FORESIGHT

New Horizons:

Future Scenarios for Research & Innovation Policies in Europe

Research and Innovation

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A report from project BOHEMIA

Beyond the Horizon: Foresight in Support of the Preparation of the European Union's Future Policies in Research and Innovation

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FOREWORD

Research and Innovation play an essential part in creating opportunities for a dynamic economy and options for a better society. We want it to play an ever-more important role in creating the future we want.

Our reflections on the future EU Framework Programme for Research and Innovation are fashioned by our experience of the past, our knowledge of the present and our anticipation of the future. Foresight helps translate our anticipation of the future into our policy choices today.

The future is partly shaped by forces beyond our control. But we have the ability to develop skills and strategies to shape the future, to help strengthen our resilience, and to create a prosperous and safe future. Jean-Claude Juncker, President of the European Commission, in his White Paper on the Future of Europe offered five scenarios on how we might do exactly that.

Echoing the White Paper, this report, authored by the leads of the Bohemia Project, presents a set of scenarios that navigate between megatrends – forces that drive the future of the world and our planet - and the policy goals and values of the European Union. Of special significance is the UN 2030 Agenda for Sustainable Development which the European Union, its Member States and all countries in the world have embraced as a unique opportunity for a better future. Realising the Sustainable Development Goals is both a challenge and an opportunity for the world; it is a call for action through research and innovation throughout the EU and globally.

The scenarios in this report are neither scientific forecasts nor predictions coming from scientific models. They are not images of what will be. Rather, they are images of what might be. They are part of a deliberative process that aims to position the debate on the next Framework Programme in the context of evolving challenges, which the programme should enable us to respond to. It is not about drawing firm policy conclusions. It is rather about opening the discussion on future research and innovation policy and investment, and about promoting engagement and participation by society in the policy process. The scenarios are intended to stimulate debate and reactions that will help us develop the next Framework Programme.

This report provides very important input and I hope it will help the European Commission to spark an innovation revolution, with Europe in the driving seat. Feel free to respond already to the ideas expressed in this report and to share with us what implications you may draw from it, by writing to RTD-Foresight@ec.europa.eu.

Carlos MOEDAS

Commissioner for Research,
Science and Innovation
European Commission

EXECUTIVE SUMMARY

The world, it seems, is getting more complicated. A confusing mix of positive and negative trends, constructive and destructive forces, vie for our attention every day.

On the scary side: international conflicts are multiplying, a large European Union member has vowed to leave, and immigration and terrorism have risen in just five years to be the No. 1 and 2 concerns among European citizens. The stubborn persistence of slow economic growth, high unemployment and steep income inequality disturbs many. Climate change, disruptive technologies, cyber-espionage, a demographic time bomb – the list of frightening developments seems endless.

But on the brighter side: We have ever-lengthening life spans, the lowest hunger and poverty levels in human history, and the highest literacy rates. Our scientific knowledge, cultural interchanges and international trade have grown as never before. Our ability, with robust public institutions and a vibrant civil society, to organise industry, technology and people to do the right thing has never been stronger – even if our will to do so often falls short. We do, as Charles Dickens put it, live in the best of times and the worst of times.

How will this story turn out, for the world and for Europe, over the next 20 or 30 years? Of course, we cannot know today. But we can create options – new sources of technology, wealth or wisdom to cope with whatever may happen. Options permit a company to adapt, employment to adjust, the environment to recover, a city to stabilise. Options are what a government needs to manage a crisis effectively. Any policy maker, with the foresight to imagine nightmares or dreams for tomorrow, will want to take steps that maximise options today.

And that is one of the primary roles of research and innovation: To create and enable options for society. This report summarises a range of realities we might be facing in the 2030s, and suggests ways research might create options to cope and flourish. We could be facing a fragmented, fractious future, with hostile nations, class warfare between rich and poor, and a workforce hollowed out by technology. Or, we could be enjoying a peace in which we strengthen supra-national structures to resolve disputes, harness technology to create jobs, and manage our planet to support an educated, fulfilled population.

Our policy choices will decide which scenario proves closest to the truth – but, again, the options before policy-makers at each step along the way will be shaped by the tools they have available. Will they have the technology to feed and provide energy to growing cities, without risk of climate-induced flooding or desertification? Will they have the medicines, treatments and preventive measures to prolong productive lives at reasonable cost, or will their health systems be bankrupt by an ageing, ill and increasingly distressed population?

Research and innovation are about creating solutions, opportunities and options – across the entire economy. Agriculture, health, justice, monetary policy, the economy, manufacturing, resource management: There isn't a single sector of EU and member-state policy that would not be aided by more and better options. Drafting a new Framework Programme, an exercise on which the EU is about to embark, is thus not a narrow issue of how to spend R&D money; rather, it is a process of agreeing on a common vision of the problems we may face, the opportunities we could seize, and the tools we will need for either eventuality.

Of course, we know which outcomes we would prefer – in fact, they are codified already in the Sustainable Development Goals of the United Nations, to which EU members and most other nations in the world committed themselves in a 2015 UN resolution. These 17 goals are high-minded: end hunger and poverty, assure clean water and sustainable energy, reduce inequalities and promote justice, ensure healthy well-being and inclusive education for all. All of these goals are, already, reflected in one way or another in EU policy and that of the member-states. Through Horizon 2020, researchers are working to keep the oceans alive and the air clean, to make the electricity grid more efficient and energy-generation carbon-neutral, and to help doctors target treatments to the individual and researchers move their ideas faster to market.

The Sustainable Development Goals are reflected in the positive scenarios in this report, and, by their absence, in the negative scenarios as well. The negative scenarios ate characterized by the perseverance of trends and of the basic principles and structures of our economies and societies, leading to contradictions, crises and turbulence. The positive change scenarios depict what might happen if, as a society, we consistently acted on our values. In these scenarios, we work towards the Sustainable Development Goals. Our leaders act wisely, in the interest of all people. In Europe and globally, we work together. And, due to the fruits of research and innovation, we have the necessary tools to act effectively. In these scenarios, we see Europe as a moral, social and technological leader – punching well above its weight on the world stage, even as its share of global population diminishes.

A Turbulent tomorrow: The 'perseverance' scenarios in short

By the 2030s, Europe's population is ageing and shrinking, while immigration pressures rise from younger, poorer neighbours. A generation gap, between the many retired and the fewer working, widens. Health problems multiply, but the rich have better access to new medicines and care than do the poor. More people crowd into sprawling, polluted cities. Technology is rushing ahead, changing the way we work and live; but it mainly benefits the biggest companies with the top labs, most patents and best distribution and supply chains. Small companies have trouble breaking through, and many people struggle to make ends meet in the 'gig' economy. Despite their green promises, governments never managed to act decisively to prevent climate change, and the effects are visible: conflicts and critical shortages in resources. Europe, no longer a leader in the world, is just one among many unhappy voices.

Inequality is the key word, here – and a failure of our leaders to make the right choices, develop the right technologies, and work together within Europe and across the globe.

Transition to a better age: The 'change' scenarios, in short

By the 2030s, Europe and the world have made progress towards the UN Sustainable Development Goals. A rapid switch to low-carbon energy is reducing the risk of climate change, and society is adopting the models of the circular economy: Recycle and re-use, rent and share rather than buy and toss, design for sustainability. A new social contract, funded by resultant productivity gains, provides a basic income and a 'social budget' for all. Living a productive, healthy 100 years is growing common, as healthcare now prevents and manages disease holistically, and regulation permits a healthier work-life balance. Education, digital job markets and productivity-enhancing technologies create new work opportunities. The growing cities have become laboratories of good governance, and transport is more efficiently organised. All this has made society, and the world at large, more secure.

Fairness is the key word, here – and the ability of our leaders to make the right choices, develop the right technologies, and work together within Europe and across the globe.

In the scenarios, we have suggested several areas in which research and innovation could help us find new solutions to old problems. The migrant crisis: Let social science tell us, from evidence, what policies are best at integrating a new population. Financial market crises: Can data analytics and economic modelling find better ways to manage the economy? Ocean life is choking on pollution: Find a cheap, safe way to clean the water up. The climate is warming: Figure out how to manage the grid, expand solar and wind power, make nuclear energy safe. The demographic time bomb of ageing: Invent tools for people to keep themselves healthy, prevent disease, and work longer. Unemployment: Use the Internet to match jobs and people, and devise forms of automation that can create, rather than destroy, jobs.

These and any number of other possibilities one can list fall into three categories of research and innovation. First, we must find novel solutions for the challenges identified as critical to Europe's future ("solutions-oriented R&I"). Second, we often lack knowledge of the challenges we face, and thus need research to better understand them ("understanding-oriented research"). Third, we must explore scientific frontiers to make society more resilient in the long term ("frontier research"). The EU Framework Programmes, as many Member-State programmes, are already organised along these lines – so that is a good sign for the future.

But it is not our intention here to propose any specific policy or project. Rather, the point is simpler: Let research and innovation invent opportunities for society. Indeed, this idea is first in our list of basic principles for research and innovation that emerge from our scenarios:

- **Build resilience by developing options before, rather than after, a crisis strikes:** As climate or security crises mount, we will face more difficult policy choices: nuclear or not, geo or bio engineering, collective security or individual privacy. The history of technology is full of ideas that were tried and rejected, and then revived and made to work by a later generation that needed them to solve some urgent, unexpected crisis. Whatever policy choices we make today, they should not cut off or otherwise restrict research and innovation that could provide answers for tomorrow and make our world more resilient to crisis.

- **Experiment in real world settings**: The level of the challenges faced, the complexity of the transitions that need to happen, and the speed of change in innovation will force our leaders to make major decisions fast, with little information and great uncertainty. How will they know which solutions work, and which do not? Experimentation, rapid prototyping and testing solutions need to become an important part of policy everywhere.

- **Learn from the best:** Right now, in policy areas from agriculture to security, there are hundreds of social and technological experiments going on across the EU regions and cities. Each, from Apulia to Lapland, has its own strengths in individual sectors, successes in social inclusion, new ideas to improve city life or gender equality. The rest of Europe can learn from these best-of-class models – but it takes systematic research to identify them and figure out which of their features can be transplanted elsewhere.

- **Get the governance right - inclusiveness and fairness as policy principles:** Developing great technology requires both support from the public sector and appropriate regulation of the private sector. But it especially needs support from the citizen. Increasingly, people are concerned about technology (will this new thing harm me or my job prospects?). They also expect much from it (will they invent a cure for my disease?). This trend will reshape the relationship between technology and government in fundamental ways. Medicines regulation will get faster. Product and substances regulation will get more thorough. Scientific equipment will be more regulated; after all, gene-editing kit can be used to make pathogens as well as medicines. More and more, the people affected by these technical questions will want to have a stronger voice in the decisions. As a result, in this century, a major challenge of government everywhere will be devising the right ways to make policy for and regulation of innovation and technology more inclusive, more participative and fairer in its societal outcomes whilst promoting a vibrant innovation ecosystem.

- **Look to the cities as laboratories:** As outlined in the scenarios, cities – big or small – are where most of our citizens, opportunities and challenges will be found in this century. Each one is unique. That means each one can be a laboratory for policy, technology, social cohesion, employment and more. Result: With hundreds of simultaneous experiments in the future underway, we can more quickly identify the right solutions and scale them up across the EU. Planning research and innovation should take this local dimension into account.

- **Connect and collaborate, across sectors:** There are no islands in policy. Our scenarios cut across each other, with synergies and trade-offs. For instance, we will not get a digital society or a liveable city if we do not have security. We will not have healthy citizens if we are still using 19th century fossil-based energy. Research and innovation, across all sectors, can help find ways to resolve seemingly intractable problems.

- **Be open:** Openness improves quality and productivity in science and technology; it does, as well, in public policy outside the lab. The spread of open data and e-government can improve public administration. Scientific collaboration with other nations can spread to collaboration in regulation, trade, education, energy and other seemingly disparate policy areas.

Science, technology and innovation have been the basis of many of Europe's greatest achievements, and continue to be fundamental to its performance in the world. Whichever scenario prevails, we will need strong universities, laboratories and technology-based companies. That will require a step-change in the levels of investment we deploy; the EU has yet to hit its oft-stated goal of spending at least 3% of GDP on R&D (we have been stuck below 2% for years.) As we invest, we should continue betting on R&D with the greatest potential impact, but also recognise that is affected by the framework conditions: market regulation, the skill of the workforce, the supply of capital and more. And as we invest, the scientific and technical community must be sure that what it does is, and is seen as, responsible – for society at large. Responsible research and innovation are watchwords.

These characteristics can, operating together, ensure our science and technology base is strong, flexible and responsible enough to build a better future. It can spark an innovation revolution that is Europe's to lead.

1. INTRODUCTION

1.1. The BOHEMIA scenarios and EU R&I policy

The world is becoming steadily more complex, more challenging and also more insecure. Global megatrends unfold pulling the world in directions that seem beyond Europe's control. "The human race is growing older and richer with a growing middle class and widening inequalities. Managing scarcity of resources becomes an increasing challenge, with rising energy consumption and shifting patterns of production. The interdependence of countries, now a fact of global life, is not matched by strengthening global governance. The world order becomes more fragile and unpredictable. A revolution in technologies and their applications transforms societies in almost every aspect. Digitisation is the invader and radical, disruptive change the consequence. Economic weight and political power is shifting to Asia. Sustained development of the world economy is becoming more vulnerable to challenges and to weaknesses in the globalisation process"[1].

In this context the BOHEMIA scenarios help illustrate possible policy responses to sets of challenges and opportunities that may arise. They are informed by the growing literature on megatrends, future technologies and challenges for research and innovation systems and policies. But they are not a mere literature review. Rather they are narratives that bring to the fore concerns of policymakers and analysts involved in discussions of future European policy. In the process of writing those scenarios the BOHEMIA study team has interacted extensively with Commission services, in particular in two workshops with the Commission's network of foresight correspondents, as well as with experts in the different domains and with stakeholders in EU R&I policy.

OECD describes megatrends as large scale changes which are slow to form but once they have taken root they exercise profound influence on many human activities[2] Megatrends are powerful but they ultimately result from the actions of people and are therefore amenable to influence. Furthermore, Europe and the world can face megatrends strategically, pursuing objectives and priorities within its reach, while improving its position and the livelihood of its citizens by developing capabilities to reach objectives that may currently seem out of reach. For this Europe needs Research and Innovation (R&I). R&I have been and continue to be fundamental for Europe's performance in the world[3]. R&I have been the basis of two thirds of economic growth in Europe between 1995 and 2007[4], and R&I investments are known to deliver rates of return that range from 20% to much higher multiples, especially if social returns are counted.[5] But Europe is not alone in investing in R&I. In fact as investment in R&I grows globally at a rapid pace, Europe's investment has been in a steady state, accelerating thus its losing ground and weight in the global scene.

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[1] See ESPAS (2015), p. 7

[2] OECD (2016)

[3] According to Kaiser and Schot (2014) technology has been foundational even for the process of European integration

[4] See Nesta (2013)

[5] See Hall et al (2009) Haskel et al (2014) Fougeyrollas,et al (2012)

Gross expenditure on R&D as a percentage of GDP

Data Source: Eurostat
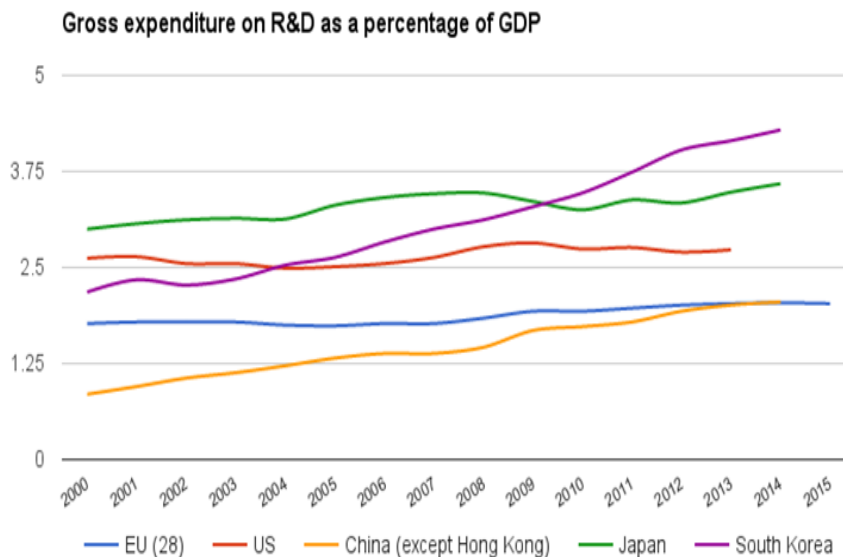
Another condition is progress in building unity amongst the countries of the European Union and amongst the people of Europe, towards shared objectives. The foundation of those shared objectives is reflected in the Treaty of the European Union.

Foundations and Aims of the EU as enshrined in the Treaty of the European Union

Article 2

The Union is founded on the values of respect for human dignity, freedom, democracy, equality, the rule of law and respect for human rights, including the rights of persons belonging to minorities. These values are common to the Member States in a society in which pluralism, non-discrimination, tolerance, justice, solidarity and equality between women and men prevail.

Article 3

1. The Union's aim is to promote peace, its values and the well-being of its peoples.

2. The Union shall offer its citizens an area of freedom, security and justice without internal frontiers, in which the free movement of persons is ensured in conjunction with appropriate measures with respect to external border controls, asylum, immigration and the prevention and combating of crime.

3. The Union shall establish an internal market. It shall work for the sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment. It shall promote scientific and technological advance.

It shall combat social exclusion and discrimination, and shall promote social justice and protection, equality between women and men, solidarity between generations and protection of the rights of the child.

It shall promote economic, social and territorial cohesion, and solidarity among Member States.

It shall respect its rich cultural and linguistic diversity, and shall ensure that Europe's cultural heritage is safeguarded and enhanced.

4. The Union shall establish an economic and monetary union whose currency is the euro.

5. In its relations with the wider world, the Union shall uphold and promote its values and interests and contribute to the protection of its citizens. It shall contribute to peace, security, the sustainable development of the Earth, solidarity and mutual respect among peoples, free and fair trade, eradication of poverty and the protection of human rights, in particular the rights of the child, as well as to the strict observance and the development of international law, including respect for the principles of the United Nations Charter.

6. The Union shall pursue its objectives by appropriate means commensurate with the competences which are conferred upon it in the Treaties.

1.2. Methodology: key scenario choices

The EU aims and principles, and the commitments to the United Nations Sustainable Development Goals (SDGs) provide a strong normative direction that influenced the methodological choices of the study. The SDGs represent global commitments undertaken by all EU Member States, in the context of the United Nations. They are fully in line with the values of the EU as described in Art 3 of the Treaty of the EU, and represent important opportunities to reduce world-wide inequalities and risks of environmental catastrophes, and to manage effectively the challenges thrown up by the global megatrends. The normative context of the scenarios is shaped by the objectives of a strong Europe and by the directions set by the SDGs.

The normative meta-scenario framework of BOHEMIA
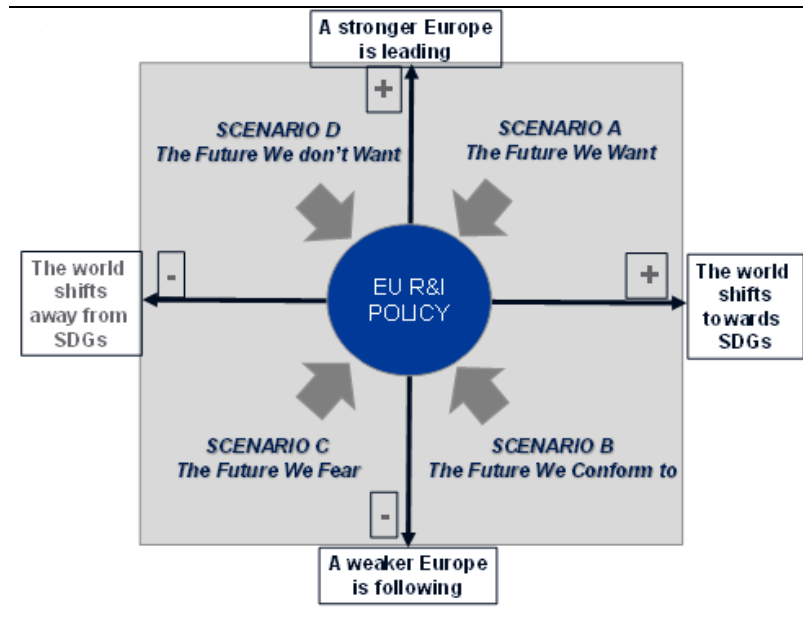
As the global context moves towards or away from the SDGs, the ability of the EU to fulfil its aspirations and those of its citizens requires different strategic choices. To map out the areas of strategic choice we explore two types of scenarios:

a) 'perseverance scenarios', in which the future is driven by megatrends and the basic principles and structures of operation of our economies and societies reside remain stable; and

b) 'Change scenarios', in which the EU leads the transformations to 'the future we want'

The scenarios build positive and negative images of the future in order to highlight desirable transitions from situations that lead to crises because of increasing external risks (as scenarios C and D in the above figure) and/or because of internal weaknesses (as in scenarios B and C in the above figure), to situations that mitigate, adapt to, and overall avoid crises. These ate the 'change' scenarios that correspond to scenario A in the above figure.

The choice of scenarios areas has been based on first and foremost an analysis of the relationship between megatrends and the sustainable development goals. Megatrends are large scale changes which are slow to form but once they have taken root they exercise profound influence on many human activities[6]. There are a number of analyses of global megatrends that provide overlapping but somewhat different lists. The EEA has developed a list of 14 Global Megatrends[7]. The OECD[8] describes megatrends affecting science, technology and innovation in the areas of natural resources and energy, climate change and the environment (the Biosphere), globalization, roles of states (Governance) demography, economy, jobs and productivity, society, health and well-being (Social Needs). In the context of BOHEMIA we consider accelerated innovation and urbanization to

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[6] OECD (2016)

[7] EEA (2015)

[8] OECD (2016)

be megatrends in their own right[9], which have extremely important implications for the ways in which the challenges and opportunities of the future across the board, will be managed.

Using this framework, scenarios have been prepared as follows:

- Governance: Global political and socio-economic context

- Biosphere: Climate and Energy / Environment and ecosystems resources and services

- Social needs: Health/ Security and resilience

- Key drivers of change: Accelerating Innovation: people and tech-convergence /Towards a world of cities

The choice of scenarios enables a highly aggregated picture of future developments that captures the main sets of future risks and opportunities, and enables us to think about important transitions for the future in Europe and the world, in a small number of narratives. One consequence of this choice is the loss of potentially important detail. We cannot claim that these scenarios cover all important future risks or all important desirable transitions or all important factors and forces at play. We cannot claim that they cover all important variants. In fact, we believe that more focussed and more detailed scenarios (for example on ways of eliminating hunger and improving food and nutrition) can provide better strategic insights for the many transitions that need to happen for the world to achieve sustainability. However, we believe that between them the 7 scenario areas cover important concerns relating to all SDGs, and to the potential of EU policy and R&I investment to enable important transitions for Europe and the World. This is presented in the figure below.

The BOHEMIA scenarios' space and the SDGs
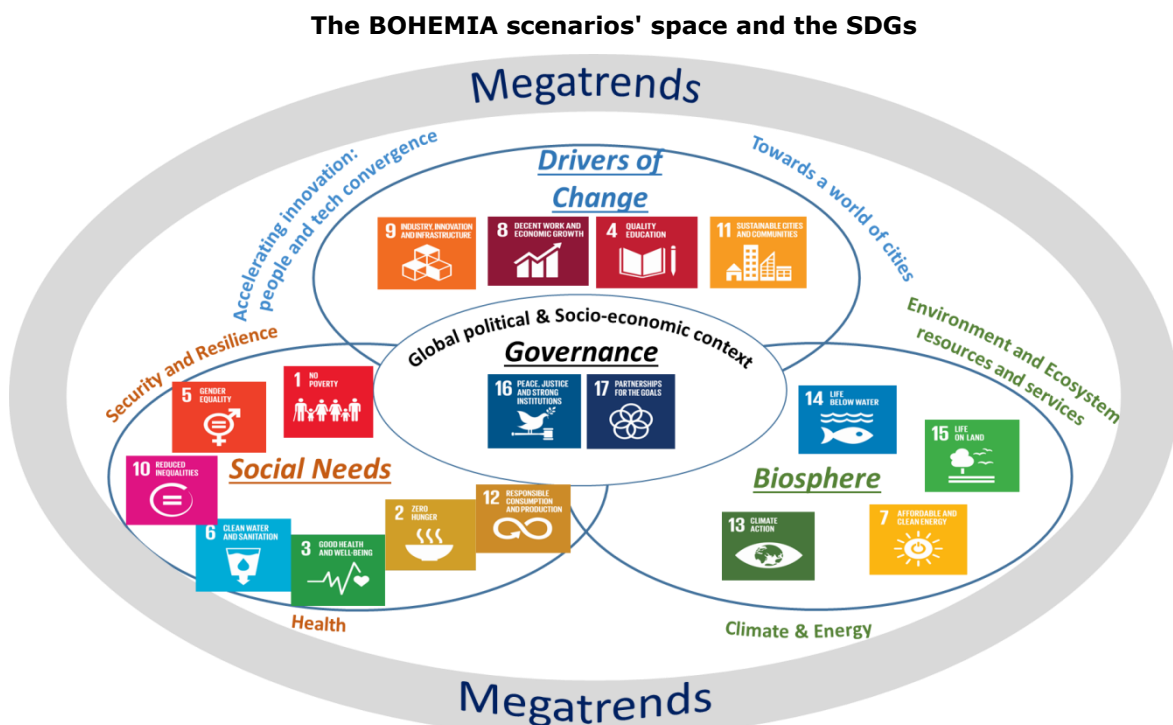
In the figure above each circle represents a category of megatrends containing a set of SDGs. The titles of the scenarios are represented by the curved writing. The representation helps to quickly assign a primary character to each scenario. At the same time the scenarios developed do not entirely cover the scenario space. For example, while health and security and resilience are very important social needs[10], they do not cover social needs related to food and nutrition security, eliminating poverty and hunger, equality, sanitation and water, inequality and sustainable production systems are not really covered in these scenarios. These issues are however covered by scenarios that are primarily assigned to the other three spaces. The inter-penetration of spaces, be

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[9] Following EEA (2015), OECD (2016) considers technological change separately and urbanization as part of the general demographic trends.

[10] See Eurobarometer (2014) and EPSC (2016b)

they individual scenarios or categories thereof, is also a characteristic of the world of policy and the world of Research and Innovation. This is important as fundamental disruptions tend to happen when different scenarios collide and/or merge. These disruptions as opportunities to "do things differently" need to be highlighted throughout the follow-up of this initial exercise.

