation for both intermediate and final (non-food) consumer goods. The third factor affecting the inflation upswing is the base effects associated with the reversal of the 2020 VAT cut in Germany and the sharp drop in oil prices in 2020.

Price pressures from energy commodity prices and from demand outrunning supply are both lasting longer than we initially expected. But we expect inflation to peak before the end of the year, and then to decline in the course of next year, as the impact of these factors currently pushing up inflation will either fall out of the year-on-year inflation calculation or ease in the course of 2022. The impact of the reversal of the temporary VAT cut will fall out of the inflation calculation in January. Our projections are conditioned on the paths implied by energy commodity futures prices. Current profiles of these prices suggest that we will likely see a noticeable easing in energy inflation in the first half of 2022. Oil futures point to a gradual decline from the beginning of 2022, while gas and electricity futures suggest a drop in the spring.

Price pressures from demand outrunning supply are also expected to ease in 2022 as the demand boost in the reopening phase spreads more evenly and supply constraints ease.

The surge in prices could become longer-lasting only if it led to a wage-price spiral whereby employers agree to continuous increases in nominal wages – over and beyond what is justified by growth in productivity and by a medium-term inflation of 2% – on the expectation that they can keep increasing prices commensurately to protect their margins. There are no signs that this is happening or likely to happen.

Growth in negotiated wages has remained moderate (1.3% in the third quarter of 2021), but the data reflect negotiations that took place before the current inflation surge. At the same time, we still observe slack in the labour market that should contain wage pressures. Although the unemployment rate has returned to its pre-pandemic level, there is still substantial support from job retention schemes.

Medium-term inflation expectations are well anchored and remain slightly below our 2% target, which suggests that excess inflation pressure will not persist over time.

This being said, we monitor the possible consequences related to the current inflation surge closely.

Patrick Flandrin: Predicting the future is just impossible. Forecasting is possible but difficult, and it can only be approached via some in-depth knowledge of what happened in previous periods and/or on adequate models. Models are most often based on the behavior of agents that are supposed to act "rationally". This can be reasonably effective in normal situations, i.e., in the absence of severe drifts or of shocks. Designing better models for such situations is desirable but intrinsically difficult, with the need to introduce behavioral loops. As for inflation, much has certainly to be learned from the past, and central banks, which have been on the frontline in former crisis situations (e.g., in 2008), should be equipped for adjusting models and better anticipating further developments.

Wolfango Plastino: *You regularly use your status as global public personae to promote a better gender balance in politics, corporations or public institutions. Are you satisfied with the progress that you observe in this regard?*

Patrick Flandrin: There is no discussion that a better gender balance should be promoted in all sectors of activities. This includes

in particular higher education, research, and scientific activities at large. While some progress has been observed in the recent past, much more is still to be done, and the question is: how? Imposing quota rules is a possible answer that could be effective in some situations – e.g., when used for a restricted period of time as a kick-off process – but it has several drawbacks, especially in academia. For instance, from a strictly quantitative perspective, the current situation in France is that only about one third of academic positions are hold by women. As a consequence, imposing an exact gender balance in panels, commissions, boards, etc., leads inevitably to an overcharge for women, which negatively impacts the time they can devote to their own research and, ultimately, their career. Another difficulty relates to legitimacy, many women being reluctant to accept any form of positive discrimination that could suggest they have not been recognized on the basis of their merits alone. Those caveats do not preclude development of all kind of incentives based on an explicit recognition of the situation and of the possible cognitive biases (conscious or unconscious) that resist change. The observed gender imbalance in science results also from a possible lack of confidence on the part of female students to engage in scientific studies, a question that can be given at least two answers. The first is the importance of being able to put forward "role models" whose professional trajectories can allow young girls to identify themselves and gain confidence. The second, which is closely linked to the first, is an educational effort that must be undertaken from school onwards, to overcome the prejudices that still too often exist about the gendered nature of scientific practices.

Alberto Quadrio Curzio: Gender balance is a crucial topic. I would require more space to adequately address it. Thus, I will limit myself to mentioning a few instances.

