13
GLOBAL CHANGE AND K-WAVES
Exploring future nexus patterns

Markku Wilenius

Introduction

In the early 1970s, a group of leading system analysts at the Massachusetts Institute of Technology (MIT) built the world’s first simulation model, which used a set of parameters¹ to evaluate global development over the course of the next 130 years. The model was commissioned by the Club of Rome (founded by Italian industrialist and scholar Aurelio Peccei), which had taken upon itself the task of examining key issues affecting the long-term survival of humanity. The result of the MIT simulation was the book Limits to Growth (1972), which upon its publication rocked the industrial world. (Meadows, 1972)

The book takes the form of a “scenario analysis,” which seeks to answer one question: “What will happen over the next 130 years if humanity decides to adhere to certain policies?” It serves not as a forecast but as a mapping of possible futures. It describes how societal resources might be used to accelerate technological solutions to obvious problems of the time: population growth, food and resource shortages, and environment damage. The model has been used to assess the impacts of alternative policies on global emissions and other parameters. The approach is systemic; family size, for instance, can only be regulated with sufficient levels of health care and education.

Back in 1972, The Limits to Growth was met with an outcry, particularly by the industrial sector, largely because the report effectively challenged the prevalent notion at the time—and no less today—regarding the blessings of unfettered growth of materially intensive consumption.

The book’s conclusion is that we are at risk of overstepping the limits of physical growth unless profound changes are enacted.

Forty years since the book’s release, we can now see that although alarms were being sounded, nothing has since been done to significantly redress the situation. For starters, in spite of international treaties, global greenhouse gas emissions continue to increase. Natural resources are being depleted, and most ecosystems have degraded seriously, as reported by the United Nation Millennium Ecosystem Assessment. (Millennium Assessment, 2005) The World Wildlife Fund’s Living Planet Report similarly indicates that the population of vertebrates has declined by more than one-half from since 1972, when the Club of Rome report was published. (WWF, 2014)

If a company or state were to deteriorate at this rate, it would be facing bankruptcy and insolvency. And we are indeed driving nature into bankruptcy, as Anders Wijkman and Johan
Rockström observe in their Club of Rome report from 2012. (Wijkman and Rockström, 2012) Just like with Greece in its decade-long borrowing scheme that brought huge debt upon the country, we have refused to face the facts: Instead of trying to repay the debt in some way, we are borrowing more.

We need to be humble about the future. Most long-term forecasts or projections are wildly off the mark. The overshoot-scenarios that the Club of Rome produced back in 1972 have come true with alarming accuracy: We have failed to adopt global policies that will significantly alter the projected course of the business-as-usual scenario. (Meadows, 1972) In spite of all the international treaties, the situation has only worsened over the decades.

**Excess and energy**

It is obvious that energy consumption is at the heart of global problems. In his book 2052, Jørgen Randers (an internationally acclaimed Norwegian business school professor and a member of the original MIT research team) examines the course that energy consumption will follow into the future. (Randers, 2012) In 2013, 81.4% of all energy was produced using the three fossil fuels (coal, oil and gas), while nuclear accounted for 5% and renewables covered the remaining. (IEA, 2015) If we wish to stop using fossil energy sources, there is a lot to do!

So what will the future be like? According to Randers, we will continue to be plagued by the inherent short-sightedness of politics and the structures of the capitalist system for 40 years to come. Based on this assumption, he has devised a scenario that suggests that the share of renewable energy sources will increase to 37% by the mid-century. That is not much, considering what we need to achieve. According to the World Wildlife Fund, we will need to produce 95% of our energy from renewables by 2050. (WWF, 2014) At the other end of the spectrum is the International Energy Agency, whose basic scenario some years back suggested an increase in the share of renewables by up to a mere 14% by 2050. (IEA, 2010)

It’s important to remember that in the early stages of technological revolutions, very few people believe that a breakthrough will occur. Electronics pioneer Ken Olsen, who in the 1970s was director of Digital Equipment Corporation, famously observed in 1977, “There is no reason anyone would want a computer in their home.” (Digital Trends, 2012) On the other hand, Jorma Ollila, the former CEO of Nokia, was the butt of jokes in the early 1990s when he announced his vision of putting a mobile phone in everyone’s pocket. Human thinking follows the generally safe logic that things will go on just as they have before. The reality, however, is different, with real potential for both leaps or discontinuities and either exponential growth or collapse.

The world of energy production is currently dominated by large institutions. Researchers talk about a “lock-in.” (Foxon, 2002) The predominant system of energy production has a built-in interest — backed by enormous power and resources — to bleed the market of all conceivable profit before “the sky falls on our heads” and before the consequences of fossil energy use become unbearable. Yet, there is reason to think that the current paradigm is changing in fundamental ways.