1.3. Underlying assumptions: the futures we take for granted

Even though we argued that megatrends can and should be approached strategically, they are strongly resilient. As they unfold in the near and medium-term future there are some aspects which we take for granted[11]. Principle amongst this is demographic forecasts. Forecasts on the growth of world population and demographic ageing have a high degree of reliability. Although important changes may happen, for example, because of catastrophes or improvements in the human condition and medical practice, we consider the trends and the forecasts on concomitant pressures to be reliable. This extends to forecasts about the rise of urbanization and migration. Whilst their incidence and impact in Europe would strongly depend on policy, at the global scale the phenomena will continue to rise. Another set of forecasts that we consider reliable concern the acceleration of the expansion of human capability through technology. Whist there is a debate on exactly what the phenomenon is, the continuous increase in human effort to create new technology and knowledge, and the continuous increase in the efficiency of this effort, through the use of largely digital technology, produces what we observe as accelerated change and innovation. A third set of megatrends that we take for granted concern globalization. We assume that globalization will continue to advance, and that the OECD forecasts of the shift of the centre of the global economy towards the far East is reliable. However we see the mechanisms of globalization shifting from the movement of goods to the movement of people and information[12]. We see a new impetus to globalization coming from the realization that there are serious global problems that can bring crises to many countries but that cannot be handled by any individual country. Principle amongst these is global climate change, and the broader deterioration of the biosphere. It is the interdependence between human settlements and the planet that drives a globalization process of a new kind, that demands inclusiveness[13] and is expressed in the SDGs.

These assumptions about the future are painted in more detail in the scenarios of the global political socio-economic context. The first one titled "turbulent transitions" draws a picture of challenges raised by such assumptions, while the second one titled "transforming our world for the better" illustrates the promise of the SDGs as a framework for managing the future risks posed to political, economic and social systems. R&I is of key importance for pursuing the SDGs, for designing and managing transition processes, and of course, for providing solutions to problems generated in the transition processes.

These become more apparent in the scenarios focussing on key aspects of the biosphere, social needs and key-drivers of change. In particular, in the context of the biosphere, scenarios focus on systems that need to change for achieving the SDGs, associated with i) climate and energy ("climate calamity" and "low carbon transition"); ii) environment and ecosystem resources and services("the age of overexploitation" and "towards a new wellbeing"). In the context of evolving social needs, scenarios are developed for health ("health divide" and "towards health for all") and for security and resilience ("racing threats" and "building societal security"), two sets of rapidly rising concerns of people in the EU and beyond. The discussion of drivers of change focusses on scenarios on accelerating innovation: people and tech convergence ("losing the race against the machine" and "the innovation revolution for everyone") and on the urbanisation megatrends towards a world of cities ("urban jam" and "new models of urban development") which is where global problems find local solutions and where the new sets of global problems will originate from.

The contrasting narratives are meant to illustrate desirable and/or necessary transitions and to explore policy options that could enable and support those transitions. Those transitions frame market creation processes in which R&I are of critical importance. The narratives themselves provide the backbone of the discussion of policy options and recommendations in the concluding outlook of this report. This starts with a discussion of the global context a as a window of opportunity followed by for a scenario for strong Europe, which combines a discussion of general characteristics of the scenario narratives on desirable transitions with the political priorities of the

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[11] Here we follow ESPAS (2015)

[12] See WEF (2015)

[13] See e.g. the issues for discussion at next WEF, https://www.theguardian.com/business/2017/jan/14/davos-issues-trump-capitalism-china-brexit

Juncker Commission, and leads to some general conclusions on important elements of an EU R&I strategy that is needed to enable and support the desirable transitions.

2. GLOBAL POLITICAL AND SOCIO-ECONOMIC CONTEXT SCENARIOS

2.1. Turbulent transitions

It is now 2030. The persistence of current economic, political and societal trends has led to an increase of systemic risk and to frequent turbulent transitions. Globalization has been advancing in unsustainable and non-inclusive directions. The world has become more fragmented. The importance of non-OECD economies in the world economy has continued to rise, with expanding global supply chains and growing inter-linkages among trade and investment partners. Fiscal consolidation pressures, financial shocks and environmental degradation and catastrophes have imposed heavy costs on countries, compounding the social effects of income inequality. Resource and security concerns led to protectionism and efforts to secure strategic supplies, while free trade areas across the planet, with their different levels of economic integration, still face internal turbulence.

Source: ESPAS report, http://ec.europa.eu/epsc/sites/epsc/files/espas-report-2015.pdf
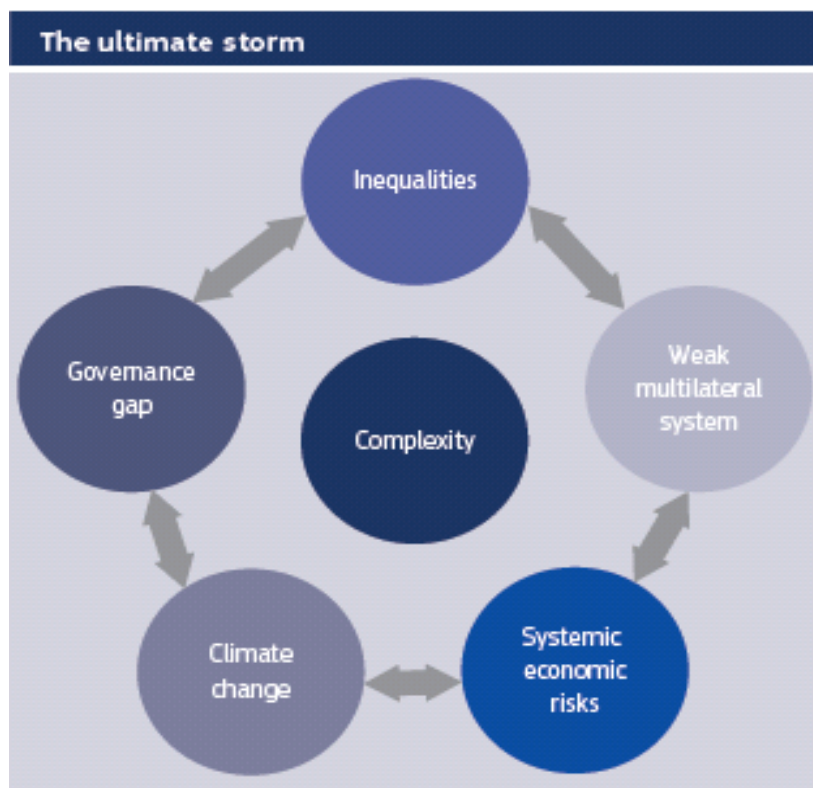
The key characteristic of recent trends has been a continuous rise of the risk of environmental and human catastrophes. Climate change is still making the planet a more insecure place for the human species. And population, social, political and economic trends have been fuelling conflict and human misery. Disparities in the gross domestic product (GDP) per capita have narrowed, and may continue to narrow across countries, but inequalities continue to grow within both developing and developed countries. Rising wealth and income in the developing economies is shaping a global middle class[14], but significant gaps in living standards remain between advanced and emerging economies as well as between them and the least developed countries. In contrast within the

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[14] By current projections, the global economy's middle class is expected to more than double between 2009 and 2030, from 1.8 billion to almost 5.0 billion, accounting for about 60% of the world population. Some two-thirds of those middle-class citizens are expected to be found in Asia.

majority of developed countries inequality and poverty rates increased between the mid-1990s to the 2010s. Particularly at risk were young adults, who make up an increasing share of the poor[15].
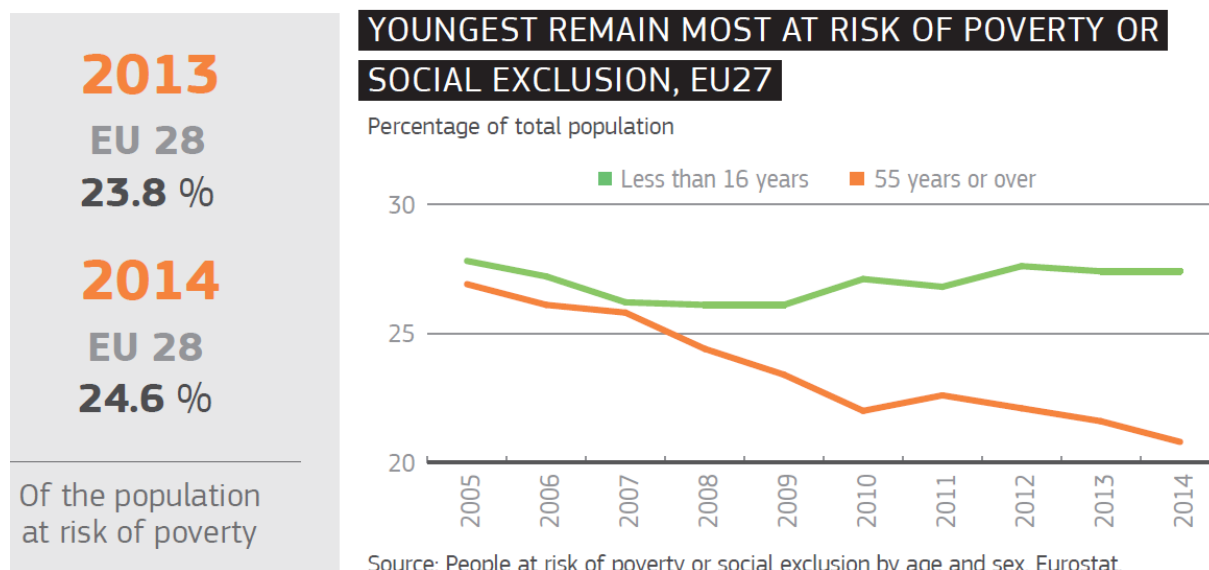
Source: From Trends to Policy https://ec.europa.eu/epsc/publications/other-publications/eu-2016-trends-policies_en

The world's population has continued to grow during the 21st century, though at a slower rate than in the recent past. Following the predictions of the UN's 2015 medium-variant projection, the global population reached 8.5 billion and is on course to reach 9.7 billion by 2050. Growth has been coming almost entirely from less developed countries. Africa accounts for more than half the increase in global population between 2015 and 2050. Population size in much of the developed world has stabilised and in some countries it has begun to fall.

Some developing countries have been experiencing substantial youth bulges. The number of youth aged 15-24 years is growing rapidly in Africa has increased by 42% since 2015 and is projected to more than double by 2055[16]. The Middle East is home to more persistently youthful countries. A high proportion of working-age adults could offer these countries an economic boost. However, these countries have been among the poorest, struggling to provide educational and employment opportunities for their young people. A reservoir of disaffected young people with low education and few job opportunities has been fuelling political and social instability.

Low fertility rates across much of the developed and, increasingly, developing world, notably in Japan and much of Central and Eastern Europe, has led to falling populations which are expected to fall by more than 15% by 2050 (as compared to 2015). At the same time, life expectancy at birth continues to rise and is projected to reach 83 years in more developed countries by mid-century and 75 years in the less developed regions. **Ageing population continues to be the future in all major regions of the world.** In 2050, there will be almost complete global parity between the number of over-60s and the number of children. Ageing has significant implications for life-styles and the types of products and services in demand. The prevalence of non-communicable diseases and increased disability among the elderly burdens healthcare and other services.

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[15] See McKinsey Global Institute (2016)

[16] See UNDESA (2015)

Projected World Population until 2100 (in Billions)
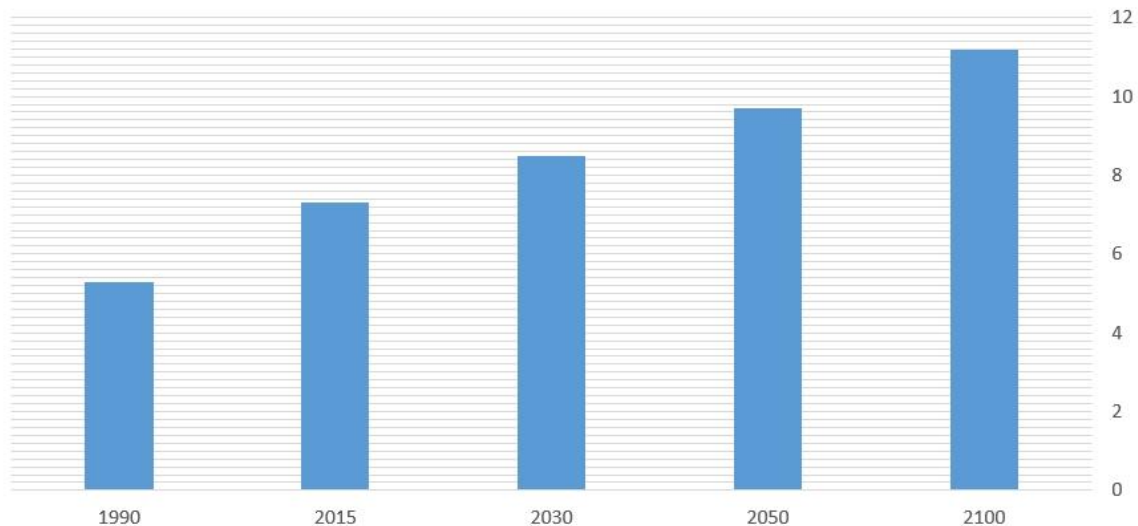
Data Source: United Nations Department of Economic and Social Affairs

The size of the working-age population (15-64) has begun to diminish in many parts of the planet. The ratio of working age population that provides social and economic support to dependent population (i.e. children under 15 and persons over 65 years of age) has been falling. The problem has been partially addressed through increasing the retirement age in several countries. Still, old-age dependency ratios are reaching very high levels in some OECD countries – 70% in Japan and over 60% in Italy, Korea, Portugal and Spain by 2050[17]. **Fiscal pressures have given rise to inter-generational conflicts[18].**

While the ability of elderly citizens to remain active and continue working beyond official retirement age has been increasing, this alone has been insufficient for meeting workforce shortages. Technological change is an important factor. Robotics and artificial intelligence have been contributing to reducing the demand for migrant workers' labour and skills, while enhancing the ability of people to work longer in their lives[19].

Nevertheless, **youth bulges in parts of the developing world continue to create outward migration**: lack of employment opportunities and growing risks of internal conflict force many to seek better lives and safety elsewhere. Inflows of migrant workers continue to be important for most OECD economies[20]. Climate change also has more of an influence on international migration flows. Existing diasporas in developed countries continue to facilitate migration and settlement of friends and family from the less developed world[21].

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[17] See UNDESA (2011) Without international migration, the working-age population in developed regions would decline by 77 million or 11% by 2050; the situation in Europe is even more severe, where the size of the working population would decline by 20%.

[18] See USNIC (2012)

[19] For example through increasing physical and cognitive capacities.

[20] See Westmore (2014)

[21] See EUISS (2012) Migratory movements show no sign of slacking, as the long drawn-out conflicts among other places in North and sub-Saharan Africa and the Middle East drive people to seek safe havens in Europe, and income and wealth disparities across the globe continue to attract people from poorer to more prosperous countries. Many, of course, bring qualifications and skills with them. In the decade to 2010/11, for example, the number of tertiary educated immigrants in the OECD increased by 70%, to reach 27 million. All the signs point to a further strengthening of factors pushing and pulling migratory flows in the decades to come.

Age structure of immigrants by citizenship, EU, 2014
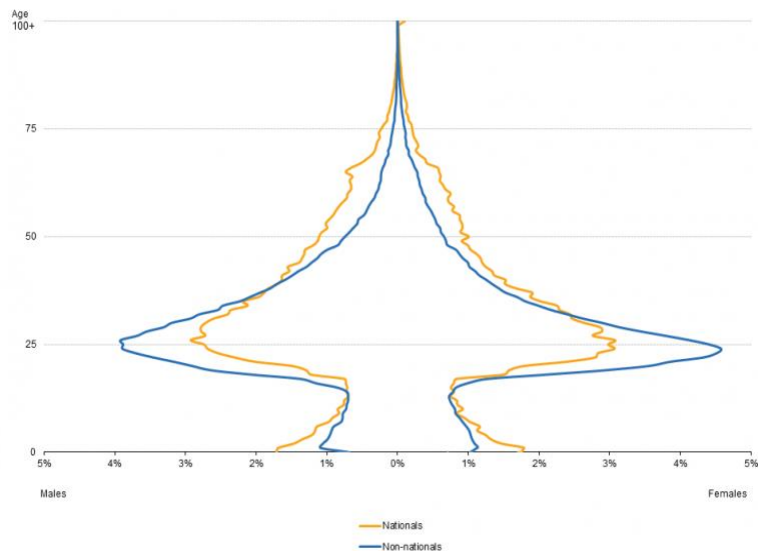
(*) Excluding Slovakia. Bulgaria and Poland: provisional.

Source: http://ec.europa.eu/eurostat/statistics-explained/index.php/Migration_and_migrant_population_statistics

International migration, while contributing to solve anticipated labour and skills shortages in receiving countries, has increased the size and importance of ethnic minority communities. Some of these continue to be poorly integrated and economically disadvantaged, leading to further tensions and instability[22], often reinforced by diverse values, cultures and religious belief systems. This will make it more difficult for governments to win support for more open and forward-looking immigration policies[23]. **Immigration is challenged by inequalities**: in host societies with shrinking middle classes, openness is perceived as a threat to well-being and job security. Faced with rising populism some governments use migrants as scapegoats for existing social problems[24].

Can science help immigrants feel at home?

As immigration rises, a serious policy question is how best to ensure participation of the new arrivals in society. Maurice Crul, a researcher at the Free University of Amsterdam, received a European Research Council grant to help answer that question.

So far, his research group found in studies across nine EU countries that enrolling immigrant children in school before age 6 – and in mixed classes – is especially important, providing them a base in both their old families and their new countries. "What we learned is that the children who are successful are those who live not just between cultures, but in two cultures at the same time," Prof. Crul wrote recently in *The Guardian* newspaper[25].

The growing maturity and convergence of digital technologies have had far-reaching impacts on productivity, income distribution, well-being and on the environment. Impacts have varied across industries, countries and sections of the workforce[26]. **Firms are predominantly digitalised**, enabling product design, manufacturing and delivery processes to be highly integrated and efficient. The Internet of Things, big data analytics, artificial intelligence and machine learning tools have enabled the emergence of smart machines, increasingly adjustable through sensor technologies, cheap computing power and the real-time use of algorithms.

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[22] See UK MoD (2014)

[23] See ESPAS (2015)

[24] See EUISS (2010)

[25] See Crul (2016)

[26] See DASTI (2016)

The decreasing cost of computing power and other advances in digital technologies have been a source of disruption for labour markets[27]. Advances in machine learning and artificial intelligence continue to expand the capabilities of task automation. Large parts of the workforce have been made redundant and need to be retrained. **Hyper-scalability of business ventures intensifies competition and leads to frequent radical job-shifts across the globe. Structural unemployment has become a permanent feature of most national economies even in the developed world[28].** The "gig economy", in which an increasing number of workers have to perform a variety of different part-time jobs, continues to grow[29].

World population and number of connected devices
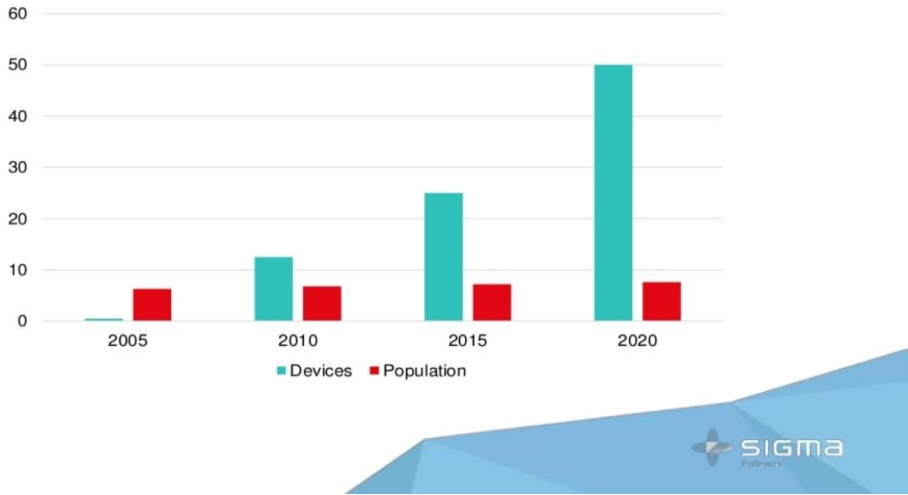
Source: Sigma Software

We have been witnessing an eastward shift of the economic centre of gravity of the world economy. Developing countries currently contribute two-thirds of global growth, half of global output, and are the main destinations of world trade. Considerable changes have taken place in the relative size of the world's major economies over the last 15 years. The top economies are United States and China, while the European Union and India compete for the third place[30]. Mexico, Indonesia, Turkey, Nigeria and Vietnam[31] are amongst the new large economies. **China and India have seen their combined GDP surpass that of the Group of Seven (G7) economies.** They are set to overtake that of the entire current OECD membership by 2060[32].

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[27] See Brynjolfsson and McAffee (2012) OECD (2015)

[28] See EPSC (2016a)

[29] See DASTI (2016)

[30] See Gros and Alcidi (2013)
[31] See ESPAS (2015)

[32] See Johansson et al. (2012)

OECD Projections of the global distribution of GDP from 2011 to 2060

Shares of Global Middle Class Consumption, 2000-2050
(Source: OECD)
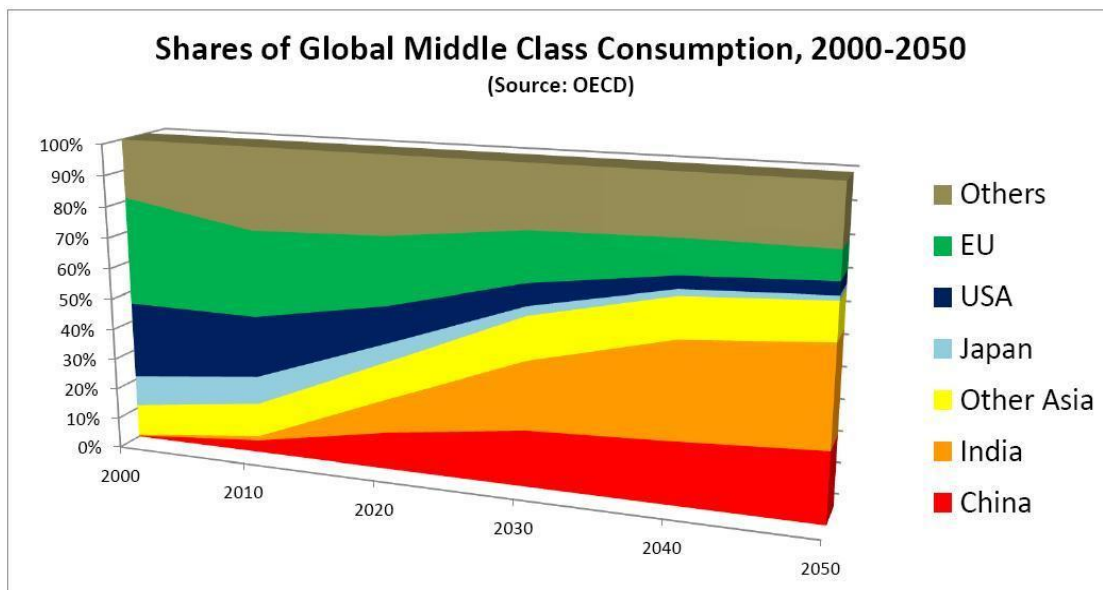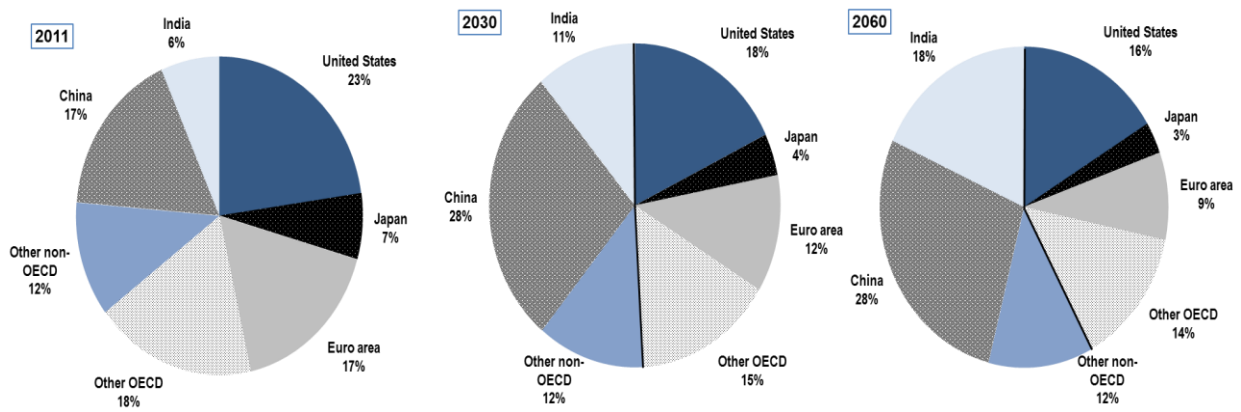
The changing geographical distribution of power has been accompanied by changes in the features of power. **A growing list of emerging states has been looking to translate their economic gains into more meaningful global influence.** Europe and other developed regions are finding themselves less and less in the position of global rule-makers in issues like trade, FDI or IPR. Global governance structures evolve as key groupings take on board the growing presence of some of the new vibrant economies. Non-state actors such as multinational businesses, non-governmental organisations, sovereign wealth funds, major cities, academic institutions and foundations endowed with global reach play increasingly influential roles. In some cases they are instrumental in the creation of new alliances and coalitions that have the wide public support to tackle some of the global challenges facing the planet[33]. Other globalising non-state actors, such as terrorist networks and organized crime, contribute to bring turbulence to the global system.

2.2. Transforming our world for the better

With the adoption in 2015 of the new UN 2030 agenda for sustainable development, the 193 UN member states committed to achieve sustainable development in three dimensions – economic, social and environmental – in a balanced and integrated manner, adopting a system of 17 SDG and 169 targets to trigger and gauge the process of global sustainable development. In 2030, the goals and targets of the agenda are substantially achieved. The world has changed for the better in several areas. Poverty has been eradicated. Inequality within and among countries has shrunk. The SDGs have ensured that preserving the planet, creating sustained, inclusive and sustainable economic growth and fostering social inclusion guide policies across the whole world. National strategies acknowledge that all these issues are linked to each other and are interdependent. They

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[33] See USNIC (2012)

also recognize the importance of regional and sub-regional dimensions, regional economic integration and interconnectivity in sustainable development.[34]

Human Development Index & Ecological Footprint per person for nations
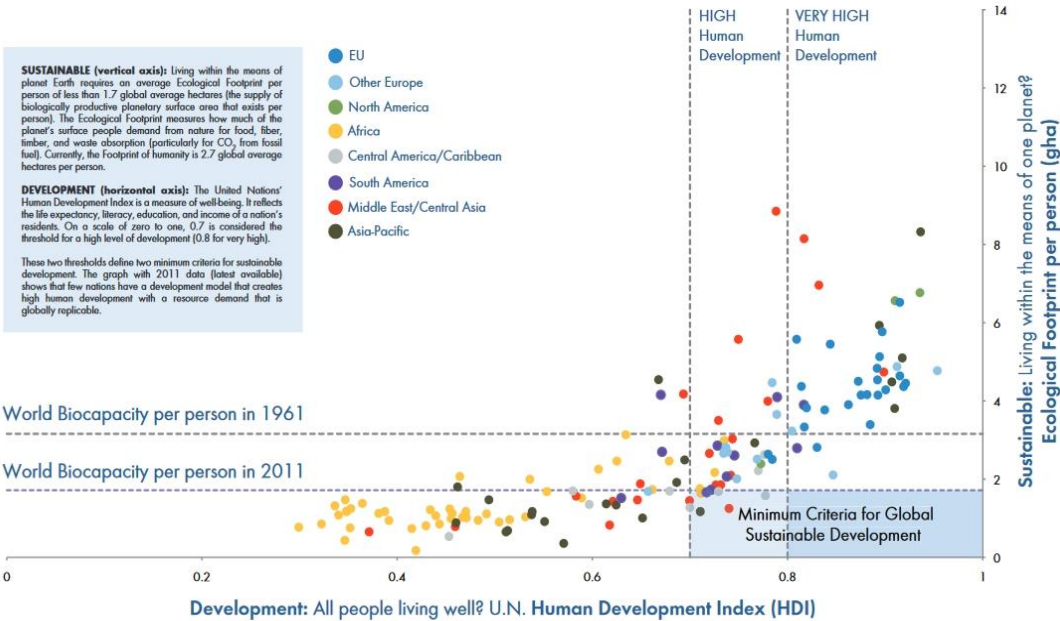
Source: 2016 Global Footprint Network. www.footprintnetwork.org

A core regional actor contributing to the achievement has been the European Union. It has been setting the standards in environmental and social performance worldwide, whilst building its economic, technological, political and cultural leadership of the world on the advantages offered by living sustainably. **Progress down the path of SDG involved a lessening of the differences between Europe and other parts of the world, creating the conditions for a more open EU in a more open world (or, to say it differently, a less fragmented EU in a less fragmented world).** The path has involved changes in living standards, technologies, infrastructures and a host of other conditions, which, in order to take place, required economic activities, investment, production, consumption, and opportunities for innovation, competitiveness, benefit and income. EU leadership has ensured the prosperity of EU citizens, providing important economic opportunities for European players in the world economy.