I shall start from the Farewell Event for Mario Draghi as President of the ECB held in Frankfurt on 28 October 2019, which he invited me to attend. His speech will remain a masterpiece not only on the past but also on the future of monetary and fiscal policies. Various illustrious dignitaries made speeches, but I shall focus on three. Mario Draghi in addressing the President elect: "The time has come for me to hand over to Christine Lagarde. I have every confidence that you will be a superb leader of the ECB"; Christine Lagarde expressing her admiration for Draghi: "let me thank you for all that you have done in bringing about the success of the euro area and more importantly the well-being of its people. Your legacy is a call for us to excel, to exceed expectations and to

deliver on the mandate and to serve the European mission as you have served it with wisdom, with determination and with commitment"; and Angela Merkel, who stressed that "for the first time since the ECB was established there will be a female President very shortly at the helm of this institution." She also warmly praised Draghi, as did President Mattarella and President Macron, who also highly praised Cristine Lagarde. Ursula von der Leyen, President elect of the European Commission, sat in the front row. In short, six admirable personalities, men and women from the founding countries of the EEC. The event was emblematic of the important role of women in the EU and its institutions.

Let me briefly mention also two scientific examples. The first was a series of conferences that I organized in 2018 as President of the Accademia Nazionale dei Lincei. They were held by six eminent women from the sciences and humanities: Fabiola Gianotti, physicist, Elena Cattaneo, neuroscientist, Emanuelle Marie Charpentier, microbiologist, Bina Agarwal, economist, Marcella Frangipane, archaeologist, and Berit Reiss-Andersen, lawyer. The second is an event that was organized by a UNESCO programme unit based in Trieste, the Organization for Women in Science for the Developing World from 8 to 19 November 2021 on *Women, Science and Development*. As its Ambassador, I was involved in promoting and participating at the event organized by Jennifer Thomson, OWSD President and Tonya Blowers, OWSD Programme Coordinator, at which there were too many renowned female scientists and dignitaries to list here.

Christine Lagarde: Looking around us, we see that our reality is still predominantly driven by male decision-makers. Men make up 75% of parliamentarians, hold 73% of managerial positions and constitute 70% of participants in climate and peace negotiations.[2]

And it was no different during the pandemic. From a total of 115 national task forces from 87 different countries dedicated to tackling the pandemic, only 3.5% of them had gender parity while around 85% were made up mainly of men.[3] Yet a recent global survey showed that women leaders were more effective than their

[2] UN Women "Women's Rights in Review 25 Years after Beijing", 2020, https://www.unwomen.org/en/digital-library/publications/2020/03/womens-rights-in-review.

[3] European Commission, "2021 Report on Gender Equality in the EU", 2021, pp. 37-38, https://ec.europa.eu/info/sites/default/files/aid_development_cooperation_fundamental_rights/annual_report_ge_2021_printable_en_0.pdf.

male counterparts during the pandemic. According to this study, women performed better under pressure and rated more positively on most of the competences involving interpersonal skills, which were the most appreciated by employees.[4]

Progress is not certain and we should not take it for granted. The pandemic has once again shown us how quickly progress can be challenged and even reversed. Women's jobs are more vulnerable to this crisis than men's: more than half of overall job losses during the pandemic affect female workers.[5] Women work disproportionately in the sectors that have been worst hit by the crisis and they are more likely to have informal work that falls outside the scope of government support programmes. Additionally, while many women were at the frontline of fighting the pandemic, they have also been left with the responsibility to care for family members while trying to keep their own careers on track.[6] The Malala Fund estimates that 20 million girls in developing countries may never return to the classroom after the pandemic-related school shutdowns.[7] This is unacceptable.

So we have the evidence to inform better decisions in the future – it is up to us to take them. The future is inclusive and sustainable, and clearly it is in everyone's economic interest to ensure that talent does not go to waste. But things will not change by themselves. According to the World Economic Forum's *Global Gender Gap Report 2021*, there has been a decline in gender parity globally and it will now take 135.6 years to close the gender gap.[8]

It is time to rise to this challenge together. I see many young talented women who are taking a leap and going for it. But ending gender inequality will also require concentrated actions by institutions and governments.

[4] J. Zenger, J. Folkman, "Women Are Better Leaders During a Crisis", *Harvard Business Review*, December 2020, https://hbr.org/2020/12/research-women-are-better-leaders-during-a-crisis.

[5] McKinsey Global Institute, "COVID/19 and Gender Equality: Countering the Regressive Effects", July 2020, https://www.mckinsey.com/featured-insights/future-of-work/covid-19-and-gender-equality-countering-the-regressive-effects.

[6] European Commission, "2021 Report on Gender Equality in the EU", cit., p. 40.