First, whatever our interpretations of the current situation and the future are, no one seems to be denying that the challenges facing us today are greater and more critical than any other time in human history. Climate change, land degradation, water and energy scarcity, waste management, fish stock depletion, and rain forest and biodiversity loss are only some of the most serious current environmental concerns. It is clear, however, that the gap between resources and their use will only widen in the future. Although growth has slowed, world population will still increase by more than 2 billion people. It is expected that the global population of 9.7 billion
people will be reached in 2050. (UN, 2015) At the same time, however, millions of people around the world are rising from poverty towards a better quality of life.

Second, the factors discussed above seem to be incontrovertibly pointing to the conclusion that the expansion of the human race and the limited resources of the planet are on a collision course. We have simply consumed far too much of the planet’s limited resources, and there is no longer enough left for the impending increase in population. The same processes that in the past 200 years have produced unprecedented wealth are now threatening to take us to extinction.

Third, awareness of the above-mentioned trends is inexorably spreading among a growing number of people. The concerns and values relating to nature and its exploitation have already changed, and the world’s capacity for innovation is increasingly being focused on finding solutions to humanity’s greatest problems. Another factor pushing development in this direction is awareness of the biosphere’s imminent and irreversible tipping point.

Real change may sound like a utopian dream. We know how difficult it is to change the behavior of an individual, even if the positive consequences of change are obvious, while the history of international climate negotiations show us how difficult it is to achieve change on a collective scale.

Yet, there have been situations in the history of the human race where entire societies have successfully accomplished radical changes in just a few decades. Such changes are most likely to happen when the pressures for change become compelling.

**Turning up the heat**

In November 2012, the Potsdam Institute for Climate Impact Research (one of the world’s most respected research institute on global warming) came up with new and rather dramatic results concerning the so-called 4° Celsius world, or a world in which the average global temperature surpasses preindustrial levels by 4° — which will happen unless much more radical steps are taken to curb greenhouse gas emissions. (The World Bank, 2012) And then, in June 2013, a sequence to the report was published that dealt with climate extreme and the regional impacts climate change will have.

In those reports commissioned by the World Bank, the major point is this: It is impossible to believe that we might possibly preserve decent living conditions for all people on this planet if this scenario should become actuality. Using various simulations, they convincingly demonstrate what will happen to coastal cities when sea level rises (a substantial share of big cities are located on the coast), and particularly what will happen to some of the least developed countries when they are hit by drought and heat waves. All this has been supported in the recent Intergovernmental Panel on Climate Change’s *Fifth Assessment report* (IPCC 2014) In a very short time, the world in those corners will become a rather unpleasant place to live. And for the rest of us living in the northern latitudes, indirect consequences, such as the pressures resulting from massive human migration, would be devastating as well.

These reports make it very clear that this decade is our last chance to start a more radical phase in global warming management. It is our last chance because of the necessary time delays between the various phases — from resolutions to binding targets to political decisions to measures to emissions to concentrations. The December 2015 UN Climate Change Conference (COP21) in Paris provided some hope that governments are slowly realizing the real task ahead, which is to actually reverse climate change.

All of our efforts must be geared towards building more sustainable economies and lifestyles. This is the ethical challenge of the coming decades, and we simply cannot afford to fail in it.
In essence, this entails the dematerialization of our economies on a massive scale, as well as the dematerialization of our lifestyles, but it also requires commitment from the international community to utilize the various means at our disposal for imposing the necessary legal structures.

In that “turn down the heat” report, there is a telling foreword by the chairman of the World Bank, Jim Yong King, in which he writes, “It is my hope that this report shocks us into action.” Indeed, as we learn from the report, there has been a growing number of extreme climatic events in the last 10 years or so. Some of them have been caused by climate change and some by environmental degradation, such as deforestation. The massive scale of environmental destruction, so well observed in the UN-led Millennium Ecosystem Assessment, has already brought our biosphere into an increasingly fragile state. (Millennium Assessment, 2005) As the assessment and its follow-up studies have shown, virtually all of Earth’s ecosystems have been significantly transformed through human action.

The power of long waves

In the 1930s, Soviet economist Nikolai Kondratiev developed a theory of socio-technological cycles that he considered to be an integral aspect of the economic structure (Kondratiev, 1984). According to his theory, modern economies change radically in cycles of 40–60 years. In my more holistic reinterpretation of Kondratiev waves, technological innovations percolate through economic and social structures, productivity increases constantly and the result is an economic upswing. Such a development is always accompanied by new value systems, new forms of social activity and new cultures of organization. At some point, however, investments in the networks of new technology and the profits they yield will inevitably begin to decline. This in turn leads to stagnating credit demand, which pushes interest rates ever closer to zero, thus resulting in economic recession. Sooner or later, some new form of technology again jump-starts the upward cycle. Major economic crises in the past 200 years — including the most recent one — have all followed this pattern (see Figure 13.1).