World inequality index[35]

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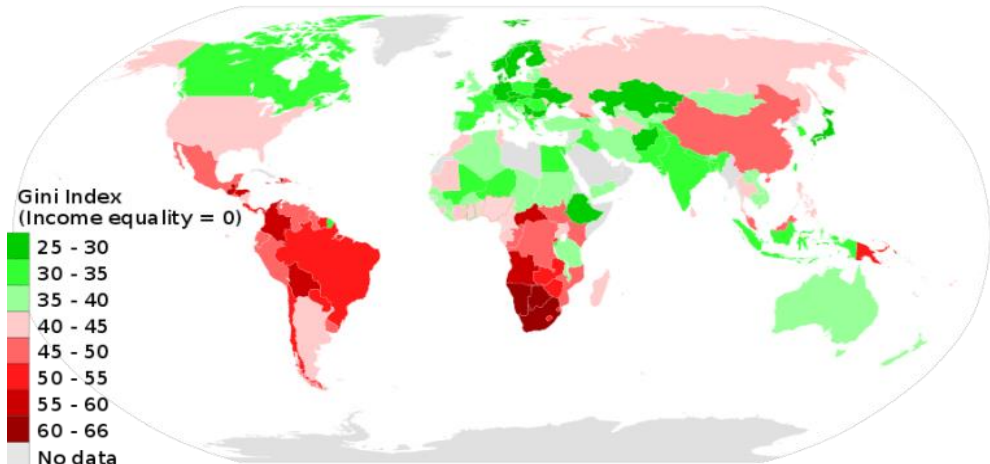
[34] See UN (2015)

[35] See https://en.wikipedia.org/wiki/File:2014_Gini_Index_World_Map,_income_inequality_distribution_by_country_per_World_Bank.svg Created by Tracey Hunter in 2014 based on Table 2.9 of The World Bank: Word Development Indicators http://wdi.worldbank.org/table/2.9

The last part of the 2010's was **a turning point; a transitional period of a 'quest' for a global system that best fitted the sustainability target in all respects – economic, environmental and social[36]**. This was a time for policy action in anticipation of new challenges, to drive change towards a new paradigm able to produce such a better system. The policies were different from simply responding to challenges through quick fixes and ad hoc solutions. Part of the recipe was the understanding that policy alone would not be enough to achieve the transformation required. A truly new system required changes in individuals' behaviour and preferences, which are beyond the control of policy-makers. Political leaders, economic actors and societies have understood the need to share the planet. New purpose-based business models that consider the longer term became profitable. Sustainable and inclusive globalization management led to wide spread, rather than to a concentration of, opportunities and benefits from globalization. Now, sustainability-oriented innovation thrives. People empowerment and social safety nets are accepted as building blocks for the co-created future human society; an established "new humanism" based on European core values.

What if…could new business drive an economy that works for all?

Economy, Society, Environment: A Nested Relationship

An **economy that works for all** must be embedded in society[37]. EPA redesigns sustainability in a **nested** relationship with a *"resilient and robust economy existing within a healthy society dependent on an intact and functional environment"[38]*.

The Stockholm Resilience Centre[39] has developed the sustainability "**the wedding cake**", in which economies and societies are seen as embedded parts of the biosphere, aiming to *transition toward world logic where the economy serves society so that it evolves within the safe operating space of the planet."*

The need to translate the paradigm change into successful business models d raises an array of questions for research, business model innovation and experimentation. What should be the role of business leaders in society? How can we best combine profitability and social purpose in business? How far could not for profit enterprises go into mainstream? How can investment influence the sustainability of our economy? What are appropriate public policy structures, processes, objectives and criteria? These are not questions only for theoretical academic research, but also pertinent questions for policy experimentation.

The global transformation involved two main transitions. The first was a **transition to a sustainable consumption and production system**: the circular economy[40] and the "resource revolution". It was enabled, among other things, by a productive use of ICT to increase the virtualization of economic transactions and the sharing of resources and assets.[41] The second was

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[36] This quest includes all societal actors and business play an important role in it.

[37] Jenkins (2014)

[38] EPA (2014)

[39] Rockström and Sukhdev (2016) [

[40] See Wijkman and Skånberg (2015)

[41] See Heck (2014)

a socially responsible transition to a model of inclusive co-creative development. In this inequalities, potentially induced by technological progress and automation, were reduced through an international agenda combining new growth (mostly sourced from knowledge-based capital productivity[42]) with a new welfare model[43]. This was not about a disappearing European welfare state model that needed to be replaced with something else. It was about a global version of welfare that internalised the values of European welfare states, adapted to the challenges that automation and shrinking labour have brought to social security systems. Equally, this was not only about managing the challenges of ageing, migration and accelerating technology inside the European Union. It was about recognising that those challenges were global, that the SDGs were about addressing those challenges in particular ways; and that Europe needed to lead the way to managing their consequences at a global level. The economic, social and political transformations referred to above, together, have substantially lowered the risks of catastrophes and conflicts underpinned by climate change, over-exploitation, resource scarcity and current trends in world politics. However those risks did not disappear altogether. The SDGs have been an important first step towards a transition that continues to require important improvements in global governance.

World resources for world problems: the custodians of the oceans

Ocean pollution is a huge problem of our biosphere that requires urgent attention. While coastal nations are busy exploiting the Oceans a major international effort is needed to clean the oceans from plastics and other pollutants, and to move towards a sustainable management of marine resources and marine ecosystems. While coastal fishing communities worldwide suffer from depletion of fishing stocks and unemployment, plastic waste accumulates in the sea with terrible consequences for ocean ecosystems. Cleaning up the oceans from plastic has been a controversial project that some say "would bankrupt any government"[44]. While many governments together could finance what "any government" could not afford on its own, a private foundation from the Netherlands is setting off to clean the oceans from plastic, using the natural currents and aiming to recycle the material to finance its operations[45]. Goal 14 of the Sustainable Development Goals is to

"Conserve and sustainably use the oceans, seas and marine resources", including targets of

- By 2025, prevent and significantly reduce marine pollution of all kinds;

- By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans;

- By 2020, conserve at least 10 per cent of coastal and marine areas;

- Increase scientific knowledge, develop research capacity and transfer marine technology.

The transition was driven by political commitments to realize the SDG agenda, and to **deliver high levels of prosperity and wellbeing to the majority of people**. One key contribution to this came from technologies which were mobilized to solve major societal challenges, such as health threats, poverty, gender exploitation and poor education, through direct delivery of information products to individuals. Another key contribution came from **policies for the creation of new jobs and employability[46]**, including programmes of investment in innovation, to increase employment in the short term and productivity in the long term. One crucial area of public investment was education – a highly educated population is a fundamental driver of economic growth. Eventually, all routine work could become automated and human labour increasingly creative and collaborative, and even be and provided on a voluntary basis[47]. Basic commodities and public services could be free and would need to be. Economic management has become primarily an issue of providing public goods (transforming energy into value) and dealing with the consequences of negative externalities – e.g. congestion and stress to "planetary boundaries".

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[42] See OECD (2013)

[43] See Atkinson (2015)

[44] See for example Stone (2009)

[45] See The Ocean Cleanup Foundation (2017)

[46] Programmes for the creation of new jobs and employability would best be geared towards unleashing the imagination and creativity to "invent" new kinds of jobs and needs.

[47] See Fox (2015), Frey (2013)

> **Can the rise of inequality be reversed without economic growth?**
>
> The need for economic growth is often asserted by economists and policy-makers. Economic growth is synonymous to progress and generates optimism that propels actors to produce thereby improving the standards of living of everybody. Without growth, people grow depressed and leave for places of higher promise. Conventional wisdom is that in order to address the problem of non-convergence and increasing inequality in Europe, economic growth is necessary. Economists say that some inequality is needed to propel growth. Without the carrot of large financial rewards, risky entrepreneurship and innovation would grind to a halt. Yet increasing numbers of voices are saying that inequality has reached levels at which it is harmful for economic growth. Over the past generation or two, inequality has risen most in places where progressive policies, such as high top tax-rates, have been weakened. New OECD analysis suggests that income inequality has a negative and statistically significant impact on medium-term growth[48]. Thus the question is not whether inequality can be reversed, but rather whether inequality will be allowed to harm our economies. "We have reached a tipping point," said OECD Secretary-General Ángel Gurría. "Inequality in OECD countries is at its highest since records began. The evidence shows that high inequality is bad for growth. The case for policy action is as much economic as social. By not addressing inequality, governments are cutting into the social fabric of their countries and hurting their long-term economic growth." (quoted in the WSJ May 21, 2015) As The Economist (July 15, 2015) put it "a little more redistribution now might improve the quality and quantity of economic growth—and reduce the demand for more aggressive state interventions later". Businesses have also begun to see inequality as a threat and to understand that addressing inequalities has become an imperative of economic sustainability[49].

A key driver has been the development of a data-driven economy that has been disrupting established businesses and markets.[50] **Evidence of past technological transitions suggests that turning "disruption" into "creative destruction" is essential to fuel long-term economic growth.** However, with the sluggish global recovery, business and policy leaders needed to harness these forces to facilitate structural shifts to a stronger and more sustainable economic and environmental future. Labour markets were affected, as data and analytics enable the automation of an increasing number of tasks. More middle and higher income jobs were negatively affected – as the more expensive the task the higher the incentive to automate it. New jobs have been emerging, especially ones involving either highly knowledge intensive tasks (e.g. solving of unstructured problems which lack rules-based solutions) or non-routine manual tasks. As job destruction and creation processes unfold unevenly between countries, unemployment and social disintegration issues have required management across the world by governments and corporations. **Besides investments and new regulations to facilitate employability and the shift to new jobs and more flexible forms of work, the greater productivity of the economy allows for introducing new forms of social security.** These include flexible social insurance mechanisms that come to terms with a changing labour market, forms of child benefits to foster intergenerational equality of opportunities, and for all adult people forms of basic – or "citizen's'" – income. While more people enjoy more leisure time and lifestyles and individual aspirations are changing (e.g. we have seen a continuous rise of female participation in the labour market), consequences of a citizens income have included changes in the nature of work with a stronger focus on quality work – which has been challenging for existing business models -, and a rise in entrepreneurial activity, as people feel secure enough to embark on risky ventures in the volatile digital economy. Beneficial voluntary activities which create value for society or the environment have also risen[51].

Concerted action has been taken, within and between nations, with strong international collaboration, especially to anticipate and address potentially disruptive effects of the data-driven (digital) economy[52]. In some cases, local action was most appropriate. Local

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[48] See OECD (2015b)

[49] See Lesser et al. (2016)

[50] See OECD (2015)

[51] See Forget (2011)

[52] As proposed by Anthony B. Atkinson in his seminal book Atkinson (2015) a range of anticipatory policies are needed to steer the direction of technological change towards more equality outcomes. A recent study of McKinsey Global Institute (July 2016) also proposes measures to reverse the growing phenomenon of flat or falling incomes in advanced economies. The adoption of "inequality curbing" international agendas is a dominant feature of this scenario.

governments endeavoured to develop employment in their local economies and in regeneration projects. In other cases, international agreements were required e.g. in order to establish a global fair tax regime. The attention of policy has moved from GDP growth, to a combination of growth with reduction of unemployment and inequality. Policy makers acknowledged that inequality could become a major issue, in particular if access to urgently needed high-quality education to take advantage of the job creation opportunities ahead is limited to a few. **A double strategy involved promoting continuous education, training and skills development, while addressing the risks of inequality in earnings in labour markets through social and tax policies**. The weak global recovery of the 2010's and the lingering high unemployment in major advanced economies, made this strategy necessary.

Towards a world where nobody is left behind

While poverty in the world is decreasing and many talk about the emergence of a global middle class[53] the UNDP 2015 World Development Report "Work for Human Development" warns about a polarization in the world of work and new potential rises in inequality. Income convergence and technological catching-up are important concerns for global governance. **Official Development Assistance is set to reach 1% of GDP of donor countries[54].** However, the ability of all countries to draw on the global technological frontier is key. Technology flows from developed regions to low and middle income regions. **Developed countries could agree to renounce on intellectual property rights on chemical and biological substances, including pharmaceuticals, boosting access to technology in the field of agriculture, health and others areas**. Faster and sustainable growth in less developed regions generates a positive feedback on the development of advanced regions. Global wealth, trade and economic growth accelerate and are equitably distributed across world regions.[55]

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[53] See ESPAS (2015)

[54] In 2015, five EU Member States exceeded the 0.7% ODA/GNI mark: Sweden (1.4%), Luxembourg (0.93%), Denmark (0.85%), and the Netherlands (0.76%) and the United Kingdom (0.71%). The EU average was 0.47%.

[55] See AUGUR (2012)

3. CLIMATE AND ENERGY

3.1. Climate calamity

In the year 2030 - and climate change has been happening. Greenhouse gas emissions have been following the pattern predicted by the business as usual scenario of the International Energy Agency. The adaptations required to reach the "mitigation" targets set out at the COP21 conference in Paris in 2015 have proved too challenging. While national pledges have shown a positive impact in slowing down the growth in global energy-related emissions, these have continued to rise from 2013 to 2030. The share of fossil fuels in the world energy mix has declined to 75% in 2030. Renewables have become the leading source of electricity by 2030, but subcritical coal-fired capacity has declined only marginally. The global economy continues to exploit fossil fuels. Most (national) systems of energy production, distribution and consumption continue to rely on a centralised structure, even if some elements of renewable energy are integrated in this system. The carbon intensity of the power sector has improved by 30%. Scientists predict a rise in global temperature of between 2.9 and 3.5 °C by 2100.

Rising seas will challenge coastal cities

Coastal cities need a special mention. In recent decades, many people have moved to coastal regions to enjoy the water or be closer to major cities. Some 600 million people around the world reside in poor areas that experience periodic flooding. In the United States, climate experts claim that "40% of the population lives in relatively high population-density coastal areas, where sea level plays a role in flooding, shoreline erosion, and hazards from storms." A recent publication (Brookings, 2016) suggests that areas at risk include some of the globe's most prominent cities: New York City; Boston; Washington, D.C.; San Francisco; Los Angeles; Miami; Amsterdam; Venice; Cape Town; Tokyo; Shanghai; Hong Kong; and St. Petersburg, among others.

All of these cities are located on low-lying waterfronts, so a significant increase in sea levels could put parts of them underwater. There likely would be serious consequences for international politics arising from climate change. Economic deprivation and social unrest often leading to war, refugees, and societal conflict.

Nations that lose territory or cropland because of rising seas, sustained drought, and other climate change factors may become more aggressive in dealing with their neighbours. They may seek new territory for their people or areas that can grow food. The prospect of "climate change refugees" already has raised widespread concern because people may have to flee home environments made hostile by higher temperatures, worsening storms, or sea-level rise. This would accelerate mass population migrations in difficult times for migrants.

The ice sheets of the North Pole are disappearing fast. Sea levels are rising and are projected to reach, on average by the end of the 21st century 1m higher than where they were at the beginning of the century[56]. Heatwaves and extreme rainfalls are ever more frequent and ever more severe in most parts of the planet. However, dry subtropical regions have become dryer[57]. The change in climate is having profound effects on the abundance, distribution and composition of plant and tree species and animal populations, with a cascading effect on whole ecosystems.[58] This has economic impacts on forest productivity and downstream value chains. Agricultural crops show a high level of sensitivity to increased temperature and its variability and have suffered[59]. Despite infrastructure

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[56] Low elevation coastal zones occupy 2% of the world's land area but contain 13% of its urban population, see UNFPA (2007). The coastal location of many cities predisposes them to flooding and, in some areas, exposure to extreme events, in particular hurricanes and faster than expected melting of ice sheets and sea level rise, see Royal Society (2014).

[57] Exposure to dangerously high temperatures in urban centres is also increasing because of global climate change and the urban heat island effect, see Patz et al. (2014) and is exacerbated by urban sprawl, see Stone et al. (2010).

[58] See IPCC (2014)

[59] Farmers have some capacity to adapt to increased mean temperatures by developing new cultivars or changing the timing or location of their planting, but increased temperature variability is much more difficult to adapt to.

investment average crop-yields have been decreasing, while demand for crops is up by 25%[60]. Ocean acidity has been increasing[61] and is predicted to further increase by up to 170% by 2100. Ocean ecosystems have suffered as a result. Coral reefs have died and all kinds of marine populations have collapsed[62]. Biodiversity in the sea is substantially challenged[63].

In this challenging context human healthy life-expectancy across the world is beginning to fall. Building resilience to disasters has become the largest sector of the human economy. Effective surveillance and early warning systems – e.g. heatwave early warning systems – are continuously developed and expanded. New agencies, with multifunctional teams ready to intervene across the world, stand by continuously 24/7 ready to intervene in times of emergency.

What if...we would not reverse the transgressions of planetary boundaries?

Current status of the control variables for seven of the planetary boundaries. The green zone is the safe operating space, the yellow represents the zone of uncertainty (increasing risk), and the red is a high-risk zone.
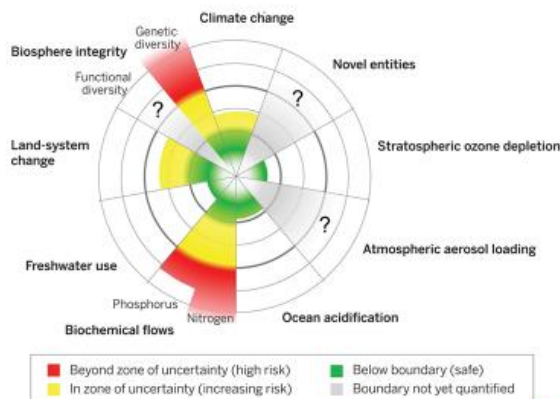
Will Steffen et al. Science 2015;347:1259855
Published by AAAS

Four of nine planetary boundaries[64] have now been crossed as a result of human activity, says an international team of 18 researchers in the journal Science (16 January 2015).

The four are: climate change, loss of biosphere integrity, land-system change, altered biogeochemical cycles (phosphorus and nitrogen). Two of these, climate change and biosphere integrity, are what the scientists call "core boundaries". Significantly altering either of these "core boundaries" would "drive the Earth System into a new state".

"Transgressing a boundary increases the risk that human activities could inadvertently drive the Earth System into a much less hospitable state, damaging efforts to reduce poverty and leading to a deterioration of human wellbeing in many parts of the world, including wealthy countries," says Lead author, Professor Will Steffen, researcher at the Centre and the Australian National University, Canberra.

Can we reverse the transgressions? What will happen if we do not? In 2010 Frank Fenner, one of the leaders of the effort to eradicate smallpox said that homo sapiens can be extinct in 100 years.[65]

But if we can reverse the transgressions, would that not increase our incentives to transgress again?

Despite the pressure for humanity to organise itself against the ever rising risks for catastrophe, tensions rise for a number of reasons. First of all, relying on finite fossil resources makes it increasingly difficult to maintain overall wealth and consumption levels. Wealthy nations and populations can still meet their demands for oil and gas at the expense of poorer nations and populations, which are the most affected by the consequences of climate change. As resources for adaptation measures are much more limited in the poorer nations than in the advanced economies, the disparities between the planet's rich and poor will grow even larger. This widening gap becomes a real threat to humankind, as world population will continue to grow to the end of the

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[60] Based on IPCC (2014). The effects of climate change are predicted to be worst in sub-Saharan Africa, increasing stunting in children due to malnutrition by about 23%, and south Asia, where stunting rates might increase by as much as 63%, see Lloyd et al. (2011).

[61] The pH of the oceans has, on average, decreased by 0,1 pH since the beginning of the Industrial Revolution 250 years ago—equivalent to an increase in ocean acidity of about 26%, see IPCC (2013).

[62] See IGBP; IOC, SCOR (2013)

[63] See SCBD (2014)

[64] Stockholm Resilience Institute (2015) http://www.stockholmresilience.org/research/research-news/2015-01-15-planetary-boundaries---an-update.html

[65] See Cherryl Jones reporting in The Australian 16 June 2010: http://www.theaustralian.com.au/higher-education/frank-fenner-sees-no-hope-for-humans/news-story/8d77f0806a8a3591d47013f7d75699b9

century or beyond, and in particular in the poorer parts of the world.[66] Secondly, the impacts of transgressing "planetary boundaries"[67] are becoming visible at global and regional scale (e.g. in terms of climatic changes and extreme weather events undermining living condition), as well as at the local scale (e.g. in terms of biodiversity loss). Severe local impacts spill over easily to become global problems, as substantial changes locally induce rapid, non-linear, and potentially irreversible changes in the Earth's environment that would be disadvantageous to human development and health.

What if…the changing outlook of geo-engineering options

Geo-engineering against climate change is a highly divisive topic. Experiments of different kinds have shown that it is possible to engineer various aspects of the weather, and there are claims that weather altering methods could mitigate global warming[68]. At the same time the effects of those methods are incalculable. Local effects can generate global problems, and global effects could generate local problems. Questions about authority and responsibility, who decides and who is impacted make geoengineering a very difficult choice. As the impacts of climate change show more and more, the promise of geoengineering becomes more and more appealing, pushing humanity to take on further systemic risks.

3.2. Low carbon transition

At first glance, the low carbon transition goal was very ambitious right from the start i.e. in the follow-up to the Paris climate conference. It was based on a *structural* departure from the prevailing system of energy provision, affecting the entire energy supply value chain as well as the architecture of the energy system.

To meet the targets of the 2015 Paris climate conference of 40-70% reductions in global GHG emissions by 2050 compared with 2010, a stringent mitigation programme was put in place. At the heart of this plan, **the share of low-carbon electricity supply is meant to increase from approximately 30% in 2015 to more than 80% by 2050[69].** In the power sector, while onshore wind and solar PV were ready to be mainstreamed in many energy systems, very high levels of deployment have been enabled by further innovation in complementary technologies – for example, in energy storage and smart grid infrastructure.[70] Battery technology has been key for the transition.

What if…solar power and batteries and carbon capture and usage against climate change

Solar energy is considered by many the game changer in low carbon electricity supply. Solar energy harvesting technology is improving and becoming cheaper at a rapid pace and our ability to store it in batteries is also improving. In the 2015 National Geographic documentary "Before the Flood" Elon Musk tells the host that 100 gigafactories like the one Tesla is building in Nevada can take care of all the energy needs of the planet. While there are certainly bottlenecks on the way to this vision, the combination of batteries and solar energy can certainly provide much needed energy security to off-the-grid communities, especially in poorer nations. The undeniable environmental benefits of solar energy can also inspire off-the-grid approaches in Europe, and can help establish electricity markets in which energy prosumers can optimise their trading relationship with the grid. New generations of less resource-intensive organic solar technology are integrated everywhere from roof tiles to wall coatings. New industrial processes using bacteria as catalysts are transforming greenhouse gases into fuels and products.[71]

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[66] See Gerland et al. (2014)

[67] The planetary boundaries identify those biological and physical processes and systems important to the maintenance of the Earth's functions that human beings rely on to grow and flourish – the so-called "safe operating space" See Rockström et al. (2009) Steffen et al (2015)

[68] See for example "Climate science: can geoengineering save the world" The Guardian 29/11/2013 https://www.theguardian.com/sustainable-business/blog/climate-science-geoengineering-save-world

[69] See IPCC (2015)

[70] See IEA (2014)

[71] http://co2-chemistry.eu/

Knowledge of CO2 storage opportunities has expanded dramatically as did support to the widespread adoption of afforestation, carbon storage in wood and other biological products, CCS (Carbon Capture and Storage) **and CCU** (Carbon Capture and Usage). Breakthrough technologies in the energy-intensive industries have been necessary. In industry, transport and buildings energy efficiency technologies play a leading role in achieving the 2°C targets. While rapid economic development holds significant potential to deploy the latest low-carbon technologies across all energy sectors, incentives (e.g. emissions-trading systems) and access to technology have been key. **Important bottlenecks had to do with the supply of raw materials, including critical raw materials[72], which prevented promising technologies from being deployed.** These were overcome through trade, international cooperation and concerted effort to develop solutions such as substitution of critical raw materials, recycling technologies and/or upscaling the innovative, sustainable production of primary raw materials[73]; that can apply in large areas of the planet.

Extraction of primary raw materials is still required for many applications: global demand cannot be covered just with recycled, secondary raw materials. Some raw materials still face increasing demand, such as those required for the deployment of a low-carbon, circular economy (e.g. lithium). However, extractive industries have intensified their sustainable practices: as anticipated in a report from 2016[74], the mining industry has ramped up its engagement, partnership and dialogue with other industry sectors, government, civil society, local communities and other stakeholders, and has confirmed its potential to positively contribute to all 17 SDGs. Similarly, downstream industries have implemented systemic innovations to support economic, social and environmentally sustainable development.

What if…safe and environmentally friendly nuclear energy

Nuclear energy is a highly contested source of energy. High safety risks and concerns with waste disposal and security have lead half of Europe's countries to disentangle themselves from its use for energy production purposes. Energy security considerations have led other countries to construct new nuclear power-plants. The arguments are well known. There are short-, medium- and long-term risks from the extraction and production of nuclear fuel, from construction, operation and decommissioning of plants, and from the storage of waste. There are risks of accidents and risks of security. On the other hand, there are benefits. In operation, nuclear power plants do not emit significant amounts of CO2, although there are environmental costs associated with mining for and transporting nuclear fuels and with nuclear waste. Smaller and new safer designs like the "Secure"-type of combined heat and electricity providing unit are being developed, while there is an important need to develop new technologies to improve the safety of handling the waste of our nuclear past. Nuclear fusion is still seen as a highly promising option for the long term. Small units require significantly less capital investment and can more readily slot into brownfield sites in place of decommissioned coal-fired plants. Many are designed to be placed below ground level, increasing thus security. The promise of even less risky form of nuclear fission power comes from thorium. Thorium is more available than uranium, its fuel cycle in the reactor can be shot down much quicker than the uranium - making thorium reactors less prone to accidents - and its nuclear waste is meant to be orders of magnitude lower than conventional nuclear power, though experts disagree about exactly how much. Europe (still) has a lot of expertise and experience in building, operating and decommissioning nuclear plants safely, including all kinds of measures to address nuclear hazards. This knowledge is an important asset, and not only if Europe decides to continue investing into the nuclear path. It could also be of great benefit in other parts of the world, where the nuclear option is pursued proactively. The decision whether or not Europe continues to invest in nuclear research, innovation and education is thus not only a matter of using and exploiting nuclear power in Europe, but also of whether Europe's expertise could be an important asset on global markets. In recent decades, stories about safe, green nuclear power in popular media have tended to focus on the quest for nuclear fusion. Certainly, we can expect, and should hope, for continued progress toward that type of power. But while that

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[72] A number of rare metals increasingly matter in the global economy, not only because they are vital to the production of advanced electronics equipment – cell phones, batteries, plasma screens – but also because they are part of the "green technology revolution", being essentials in the construction of hybrid cars and wind turbines. For instance, the majority (88%) of the world's platinum is produced by just two mines in South Africa and most of the rest comes from a single mine in Russia. Platinum is recovered at a rate of about 200 tonnes per year. If used to increase the number of cars powered by fuel cells, this quantity is only enough to produce 2 million such vehicles by 2030, which is only around 5% of the world's current car fleet, see EC (2012).