[7] Malala Fund, "Girls' Education and COVID-19: What Past Shocks Can Teach us about Mitigating the Impact of Pandemics", 2020, https://downloads.ctfassets.net/0oan5gk9rgbh/6TMYLYAcUpjhQpXLDgmdIa/3e1c12d8d827985ef2b4e815a3a6da1f/COVID19_GirlsEducation_corrected_071420.pdf.

[8] World Economic Forum, *Global Gender Gap Report 2021*, 2021, https://www3.weforum.org/docs/WEF_GGGR_2021.pdf.

Wolfango Plastino: *Along with other central banks, the ECB is preparing the introduction of a digital euro. Why should citizens in the euro area support a digital euro? Will they have to stop using euro bills and coins?*

Christine Lagarde: The ECB intends to ensure that people continue to have access to cash. The central bank needs to guarantee that sovereign money remains fully accessible and usable, so that it can continue to act as an effective anchor at times when payment behaviours change. Providing citizens with riskless money for their payments is a key part of the Eurosystem's mission and a digital euro would be riskless money in another form. It would complement cash, and citizens would choose which means of payment to use. For example, at a physical store today, citizens wishing to use central bank money can opt to pay with cash. Neither they nor the merchant will be charged any payment fee or fee for holding the banknotes for them. Just the internal cash handling costs. But cash can hardly be used in digital payments, such as for e-commerce. One of the business cases for a digital euro is to make possible in e-commerce what has always been possible in a physical store: to pay digitally with central bank money and enjoy its advantages.

The benefits of a digital euro would also go beyond that. They relate to the role of the ECB as a public institution free of commercial interests. A digital euro would contribute to a fairer, inclusive, more diverse and more resilient European retail payments market. It could create synergies with private payment solutions and provide an alternative to foreign payment providers for fast and efficient payments in Europe and beyond. For small businesses, a digital euro would be another way of receiving payments from their customers. It would also ensure a high level of privacy. The ECB has no commercial interest in monetizing payment data. Overall, a digital euro would promote inclusiveness, diversity and privacy of the European payment system.

Patrick Flandrin: "Digital euro" rings the bell of something like bitcoins and cryptocurrencies, which are often associated with some way of getting rid of central banks… The actual situation should be different but it would benefit from a clearer explanation. From a naive perspective, one is already familiar with some forms of virtual money in the generalized use of credit cards or electronic payments, and less and less bills and coins. Going further, however, will be a matter of trust, as it raises cybersecurity issues that are observed every day growing in importance and which are known to have non-trivial solutions. Increasing security may also involve

the development of refined protocols that have a significant energy and environmental cost that cannot be ignored. Moving from feasibility to usage, forgetting bills and coins is not guaranteed to be socially accepted in the same way by citizens of different EU countries. As with the first question on preparing for future pandemics, it is clear that purely technical issues and social science approaches must be considered together.

Alberto Quadrio Curzio: I am very cautious about digital currencies. Many seem worrisome and appear speculative in nature. I fear they could undermine monetary policies and jeopardize the central banks' role of providing stability and solvency. I am not, however, able to distinguish between digital currencies that could fall within a sovereign monetary policy and those which escape any form of institutional oversight. I will conclude my remarks on this issue by mentioning again Luigi Einaudi in his magnificent work *Teoria della moneta immaginaria nel tempo da Carlomagno alla Rivoluzione Francese* (1936), where he addresses the relationship between contractual monetary units and units of payment, between imaginary money and real money, reminding the reader that an increase in the nominal "value" of the latter, in terms of the "former," merely gives the illusion of being richer.

One of his affirmations has always impressed me, and even more so today. I shall quote his refined Italian:

"La manovra monetaria opera su un congegno delicatissimo e complicatissimo; e riesce quel manovratore il quale alla chiarezza delle idee astratte sa unire l'apprezzamento rapidissimo dei fatti invisibili".[9]

This sentence is almost impossible to fully translate with all its nuances; the gist is that an outstanding Central Banker should not only have a profound understanding of monetary theory and policies, but also the sensitivity to make extremely quick decisions that include an intuition of the public's response.

This is a challenge for central bankers from orderly states faced with creating "digital currencies". I hope that they will take into account monetary history and monetary theory, since for many centuries, currency has been considered a symbol of sovereignty and reliability.

[9] L. Einaudi, "Teoria della moneta immaginaria nel tempo da Carlomagno alla Rivoluzione Francese", *Rivista di Storia Economica*, 1936, 1, 1, pp. 1-35, p. 27.

APPENDIX

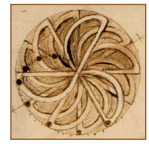
Special Events of the *Colloquia* on Science Diplomacy

MMXX ✦ MMXXI

ACCADEMIA NAZIONALE DEI LINCEI

Colloquia on Science Diplomacy

MMXX ✦ MMXXI



Leonardo da Vinci, Codex Atlanticus (1494)

SPECIAL EVENT
with

H.E. Paul Richard Gallagher

PROGRAMME

23 November 2020, 4:00pm CET

Welcome addresses	Prof. Giorgio Parisi *President of the Accademia Nazionale dei Lincei* H.E. Amb. Elisabetta Belloni *Former Secretary General of the Ministry of Foreign Affairs and International Cooperation, and Director General of the Department of Information Security*
Lectio Magistralis	"Fraternity, Integral Ecology and Covid-19. *The Role of Diplomacy and Science*" H.E. Most Rev. Msgr. Paul Richard Gallagher *Holy See Secretary for Relations with States*
Roundtable	moderated by Prof. Wolfango Plastino *Chair of the* Colloquia *on Science Diplomacy* H.E. Most Rev. Msgr. Paul Richard Gallagher *Holy See Secretary for Relations with States* Prof. Marcia McNutt *President of the US National Academy of Sciences* Prof. Giorgio Parisi *President of the Accademia Nazionale dei Lincei*

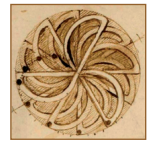
VENUE

Accademia Nazionale dei Lincei
Biblioteca Corsiniana
Palazzo Corsini
Via della Lungara 10
Rome

ACCADEMIA NAZIONALE DEI LINCEI

Colloquia on Science Diplomacy

MMXX ✦ MMXXI



Leonardo da Vinci, Codex Atlanticus (1494)

SPECIAL EVENT
with

H.E. Qu Dongyu

PROGRAMME

25 February 2021, 4:00pm CET

Welcome addresses	Prof. Giorgio Parisi *President of the Accademia Nazionale dei Lincei* H.E. Amb. Giorgio Marrapodi *Director General for Development Cooperation of the Ministry of Foreign Affairs and International Cooperation*
Lectio Magistralis	"Agri-Food Systems Transformation. *From Strategy to Action*" H.E. Qu Dongyu *FAO* Director General*
Roundtable	moderated by Prof. Wolfango Plastino *Chair of the* Colloquia *on Science Diplomacy* H.E. Qu Dongyu *FAO Director General* Prof. Joachim von Braun *President of the Pontifical Academy of Sciences (Holy See)* Prof. Giorgio Parisi *President of the Accademia Nazionale dei Lincei*

VENUE

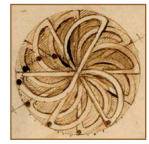
Accademia Nazionale dei Lincei
Sala Scienze Fisiche
Palazzo Corsini
Via della Lungara 10
Rome

* Food and Agriculture Organization of the United Nations

ACCADEMIA NAZIONALE DEI LINCEI

Colloquia on Science Diplomacy

MMXX ✦ MMXXI



Leonardo da Vinci, Codex Atlanticus (1494)

SPECIAL EVENT

with

H.E. Inger Andersen

PROGRAMME

14 April 2021, 3:00pm CEST

Welcome addresses	Prof. Giorgio Parisi *President of the Accademia Nazionale dei Lincei* H.E. Plen. Min. Luca Sabbatucci *Director General for Global Affairs of the Ministry of Foreign Affairs and International Cooperation*
Lectio Magistralis	"Science and Solidarity for a Sustainable Planet" H.E. Inger Andersen *UN* Under-Secretary-General and Executive Director of the UN Environment Programme*
Roundtable	moderated by Prof. Wolfango Plastino *Chair of the* Colloquia *on Science Diplomacy* H.E. Inger Andersen *Under-Secretary-General of the UN and Executive Director of the UN Environment Programme* Prof. Dan Larhammar *President of the Royal Swedish Academy of Sciences* Prof. Giorgio Parisi *President of the Accademia Nazionale dei Lincei*