[73] See EC (2016c)

[74] See UN (2016)

happens, the investments by China, India, and other countries suggest that thorium is en route to contribute to the grid in the near term – and to play an important role in the fight against climate change.

Having achieved the targets of the Paris climate agreement has not done away with all risk of extreme weather phenomena and environmental catastrophes which have raised **the importance of adaptation and resilience across the globe**. Important steps were taken to improve governance, harness new knowledge, and exploit a range of technologies that contributed to improve health[75] and reduce environmental damage. However, the huge investment in reorienting energy systems and mitigating destructive climate change by shifting to a carbon-neutral energy path has paid off by keeping longer-term adaptation costs within reasonable limits.

4. ENVIRONMENT AND ECOSYSTEMS RESOURCES AND SERVICES

4.1. The age of overexploitation

In 2030 biodiversity losses have led to the breakdown of important eco-system services and shortages of natural resources emerge in many regions across the world. Population growth and resource-intensive economies demand more resources: fossil fuels, land, water, food and minerals. Yet, the environment struggles to provide. Overexploitation brought increasing depletion of resources and degradation of the environment. Trends, which were visible in 2015 when the UN Sustainable Development Goals were adopted, have carried on. Despite their initial commitment, the UN member states failed to resolve the contradictions between growth and sustainability.

Global population has increased, and the trend continues pointing to a world population in 2100 between 9,0 and 13,2 billion with a probability of 95%.[76] Technological advances increased resource use efficiency, but this did not result in an overall reduction in the environmental footprint because these efficiency gains eventually stimulated consumption of additional goods.[77] The circular economy model and sustainable consumption behaviour and lifestyles are still cult but they have not managed to break into the mainstream. The age of overexploitation has brought:

- **Freshwater shortages**: In 2030, water demand is higher than 30 years before, and is still projected to increase by 55% worldwide by 2050. Linked with urbanization trend, the increase in demand arises mainly from manufacturing (400% increase in water demand), electricity (140% increase in water demand), and domestic use (130% increase in water demand)[78]. Nutrient pollution of groundwater (in particular with Nitrogen and Phosphorous) has increased the cost of fresh water provision. Irrigation (which accounts for about 70% of all water used globally at present) cannot expand,[79] while climate change is reducing renewable surface water and groundwater resources significantly in most dry subtropical regions, exacerbating water stress[80].

- **Collapsing oceans**: the ocean and its resources are indispensable for addressing the multiple challenges that the planet faces in the decades to come. The potential of the ocean to help meet the requirements of global population and economic growth is huge, but fully harnessing it requires substantial expansion of many ocean-based activities[81]. However, the ocean has

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[75] See Dora et al. (2015)

[76] See Gerland et al. (2014). Gerland and colleagues concluded that population growth is unlikely to end this century without unprecedented reductions in fertility in sub-Saharan Africa.

[77] This situation is often known as the rebound effect or Jevons' paradox, see Alcott (2005). In developed economies, rebound effects, for example, for household energy efficiency measures, are between 20–45% and are probably higher in low-income countries, see IPCC (2014).

[78] See DASTI (2016)

[79] See OECD (2012)

[80] See IPCC (2014)

[81] The global ocean economy, measured in terms of the ocean-based industries' contribution to economic output and employment, is significant. Calculations on the basis of the OECD's *Ocean Economy Database* value the ocean economy's output in 2010 at USD 1.5 trillion in value added, or approximately 2.5% of world gross value added. Offshore oil and gas accounted for about one-third of total value added of the ocean-based industries, followed by maritime and coastal tourism (26%), ports (13%) – measured as total value added of

been under stress from over-exploitation, pollution, marine litter and micro-plastics, declining biodiversity and climate change causing ocean warming, sea rise and ocean acidification. In 2015 the WWF[82] warned that oceans are under such severe pressure that essential natural systems may simply stop functioning and the OECD[83] estimated that the economic potential of the ocean could double by 2030 if sustainably harvested. Growth in human population and reliance on the sea made restoring the ocean economy and its core assets a matter of uttermost global urgency. This did not happen. Coastal communities continue to be ravaged by unemployment and competing uses of declining oceanic ecosystem services become increasingly sources of conflicts between communities and between countries.

- **Land use conversion**: Land use and habitat conversion continued at a rapid pace in many places, especially in tropical and subtropical regions, driven by a growing demand for animal products as populations increase in wealth - shifting to a growing consumption of meat[84] and the conversion of natural habitats to grow non-food crops (e.g., maize, sugar cane, and oil palm) for biofuel and cosmetics. Changes in land use (particularly tropical deforestation and oil palm plantations) have contributed to substantial losses of native species.[85] Burning of forests through land clearing activities increases local levels of air pollution and contributes to global greenhouse gas emissions — contributing to climate change.

- **Soil degradation:** Land clearance accelerated natural soil degradation processes, which were also exacerbated by urban development (which paves over the top soil) and unsustainable use of the land by industry.[86] The effects of soil degradation include threats to food security[87], flooding due to decreased freshwater retention, and microbial biodiversity loss from soil. Soil also acts as a carbon sink and its erosion (especially when leading to a loss of peat lands or permafrost) contributes to increased greenhouse gases in the atmosphere due to a reduction in their removal by carbon fixing.

- **Increased nitrogen and phosphorus pollution**: Following past trends, levels of biologically available nitrogen and phosphorus in the environment have increased substantially. Excess nitrogen running into terrestrial ecosystems, especially temperate grasslands, shrub lands, and forests, led to decreased plant diversity; excessive amounts of nitrogen and phosphorus in water bodies, such as rivers and other wetlands, led to increased algal blooms and eutrophication. [88]

- **Increased toxic chemical pollution and exposure**: Production and consumption of most types of chemicals have expanded greatly worldwide since 1950, and continues to do so. Global chemical sales have been increasing by about 3% per year since 2015, while production has been shifting from established high-income economies to low-income and middle-income countries. [89] The total quantity of chemicals released into the environment as waste globally remains unknown, but evidence is increased about how several kinds of toxic chemicals cause reduced ecosystem function and thus can indirectly affect human health.[90] The impact on the environment and human health of complex mixtures of chemicals is important to assess

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global port throughput – and maritime equipment (11%). The other industries accounted for shares of 5% or less. While the share of industrial capture fisheries is small (1%), the inclusion of estimates of the value added generated by artisanal capture fisheries (mainly in Africa and Asia) would add further tens of billions of USD to the capture fisheries total. The ocean-based industries contributed some 31 million direct full-time jobs in 2010, around 1% of the global work force (and about 1.5% of the global workforce actively employed). The largest employers were industrial capture fisheries (36%) and maritime and coastal tourism (23%).

[82] See WWF (2015)

[83] See OECD (2016b)

[84] See Tilman and Clark (2014)

[85] See Foley et al. (2005)

[86] See Koch et al. (2013)

[87] See OECD (2013a)

[88] See Millennium Ecosystems Assessment (2005)

[89] See UNEP (2013)

[90] Major sources of chemical contamination and waste include pesticides from agricultural run-off; heavy metals associated with cement production; dioxins associated with electronics recycling; mercury and other heavy metals associated with mining and coal combustion; butyl tins, heavy metals, and asbestos released during ship breaking; mutagenic dyes, heavy metals, and other pollutants associated with textile production; toxic metals, solvents, polymers, and flame retardants used in electronics manufacturing; and drug or pharmaceutical pollution through excretion in urine and improper disposal.

because together they might cause substantial toxic effects, even if all individual chemicals are only present at individually non-toxic concentrations. Such assessments are however difficult to implement because of the large numbers of chemicals that are emitted.[91]

- **Food and nutrition insecurity:** Unsustainable food and nutrition[92] systems continued to threaten planetary boundaries, jeopardize climate action, erode health outcomes, fuel migration, harm development and contribute to food poverty and non-inclusive societies. Already in 2013, FAO has warned humanity that, if food waste were a country, it would be the third CO_2 emitter after USA and China. The European AGRIFISH Council of June 2016 remarked that food waste costs the global economy about USD 1 trillion annually, consumes a quarter of all the water used for agriculture and a cropland area the size of China.[93] Major proportions of the world's crops continue to feed animals (subject as they are to conversion inefficiencies, with the ratio of animal product calories to feed calories still only about 10% on average) and are used for biofuels. All in all 41% of the calories available from global crop production are being lost to the food system.[94] Dietary trends with overconsumption of animal products continue to expand in emerging economies.[95] The shift in these economies towards high consumption of fats and oils, meats (particularly from ruminants), processed foods, and refined carbohydrates is a major contributor to the non-communicable disease burden, and to greenhouse gas emissions, land use change, and agrochemical pollution.[96] Hidden hunger (due to bad diet) increases as does malnutrition and visible hunger. An increasing number of developing countries suffer from the double burden of under-nutrition and obesity.[97].

- **Rising consumption of raw materials**: Alongside energy, the growth in consumption of many of the world's main raw materials, including metals, minerals and biomass is also on the rise[98]. As BHP Billiton projected, in the last 15 years to 2030 we consumed more copper, more aluminium and more steel than we have in human history. China's demand for steel doubled between 2015 and 2030s, while in India steel production quadrupled between 2010 and 2020. Construction continues to expand around the globe. While mining used to cause considerable environmental damage, new technology, environmental regulations and strong metal recycling policies have protected important parts of the planet from environmental impacts of mining. . Similarly, the demand for biomass for industrial and energy use has been also increasing with a rise of global demand not only for traditional application, but also new emerging bio-based products and bioenergy, together with awareness of the need for sustainability. Materials prices continuously cause concerns about scarcity and insecurity of supply.

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[91] See Diamond et al (2015)

[92] See Haddad et al (2016)

[93] As for Europe, the results of the EU-supported FUSIONS project indicate that EU-28 produces about 88 million tonnes of food waste per year, the equivalent of 20% of the total food, especially at the household, service and retail level.

[94] See Cassidy et al. (2013)

[95] The expected 76 % rise in the global appetite for meat and animal products by 2050 could increase greenhouse gases by 80 % (cfr. Growing Greenhouse Gas Emissions Due to Meat Production, (UNEP 2012) calling for action to mitigate climate change induced by livestock (cfr. Herrero et al (2016), Greenhouse gas mitigation potentials in the livestock sector, Nature Climate Change 6, 452–461). This dietary shift is a further threat to sustainability given the high resource footprint of producing animal-derived food products, a factor underpinning a growing interest amongst some consumers for more 'sustainable diets' based upon alternative sources of protein.

[96] See Tilman and Clark (2014)

[97] See The Lancet (2016)

[98] See EC (2016d)

> **What if...a series of counter-trends: resources, technology and the environment**
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> Driven by problems as they appear, social and technological change is likely to be reducing the relative environmental impact of the rise of human population and its affluence. Sustainable agricultural intensification, ecological practices (e.g., conservation agriculture, agro-ecology, organic agriculture, agroforestry, and integrated pest management and bio-pesticides to minimise use of chemical inputs), genetic and genomic developments (plant and animal breeding), and more sustainable supply chains, have been helpful directions of technological and social change. Other such directions include more efficient use of water and fertilisers, and strategies to increase irrigated crop yields while reducing water losses, and recycling of phosphorus in regions of excess to regions of deficiency so usefulto mitigate eutrophication, increase crop yield, and address potential global shortages of phosphorus. Innovative sources of nutrition and alternative proteins including insects could become widespread and more sustainable aquaculture could emerge. Most importantly, consumers have adopted more sustainable dietary patterns and lifestyles. Whether such trends will prevail will depend on the combination of economic, social and political incentives to put them in place - and this is far from trivial. Furthermore, whether the problems are solved will also depend on the interfaces with energy and climate. Energy itself absorbs resources - e.g. through biofuels - with direct impacts on climate change. Energy can also help alleviate resource constraints, through for example, water desalination. Social, economic and technological change needs to drive the systemic interactions between all ecosystems and the planet as whole towards planetary health.

In the year 2030 the resilience of man-nature systems is overstretched leading to the need to adjust to new less preferable environmental conditions. Competition for land and water between different uses of biomass is still a problem, together with the **shortages in water and resources. Food and nutrition insecurity spread through rapid commodity price increases,** contributing to social unrest and increased poverty in societies across the planet, with important economic, social and political consequences[99].

4.2. Towards a new wellbeing

The recognition of the need to **transform the economy to support planetary health, along a green and jobs-friendly trajectory of growth and prosperity**[100] predates the SDGs considerable. In a number of places around the globe steps have been taken to reduce waste through material and energy efficiency in production and use, to incentivise recycling, re-use, and repair; and to substitute hazardous materials by safer alternatives. Innovations in design and manufacture built on the potential restorative powers of natural systems, combined with strategies to reduce overall demand for resources, leading ultimately to the **circular economy.**[101]

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[99] Under-nutrition and malnutrition combined with increasing levels of obesity will be a sizeable global cost (e.g. obesity is estimated to cost the EU economy of € 70bn annually)

[100] Indeed, when looking at the potential for employment and economic prosperity, it is important to define 'green growth' and the 'green good life' in a very broad sense, recognising the potential for innovation across every industry and activity. 'Green' not only includes all the trends in energy conservation, renewables and sustainable goods, but innovation in the productivity of resources; the shift from products to services and tangibles to intangibles; an increase in the use of bio-materials and bio-chemistry; a reorientation towards reuse and recycling; and so on.

[101] See Perez et al (2016). There is a huge competitive opportunity for Europe to ride this 'green' trajectory and turn environmental problems into solutions for promoting investment and jobs. Such a green direction implies the use of technological capacities (which the EU has) in order to drastically increase the productivity of energy and material resources (which the EU only has in limited quantities). New 'green' lifestyles are creating new markets domestically and will gradually entice the new millions joining the middle classes across the world.

The benefits of the circular economy

A study of EMF, Mckinsey and SUN[102] has concluded that a circular economy, enabled by the technology revolution, allows Europe to grow resource productivity by up to 3 percent annually. This would generate a primary resource benefit of as much as € 0.6 trillion per year by 2030 to Europe's economies. In addition, it would generate € 1.2 trillion in non-resource and externality benefits, bringing the annual total benefits to around € 1.8 trillion versus today. This would translate into a GDP increase of as much as 7 percentage points relative to the current development scenario, with additional positive impacts on employment. Looking at the systems for three human needs (mobility, food, built environment) the study concludes that rapid technology adoption is necessary but not sufficient. Circular principles must guide the transition differently from those that govern today's economy, and then the economic promise is significant and the circular economy could qualify as the next major European political economy project.

In 2030, both OECD and non-OECD countries have moved to a resource-efficient economy decoupling material consumption from economic growth.[103] **Networked service provision at "zero marginal cost", advanced automation and new materials contribute to the new production and consumption model[104].** The efficient use of natural resources (such as water, forest, land), energy efficiency and the avoidance of waste have increased significantly. 'Green' approaches benefit from advances in nanotechnology, biotechnology and information- and communication technologies. "Advanced materials" provide solutions to problems caused by shortages in raw materials. The fossil-based chemical industry has been replaced by a smarter, more resource efficient bio-based chemical industry that provides better, safer products. Healthier and more sustainable diets have taken hold.

What if…the promise of the oceans

The OECD[105] estimates the ocean economy to represent a gross value added of 1.5 trillion US $, projected to rise to 3 trillion US$ by 2030, approaching the GDP projections of large European economies, and providing 40million jobs. The ocean economy encompasses ocean-based industries, but also the marine assets and ecosystem services. The two parts are inextricably linked, and the ocean economy has been making huge contributions to global wellbeing, through food, energy, materials, transport, leisure and broader ecosystem services.

Particularly important have been the contributions of the oceans to global food consumption and renewable energy generation which increased dramatically helping food security and the fight against climate change. The total catch of fish from the sea which peaked in the 1990s has dramatically decreased. Aquaculture had been growing at around 6% a year globally. Harvest organic production from the oceans has improved in various ways. Harvesting krill, mesopelagic fish or marine mammals became the norm. Fish farms were designed to use increased vegetable content in farmed fish diet and to process algae. New products from the sea including algae and seaweed have gained momentum and scale and multi-purpose platforms serving various ocean activities are exploiting new synergies

Bringing emerging blue industries to scale has required forward vision, good governance, regulation, investment and behavioural change There have been important contributions of biotechnology, for instance in breaking down algae for use as biofuel, as well as from mass production and increased operating experience bringing down the cost of tidal and wave energy and partly due to finding products and markets for species to replace the carnivores that make up a substantial proportion of seafood today. This has resulted in a substantial reduction in demand for terrestrial resources – particularly land and water and an ocean that will continue to provide benefits for generations to come. In 2030 the ocean was announced as the UN "saviour of the planet".

A change from ownership to sharing - adopted everywhere and rewarded by policy – has delivered a flourishing rental and sharing economy, with the massive creation of jobs for maintenance,

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[102] See Ellen Macarthur Foundation, SUN and McKinsey (2015)

[103] Economic modelling results suggest that resource productivity improvements of around 2% to 2.5% pa can be achieved with net positive impacts on EU28 GDP. It is estimated that resource efficiency improvements all along the value chains could reduce material inputs needs by 17%-24% by 2030.

[104] See Rifkin (2014) Mason (2015)

[105] See OECD(2016)

distribution and installation activities. Electronic tags record the history of each appliance and help determine the rental prices, while 3D printers produce replacement parts without the need for costly inventories. Producers concentrate on luxury products incorporating the latest technologies, the best and most durable materials, the most advanced designs, the lowest energy consumption, and so on, in order to provide the top end of the rental market at the highest price, for the highest profit. From there down the rental economy takes over and maintains products at a variety of prices for their several-decades-long lifetimes, until they are finally disassembled and recycled. The whole process reduces the cost of access to the basic durable goods, while reducing the amount of materials required for doing so and increasing the quality and environmental friendliness of the products.

The scaling up of the circular economy delivered substantial economic and corporate benefits. New services and business models are directed towards repair, re-use, re-distribution, remanufacture and recycling of products. Households face a higher income due to reduced costs of products and services, and the shift towards labour-intensive recycling and reuse sectors has a positive effect on employment. A consequence of the new change in economic model is a new focus on local circulation rather than on a wider geographic scale[106]. Some cities have created their own local and regional markets for food and secondary materials, rather than relying on export markets to satisfy demand. So, **globalization has continued, but with a different shape – with greater exchange of knowledge and intangible services and less of material goods travelling long distances.**

As for the environment, by 2030 ecosystem degradation is reversed globally, ecosystem services are highly efficient, and biodiversity is at the core of politics guaranteeing the wellbeing of societies. Bioremediation is a booming business worldwide. Healthy and productive oceans represent a new economic frontier.[107] Effective governance of the environment is achieved through effective multilateral environmental agreements which provide support to countries in need, with knowledge and capital required to effectively implement their commitments. A comprehensive system of valuation of environmental services supports decision-making at all levels.

Importantly, the circular economy transformation also delivered solutions on the demand side to sustainably closing the food gap, reducing food loss and waste, a factor coming only second to shifting diets in the emerging economies as cause of over-exploitation. Seafood seems also well placed in this scenario to help close the food gap to 2050, providing high quality protein with lower impact on the environment.[108] In the now dominant circular economy paradigm, the criteria to judge what a successful food system is have changed. Historically, the criteria have been high output, low prices, and eradication of deficiency diseases. With the raise of global affluence, this understanding was however increasingly outdated and in need of redefining. A successful food system is now one that delivers high wellbeing, social justice and environmental stewardship[109].

What if:…A new agriculture in Europe

Agriculture in Europe is shaped by the convergence of many trends. The key evolution is the progressive dissociation of agriculture from food security. Agriculture is associated with an increasing range of purposes, from environmental remediation and management to phytomining, raw materials, energy production and nature-based solutions. At the same time food production can become associated with new sources and processes (e.g. algae, yeast and fermentation, synthetic production of food in bio-refineries[110]) that have little in common with agriculture. As foods can be produced in different settings, urban agriculture could take-off producing new sets of opportunities and challenges for urban regeneration. The circular economy paradigm and ICT could strengthen local and regional agriculture.

European agriculture is now characterized by diversity of functions. Differentiated food streams co-exist: organic, conventional, mainstream, cheap, luxury and many hybrid forms. More demanding and engaged consumers wanting to know how materials are sourced and processed, how food is produced and whether it is based on traditional 'granny' recipes like homemade food. The demand for different types of food and production methods is high. Regional food is popular.

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[106] For example food systems will make space for short circuits through urban agriculture and other approaches.

[107] See OECD (2016)

[108] It will also help fight malnutrition which progresses in all countries in the world and is a leading global driver of disease. (Global Nutrition Report 2016).

[109] Devlin et al. (2016)

110 See Ceurstemont (2017)

Labelling and certification provide full transparency and the buyer can trace the history of an individual product with ICT. Branding and brands have increased in importance, partly as a result of increasing consumer demand for experience and a (regional) authentic character.

There are few specialised farmers as mixed food farming (often organic) is preferred. Besides food production, some farmers also supply speciality crops and residues for the bio-based chemical industry, and generate a fair income by being fully integrated into the new value networks of the bio-based circular economy In many regions multi-functionality is important. Farmers are highly educated operating in high-tech environment and skilled in traditional agriculture. Some are mainly farm entrepreneurs focussing on food production and quality. Others focus on land remediation, nature and landscape maintenance.[111]

5. HEALTH

5.1. Health divide

Due to the simultaneous dynamics of fertility and life expectancy, the population of Europe has declined from 738 million in 2015 to 734 million[112] in 2030 and the old-age dependency ratio has risen from 27.8% to 39.0%[113]. These numbers do not capture the possible escalation of migration flows for social, economic and environmental[114] motives. Many of the migrants arriving in Europe work – legally and illegally - for the health care of the "aged baby boomers"[115]. Health priorities are in line with the promotion of individual autonomy and freedom, and rely on markets for health service improvements through new technologies[116]. Public health strategies address mainly Non Communicable Diseases[117], the risks of new pandemics[118] - driven by increased mobility - and environmental related diseases. Health care costs soar.

Projected public health and long-term care expenditure in OECD countries (% GDP 2060)

Source: OECD: http://dx.doi.org/10.1787/888932844296
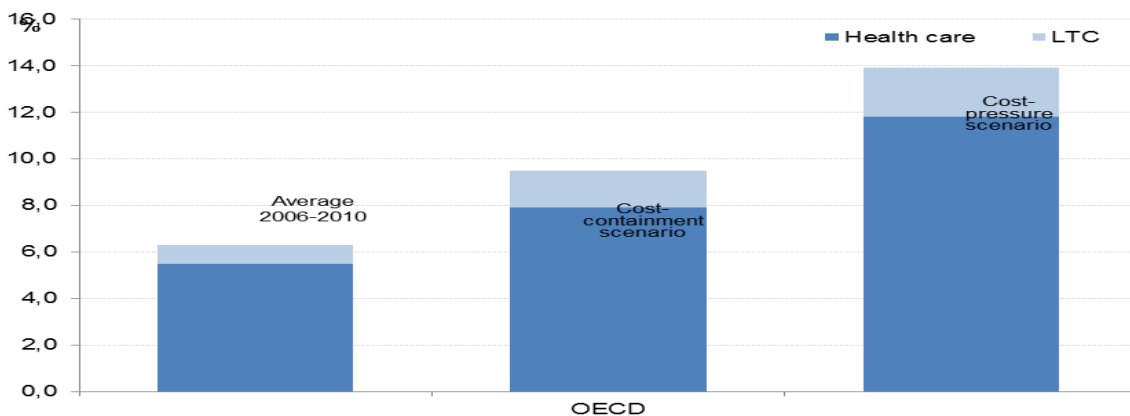
The worldwide market for treatments for NCD expands and so the private healthcare sector booms, as those who can pay do so, to access the latest drugs and other means of diagnosis, prevention

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[111] See EC (2016a)

[112] See UNDESA (2015)

[113] See Eurostat (2016a) Old dependency ratio indicator

[114] The 'Migration, Environment and Climate Change: Assessing the Evidence' study stresses "The high degree of complexity and uncertainty in calculations make projections for climate change-induced migration by 2050 vary from 25 million people to one billion people" See IOM (2009)

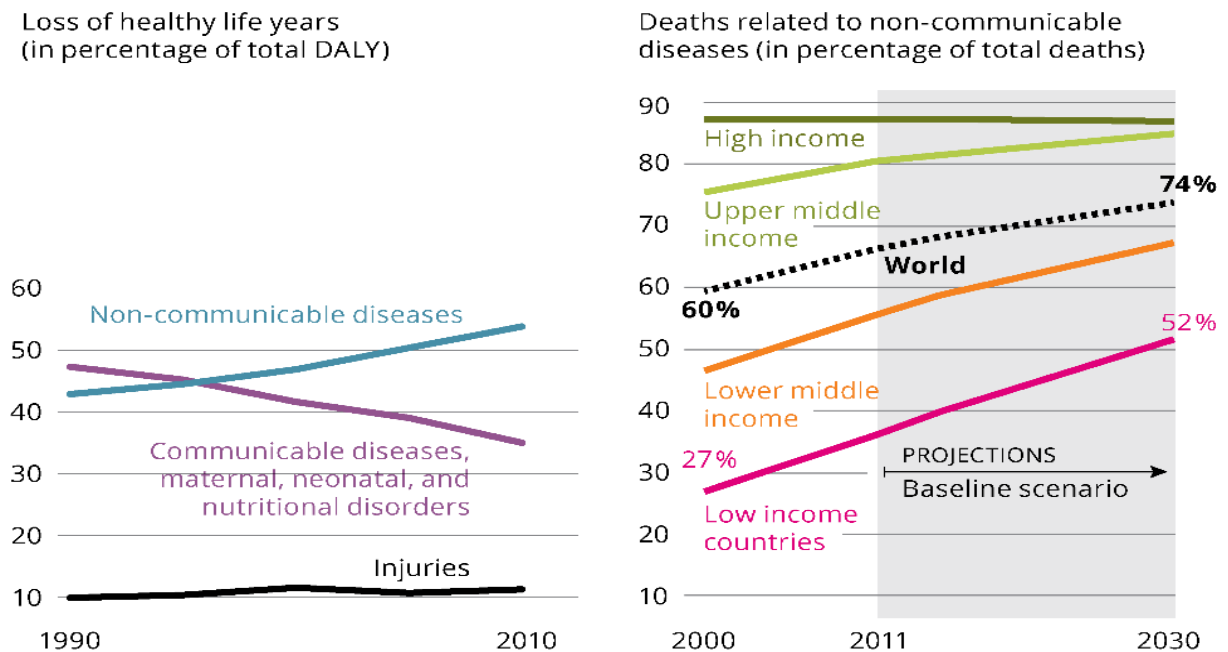[115] See Kobzar S., Hellgren T., Hoorens S., Khodyakov D., Yaqub O. (2012)

[116] See National Institute for Public Health and the Environment (RIVM) (2014) Adoption of new technologies frequently drive healthcare cost up. However, some innovative technologies replace less cost-effective ones and can contribute to more sustainable systems

[117] See WHO (2014b), ADI (2015)

[118] See WHO (2014 a, b)

and treatment. [119] The market for services, medicines and products flourishes and offers a myriad of solutions and opportunities. Groups of elderly are bankrupting themselves in their desire to have the latest life-extending drug or palliative care[120].