VENUE

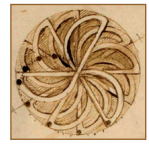
Accademia Nazionale dei Lincei
Biblioteca Corsiniana
Palazzo Corsini
Via della Lungara 10
Rome

* United Nations, *Nobel Peace Prize 2001*

ACCADEMIA NAZIONALE DEI LINCEI

Colloquia on Science Diplomacy

MMXX ✦ MMXXI



Leonardo da Vinci, Codex Atlanticus (1494)

SPECIAL EVENT

with

H.E. Rafael Mariano Grossi

PROGRAMME

15 June 2021, 4:00pm CEST

Welcome addresses	Prof. Giorgio Parisi *President of the Accademia Nazionale dei Lincei*
	H.E. Amb. Pasquale Ferrara *Director General for Political and Security Affairs of the Ministry of Foreign Affairs and International Cooperation*
Lectio Magistralis	"Atoms for Peace and Development. *Science and Technology for a Better and Safer World*" H.E. Rafael Mariano Grossi *IAEA* Director General*
Roundtable	moderated by Prof. Wolfango Plastino *Chair of the* Colloquia *on Science Diplomacy*
	H.E. Rafael Mariano Grossi *IAEA Director General*
	Prof. Jeremy McNeil *President of the Royal Society of Canada*
	Prof. Giorgio Parisi *President of the Accademia Nazionale dei Lincei*

VENUE

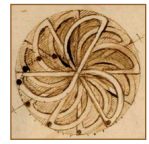
Accademia Nazionale dei Lincei
Biblioteca Corsiniana
Palazzo Corsini
Via della Lungara 10
Rome

* International Atomic Energy Agency, *Nobel Peace Prize 2005*

ACCADEMIA NAZIONALE DEI LINCEI

Colloquia on Science Diplomacy

MMXX ✦ MMXXI



Leonardo da Vinci, Codex Atlanticus (1494)

SPECIAL EVENT
with

H.E. Henrietta Holsman Fore

PROGRAMME

27 September 2021, 4:00pm CEST

Welcome addresses	Prof. Roberto Antonelli *President of the Accademia Nazionale dei Lincei* H.E. Plen. Min. Gianluca Alberini *Principal Director for the United Nations and Human Rights of the Ministry of Foreign Affairs and International Cooperation*
Lectio Magistralis	"Youth in Science Diplomacy" H.E. Henrietta Holsman Fore *UNICEF* Executive Director*
Roundtable	moderated by Prof. Wolfango Plastino *Chair of the* Colloquia *on Science Diplomacy* H.E. Henrietta Holsman Fore *UNICEF Executive Director* Prof. Hans Petter Graver *President of the Norwegian Academy of Science and Letters* Prof. Giorgio Parisi *past President of the Accademia Nazionale dei Lincei*

VENUE

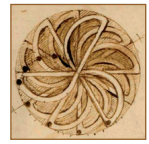
Accademia Nazionale dei Lincei
Sala Scienze Fisiche
Palazzo Corsini
Via della Lungara 10
Rome

* United Nations Children's Fund, *Nobel Peace Prize 1965*

ACCADEMIA NAZIONALE DEI LINCEI

Colloquia on Science Diplomacy

MMXX ✦ MMXXI



Leonardo da Vinci, Codex Atlanticus (1494)

SPECIAL EVENT
with

H.E. Christine Lagarde

PROGRAMME

29 November 2021, 6:00pm CET

Welcome addresses	Prof. Roberto Antonelli *President of the Accademia Nazionale dei Lincei* Eng. John Elkann *President of the Fondazione Agnelli* Prof. Giorgio Barba Navaretti *President of the Collegio Carlo Alberto* H.E. Amb. Ettore Francesco Sequi *Secretary General of the Ministry of Foreign Affairs and International Cooperation*
Lectio Magistralis	"Dialogue in a Changing World" H.E. Christine Lagarde *President of the European Central Bank*
Roundtable	moderated by Prof. Wolfango Plastino *Chair of the* Colloquia *on Science Diplomacy* H.E. Christine Lagarde *President of the European Central Bank* Prof. Patrick Flandrin *President of the Academy of Sciences (France)* Prof. Alberto Quadrio Curzio *President Emeritus of the Accademia Nazionale dei Lincei*

VENUE

Fondazione Agnelli
Collegio Carlo Alberto
Teatro Carignano
Piazza Carignano 6
Turin