Change in the global burden of disease and share of non-communicable diseases by world regions (1990–2030)[121]

Loss of healthy life years (in percentage of total DALY)

Deaths related to non-communicable diseases (in percentage of total deaths)

In the better off European countries/regions/cities demand for personalised treatment and care is high. National health systems improve public care provision through collaboration with medical schools and industries in business models that allow them to provide cost-effective innovative treatments. Smart cities[122] offer more sophisticated diagnostic services and data services. Smart and healthy cities become highly competitive and desirable places to live as health and longevity benefits are priced into property markets. As wealthy people concentrate in smart and healthy cities, many parts of Europe struggle to provide adequate health care services. Obesity has become one of the major public health issues exposing public health systems and the broader economy to substantial burdens. [123] These high added value societies struggle also with providing care to older or disabled citizens – as the hourly costs of the human assistants exceeds the available budgets. They rely a lot on distance or robotic assistance, but this is not sufficient to ensure emotional well-being.

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[119] See NHS (2009)

[120] See The Economist Intelligence Unit (2011)

[121] EEA (2015) DALY refers to Disability Adjusted Life Years, defined by WHO as "the sum of Years of potential life lost due to premature mortality and the years of productive life lost due to disability".

[122] See Saunders (2015)

[123] McKinsey notes in 2015: "This crisis is not just a pressing health concern; it is also a threat to the global economy. The total economic impact of obesity is about $2 trillion a year, or 2.8% of world GDP—roughly equivalent to the economic damage caused by smoking or armed violence, war, and terrorism, according to new research by the McKinsey Global Institute (MGI)." http://www.mckinsey.com/mgi/overview/in-the-news/the-global-obesity-threat

What if...treatment options expire?

Antimicrobial resistance is one of the major threats humanity is facing, projected to account for 10 m deaths by 2050[124]. The combination of biological adaptation (microbial genes in our bodies outnumber our genes by a factor of 100 to 1) and a slow-down in the discovery pipeline of pharmaceutical companies is threatening with disappearance the most powerful weapons in our arsenal against harmful microbes.

Deaths attributable to antimicrobial resistance every year by 2050

North America
317.000

Europe
390.000

Aisa
4.730.000

Latin America
392.000

Africa
4.150.000

Oceania
22.000

Data source: Review on Antimicrobial Resistance (2016)

We can imagine unmanned systems, or robotics, emerged as useful tools in various aspects of healthcare, with applications including service provision in hospitals, enhancing communication to the elderly, remote care, improving prosthetic limb design, robotic therapy for children, movement assistance in paralysis, and micro-bots for technical use in surgery.[125] The sterile environment imagery that accompanies these visions can be the face of the quarantine for those whose microbiota has turned against them. Knowing our microbiome[126] promises a better management of our relationship with microbes and with the co-evolution of our genomes.

The EU and governments are under pressure to balance the need for fast release of the new drugs and the needs of consumer protection and information. The development of genome and proteome technologies has led to the creation of personalised drugs. These are still only available in the private sector and still remain the preserve of the rich. Many of the middle classes feel disgruntled that they cannot access these expensive new drugs[127]. Health inequalities spread in the same way as income inequalities have spread across Europe.

As the gap between rich and poor increase, even the most successful countries register an increase of the unmet needs for medical care, as financial and cultural barriers prevent health care access to people of lower socio-economic status[128]. Those with low health literacy, poor education and low incomes, homeless people and migrants are alienated and suffer malnutrition, obesity and age-dependency problems. Increasingly also young couples facing housing and job insecurity, experience difficulties in accessing healthcare services and rely on virtual self-diagnosis and prescriptions[129]. The promise of instant cure from the consequences of unhealthy lifestyles, through pills or surgery, still goes a long way towards keeping people healthy. . Nutritional supplements provide a 'nutritionally complete' meal in the form of powder, pills prevent appetite and operations fix the body in case of failures[130] However, diverging life-expectancies between socio-economic groups and between localities tell the story of an increasing divide between those who can afford care and those who cannot. Inter-generational, inter-community and inter-locality conflicts about access to health and to care become political.

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[124] See The Review on Antimicrobial Resistance (2016)

[125] See Martel (2012)

[126] See http://www.human-microbiome.org/

[127] See NHS (2009)

[128] See Dubois and Molinuevo (2014)

[129] See NHS (2009)

[130] See German et al. (2011)

5.2. Towards health for all

The population of Europe has declined from 738 million in 2015 to 734 million[131] in 2030 and the old-age dependency ratio has risen from 27.8% to 39.0%[132]. Migration flows to EU countries are limited and well managed thanks to increased international cooperation, the sustainable development of emerging economies and the implementation of stronger EU policies[133]. EU countries have undergone pensions and healthcare reforms with no major social and political conflict thanks to emergence of a shared health vision that combines planetary and lifelong human health in one integrated and holistic approach[134]. In 2030, priorities lie with promoting healthy lifestyles, preventing illness and curing promptly while supporting vulnerable people and enabling social participation[135]. Digital health[136] is common and empowers individuals to manage, track and potentially improve their own health. Technologies such as wearable devices, remote diagnostics, tele-medicine and personalised medicine are successfully developed to reduce inefficiencies and improve access to healthcare, with apps and social networking providing innovative platforms. The commercial sector is a key partner for advancing in this area, starting with initiatives such as Google DeepMind Health[137] and IBM Watson Health[138].

What if…the ultimate electronic health manager[139]

I-Pocrate is this little chip on my wrist. It is my health virtual personalised App, which keeps on acquiring new capabilities to sharpen its predictive functions, based on my lifestyle database coupled to my epigenomic data It is updated with any consolidated mutation in my body caused by diet, exposure to pollutants, my levels of fitness and son on… Anything I do, it faithfully registers and calculates implications for my body. My I-Pocrate last year detected a predisposition to lung cancer BUT I followed its advice and improved my life style. Hence, earlier this year, I-Pocrate forecasted, with 90% confidence, that I will live disease-free until 90 years old … and I could negotiate a 20% rebate to my health-wellbeing insurance!

The WHOPP (World Human Operational Programme for risk Prevention, to which anyone can freely register and contribute to), fuses data from environmental sensors and omics databanks. Such anonymised hyper massive data and their sense-making allowed tremendous progress in medicine, personalised vaccination and personalised improvement of life styles, anywhere in the world.

Fantastic how I-Pocrate advises me. This morning, he prompted me to take an immune-stimulation, as he computed that I was deficient in a self-repairing cell factor which is probably a result of my smoking, when I was a teen ager, at the time tobacco was not yet internationally forbidden.

Health management and disease prevention have become a daily and much easier task.

Health and well-being objectives and assessments are mainstreamed across all policies, underpinned by improvements in knowledge on causes and mechanisms of health and disease.

Policies thus address effectively determinants of health and promote health equality. Among the initiatives[140]:

● Education: better access to high level education and life-learning programs;

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[131] See UNDESA (2015)

[132] See Eurostat (2016) Old dependency ratio indicator

[133] The cumulated net migration to the EU over the period is 55 million according to the Ageing Report. See EUROPEAN ECONOMY 8|2014

[134] See The Lancet Commissions (2015)

[135] See National Institute for Public Health and the Environment (RIVM) (2014)

[136] See Sonnier (2016): http://storyofdigitalhealth.com/

[137] See DM (2016): https://deepmind.com/health

[138] See IBM (2016): http://www.ibm.com/smarterplanet/us/en/ibmwatson/health/

[139] Inspired from Schmitt (2016)

[140] See WHO (2003)

- Employment: implementation of regulatory measures on the limitation of work time, the promotion of healthy work environments, and protection for vulnerable groups;

- Environment: urban regeneration toward environmentally smart, healthy and inclusive and creative cities.

A "stronger EU" in the global arena, and the world commitment toward the SDG, facilitate the inclusion of stringent health clauses in all trade agreements and partnerships. Industrial players implement the strictest health norms (e.g. air and water pollutants, pesticides, endocrine disruptors). Internally, EU subsidies and structural funds are aligned with the Health Agenda. The Common Agricultural Policy (CAP) aligns budget allocations to the WHO/FAO dietary targets[141].

The EU coordinates strategically public health research to address population-level questions, embracing a wide range of interventions from the fiscal and legislative to the behavioural and biomedical field[142]. The research and actions are discussed with all sectors of society and funders are beyond the biomedical sphere. Health researchers and policy-makers collaborate with networks of cities for testing urban solutions, as interventions need to be assessed against their health impacts. The transdisciplinary and participative approach in research and policies has facilitated the emergence of 'disruptive innovations' in four main fields[143]:

- New models of person-centred community-based health delivery that allow a decentralisation from traditional health care venues like hospitals to integrated care models (e.g. transfer of records to patients);

- New technologies for early diagnostics, personalised medicine, health promotion, community-based therapy and care and the empowerment of patients/citizens, as well as potential curative technologies (e.g. regenerative medicine, immunotherapy for cancer);

- Person-oriented approaches for the treatment of patients with multiple chronic diseases, situations of frailty and/or of loss of functionalities in a multi-cultural context;

- Education of the health workforce and transfer of skills and tasks from highly trained, high cost personnel to personnel that is less specialised and more affordable;

- A health by design approach in urban planning and infrastructure. Improved walkability and cyclability enhance active mobility resulting in less air pollution and a wider spread of healthy lifestyles.

The paradigm shift in elaborating and implementing health policies has paved the way toward the reform of the health systems. By 2030, health systems became "proactive rather than reactive, comprehensive and continuous rather than episodic and disease specific and founded on lasting patient-provider relationship rather than incidental, provider-led care"[144]. Health systems now respond to the growing demand from the ageing population in a socially just and economic efficient way.
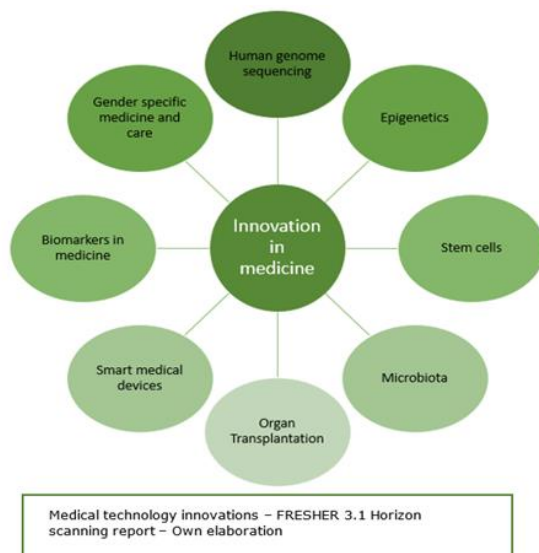
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[141] See Walls et al. (2016)

[142] See Troell et al (2014)

[143] See EC EXPH (2015)

[144] See WHO (2015)

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The long pipeline of technology breakthroughs[145]

Medical technology innovations – FRESHER 3.1 Horizon scanning report – Own elaboration

Post **Human Genome Project (HGP) a**nalysis of each person's genome supports predicting individual health risks and new treatments[146]. The HGP opened the way to the **study of effective biomarkers** and **"omic" medicine.** Biomarkers help identify at-risk individuals, diagnose conditions promptly and accurately, and better treat patients. **Electronic Health Records widely used in hospitals will expand the use of personalized medicine** P**ersonalized health care** – and **gender-specific care –** will become feasible and effective**.** Gene therapy could become a treatment option for a number of diseases. **Tissue regeneration** is probably the most important possible application of **stem cell research**. Replacement cells and tissues may be used to treat cardiovascular diseases, brain disease, heart disease or diabetes. X**eno-organ transplantation** now beckons as a viable, long-term solution to the organ shortage. There are also a lot of expectations and hopes in **foetal tissue** engineering to alleviate currently incurable chronic diseases. In organ transplantation, **3D printing** could play an important role, e.g. progress in bio-printing blood vessels is a crucial step towards printing tissues with a blood supply. **The human microbiome** is researched for a role in many diseases, including autoimmune, metabolic, gastrointestinal, and brain disorders Research into the association of the gut microbiota with health and disease continues to expand, and manipulation of microbiota offers new clinical applications. Advances in **minimally invasive and robotically and computer assisted surgery** mean that in some procedures surgeons do not directly touch or see the structures on which they operate. V**ideo imaging, endoscope technology, and instrumentation** have made it possible to convert many procedures to endoscopic ones. **Healthcare products and wearable technology** for screening and monitoring indicators related to NCDs is already in the market (**blood pressure monitors, blood glucose monitors, nebulizers, body composition monitors, pedometers**, etc). The next wave of wearable health tech will focus on gathering personal data more meaningful to a doctor, and send it directly to his or her office.

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Citizens are encouraged (and empowered) to move towards healthy lifestyles, thanks to information and continuous public monitoring. Social media and social networks share knowledge, information and good practices amongst citizens with high levels of health literacy[147], able to discern and select valuable information and knowledge on the net and social networks[148]. Wearable devices allow individuals to monitor their health and to record their life behaviours and styles. People provide data on their life parameters (e.g. weight, blood tests, etc.) and habits to apps or software and get feedback on their overall health and emerging health risks, as well as health-related recommendations about self-prevention and care[149]. Healthcare systems have re-structured to make use of these electronic records and big data, which are shared within a clear regulatory framework, developing precision medicine, remote healthcare services and broader research on specific diseases on large population dataset at lower cost[150]. Partnerships with emigration countries ensure a constant and flexible flow of trained or trainable health and care workers. These supplement the resources of trained Europeans. Local schools and professional universities in Africa, Middle-East and Asia are linked to the best EU universities providing both

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[145] See FRESHER project (2016)

[146] Most new drugs based on genetic research have yet to come out of clinical trials.

[147] Definition quoted from
http://eurohealthnet.eu/sites/eurohealthnet.eu/files/A%20healthier%20Netherlands%2C%20PHSF-2014.pdf

[148] See Graf et al. (2015)

[149] See SPREAD Project (2012)

[150] See Troell et al. (2014)

skilled resources to the solvable EU Health and Care market – and revenue to the original countries.

Through big data, Europe boasts a dynamic healthcare system which learns in real-time from every result. The cost of clinical trials has come down and treatment selection has improved. Through R&I investments and appropriate business models for the pharmaceutical sector, the EU leads the world in prevention technologies, having defeated antimicrobial resistance and allowing for personalised vaccination. The gap between life expectancy and healthy life expectancy has narrowed significantly.

By 2030, the world has witnessed many new technology waves[151] and new markets that have dramatically raised the potential for individual health and life changes[152]**.** Many people stay healthy and productive up to the grand old ages of 100 to 110, when they quickly deteriorate and die[153]. European society has continued to enjoy high levels of health and long life-spans and important positions in the expanding health markets, thanks to important public investments in R&I and successful regulation concerning the development and pricing of medicines, of privacy rules for new technologies and drugs,[154] and successful cooperation between governments, insurance, health care service providers, research and local authorities, building on the increasing engagement of citizens in health. The combination of educated citizens-patients and data availability enabled Europe to collectively address issues associated with ethics, trust, and skills, which lie at the heart of the transformation to a vibrant and competitive economy and a healthy and equitable society.

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[151] See Hanlon (2011)

[152] See EEA (2015)

[153] See NHS (2009)

[154] See Anton, Philip S. (2001)

6. SECURITY AND RESILIENCE

6.1. Security race

It is 2030, and for the last 15 years Europe has been haunted by insecurity. **Geopolitical conflicts and war in the EU's neighbourhood** continuously generate threats which spill over through waves of migration[155] raising tensions in different areas as well as through "radicalized" parts of European population[156]. **Terrorist attacks loom unabated through a dangerous combination of tactics including mass violence, cyber-attacks, lone-wolf attacks and the threat of bio warfare**.

TERROR ATTACKS AND DEATHS DUE TO TERRORISM SINCE 2001
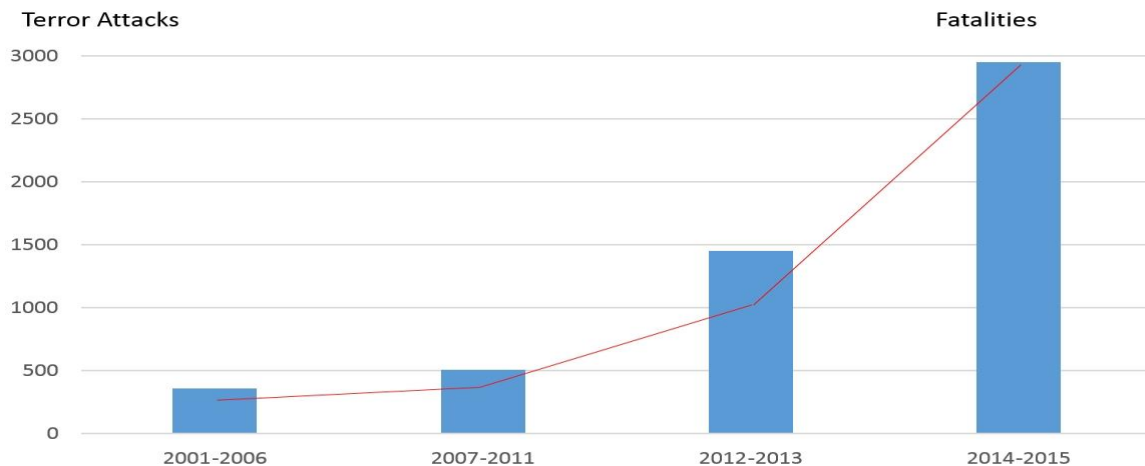
Source: The Atlantic Council *Global risks 2035 - The search for a new normal*

Countries responded to the rise of insecurity with huge investments in safeguarding external borders. National military and security budgets rise accompanied by an unprecedented growth in scientific and technological efforts to anticipate detect and neutralize threats. Cyber security policies become a political priority. National security research and technology programmes proliferate (including on criminal prediction, surveillance and compartmentalization). **Innovations in security technologies (such as non-lethal weapons, drones, molecular biology, social engineering) raised important regulatory and security challenges themselves. Misuse of technology and information is the normal practice.**

In order to mitigate cyber security risks and threats, governments rely on the corporate sector, creating a moderately business-friendly environment through existing laws and policies: tax exemptions, promotion of self-regulatory instruments, establishment of public-private partnerships, etc. Governments rely heavily on corporate supply chains for military equipment and services. Companies, in their turn, operate with minimal guidance from governments, regulating their own activities through standard (and not very innovative) codes of conduct, voluntary standards and other self-regulatory instruments.[157]

Radicalization continues unabated, as well as more in general tensions between different ethnic and religious communities living in Europe. These tensions are not about the political role of religions and churches – who have accepted the separation with the State – but about the sharing of a common set of values and norms. It is a cultural gap, not a political one.[158] Differences across

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[155] Mass refugee movements due to climate change or unliveable economic conditions lead to an overrun of host societies with increasing pressure on their cultural or religious identities.

[156] This includes all kinds of radical groups of religious, nationalist or other persuasion.

[157] See Flagship project (2015)

[158] The empirical research done by EURISLAM in Europe shows that majority populations perceive far more cultural distance towards European Muslims than the Muslim groups perceive towards the majority groups in their European host countries. Policy-makers may target Muslim communities with the best policy intentions,

European countries continue to be an important factor hampering the emergence of a common European approach to immigration and integration.
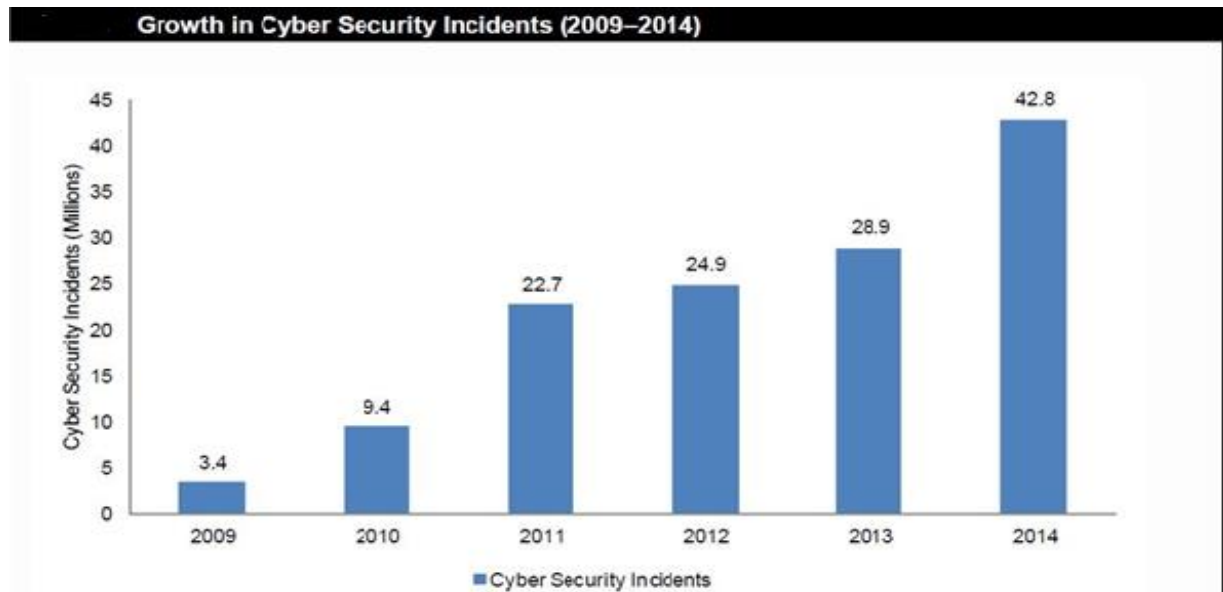
Source: PWC, The Global State of Information Security Survey 2015

Other security challenges emerge, stemming from the prolonged economic and financial crises in the context of a slow growth economy, increasing inequality and unsustainability of traditional social welfare systems in the face of population ageing and shrinking workforce. The approach to deal with these and other challenges – e.g. the extreme events caused by climate change – is however weak and poorly coordinated across the European countries. Security policies are mostly directed to control the effects without investing in efforts to remove the deeper causes of insecurity. An increasing dependence on external controls and techno-solutions – enabled by a pervasive Internet of Things – eventually reduce the ability of people to build their own security response, increasing overall fragility and over-reaction to security warnings.

What if…is war in Europe still unthinkable?

In the summer of 2016, the Prime Minister of Britain warned that the exit of Britain from the EU would increase the risk of war in Europe[159]. The unthinkability of war in Europe was based on the idea of strong European institutions that resolve differences between Member States in ways that are seen as fair by the citizens of those States. The strength and perception of fairness of these institutions are not to be taken for granted. As the PEW research centre found ever fewer Europeans have a favourable view of the European Union[160]. In 2016 the top three issues of concern of European citizens were "immigration"; "terrorism" and the "economic situation"[161]. Going three years back and before the top three issues were "the economic situation", unemployment" and "the state of Member States" public finances[162]. Migration is blamed for the economic situation and terrorism. Protectionism emerges in professions and services in Europe[163]. Identitarian movements challenge cosmopolitanism, and advocate war on

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but without adequate connected policies aimed at majority populations, will most likely not reduce the feeling of discrimination among people of Muslim origins. See EC (2016b)

[159] See MacAskill (2016)

[160] http://www.pewresearch.org/fact-tank/2016/12/06/4-factors-driving-anti-establishment-sentiment-in-europe/ft_16-12-06_europeconcerns_eu/

[161] http://europa.eu/rapid/press-release_IP-16-2665_en.htm

[162] http://ec.europa.eu/public_opinion/archives/eb/eb81/eb81_publ_en.pdf

[163] See "Numéros Inami aux étrangers: «Injuste», selon les médecins et les étudiants"; Le Soir 8 December 2016 http://www.lesoir.be/1387009/article/actualite/belgique/2016-12-08/numeros-inami-aux-etrangers-injuste-selon-medecins-et-etudiants

"the other" and legitimize violence[164]. Geopolitically, the deterioration of NATO – Russia relationships and the continuing war in Syria and Iraq provide good reasons to worry[165]. The last taboo could break when nationalist governments, under pressure from their disappointed populations, revert back to the old scapegoats of external aggression[166] and go to war against neighbouring countries over disputes on migration or resource issues, or threatened economic interests. Following the UK vote Mr Cameron resigned.

Wealthy local communities protect themselves as far as possible. Insecurity has thus created unprecedented security inequalities and mistrust: EU vs. non-EU; richer vs. poorer member states; wealthy vs. poor communities.

6.2. Building societal security

The realization that the rise in insecurity experienced in Europe the middle of the 2010s was partly due to problems of inequality and lack of social integration in Europe itself, and partly due to crises in other parts of the world that could have been avoided, generated **a movement for a broader approach to societal security**. Going beyond an "end of the pipeline" mind-set, security policies have addressed also the deeper causes of insecurity – in combination with active policies in other areas to mitigate social and environmental challenges - and not only the effects.

The **weight of security in national and European budgets rose dramatically** entailing more coordinated and combined use of different means including marginalized and vulnerable groups and countries and related infrastructures. **Security became an increasingly cross-cutting policy (and science) field**, shifting the emphasis from the prevailing industrial policy concerns to the full range of security dimensions including economic, societal and environmental aspects in a coherent, integrated way, focusing on societal and environmental resilience.

In practice this led to **a new emphasis to addressing social disaffection and its causes**, **and in huge investments in system level 'security by design' programmes[167],** which were added to the investments in military and civil security technologies (aiming at predicting, identifying and neutralizing threats). Participatory processes have involved end users in the co-design of security solutions in a consistent way (e.g. to prevent possible weaponisation of civilian technologies) and the boost of pre-emptive measures, such as smart design of cities and localities, have strengthened the (real and felt) level of security. Intense societal engagement in the design of new security measures contributed to an open and trustful society with low levels of surveillance and individual and collective protection.

Cyber security policies have played a key role in maintaining a long-lasting period of non-conflict between countries. Governments, in coordination with private companies, design, develop and launch cyber security public-private partnerships, namely alliances that provide specialized training and internships, as well as awareness raising initiatives. Companies increasingly integrate cyber security into their Corporate Social Responsibility. Non-profits have become the watchdogs of the new corporate social responsibilities roles embraced by the business industry, including its cyber security pledges.

Radicalization and terrorist attacks have triggered an important mobilization the European Union and several of its key Member States, to better integrate those citizens with a post-colonial immigrant background and also preserve fundamental rights. The EU had to promote specific policies to reinforce its democracies. Beyond their own specificities and disastrous security impacts, it was recognised that jihadist terror attacks are also the symptoms of social and cultural problems that have flourished in Europe's urban and suburban enclaves.

Building resilience to societal and environmental disruptive events has become an imperative. Security policies were re-imagined and widened in scope, changed to address broader concerns such as equality, employment, education (training) and resource security. The new vision for economic development was structured around efforts to counter inequality, and foster different models of ownership and accountability. Sudden failures in essential systems such as health care

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[164] See Willinger (2013) see also https://www.bloc-identitaire.com/

[165] See Apps (2016)

[166] See Monbiot's article in the Guardian commenting on turning internal anger into external aggression, https://www.theguardian.com/commentisfree/2016/nov/23/donald-trump-climate-change-war

[167] An EU investment programme for Africa reinforced by other investments has provided opportunities and safeguarded livelihoods for millions

and public health, flood defences, or emergency responses can have disastrous consequences for many people. Building resilience has therefore required careful planning and preparation based on assessments of risks; development of capacity to restore functions quickly and effectively in the face of disruptions; and the capacity to adapt and change after a shock. [168] Effective surveillance and early warning systems are in place and coordinated at the international level as necessary. The vulnerabilities of specific subgroups to environmental change are better understood and plans are in place – e.g., heatwave early warning systems – to permit rapid intervention, particularly for elderly people living alone or in high risk institutions.[169]

A study[170] conducted for IBM in 2016 examined 383 companies in 12 countries and found the average cost of a data breech to have increased by 29% in 3 years to $4 million. The study showed that organizations find it difficult to identify malicious and criminal data-breaches and to contain them.

National governments have an important role in strategic planning for resilience, but plans need to involve local initiatives, including providing advice and technical and financial resources. In the poorest countries, support is provided from international institutions and initiatives such as the UN Framework Convention on Climate Change, the UN International Strategy for Disaster Reduction, and the new SDG process. Cities are able to catalyse effective policy and action at the national level.[171]

What if...Space exploration as a world pacifying project

While Space is an important part of global telecommunications and earth observation infrastructures, and increasingly a domain of economic competition, it is also a vast unexplored area the exploration of which enables humanity to learn about the origins of the universe, to satisfy fundamental curiosities about nature, and to potentially benefit from the resources of the universe.

Space exploration is a domain of growing international cooperation with other continents, epitomized by the continuous functioning of the International Space Station and by the international agreements established to solve the growing problems of spatial debris.[172] This cooperation enacted for the common purpose of outer space exploration and exploitation could make a great contribution to build a climate of security across Europe and beyond, with other international partners (namely Russia, China, India and US).

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[168] See The Lancet Commission (2015a)

[169] See Tolo et al. (2013)

[170] See Ponemon Institute (2016)

[171] See Rockefeller Foundation (2015)

[172] Nowadays, there are hundreds of pieces of debris that are potentially dangerous for the International Space Station (ISS). Those whose trajectory comes within the 'safety area' are tracked particularly closely. As they approach, a debris avoidance manoeuvre might be made. If that is not possible, crews take refuge in the Soyuz spacecraft.

7. ACCELERATING INNOVATION: PEOPLE AND TECH-CONVERGENCE

7.1. Losing the race against the machine

It is now 2030. The last 15 years witnessed a massive acceleration of innovation, with new technologies generating unprecedented possibilities for new monopolies and novel challenges at a very fast pace. Firms across all sectors of the economy are predominantly digitalised. Ubiquitous sensing, big data analytics, machine learning, advanced robotics and service bots are highly integrated in multinational companies. Product design, manufacturing and delivery are highly integrated and efficient for the dominant players. Additive manufacturing technologies allow products to be tailored to specific user needs using computer-assisted drawing software. Placing an order is a matter of uploading a file providing the desired specifications, which triggers automated manufacturing and delivery processes. These processes are mainly controlled from outside Europe.

Firms on the global productivity frontier are typically larger, more profitable and more likely to apply for patents than other firms[173]. They are also typically "global firms" in the sense that they operate in different countries, and are interconnected with suppliers/customers from different countries along global value chains. This makes them better placed than other firms to enhance productivity, using their capacity to innovate, which increasingly requires not only investment in R&D and advanced technologies, but also a combination of technological, organisational and human capital in production processes. **Global frontier firms are in a better position to harness the power of digitalisation to rapidly diffuse and replicate cutting-edge ideas, technologies and business models.**

There is a rising gap in productivity growth between firms at the global frontier and other firms, as non-frontier firms face increased difficulties in learning from the frontier. Network externalities (e.g. in industries involving digital platforms) lead to growing concentration in certain markets. The dependency in Europe on platforms and IPR rules of multinationals has become a main barrier for new innovators to develop independent solutions in for local and regional needs and to create new European innovation pathways[174].

The evolution of the agricultural sector shows the prevailing dynamics. Owing to the removal of barriers for globalisation through far-reaching international agreements, the trend to big data in ICT and patents on agricultural organisms in genetics, large private multinational companies with huge resources and influence are dominating the food chain and agricultural production. Multinational retail chains are closely linked with them, building agro-industrial business clusters. Much attention and means go to chain management, including precision agriculture using wireless sensor networks: They are run by multinationals that provide the integrated services in the agroindustry 4.0. Private research and IPR on new seeds and breeding technologies are strongly enforced. Extreme public budget cuts, trade liberalization and deregulation fuels this process[175].

This is a new world economy in which Europe struggles to take leadership. **Hyper-scalability means that businesses grow massive and comparatively few mega-multinationals buy promising new firms in Europe. Newcomers disappear within a few years. Profits and jobs change locations frequently. Infrastructure investment decisions become risky, as technologies depreciate at an accelerated pace.**

7.2. The innovation revolution for everyone

It is now 2030. The last 15 years witnessed a massive acceleration of innovation, with new technologies generating unprecedented possibilities and novel challenges at a very fast pace. These have been the years of Europe's revival. **The EU embraced the innovation revolution, invested in research technology and innovation (social and technological) and developed its regulatory systems.**

Key for Europe have been the forward looking investments in infrastructures that facilitated innovation. From ICT infrastructures to Satellite Communications, from smart cities to smart countryside, from transport links to environmental improvements, infrastructures form the bedrock

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[173] See Andrews et al (2015)

[174] See OECD (2016a)

[175] See EC (2016a)

for new generations of social and technological innovation. Particular place amongst the infrastructures hold the scientific and technological research facilities which have clustered important mass of talent across all disciplines and investment in equipment, in vibrant cities which have been transformed into hubs of innovation. Biotechnology, nanotechnology, new materials and all sorts of science, engineering and scholarship produce new ideas, knowledge and innovation in an open environment.

An open system for innovation across Europe makes it possible that all actors can become active in the innovation system. It goes beyond open access to science: open culture, open standards, open markets, open debate, open government. Openness in the ways knowledge is created, transmitted and applied empowers European citizens. **A strong life-long-curiosity initiative** built on the strong social protection and university base of the EU, to ensure that everyone can learn, discover and innovate. Emphasis is on inclusiveness and social solidarity, and **infrastructure investment across the continent enables all regions to participate in the new economy**.

Openness does not mean lawlessness, and regulation and standardization have become sciences in which Europe leads the world. Appropriate regulation includes of course markets, where, building on the success of the Digital Single Market, Distributed Ledger Technology provides the contractual infrastructure for frictionless management of contract, payment, tax and social security settlements in the gig economy. **European companies excel in modular infrastructure designs, and in appropriate regulation of autonomous systems. F**ast growing European start-ups compete strongly with American and Chinese companies in key global sectors, such as space exploration and travel, virtual reality, healthy environments, bio-based solutions, ultra-fast decision-making, energy storage, carbon storage, circular mobility, 3D scanning and 4D printing.

Success in this new economy brings massive, though ephemeral, rewards. The losses of failure are amortized by a system of Europe-wide insurance and transfers. Change indeed means effort for all and at least short-term losses for some. So shared ownership of the innovation revolution in the EU was not a matter of simply predicting that the robots or the gig economy eat jobs, and then make rules about that alleged danger[176]. The harder task was instead planning to benefit from the best of new manufacturing and service technologies, while maintaining decent income for decent employment and a life-long funded social safety net.[177]

Overall the acceleration of innovation has brought not only the economic benefits of better services and products but also the social benefit of cohesion in Europe, where citizens are able to shape the future of rapid change together. Indeed, the creation of a coherent vision and of a more coherent conversation on open innovation in the EU has been key to navigate the challenges, and achieve the desired outcomes in productivity, growth and jobs, but also in social inclusion and sustainability.

Widespread introduction of **household or individual basic income, and life-time social budgets for the education, health and skills of each citizen**, mediated through similar technology networks, was the key to innovate social welfare in the Internet age[178]. The benefits of higher productivity growth were also better shared in the economy, with an increasing number of people earning from entrepreneurial and creative activities, and a reduction of the working hours for permanent employees in the most productive companies without reduction of their wages. Greater free time was also converted in more time devoted to voluntary work in the social economy and/or civic activities. The deepening and extension of the **Grand Coalition for Digital Jobs,** offered a distributed model for matching individual skills portfolios with employer needs, across specific locations, with learning opportunities, EU-supported but locally made. It has broken old siloes between skills actors, especially between government, education and business.[179] The coalition was able to scale up and grow faster with Internet-age support tools, using real-time labour market data and data analytics to better map needs and gaps. But broader cooperation and sustained impetus was the key to success.[180]

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[176] See Madelin (2016)

[177] See Madelin (2016)

[178] See Madelin (2016)

[179] The coalition has proved since the beginning that there was huge unmet demand for such training, that at least 40% of that demand was from girls and women, and that the employment opportunities following training were real.

[180] Although successful, the coalition for digital jobs alone could not had been enough to redesign an educational system for Europe that created the innovative potential as the core asset on which future prosperity

8. TOWARDS A WORLD OF CITIES

8.1. Urban jam

Global urbanization continues at unprecedented levels, mostly outside Europe[181]. By the end of the 21st century, urban population could reach 9 billion, corresponding to close to 85% of the projected total population[182]. Almost all urban population growth will occur in developing countries, with nearly 90% occurring in Asia and Africa. **In 2030 the world contains 40 megacities of more than 10 million inhabitants**. The fastest growing agglomerations are still cities of less than 1 million inhabitants. A growing proportion of low-income groups has become urbanised and **in some regions, urban growth has become virtually synonymous with slum formation**. Urban slums suffer from substandard housing and inadequate water, sanitation and waste management services, with negative consequences for human health and the environment[183]. Air pollution and unmanaged waste are major concerns for public health in many urban areas. **Over-stretched infrastructures and congestion combined with extreme weather events stem the economic potential of many cities and turn them into nests of conflict and social unrest**.

As people move, some cities shrink in size. Unmanaged, this process creates swathes of urban decay. In highly urbanized Europe, urban sprawl continues to expand preventing the potential benefits of cities in productivity and quality of life from materialising and further breeding the vicious circle of poor accessibility. Asymmetrical housing markets continue to push people to suburban or peri-urban areas, further apart than they would otherwise wish to be. As the distance to the city centre increases and the density of population decreases, car emissions dominate total emissions[184].

What if…can clogged cities be vibrant, creative and innovative spaces?

Cities are emerging as hubs of technological innovation, as innovative activities move from technology parks in suburban areas, to city locations. There is a global trend of start-ups in cities like Berlin, Buenos Aires, Mumbai and Madrid. The rise of technology start-ups in cities is leading to new sources of employment and economic growth[185]. Not all cities are as innovative. A concentration of scientific and technological infrastructure and brain-power helps. Cultural life helping connections between people is also important[186]. The report "The Knowledge Future[187]" developed a vision of Europe as a collection of vibrant and dynamic innovation ecosystems based on cities. While that report put emphasis in the interaction between education, research and innovation, transport infrastructures are amongst the important assets of cities. Mobility opportunities are associated with quality of life and opportunity for interactions [188] A strong IT network infrastructure is also a characteristic of smart, innovative cities, but the quality of life advantages offered by easy mobility are huge. In smart cities, the ICT networks support mobility rather than substituting for it.

Automation has taken hold in some segments of transport. Major technological advances in ICT, Big Data and the Internet of Things facilitate the deployment of connected and autonomous vehicles. To a certain extent, the pace of innovation in the traditional transport market is set by

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depends. Dedicated approaches to early childhood innovation thinking, earlier and more consistent exposure to experimental and creative problem solving, as well as measures to prepare an aging workforce to adapt, were also widely acknowledged and created a renewed commitment to an impact agenda for innovation-oriented education as a no-regrets investment for Europe. See Madelin (2016)

[181] See EC (2012)

[182] See OECD (2015a)

[183] See OECD (2012)

[184] See VandeWeghe (2007)

[185] See Mulas et al (2015)

[186] See Florida (2002)

[187] See Hudson et al (2015)

[188] See Mulas et al (2015)

new entrants (e.g. ICT companies developing automated vehicles)[189]. The transition from conventional to automated transport could contribute to improving mobility and to lessen its impact on the environment, but could also be hindered, by insufficient attention to the dynamics of demand and to the systemic needs and effects of changing mobility paradigms[190]. Lack of business model innovation in the freight sector hampers decarbonisation processes. New production and consumption paradigms are insufficiently exploited and most goods are still physically moved over long distances. Congestion and air pollution proceed largely unabated, further driving environmental costs towards unsustainable highs.

The infrastructure and the complexity of data handling operations required for the diffusion of connected cars and autonomous vehicles pose potentially important bottlenecks, especially when combined with privacy concerns. The smart-city nexus of energy, transport and environmental quality is prevented from emerging for lack of governance and investment. The transport industry suffers from the effects of a shrinking traditional market and the demographic consequences of an ageing society.

Mega-city urbanisation in emerging economies drives the choices of Europe's automotive manufacturers and guides the efforts of large engineering concerns to support the rapid expansion of infrastructures in energy, transport and environmental services provision required. As megacities struggle to control the environmental degradation, public health and social problems of expanding slumps, those problems spill over to unprecedented scales - through worldwide migration of people, pollution and discontent, resulting in a global vicious cycle of spreading insecurity, disease and public unrest.

While Europe struggles to deal with the consequences of the spillovers, there is a reflection on the missed opportunity, when the prospect of a rise of urban populations worldwide by more than 2 bn people over the period 2015-2030, was translated to an opportunity to sell expensive hardware to struggling megacity governments, rather than to develop the new markets, technology and governance solutions that could improve massively the livelihoods of those populations. The opportunity was missed because of overestimating the importance of technology, and because of underestimating the need to invest in radical alternatives. For example, in transport, overwhelmed by the short term economic success of competitive emerging markets, Europe's industry overestimated the importance of technological progress alone, and missed the opportunity to adapt business models and technological solutions to new needs, including sustainable mobility patterns[191]. Because of the short term increases in its modal share of air transport, Europe's industry has failed to recognize the urgency of radical innovation and found itself unprepared for the era of all-electric aircrafts (the "Tesla of the air"), which is already a small but established segment of air transport.

8.2. New models of urban development

A key milestone in this urban blooming scenario was the adoption of the New Urban Agenda (https://habitat3.org/the-new-urban-agenda) at the Habitat III conference in Quito, in 2016, insisting of the transformative power of urbanization to achieve the UN SDGs. Recognising that throughout history urbanization has been a major driver of growth and poverty reduction, governments promoted a **new model of urban development** that was able to integrate all facets of sustainable development to promote equity, welfare and shared prosperity. The New Urban Agenda was an action-oriented document setting global standards of achievement in sustainable urban development, rethinking the way the cities are built, managed, and provide the living environment for an increasing share of urbanised population, through drawing together cooperation with committed partners, relevant stakeholders, and urban actors at all levels of government as well as the private sector.

With more than 80% of global GDP and more that 70% of GHG emissions generated in cities[192], well managed urbanisation has been key for sustainability, contributing to growth and increasing productivity and innovation. Productivity greatly depends on citizens' easy access to education, healthcare, security, food, water, transport, clean air and electricity, enjoying good quality of life. Building on advances in sensors and their connectivity through high-performance computing and the Internet of Things, urban areas in more advanced and emerging economies will increasingly

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[189] See RACE 2050 project (2015)

[190] See TAG (2016)

[191] Id.

[192] See World Bank (2016)

become "smart cities". **Utility and transport networks and systems will become progressively interconnected, supporting more sustainable use and management of resources[193] as compact cities ensure greater accessibility and higher energy and carbon efficiency than a dispersed built environment[194].** Smart use of "smart-city data" has helped cities become important sources of innovation. Nature-based-solutions have been be widely adopted and movements for sustainable food cities are widely followed.

The urban transformation has posed completely different challenges to the old cities of Europe, than to the rapidly expanding cities of Asia and Africa. In Europe there was a major need to retrofit the old infrastructures with new functionalities associated with smart, sustainable and healthy cities. In Asia and Africa town-planners are designing from scratch urban areas that conform to current views of smart, sustainable and healthy cities. Modern town planners know that technology and resources are seldom used exactly in the way they are meant to be used, and this applies to urban space too. So, the design of successfully smart, sustainable, resilient and healthy new cities that promote social integration is informed by the experience and the solutions of the old cities of Europe. At the same time, the new cities become laboratories for the study of new models of urban development, incorporating, for example, nature based solutions to classic city problems such as waste treatment and air quality.

Experimenting cities

Deployment of ICT infrastructure and developments in participatory governance have been at the origins of the movement of smart cities. Smart cities use data analytics and technologies like the Internet of Things to improve planning, energy efficiency, traffic management and all kinds of city functions and services that improve environmental management and quality of life of city inhabitants and visitors. The trove of data that is accumulated in the context of smart city operations is very valuable for research in health and medicine (e.g. on health and pollution, the spread of pathogens etc.) but also in behavioural sciences and in relation to the deployment of new technologies and innovations. Smart, healthy and environmentally sustainable cities, resilient cities, carbon neutral cities, happy cities, are some of the many movements to develop cities into innovative environments favouring particular characteristics. Not only technopoles but also dynamic, vibrant social spaces. Increasingly through participation and engagement of their inhabitants, cities develop into laboratories for social and policy experiments, and as environments that can, with appropriate governance, to stimulate innovation and creativity and become the engines of national and international economies.

The need for an effective decoupling of transport from economic growth has prompted a stringent application of the "users pay" principle and the accelerated development of radically new technological options such as hyper loops. In Europe there are discussions about adapting such options to the European landscapes, but their deployment elsewhere has unleashed a process of improving existing mobility infrastructures across the continent. In an increasingly polycentric Europe, this drives the development of high-efficiency connections between large and medium size cities, thus contributing to the curbing of urban sprawl[195].

In the freight sector, the need to reduce environmental costs has driven substitution of transport by virtualisation through 3D printing and a flourish of local loop economies. Big data developments combined with (local and remote) sensor technology and new materials have allowed transport networks to reach near-zero maintenance and self-repairing status, thus increasing the lifetimes of infrastructure and assets of road, rail, maritime and air[196]. **A circular mobility system shared, electrified, autonomous, multi-modal, and looped, offers more mobility choice, with fewer, better-utilised cars, less congestion, less land and investment committed to parking and roads, and less air pollution.** Cost per average passenger-km could drop by as much as 80 percent by 2050. In 2030, with roughly half of passenger-kilometres covered in a system-optimised way, mobility emissions in Europe have fallen by as much as 55 percent. By 2050, the sector could be 95% decarbonised[197].

[193] See EC (2014)

[194] See CEPS (2013)

[195] See EC (2012)

[196] See TAG (2016)

[197] According to IEA, in 2015 93% of final energy consumption in transport was covered by oil products.

The uptake of connected and autonomous vehicles has been supported by the transition to the "sharing economy"[198] paradigm. The transport market has become service-oriented, with traditional players accordingly changing their business models to serve new and more sustainable mobility patterns and retain their competitiveness on the market. Different kinds of sustainable transport in cities (see figure below) continue to expand across Europe.

Figure: Spread of sustainable mobility scheme across cities
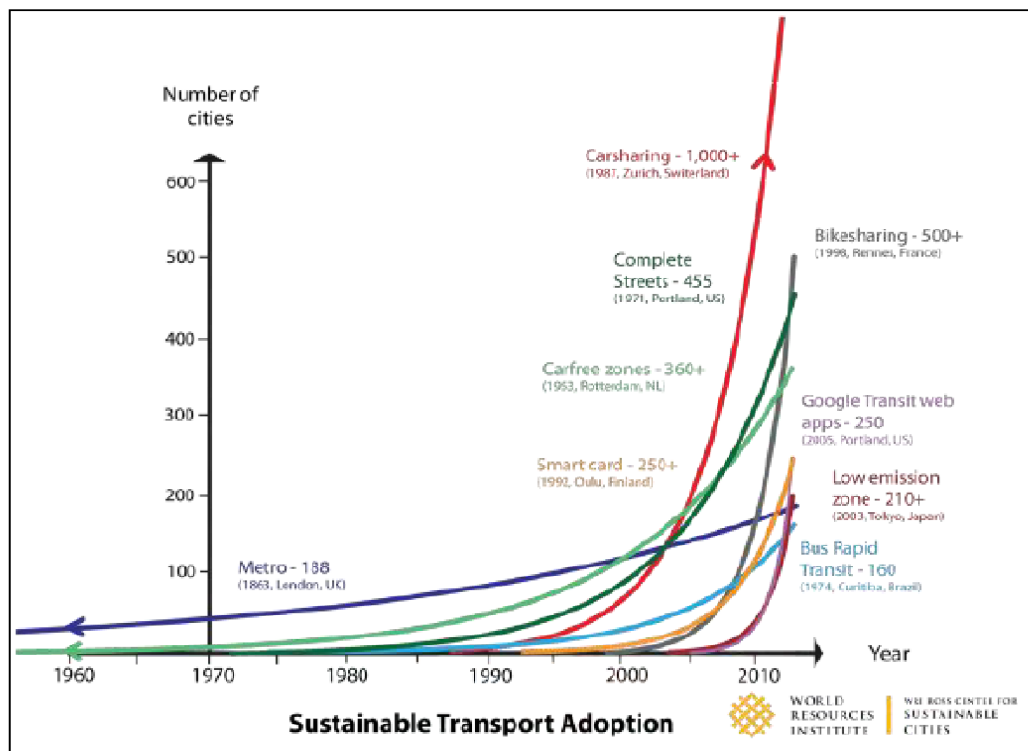
A built environment based on circular economy principles has increasingly reclaimed inner-city land to create high-quality spaces where people can live, work, and play, integrating green infrastructure (e.g., parks) with durable, mixed-use buildings with modular designs and built with looped non-toxic materials. Buildings generate power and food, and recycle water and nutrients. **The circular "urban bloom" has reduced urban sprawl in Europe by up to 30,000 square kilometres by 2050** (compared with the current development scenario). CO2 emissions fell to 85% below 2012 levels. Enhancing the walkability and cyclability of cities helped to address congestion and had substantial public health co-benefits. Cities are competing to be the most bike-friendly place.

For Europe's engineering and transport companies, leadership, strategy and competitive advantages start at home, building on the engagement of Europe's inhabitants with the governance of their cities and on their involvement in the definition of their needs. These drive environmental, health, and social standards higher and guide the development of solutions in energy, transport, environment, health and social care, security and resilience. They also build on the talent and engagement of people with innovation and on the vibrancy of the innovation ecosystems of Europe's "small and medium-sized" urban areas that continue to be amongst the most desirable places to live on the planet. This allows European firms to anticipate the dynamics of world market and retain their leadership position, combining a creative and innovative mind-set with tailored technological solutions and adaptive business awareness[199].

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[198] See https://blogs.ec.europa.eu/eupolicylab/portfolios/a-vision-for-the-eu-sharing-economy/

[199] For example in transport the potential loss of vehicles sales and related employment may be compensated by the sales in new services with high export potential - such as ICT-based remote monitoring and maintenance, software updates for autonomous vehicles, training. See RACE 2050 project (2015)

9. CONCLUDING OUTLOOK

9.1. The global context: a window of opportunity for Europe

With the start of the Juncker Commission in 2014, a range of new policy initiatives were launched in order to strengthen Europe's economic performance and its position in the world[200] and to improve the well-being of European citizens. More recently, these initiatives have been complemented by a number of outward-oriented measures, such as the proposal for a European external investment plan that complements the European Fund for Strategic Investment, or the presentation of the EU's Global Strategy for Foreign and Security Policy. At global level, the Paris Agreement on the reduction of climate change and the agreement on Sustainable Development Goals (SDGs) showed the ability of the international community to reach joint commitments. These agreements are having a major impact on policy agendas, and the European Commission has announced its strategy for responding to the SDGs and implementing the climate agreements[201].

Yet there are many problems in the world for which joint global action is needed and there is growing pressure on the global community to organize itself and lead humanity towards a better future on the planet. There is a widespread sense that 'business-as-usual' (or 'governance as usual') is not regarded as a serious option any more. It would erode Europe's global economic and political position, but also drive the world towards severe environmental degradation and growing instability and conflict. Europe becoming "an increasingly irrelevant outgrowth on the Asian continent"[202] carries massive risks for Europe and for the world as a whole. Europe cannot determine its future independently, because it is intimately embedded in developments in the global context.

A European strategy for the future must be chosen carefully in light of different future scenarios it may be confronted with. In the global perseverance scenario of turbulent transitions the world will be characterized by major environmental, economic and security risks, and Europe will be affected by them. A volatile hypercompetitive global economy in which hyper-scalable business grow and fail fast in a short lived winner takes all mode would require brave economic decisions by firms and governments and scale and scope to go with it. A strong and united Europe could stand its economic ground in this environment and overcome some of the negative repercussions of these risks, although at cost to the fulfilment of Art 3 of the Treaty for the European Union[203]. In a more optimistic outlook in line with the different change scenarios, a sustainable transition would be realised in the world, and it would offer favourable conditions for Europe to achieve a globally leading position in important areas of future promise.

Research and innovation and political will are key for overcoming current and emerging challenges, both globally and in Europe[204]. The Sustainable Development Goals, by fighting poverty, hunger and exclusion will bring a huge global expansion of markets and will provide an important stimulus to trade and economic growth. The green transition worldwide will only strengthen existing growth trends, which, for within Europe can be seen in the graph below.[205]

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[200] https://ec.europa.eu/commission/2014-2019/president_en

[201] EC (2016e)

[202] The Reflection Group (2010) http://www.consilium.europa.eu/uedocs/cmsupload/en_web.pdf

[203] Art 3 TFEU states: "The Union's aim is to promote peace, its values and the well-being of its peoples".

[204] An implicit risk is that of research and innovation making too high promises for the short- to medium-term, which, if not fulfilled, would erode the credibility of and confidence of people in science, research and innovation.

[205] See Perez et al (2016)

The EU environmental economy grows faster than the overall economy[206]

Index (2003 = 100)

Legend:
- EGSS value added (fixed prices)
- EGSS employment
- Total EU GDP (fixed prices)
- Total EU employment
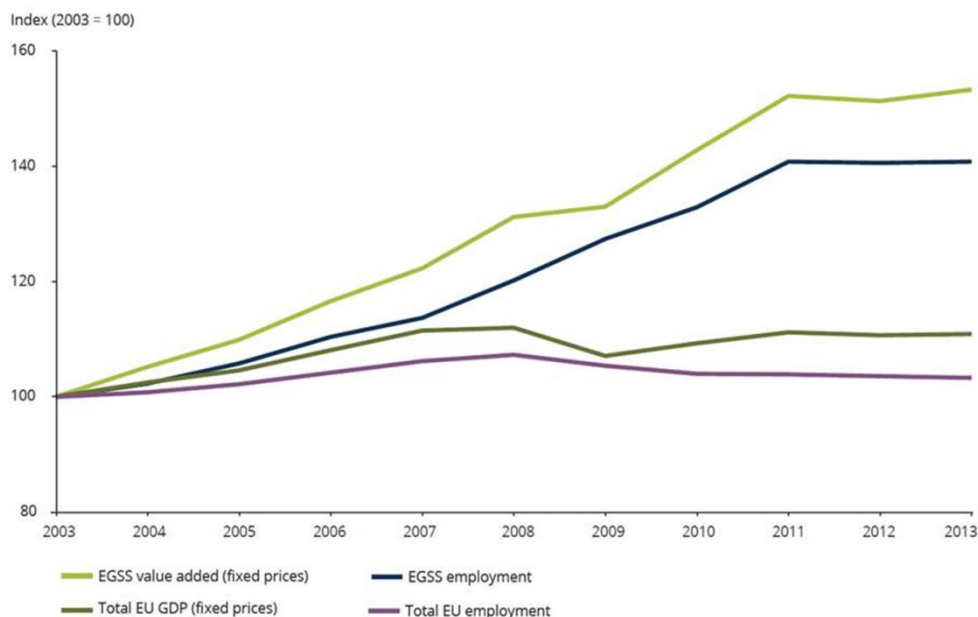
The economic promise of the global transition to the SDGs strengthens the case for fundamental systemic change. Research and innovation will be decisive for its realisation.

9.2. A strong and resilient Europe: building the Future We Want

The need for a stronger Europe is well articulated in the Global Strategy for the EU foreign and security policy[207] which emphasises the need to promote peace and security within and beyond its borders. The vision and the ambition are for a stronger Union, willing and able to make a positive difference in the world. The EU is clearly committed to a global order based on international law, which ensures human rights and sustainable development and lasting access to the global commons. The aspiration is to transform rather than to simply preserve the existing global system. External and internal policies across the Union need to be mobilized to ensure the implementation of the SDGs in Europe and abroad, and the realization of an effective migration and security policy.

What if…sources and consequences of European weakness in a turbulent global context

A turbulent global context may pose serious risks for Europe's security and for its resilience to natural catastrophes. In addition, a turbulent global context is likely to pose challenges to the global economy, which will affect the wellbeing of Europeans. A strong Europe with a vibrant and inclusive economic system could withstand and overcome such risks.

However, weakness can come from many fronts. Globalization of the European economy without further economic integration poses economic and political risks[208]. On the economic front Europe's economy may find it difficult to compete in the age of digital global markets and may stagnate, under pressure from technological unemployment and rising inequalities. On the political front, disaffected citizens in any of the Member States may join nationalist movements for their countries to break out of the Union and join the wider world alone and independent.

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[206] EEA based on Eurostat http://ec.europa.eu/eurostat/statistics-explained/index.php/ Environmental economy - employment and growth

[207] See EU (2016)

[208] Until 2015, intra-EU trade has grown at least in line with extra-EU trade, but this proved to be no longer the case since then. In 2015, intra-EU trade accounted for about 60% of the total trade of the average EU member country, but in terms of trade in value added, the proportion was lower and already closer to 50%. For jobs, which are correlated with the value added, extra-EU trade was in 2015 already as important as intra-EU trade. For the UK in 2015 extra-EU trade accounted for about 60% of total value added. As the EU was becoming a smaller proportion of the global economy, the trend continued. The jobs, associated with intra-EU trade and investment, have been gradually declining in all Member Countries.

Weakness in Europe can easily become weakness of the European Union. Diverging productivity, unemployment rates, R&D investments and all sorts of causes of rising inequalities can divide the peoples of the European Union along national lines, posing risks and increasing the potential rewards of national "go it alone" strategies.[209] Member States could compete on the basis of national tax regimes, labour regulations and public R&D support schemes. Growing intra-EU competition in R&D tax schemes could lead to further concentration of corporate R&D. Privately funded business R&D in Europe could fall far behind the US and China but also other Asian countries like Japan, Korea and other Asian "tigers".

Business R&D investment in million PPS 2005
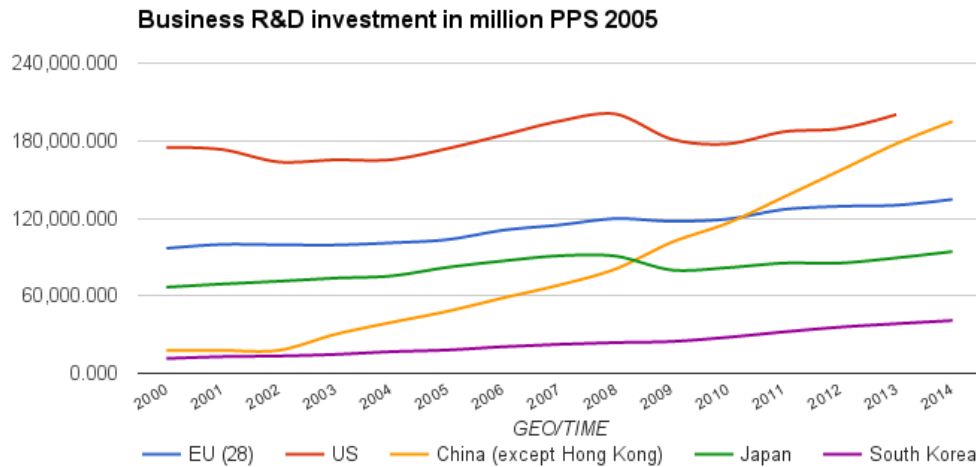
Source: Eurostat

Fragmentation of markets could increase the uncertainty on the expected rate of return to R&D investments. Whether to spread available public funds to basic science or to concentrate them on one or two highly promising areas could become a bitter debate in many countries. **Some Member States could strengthen national R&I strategies, but Member States with traditionally lower R&I performance could find themselves unable to sustain a competitive science base and to implement meaningful national R&I strategies at an efficient scale.** EU policies to close the R&I divide through networking and widening measures would be progressively undermined.

In such a future Europe, a few large universities will dominate; many less established universities would have closed. Automation would sweep across the educational system, with online certifications becoming customary and augmented cognition technologies starting to appear – and encountering the favour of big companies wanting fast, cheap graduates. In research, the top cited scientists could be very in demand – often hired by multinationals in a kind of perpetual 'consultancy without borders'. A few European companies could be rich and smart enough to stay global champions; but generally Europe's economic base is likely to hollow out, and the few innovators its universities produce quickly move abroad.[210]

In order for Europe to become strong, important transformations are needed in its key economic institutions through the creation of a true EU level playing field in taxation, a more socially oriented Monetary Union, the Banking and Capital Market Unions, and the combination of the Digital Single Market and the Single Market in Services. The reforms involve the modernization of governance and the adoption of new open models in administration, manufacturing, services and academia at all levels, from EU to national and local. Participative policy-making and open government data provide unique opportunities for research institutes, universities, firms and many societal actors, including social networks. Firms combine data and information from various public sources and generate new products and services corresponding to both new consumer and broader societal needs including sustainability. Most importantly public tools help communities to find solutions for themselves, without waiting for top-down prescriptions.[211] Moreover, the new approach to public

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[209] "Solidarity is the glue that keeps our Union together" said J.-C. Juncker in 2016 State of the Union address, https://ec.europa.eu/priorities/state-union-2016_en

[210] See EC (2015)

[211] See Madelin (2016)

services entails a massive increase in the quality, reliability and efficiency of service provision, among others in taxation, courts and regulation. Mutual trust in Member States' national justice systems and public sector capabilities will increase.

What if…the best public services for EU inhabitants

Imagine that the best performing Member States' public services are available to all people in the European Union. The best health care, the best education, the best security, the best… Imagine that convergence was to the highest quality standards, rather than to the middle or the bottom. This can be the next phase of economic integration in the EU, in which the completion of the single market and the five freedoms of movement (goods, services, capital, people[212], knowledge[213]) expands to new EU public service agendas. The single market in public services could develop through a process of "smart specialization" in public services, with each Member State becoming specialized on the basis of its own, national best-practice performance in the organization and delivery of specific services to inhabitants of other European countries (e.g. internal revenue service, customs union, welfare services, etc.). Each Member State thus becomes responsible for ensuring the delivery of services across the EU, with resources drawn from the EU budget to fund the corresponding coordination agency and ensure that the delivery of services in each country meets European quality standards.[214]

A key part in Europe's strength is its ability to combine competition in industry and services, public and private, with strong positions in science, technology and innovation. In this context the EU transition towards the SDGs should be combined with the pursuit of world leadership in selected fields of research and innovation that would enable it to address challenges and pursue opportunities related to emerging social needs, biosphere conditions, and key drivers of change. Across those fields of research and innovation the scenarios give rise to the following strategic recommendations for Europe's approach[215]:

- **Build resilience by developing options before, rather than after, a crisis strikes:** As climate or security crises mount, we will face more difficult policy choices: nuclear or not, geo or bio engineering, collective security or individual privacy. The history of technology is full of ideas that were tried and rejected, and then revived and made to work by a later generation that needed them to solve some urgent, unexpected crisis. Whatever policy choices we make today, they should not cut off or otherwise restrict research and innovation that could provide answers for tomorrow and make our world more resilient to crisis.

- **Experiment in real world settings**: The level of the challenges faced, the complexity of the transitions that need to happen, and the speed of change in innovation will force our leaders to make major decisions fast, with little information and great uncertainty. How will they know which solutions work, and which do not? Experimentation, rapid prototyping and testing solutions need to become an important part of policy everywhere.

- **Learn from the best:** Right now, in policy areas from agriculture to security, there are hundreds of social and technological experiments going on across the EU regions and cities. Each, from Apulia to Lapland, has its own strengths in individual sectors, successes in social inclusion, new ideas to improve city life or gender equality. The rest of Europe can learn from these best-of-class models – but it takes systematic research to identify them and figure out which of their features can be transplanted elsewhere.

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[212] Labour mobility is a key mechanism for mitigating labour market imbalances in general, and can contribute to the eradication of poverty and to the development of sustainable living conditions for all, in the EU but also in the world.

[213] Applying this argument to public research funding it could be envisaged that the tasks of the Research Executive Agency (REA) could be taken over by the Finnish TEKES or the Austrian FFG.

[214] See EC (2012)

[215] The scenarios covered a broad ground of important domains where major changes are needed and/or likely to happen. Whether Europe should try to lead in all of them or in some, and whether leadership implies strategies of competition and/or cooperation are questions that impose strategic choices about where to invest and how. The scenarios outline the space of future opportunities and risks, and the question of which themes to prioritize from a European perspective will be addressed through the subsequent Delphi phase of the BOHEMIA project.

- **Get the governance right- inclusiveness and fairness as policy principles:** Developing great technology requires both support from the public sector and appropriate regulation of the private sector. But it especially needs support from the citizen. Increasingly, people are concerned about technology (will this new thing harm me or my job prospects?). They also expect much from it (will they invent a cure for my disease?). This trend will reshape the relationship between technology and government in fundamental ways. Medicines regulation will get faster. Product and substances regulation will get more thorough. Scientific equipment will be more regulated; after all, gene-editing kit can be used to make pathogens as well as medicines. More and more, the people affected by these technical questions will want to have a stronger voice in the decisions. As a result, in this century, a major challenge of government everywhere will be devising the right ways to make policy for and regulation of innovation and technology more inclusive, more participative and fairer in its societal outcomes whilst promoting a vibrant innovation ecosystem.

- **Look to the cities as laboratories:** As outlined in the scenarios, cities – big or small – are where most of our citizens, opportunities and challenges will be found in this century. Each one is unique. That means each one can be a laboratory for policy, technology, social cohesion, employment and more. Result: With hundreds of simultaneous experiments in the future underway, we can more quickly identify the right solutions and scale them up across the EU. Planning research and innovation should take this local dimension into account.

- **Connect and collaborate, across sectors:** There are no islands in policy. Our scenarios cut across each other, with synergies and trade-offs. For instance, we will not get a digital society or a liveable city if we do not have security. We will not have healthy citizens if we are still using 19th century fossil-based energy. Research and innovation, across all sectors, can help find ways to resolve seemingly intractable problems.

- **Be open:** Openness improves quality and productivity in science and technology; it does, as well, in public policy outside the lab. The spread of open data and e-government can improve public administration. Scientific collaboration with other nations can spread to collaboration in regulation, trade, education, energy and other seemingly disparate policy areas.

9.3. Research and innovation: foundations and opportunities for building a strong Europe

Science, technology and innovation have been the basis of many historical achievements of Europe, and continue to be fundamental for its performance in the world[216]. This will continue to be the case whether the world becomes an increasingly competitive place or an increasingly collaborative place. This argument is not new,[217] but it is now more urgent than ever. Accelerating change means that the risk of investing in R&I is lower than the risk of waiting for others to do so. The first and foremost requirement of a strong Europe is to break the steady state trend in R&I investment that characterizes European R&I. This is not new. It has been declared as a goal in the Lisbon Strategy towards Europe 2010, and again in the Innovation Union towards Europe 2020.

If Europe wants to be able to compete in world markets and to lead the world towards the SDGs, its investment in R&I has to be stepped up dramatically, and so has to do the impact of this investment. This is not about trading-off quantity of R&I investment for quality. It is about quantity and quality reinforcing each other. In the context of smart public service specialization, the quality and quantity of public R&I funding can improve substantially, as national and private funding agencies would compete, collaborate and learn from the best. In particular **European investment in research and innovation** needs to be driven towards three sets of key outcomes:

- Social and economic returns to the EU's investments in the short as well as the long run, recognising that a significant part of the returns on investment depend on the framework conditions for research and innovation in Europe;

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[216] According to Kaiser and Schot (2014) technology has been foundational even for the process of European integration.

[217] EU Industrial Policy COM(2014)14 argued: "With scarce natural and energy resources and ambitious social and environmental goals, European companies cannot compete on low price and low quality products. They must turn to innovation, productivity, resource-efficiency and high value-added to compete in global markets. Europe's comparative advantage in the world economy will continue to lie in high value-added goods and services, the effective management of value chains and access to markets throughout the world. Thus, innovation and technological advancement will remain the main source of competitiveness for EU industry."

- Leveraging a step change in the levels of investment in the future we want, with Research and Innovation enabling Europeans to fulfil their individual and collective aspirations and leading the world towards the Sustainable Development Goals; and
- Establishing openness and inclusiveness as key principles of the organization of research and innovation across the EU.

Trends in R&D intensity with EU 2020 strategy forecast
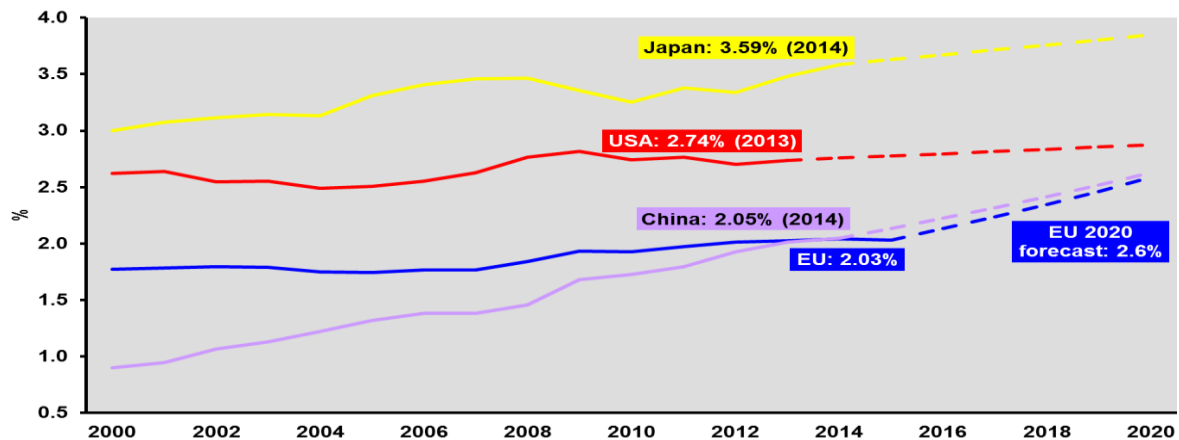
Source: EC DG RTD

The cross-cutting open and responsible research and innovation dimension as well as the need for demonstrable sustainable societal benefit should be strengthened.

Open deliberation on the directions and approaches to pursue, with the participation of stakeholders and citizens is going to be essential if the stepping up of R&I investment is to be part of a change-oriented policy strategy. Different value positions and potential value conflicts would need to be debated. The scope for joint agendas and strategies would need to be defined. At European level, this implies a much closer alignment between R&I policy and thematic policy areas e.g. in the fields of energy, security, health etc.

The change scenarios suggest that we need to move beyond the traditional role of research and innovation to explore and pilot new solutions that are subsequently taken up more widely to create economic value and societal benefits. Longer-term transition processes guided by overarching ambitions such as the Sustainable Development Goals require from R&I not only **competitiveness and growth but also value in realising transition processes of the kind described in the BOHEMIA scenarios**. In order to guide and accelerate these change processes, social, business-model and institutional innovations (e.g. demand-side innovation policies) are needed as well as new technological options are needed.

Embedding research and innovation in such a change-oriented agenda requires three types of R&I to be conducted. First of all, R&I is needed in order to come up with novel solutions for the future challenges that have been identified as critical for Europe's future ("solutions-oriented R&I"). Secondly, we often lack the necessary knowledge of the phenomena to be addressed, and thus need research to better understand the challenges ahead ("understanding-oriented research"). Both of these are geared towards handling future challenges, but from different angles. In addition, it is necessary to explore the scientific frontier in order to strengthen the long-term resilience of our society by advancing a reservoir of knowledge that may not necessarily be of immediate economic or societal use, but relies on the strengthening of serendipity ("frontier research").

Overall however it requires an overall rise of R&I in the policy agenda, a broad understanding of the different dimensions of innovation in order to underpin change-oriented policies, a substantial effort to strengthen public involvement in R&I policy-making, to support a substantial strengthening of societal engagement with, and investment in science, technology and innovation in Europe, that can break the "steady state" trend of the past 20 years and follow the rising paths of our Asian partners and competitors.

Important steps in that direction have been taken in Horizon 2020 with the promotion of openness in EU R&I policy, including openness to the participation of a wide range of stakeholders in mutli-stakeholder configurations. Key in this is the recognition that **scientific findings generated with taxpayer money are public goods and should be made public to increase social returns. Thus, open innovation, open science and open data must become the norm, and the right incentives and tools must be put in place to foster scientists and other actors to share**

their knowledge.[218] Openness towards society complements Responsible Research and Innovation (RRI) in Horizon 2020 and could stimulate research and innovation for social benefit, whilst also being much more mindful than previously about the wider social (including intergenerational), ethical, environmental, cultural or economic impacts that come with them.[219] RRI does not seek to dictate thematic priorities, but rather to help research providers and users to understand what is "responsible" and accordingly devise a responsive approach to research and innovation strategies[220].

Openness can help the EU deal effectively with value conflicts that could have perilous consequences for science and for investment in innovation. As science and innovation become ever more pervasive, they also become subject to demands for regulation - e.g. to prevent weaponisation and safeguard security - and subject to ethical controversies - e.g. "for which species should cloning be allowed for what purposes, and what do we do with clones that are used for purposes other than those they were created for"? Such controversies involve massive risks for science[221] as well as for the economy and finding an appropriate regulatory system for dealing with them will have to be at the heart of Europe's future success.

The advent of digitalization and virtualization has accelerated the pace of innovation and gave rise to completely new models of research and innovation, associated for instance to notions like Science 2.0, enabled by big data techniques, digital platforms, and various forms of experimental and 'open' approaches to research and innovation[222], which in turn have enabled enhanced collaboration and cooperation between a much broader range of actors than in the past, including not only science and industry, but also public administration, end-users and civil society. The new digital opportunities further internationalization of collaboration and cooperation in R&I along global scientific and value networks, and open up opportunities for more active citizens in R&I initiatives.

Within this open and ambitious outlook on R&I policy, considerations of time must influence policy choices. The speed of change and the rising uncertainty and complexity pose serious challenges to traditional planning. More room needs to be given to experimentation with new solutions and policies, combined with mechanisms to facilitate fast learning and adaptation. We need to experiment for many futures and in so doing to learn "what scales and what fails". The principle of openness applies also in this regard, i.e. in terms of openness to new and non-conventional approaches to tackling important challenges; approaches that may well come from a wide range of possible sources in science and society. The availability and "open" access to research infrastructures plays an important role in such a more open and flexible research and innovation paradigm.

The end result of all this will be an enhanced positive impact of R&I[223] on the achievement of a range of EU policy goals, as well as on growth and on the well-being of EU citizens. Europe and its knowledge economy will be competitive and serving society. Social innovation, business model innovation, governance and institutional innovation contribute to success. The EU will have embraced the innovation revolution[224] and its economy will be reaping the benefits of the transformations in the world economy in job creation, working conditions and greater equality, of the improvements in the world environment and in the greater resilience and sustainability of civilizations and the biosphere across the planet.

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[218] See Nielsen (2012)

[219] See MATTER (2016)

[220] For example, towards sustainable futures in the age of Anthropocene

[221] See EC (2016)

[222] See OECD (2016)

[223] In the broadest sense of the term - including ICT, biotechnology, life sciences, nanotechnologies, renewables and other green technologies and eco-innovations as well as social innovation, business model innovation, governance and institutional innovation.

[224] See Madelin (2016)

BIBLIOGRAPHY

Academy of Medical Sciences (2016) *Improving the health of the public by 2040: optimising the research environment for a healthier, fairer future*. Policy project, UK. http://www.acmedsci.ac.uk/policy/policy-projects/health-of-the-public-in-2040/

Alcott, B. (2005) *Jevons' paradox*. Ecological Economics, Vol. 54(2005), pp. 9–21.

Andrews, D., Criscuolo, C., Gal, P.N. (2015) *Frontier firms, technology diffusion and public policy: micro evidence from OECD countries*. OECD The Future of Productivity, Main Background Papers.

Atkinson, A. B. (2015) *Inequality. What can be done*? Harvard University Press, Cambridge, MA.

Apps, P. (2016) *Commentary: Risk of war returns to Europe*. REUTERS, US Edition, 6 July 2016.

AUGUR (2012) *Challenges for Europe in the world in 2030. Scenario Analysis: global business, trade patterns and technology diffusion*. AUGUR Deliverable D3.3., European Commission FP7 Funded Project.

Autor, D.H. (2015) *Why are there still so many jobs? The history and future of workplace automation*. Journal of Economic Perspectives, Vol. 29(3), pp. 3-30.

Betsch, C., Renkewitz, F., Betsch, T., Ulshöfer C. (2010) *The influence of vaccine-critical websites on perceiving vaccination risks*. Journal of Health Psychology, Vol. 15(3), April 2010, pp. 446-55. http://doi.org/10.1177/1359105309353647

Braconier, H., Nicoletti, G., Westmore B. (2014) *Policy challenges for the next 50 years*. OECD Economic Policy Papers, No. 9, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jz18gs5fckf-en

Brynjolfsson, E., McAffee, A. (2012) *Race against the machine: how the digital revolution is accelerating innovation, driving productivity and irreversibly transforming employment and the economy*. Research brief, The MIT Center for Digital Business. http://ebusiness.mit.edu/research/Briefs/Brynjolfsson_McAfee_Race_Against_the_Machine.pdf

Carpenter, S.R., Bennett, E.M. (2011) *Reconsideration of the planetary boundary for phosphorus*. Environmental Research Letters, Vol. 6(1), pp. 1-12.

Cassidy, E.S., West, P.C., Gerber, J.S., Foley, J.A. (2013) *Redefining agricultural yields: from tonnes to people nourished per hectare*. Environmental Research Letters, Vol. 8(3), pp. 8.

CEPS Task Force on Transport and Climate Change (2013) *Pathways to Low Carbon Transport in the EU, From Possibility to Reality*. CEPS, Brussels.

Ceurstemont, S (2017) Make your own meat, New Scientist, Volume 233, Issue 3108, 14 January 2017,

Chui, M., Manyika, J., Miremadi, M. (2016) *Where machines could replace humans – and where they can't (yet)*. McKinsey Quarterly, July 2016. http://www.mckinsey.com/business-functions/business-technology/our-insights/where-machines-could-replace-humans-and-where-they-cant-yet

Conway, G. (2012) *One billion hungry, can we feed the world*? Cornell University Press, Ithaca, NY.

Crul, M. (2016) *Early education is key to helping migrant children thrive*. The Guardian, 18 September 2016. https://www.theguardian.com/commentisfree/2016/sep/18/early-education-key-migrant-children-thrive-integration

DART Project (2012) *Final Report DART: Declining, Ageing and Regional Transformation*. Web Based – Long Version, INTERREG IV C, EU. http://www.dartproject.eu/fileadmin/OrdnerRedakteure/0103_Achievements/DART_final_report_web.pdf

DASTI (2016) *An OECD Horizon Scan of Megatrends and Technology Trends in the context of future Research Policy*. DASTI Danish Agency for Science, Technology and Innovation, Kopenhagen. http://ufm.dk/en/publications/2016/files/an-oecd-horizon-scan-of-megatrends-and-technology-trends-in-the-context-of-future-research-policy.pdf

Devlin, S., Dosch, T., Esteban, A., Carpenter, G. (2016) Urgent recall: Our food system under review. New Economics Foundation, UK.

Deep Mind (2016) *Deep Mind Website*. Deep Mind Technologies Limited. Accessed on 1 December 2016. https://deepmind.com/health

Diamond, M. L., de Wit, C.A., Molander, S., Sheringer, M., Backhaus, T., Lohmann, R., Arvidsson, R., Bergman, A., Hauschild, M., Holoubek, I., Persson, L., Suzuki, N.,Vighi, M., Zetzsch, C. (2015) *Exploring the planetary boundary for chemical pollution*. Environment International, Vol. 78, May 2015, pp. 8–15.

Dora, C., Haines, A., Balbus, J., Fletcher, E., Adair-Rohani, H., Alabaster, G., Hossain, R., de Onis, M., Branca, F., Neira, M. (2015) *Indicators linking health and sustainability in the post-2015 development agenda*. The Lancet, Vol. 385, 24 January 2015, pp. 380–91.

Dubois, H., Molinuevo, D. (2014) *Access to healthcare in times of crisis*. Report No. EF1442, EUROFUND. http://www.eurofound.europa.eu/publications/report/2014/quality-of-life-social-policies/access-to-healthcare-in-times-of-crisis

EC EXPH (2015). *Disruptive Innovation - Considerations for health and health care in Europe*. Expert Panel on Effective ways of Investing in Health, European Commission, DG Health & Food Safety, 29 February 2016, Brussels.

EEA (2015) *The European Environment: State and Outlook2015 – Assessment of Global Megatrends*. European Environment Agency, Copenhagen.

Ellen Macarthur Foundation, SUN, McKinsey (2015) *Growth Within: A Circular Economy Vision for a Competitive Europe*. McKinsey Center for Business and Environment.

EPA (2014) *EPA's Report on the Environment: Sustainability and the ROE*. United States Environment Protection Agency. https://cfpub.epa.gov/roe/sustainability.cfm

EPRS (2016) *Global Trendometer: Essays on medium- and long-term global trends*. Danièle Réchard (Ed.), European Parliamentary Research Service Blog, Global Trends Unit.

EPSC (2016a) *The Future of Work: Skills and Resilience for a World of Change*. European Political Strategy Centre, Strategic Notes, Issue 13(2016) http://ec.europa.eu/epsc/pdf/publications/strategic_note_issue_13.pdf

EPSC (2016b) *EU 2016: From Trends to Policies*. European Political Strategy Centre. http://ec.europa.eu/epsc/sites/epsc/files/eu2016_from_trends_to_policies.pdf

ESPAS (2015) *Global Trends to 2030. Can the EU meet the challenges ahead?* An Inter-Institutional EU project, European Strategy and Policy Analysis System.

Eurobarometer (2014) *Public Perceptions of Science, Research and Innovation*. Special Eurobarometer Report 419, conducted by TNS Opinion & Social at the request of Directorate-General for Research & Innovation. http://ec.europa.eu/public_opinion/archives/ebs/ebs_419_sum_en.pdf

EUISS (2010) *Global Governance 2025: At a Critical Juncture*. European Union Institute for Security Studies, Paris.

EUISS (2012) *Global Trends 2030: Citizens in an Interconnected and Polycentric World*. EUISS and ESPAS, Paris.

European Commission (2012) *Global Europe 2050*. Directorate-General for Research and Innovation, Socio-economic Sciences and Humanities. https://ec.europa.eu/research/social-sciences/pdf/policy_reviews/global-europe-2050-report_en.pdf

European Commission (2014) *Preparing the Commission for Future Opportunities: Foresight Network Fiches 2030*. Working document. https://ec.europa.eu/digital-agenda/en/news/european-commission-foresight-fiches-global-trends-2030

European Commission (2014a) *The 2015 Ageing Report. Economic and Financial Affairs Underlying Assumptions and Projection Methodologies*. European Economy, Joint Report prepared by the European Commission (DG ECFIN) and the Economic Policy Committee (AWG) Vol. 8(2014). http://ec.europa.eu/economy_finance/publications/european_economy/2014/pdf/ee8_en.pdf

European Commission (2015) *The Knowledge Future: Intelligent policy choices for Europe 2050. A report to the European Commission*. Expert Group on Foresight on Key Long-term Transformations of European systems: Research, Innovation and Higher Education (KT2050), Directorate-General for Research and Innovation. https://ec.europa.eu/research/foresight/pdf/knowledge_future_2050.pdf

European Commission (2015a) *Sustainable agriculture, forestry and fisheries in the bioeconomy – a challenge for Europe*. 4th SCAR Foresight Exercise. http://ec.europa.eu/research/scar/pdf/feg4-draft-15_may_2015.pdf

European Commission (2016a) *European Value Changes. Signals, Drivers and Impact of EU Research and Innovation Policies*. Final Report, Directorate-General for Research and Innovation, European Commission.

European Commission (2016b) *Agricultural Knowledge and Innovation Systems Towards the Future. A Foresight Paper*. SCAR – Strategic Working Group AKIS-3 Report 2016, Directorate-General for Research and Innovation, European Commission.

European Commission (2016c) *Addressing Terrorism. European Research in social sciences and the humanities in support to policies for Inclusion and Security*. A Policy Review. Open and Inclusive Societies, DG Research and Innovation, European Commission, Brussels.

European Commission (2016d) *Assessment of potential bottlenecks along the materials supply chain for the future deployment of low-carbon energy and transport technologies in the EU*. JRC Science for Policy Report, European Commission.

European Commission (2016e) *Raw Materials Scoreboard: European Innovation Partnership on Raw Materials*. Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, European Commission.

European Commission (2016f) *Next steps for a sustainable future: European action for sustainability*. EC COM (2016)390 final, European Commission, Strasbourg.

Eurostat (2016) *Migration and migrant population statistics*. Eurostat Statistics Explained Website, Data extracted in May 2016. http://ec.europa.eu/eurostat/statistics-explained/index.php/Migration_and_migrant_%20population_statistics

Eurostat (2016) *Old dependency ratio indicator*. Data from Eurostat, Population projections EUROPOP 2013. http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tsdde511&plugin=1

European Union (2016) *Shared Vision, Common Action: A Stronger Europe*. A Global Strategy for the European Union's Foreign and Security Policy, June 2016.

ExxonMobil (2015) *The Outlook for Energy: A View to 2040*. Exxon Mobil Corporation, Irving, Texas.

Falkenberg, K. (2016) *Sustainability, A European Brand*. Sustainability Now! A European Vision for Sustainability, EPSC Strategic Notes, European Commission. http://ec.europa.eu/epsc/pdf/publications/strategic_note_issue_18.pdf

FLAGSHIP project (2015) *Forward Looking Analysis of Grand Societal Challenges and Innovative Policies*. Reports and Policy Briefs, European Commission.

Florida, R. (2002) *The Rise Of The Creative Class: And How It's Transforming Work.* Leisure, Community And Everyday Life, Basic Books.

Foley, J. A., Defries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., Chapin, F.S., Coe, M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patz, J.A., Prentice, I.C., Ramankutty,N., Synder, P. K. (2005) *Global consequences of land use*. Science 2005, Vol. 309(5734), pp. 570–574.

Forget, E. L. (2011) *THE TOWN WITH NO POVERTY: Using Health Administration Data to Revisit Outcomes of a Canadian Guaranteed Annual Income*. Field Experiment, University of Manitoba. https://public.econ.duke.edu/~erw/197/forget-cea%20(2).pdf

Fougeyrollas, A., Le Mouel, P., Zagamè, P. (2012) *Consequences of the 2012 and 2013 FP7 calls for proposals for the economy and employment in the European Union*. ERASME, Paris, 31 May 2012.

Fox, K., O'Connor J. (2015) *Five ways work will change in the future*. The Guardian, 29 November 2015.

FRESHER project (2016) *Foresight and Modelling for European Health Policy and regulation. 8 trends for future of NCDs*. http://www.foresight-fresher.eu/en/Tools/Work-Packages/Survey-8-trends-of-NCDs/

Frey, C.B., Osborne, M.A. (2013) *The future of employment: How susceptible are jobs to computerisation?* Working paper, Oxford University Engineering Sciences Department and the Oxford Martin Programme on the Impacts of Future Technology.

GEA Writing Team (2012) *Chapter 1—energy primer*. In: Johansson T.B., Nakićenović N. (eds.), Global energy assessment, Cambridge University Press, Cambridge, UK.

Gerland P, Raftery A. E., Sevčikova H, Li, N., Gu, D., Spoorenberg, T., Alkema, L., Fosdick, B.K., Chunn, J., Lalic, N., Bay, G., Buettner, T., Heilig, G.K., Wilmoth, J. (2014) *World population stabilization unlikely this century*. Science, Vol. 346, pp. 234–37.

German J. B., Zivkovic, A. M., Dallas, D. C., Smilowitz, J. T. (2011) *Nutrigenomics and Personalized Diets: What Will They Mean for Food?* Annual review of food science and technology, Vol. 2, pp. 97-123.

Godfray H.C., Garnett T. (2014) *Food security and sustainable intensification*. Philosophical Transactions of the Royal Society London, Series B, Biological Sciences, Vol. 369(1639), Oxford Martin Programme on the Future of Food, Oxford University.

Graf, M., Ghez, J., Khodyakov, D., Yaqub, O. (2015) '*Individual empowerment'. Global societal trends to 2030: Thematic report 3*, RAND Corporation. http://www.rand.org/content/dam/rand/pubs/research_reports/RR900/RR920z3/RAND_RR920z3.pdf

Gros, D., Alcidi, C. (eds.) (2013) *The Global Economy in 2030: Trends and Strategies for Europe*. ESPAS, Brussels.

Gretton, C., Honeyman, M. (2016) *The digital revolution: eight technologies that will change health and care*. The Kings Fund TKF. http://www.kingsfund.org.uk/publications/articles/eight-technologies-will-change-health-and-care

Hall, B H., Mairesse, J., Mohnen, P. (2009) *Measuring the Returns to R&D*. In: Hall, B.H., Rosenberg, N. (eds.) Handbook of the Economics of Innovation, Elsevier.

Hanlon P. (2011) *Making the case for a 'fifth wave' in public health*. Public Health, Vol. 125(1), The Royal Society for Public Health, London.

Haskel, J., Hughes, A., Bascavusoglu-Moreau, E. (2014*) The economic significance of the UK science base: a report for the Campaign for Science and Engineering*. Imperial College Business School, Discussion paper 2014/4, London. https://spiral.imperial.ac.uk:8443/bitstream/10044/1/13751/2/Haskel%202014-04.pdf

Heck, S., Rogers, M. (2014) *Are you ready for the next resource revolution?* McKinsey Quarterly, March 2014.

Hunter, M.T. (2014) *Gini Index World Map. Figure in Wikipedia based on latest published data by World Bank in July 2014*. https://upload.wikimedia.org/wikipedia/commons/0/0c/2014_Gini_Index_World_Map%2C_income_inequality_distribution_by_country_per_World_Bank.svg

IBM (2016) *IBM Watson Health Website*. http://www.ibm.com/smarterplanet/us/en/ibmwatson/health/

IEA (2014) *World Energy Outlook 2014.* OECD/IEA, Paris. http://www.iea.org/publications/freepublications/publication/WEO2014.pdf

IGBP, IOC, SCOR (2013) *Ocean acidification summary for policymakers—third symposium on the ocean in a high-CO$_2$ world*. International Geosphere-Biosphere Programme, Stockholm, Sweden.

Institution of Mechanical Engineers (2013) *Global food. Waste not, want not*. London, UK.

IOM (2009) *Migration, Environment and Climate Change: Assessing the Evidence.* International Organization for Migration, Geneva, Switzerland.

IPCC Climate change (2013) *The Physical Science Basis Working Group I contribution to the fifth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Intergovernmental Panel on Climate Change, US.

IPCC (2014) *Impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of Working Group II to the fifth assessment report of the Intergovernmental Panel on Climate Change*. In: Field CB, Barros VR, Dokken DJ, et al., (eds.) Climate Change 2014, Cambridge, UK, and New York, USA, Cambridge University Press.

IPCC (2014a) *Summary for Policymakers*. In: Edenhofer, O., Pichs-Madruga, R., Sokona, Y., et al. (eds.) Climate change 2014, mitigation of climate change contribution of working group III to the fifth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, US.

IPCC (2015) *Climate Change 2014: Synthesis Report*. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva.

Jenkins, G. (2014) *Karl Polanyi, The Great Transformation and a new political economy*. Explanations from Clift, B., Holmes, C., Watson, M., University of Warwick. http://www2.warwick.ac.uk/newsandevents/features/polanyi/

Johansson, Å., Guillemette, Y., Murtin, F., Turner, D., Nicoletti, G., de la Maisonneuve, C., Bousquet, G., Spinelli, F. (2012) *Looking to 2060: Long-term global growth prospects: A Going for Growth report*. OECD Economic Policy Papers, No. 3, OECD Publishing, Paris. http://dx.doi.org/10.1787/5k8zxpjsggf0-en

Juncker, J.C. (2016): *State of the European Union speech on 14 September 2016*. European Union, Strasbourg.

Kaiser, W., Schot, J. (2014) *Writing the rules for Europe. Cartels, experts and international Organizations*. Basingstoke, Hampshire, Palgrave Macmillan.

Knickman, J.R., Snell, E.K. (2002) *The 2030 Problem: Caring for Aging Baby Boomers Health Services Research.* August 2002, Vol. 37(4), pp. 849–884.

Kobzar, S., Hellgren, T., Hoorens, S., Khodyakov, D., Yaqub, O. (2012) *Evolving patterns and impacts of migration Global societal trends to 2030: Thematic report 4*. RAND Corporation, Santa Monica, CA, Cambridge, UK.

Koch, A., Mc Bratney, A., Adams, M., et al. (2013) *Soil security: solving the global soil crisis*. Global Policy (2013) pp. 434–41.

Kurzweil, R. (2005) *The Singularity is near: when humans transcend biology*. Penguin Books.

Lesser, R., Reeves, M., Hamoss, J. (2016) *Saving Globalization and Technology from Themselves, Imperatives for Corporate Leaders*. bgc.perspectives, 26 July 2016. https://www.bcgperspectives.com/content/articles/strategy-globalization-saving-globalization-technology-from-themselves/

Lloyd S.J., Kovats R.S., Chalabi, Z. (2011) *Climate change, crop yields, and undernutrition: development of a model to quantify the impact of climate scenarios on child undernutrition*. Environmental Health Perspectives, Vol. 119, pp. 1817–23.

MacAskill, E. (2016) *Is David Cameron right that leaving EU could increase the risk of war?* The Guardian, 9 May 2016.

Madelin, R. (2016) *Opportunity Now: Europe's Mission to Innovate*. EPSC Strategic Notes, Issue 15, European Commission, Directorate-General for Communications Networks, Content and Technology. http://ec.europa.eu/epsc/publications/notes/sn15_en.htm

Martel, S. (2012) *Magnetic microbots to fight cancer*. IEEE Spectrum, 25 September 2012. http://spectrum.ieee.org/robotics/medical-robots/magnetic-microbots-to-fight-cancer

Mason P. (2015) *Post-Capitalism: A Guide to Our Future*. Penguin Books.

McKinsey Global Institute (2016) *Poorer than their parents? Flat or falling incomes in advanced economies*. McKinsey & Company.

MATTER (2016) *Principles for Responsible Innovation. Building the trustworthiness of innovation*. Consultation Draft, MATTER, January 2016.

Millennium Ecosystem Assessment (2005) *Ecosystems and human wellbeing: health synthesis*. In: Ecosystems in Cities. Corvalan, C., Hales, S., McMichael, A.J., (eds.) Island Press, Washington DC.

Mulas, V., Minges, M., Applebaum, H.R. (2015) *Boosting tech innovation ecosystems in cities: a framework for growth and sustainability of urban tech innovation ecosystems*. Discussion Paper, World Bank Group, Washington, DC.

National Institute for Public Health and the Environment (2014) *A healthier Netherlands: Key findings from the Dutch 2014 Public Health Status and Foresight Report*. RIVM, Netherlands.

Nesta (2013) *Plan I(nnovation) for Europe: Delivering Innovation-led Digitally-Powered Growth*. Nesta and the Lisbon Council, think tank for the 21st century. http://www.lisboncouncil.net/publication/publication/99.html

Nesta (2015) *The sticky and sweet future of food hacking*. Nesta Website. http://www.nesta.org.uk/2016-predictions/sticky-sweet-future-food-hacking

NHS (2009) *Fit for the Future - Scenarios for low-carbon healthcare 2030*. National Health Service, Sustainable Development Unit, UK.

Nielsen, M. (2012) *Reinventing Discovery: The New Era of Networked Science*. Princeton Press.

NSTC (2016) *Preparing for the Future of Artificial Intelligence*. Executive Office of the President, National Science and Technology Council Committee on Technology. Washington DC. https://www.whitehouse.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf

OECD (2008) *Biofuel Support Policies: An Economic Assessment*. OECD Publishing, Paris.

OECD (2012) *Environmental Outlook to 2050: The Consequences of Inaction*. OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264122246-en

OECD (2013) *New Sources of Growth: Knowledge-Based Capital. Key Analyses and Policy Conclusions*. Synthesis Report, OECD Publishing, Paris.

OECD (2013a) *Global Food Security: Challenges for the Food and Agricultural System*. OECD Publishing, Paris.

OECD (2015) *Data-driven Innovation for Growth and Well-being: What implications for Government and Business?* Directorate for Science, Technology and Innovation Policy Note, October 2015.

OECD (2015a) *The Metropolitan Century report*. OECD Publishing, Paris.

OECD (2015b) *In It Together: Why Less Inequality Benefits All*. OECD Publishing, Paris.

OECD (2016) *Science, Technology and Innovation Outlook: Megatrends affecting science, technology and innovation*. OECD Publishing, Paris. https://www.oecd.org/sti/Megatrends%20affecting%20science,%20technology%20and%20innovation.pdf

OECD (2016a) *The Productivity-Inclusiveness Nexus*. Meeting of the OECD Council at Ministerial Level, Paris, 1-2 June 2016.

OECD (2016b) *Ocean Economy 2030*. OECD Publishing, Paris.

Oxford Dictionaries (2016) *Online Dictionary, Entry "post-truth"*. Accessed December 2016. https://en.oxforddictionaries.com/definition/post-truth

Patz, J.A., Frumkin, H., Holloway, T., Vimont, D.J., Haines, A. (2014) *Climate change: challenges and opportunities for global health*. JAMA 2014, Vol. 312, pp. 1565–1580.

Perez, C., Vellinga, P., de Buck, P., Faulstich, M., Girouard, N., Gregori, G., Hudson, C., Kawalec, P., Marchiori, C., Stone, S., Veugelers, R., Fay, M. (2016) *Changing gear in R&I, Green growth for*

jobs and prosperity in the EU. Report of the European Commission expert group "R&I policy framework for green growth & jobs". European Commission, Directorate-General for Research and Innovation. http://bookshop.europa.eu/en/changing-gear-in-r-i-pbKI0216237/

PHG foundation (2015) *Beyond public health genomics: a framework for future personalised healthcare*. A discussion paper in the context of a European Public Health Association workshop, Rome. http://www.phgfoundation.org/file/16999/

Piketty, T., Zucman, G. (2013) *Capital is Back: Wealth-Income Ratios in Rich Countries 1700-2010.* Presentation at OECD Research Seminar in the "New Approaches to Economic Challenges", 21 October 2013, OECD, Paris.

Ponemon Institute (2016) *2016 Cost of Data Breach Study: Global Analysis*. IBM Security. http://www-03.ibm.com/security/data-breach/

RACE 2050 project (2015) *Between Dark Scenarios and a Bright Future. Aiming for a 2050 Sustainable and Competitive European Industry*. 2030 and 2050 Scenarios Narrative. Responsible innovation Agenda for Competitive European transport industries up to 2050, Project funded under the EU's 7th Framework Programme. http://www.race2050.org/fileadmin/files_race2050/Images/RACE2050_FINAL_BROSCHURE.pdf

Raudsepp-Hearne, C., Peterson, G.D., Tengö, M., Bennett, E. M., Holland, T., Benessaiah, K., MacDonald, G.K., Pfeifer, L. (2010) *Untangling the environmentalist's paradox: why is human well-being increasing as ecosystem services degrade?* Bioscience, Vol. 60, pp. 576–89

Rifkin J. (2014) *The Zero-marginal Cost Society*. *The Internet of Things, the Collaborative Commons and the eclipse of capitalism.* St Martin's Griffin, New York.

Rockefeller Foundation (2015) *100 resilient cities - 100RC*. Website. http://www.100resilientcities.org/author/100rc#/- /

Rockström, J., Sukhdev, P. (2016) *How food connects all the SDGs.* Stockholm Resilience Centre. http://www.stockholmresilience.org/research/research-news/2016-06-14-how-food-connects-all-the-sdgs.html

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin….. Foley, J. (2009) *Planetary Boundaries: Exploring the safe operating space for humanity*. Ecology and Society, Vol. 14(2). http://www.ecologyandsociety.org/vol14/iss2/art32/

Royal Society (2014) *Resilience to extreme weather*. The Royal Society Science Policy Centre report, Vol. 02/14, London. https://royalsociety.org/~/media/policy/projects /resilience-climate-change/resilience-full-report.pdf

Saunders, T., Baeck, P. (2015) *Rethinking smart cities from the ground up*. NESTA.

Schmitt, D. (2016) *Antéversion. Ce qu'il faut retenir du futur: Entre science et fiction*. Editions Fauves.

SCBD (2014) *An updated synthesis of the impacts of ocean acidification on marine biodiversity*. Secretariat of the Convention on Biological Diversity, Montreal.

Skidelsky, R. (2013) *Rise of the robots: What will the future of work look like?* The Guardian, 19 February 2013, The Guardian, London.

Sonnier, P. (2016) *Story of Digital Health website*. Accessed on 1 December 2016. http://storyofdigitalhealth.com/

SPREAD project (2012) *Scenarios for sustainable lifestyles 2050.* Deliverable 4.1, Sustainable Lifestyles 2050, Project funded under the European Commission's Seventh Framework Programme.

Stockholm Resilience Institute (2015) *The nine planetary boundaries*. Figures and data for the updated Planetary Boundaries (Steffen et al 2015). Published Online. http://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries-data.html

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., Sörlin, S. (2015) *Planetary boundaries: Guiding human development on a changing planet.* Science, Vol. 347, Issue 6223, 13 February 2015.

Stone, B., Hess, J.J., Frumkin, H. (2010) *Urban form and extreme heat events: are sprawling cities more vulnerable to climate change than compact cities?* Environmental Health Perspectives, Vol. 118(10), pp. 1425–1428.

Stone, D. (2009) *Can pacific garbage patch be cleaned up?* Newsweek, 12 October 2009. http://europe.newsweek.com/can-pacific-garbage-patch-be-cleaned-75657?rm=eu

TAG (2016) *Report of the Transport Advisory Group of Horizon 2020.* May 2016.

The Economist Intelligence Unit (2011) *The future of healthcare in Europe*. A report from the Economist Intelligence Unit. Sponsored by Janssen. The Economist.

The Lancet Commissions (2015) *Planetary health: a new science for exceptional action*. Report of the Rockefeller Foundation – Lancet Commission on planetary health. http://www.thelancet.com/pdfs/journals/lancet/PIIS01406736(15)61038-8.pdf

The Lancet Commissions (2015a) *Safeguarding human health in the Anthropocene epoch.* Report of the Rockefeller Foundation – Lancet Commission on planetary health. Vol. 386, Published Online.

The Ocean Cleanup Foundation (2017) *The Ocean Cleanup Website: The largest cleanup in history.* Delft, Netherlands. https://www.theoceancleanup.com/

The Review on Antimicrobial Resistance (2016) *Tackling drug-resistant infections globally: final report and recommendations*. HMSO. https://amr-review.org/Publications

Tilman, D., Clark, M. (2014) *Global diets link environmental sustainability and human health*. Nature, Vol. 515, pp. 518–22.

Toloo, G. S., Fitzgerald, G., Aitken, P., Verrall, K., Tong, S. (2013) *Are heat warning systems effective?* Environment Health, Vol. 12(27).

Troell, M., Naylor, R. L., Metian, M., Beveridged, M., Tyedmerse, P.H., Folkea, C., Arrow, K. J., Barrett, S., Crépina A.-S., Ehrlich, P.R., Grena, Å., Kautskyi, N., Levinj, S.A., Nyborgk, K., Österblomb, H., Polaskyl, S., Schefferm, M., Walkern, B.H., Xepapadeaso, T., de Zeeuwp, A.

(2014) *Does aquaculture add resilience to the global food system?* Proceedings of the National Academy of Sciences USA, Vol. 111 (37) 13257–13263.

UK MoD (2014) *Global Strategic Trends – Out to 2045*. Strategic Trends Programme, Fifth Edition, Ministry of Defence, Swindon.

UN (2015) *Transforming Our World: The 2030 Agenda for Sustainable Development*. United Nations Sustainable Development Knowledge Platform, Department of Economic and Social Affairs. https://sustainabledevelopment.un.org

UN (2015a) *Population 2030: Demographic challenges and opportunities for sustainable development planning* (ST/ESA/SER.A/389). United Nations, Department of Economic and Social Affairs, Population Division.

UN (2016) *Mapping Mining to the Sustainable Development Goals: An Atlas.* Columbia Centre on Sustainable Investment (CCSI), UN Sustainable Development Solutions Network (SDSN), United Nations Development Programme (UNDP), World Economic Forum. http://unsdsn.org/wp-content/uploads/2016/11/Mapping_Mining_SDGs_An_Atlas.pdf

UNDESA (2011) *World Population Prospects: The 2010 Revision*. UN Department of Economic and Social Affairs, Population Division, New York.

UNDESA (2015) *Youth population trends and sustainable development, Population Facts*. Vol. 1(2015), UN Department of Economic and Social Affairs, Population Division, New York.

UNEP (2013) *Global chemicals outlook—towards sound management of chemicals.* United Nations Environment Programme, Nairobi, Kenia. http://www.unep.org/hazardoussubstances/Portals/9/Mainstreaming/GCO/The%20Global%20Chemical%20Outlook_Full%20report_15Feb2013.pdf

UNFPA (2007) *State of world populations 2007. Unleashing the potential of urban growth.* United Nations Population Fund, New York. http://www.unfpa.org/sites/default/files/pub-pdf/695_filename_sowp2007_eng.pdf

USNIC (2012) *Global Trends 2030: Alternative Worlds*. National Intelligence Council, Washington, DC.

VandeWeghe, J.R., Kennedy, C. (2007) *A spatial analysis of residential greenhouse gas emissions in the Toronto Census Metropolitan Area*. Journal of Industrial Ecology, Vol. 11(2).

Walls, H. W., Cornelsen, L., Lock, K., Smith, R.D. (2016) *How much priority is given to nutrition and health in the EU Common Agricultural Policy?* Food Policy, Vol. 59, February 2016.

WEF (2015) *Geo-economics: Seven Challenges to Globalization.* Global Agenda Councils, World Economic Forum, Geneva. http://www3.weforum.org/docs/WEF_Geo-economics_7_Challenges_Globalization_2015_report.pdf

West, D. M. (2016) *Megachange: Economic Disruption, Political Upheaval, and Social Strife in the 21st Century.* Brookings Institution Press, Washington DC.

Westmore, B. (2014) *International Migration: The relationship with economic and policy factors in the home and destination country*. OECD Economics Department Working Papers, No. 1140, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jz123h8nd7l-en

Willinger, M. (2013) *Generation Identity: a declaration of war to the 68rs*. Arktos Media Ltd. See also https://www.bloc-identitaire.com/

Wijkman, A., Skånberg, K. (2015) *The Circular Economy and Benefits for Society*. A study report at the request of the Club of Rome with support from the MAVA Foundation.

WHO (2003) *Social determinants of health: The solid facts*. 2nd edition/edited by Wilkinson, R., Marmot, M., International Centre for Health and Society, World Health Organization, Denmark.

WHO (2011) *Global status report on noncommunicable diseases 2010*. World Health Organization, Geneva. http://www.who.int/nmh/publications/ncd_report2010/en/

WHO (2014a) Global Tuberculosis Report 2014. World Health Organization, Geneva.

WHO (2014b) Global Status Report on Non-communicable Diseases 2014. World Health Organization, Geneva.

WHO (2015) *Malaria Fact sheet N°94*. Fact Sheets, World Health Organization. Reviewed April 2015. http://www.who.int/mediacentre/factsheets/fs094/en/

WHO (2015a) *Health systems strengthening in the context of Health 2020: challenges and priorities in the WHO European Region*. Expert meeting Barcelona, Spain, 3–4 November 2014, Division of Health Systems and Public Health.

World Wildlife Fund (2015) *Reviving the Ocean Economy: The case for action.* WWF Report International, in association with the Boston Consulting Group, the Global Change Institute and the University of Queensland. http://assets.worldwildlife.org/publications/790/files/original/Reviving_Ocean_Economy_REPORT_l ow_res.pdf?1429717323&_ga=1.71143127.676886972.1478869557

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The growing complexity of the world will require that society develop more options for coping. Options will come from new discoveries, inventions, ideas – in short, from research and innovation. This foresight report, commissioned by the European Commission's Directorate-General for Research and Innovation, draws on a broad range of sources about megatrends shaping the world today and projects them forward into the 2030s.

The report describes two possible outcomes: That the trends go on unmanaged and uncontrolled, or that society takes action. The first outcome would be negative: climate change, environmental degradation, explosive migration, an unhealthy population, crowded and dangerous cities, mass unemployment and global strife – and Europe a victim. The second outcome would be positive: climate control, sustainable land and sea management, a circular economy with greater productivity, a healthier and longer-lived population with fulfilling work and leisure, peace – and Europe a leader. The report goes on to illustrate specific ways in which research and innovation could help Europe realise the positive scenario or at least minimise the harm of the negative.

Studies and reports