Kondratiev waves may be understood as an inherent, dynamic component of economic development, one which occurs with certain regularity. At the same time, however, modern societies have become ever-more complex networks of policy, technology and economy. The financial crisis that began in 2008 was the turning point upon which the fifth Kondratiev wave reached its demise and the new socio-economic cycle began. The emergence of information technologies, oil, electricity and the automobile industry were economic drivers of the preceding waves; the sixth wave will see the emergence of new drivers that will determine both the economy and the society of the future.

Technological advancement opens up whole new horizons for the comprehensive transformation of societies. One way of thinking about this is to envision the preceding wave, which was massively influenced by the development of information and communications technology (ICT), as the foundation for a new kind of planetary nervous system. This nervous system, known as the “Internet of Things,” is one in which every piece of equipment has its own IP address and which will be part of a global network — and thereby more accessible and usable with greater ease than ever before. Some of the answers to the critical challenges of the world may come from increasing ICT capacities and the intelligent infrastructures spawned by them, which may even have a decisive impact in solving the current energy problem. (Diamandis and Kotler, 2012) The new technologies are already here, but we have only just begun to apply them.

Significant technological changes often go hand-in-hand with social change. Transformations of technological paradigms and mindsets will also alter the predominant social patterns of behavior. Such changes have an impact not only on structures but also on the values on which
1st Kondratieff
1780–1830 Steam

2nd Kondratieff
1830–1880 Railway, steel

3rd Kondratieff
1830–1930 Electrification, chemicals

4th Kondratieff
1930–1970 Automobiles, petrochemicals

5th Kondratieff
1970–2010 ICT

6th Kondratieff
2010–2050 Intelligent technologies

Figure 13.1 Pattern of social waves of advancement since the birth of industrialization
society rests. Current societal challenges and the solutions presented to them will form a new foundation for social and political action. Old demarcations will no longer apply. For example, the notion of industry and services as separate sectors of the economy is a division that is no longer tenable. Industry, in terms of its mode of operation, will increasingly come to resemble the service sector.

Change is possible, because humanity possesses the capacity for innovation — the capacity to create the future, as we have seen so often in the past. What we need is a new wave of creativity for producing technological and political innovations that can help us solve the world’s critical resource problems. Such innovations can represent entirely new ways of thinking and utilize new inventions, but they can also be combinations of new and old solutions, such as industrial ecology, green nanotechnology or new energy technologies. The current progress of humanity requires even more intelligent solutions for infrastructure and urban design.

For the first time in history, the imminent wave is truly global. On the threshold of the sixth wave, competition for the next determinants of technological development, economic growth, social cohesion and even cultural activity will escalate. Awareness of the finiteness of the planet will increase both within the individual consciousness and among social groups. The key theme of innovation in the sixth wave will be a radically more efficient way to use natural resources. The impact of new innovations will be made greater by the fact that they are connected to the web-like technological and social information infrastructure that emerged in the preceding cycle.

Although the sixth wave will bring about systemic changes, the repercussions of which cannot be foretold, it is possible to pinpoint at least some basic aspects of the transformation. The focus in the sixth wave will be on key technologies and innovations that improve the efficiency of resource use. While the fifth wave saw a race towards more flexible technologies and lower costs, competition will now be focused on less material-intensive products and processes. Resource-intensive and non-recyclable solutions will be replaced by new intelligent technologies (many of which have yet to be invented), as well as by natural fiber-based products. All in all, we shall see that resource nexus will become the centerfold of political debates in the coming decades.

The world is undergoing a deep transformation from the fifth to the sixth wave. The crux of the matter is whether certain countries and regions hope to be successful in the next wave — a wave in which technological development will focus on improving material and energy efficiency by (among other things) employing digital technology and by focusing on mitigating the damage to the environment caused by human activity.

Thus, the following will be among the key areas of development in the coming decades:

- radically improved energy efficiency, particularly in end-use sectors;
- massive deployment of new energy technologies, including as-yet marginal wave and geothermal energy;
- advances in intelligent energy and power grids;
- new ways to sequester and store carbon.

In the big picture, almost every country is clearly struggling in gearing its resource use towards more sustainable ways. If the next energy transition — large-scale adoption of renewable energy sources — had occurred 20–30 years ago, we would be facing fewer problems now. If we are to avoid the escalation of climate disturbances, the rate of CO₂ emissions must be reversed to an annual decrease of 5–10% by 2020. This cannot be achieved without a massive investment in renewable energy and improvements in energy efficiency. In the latter case, we are talking about
Global change and K-waves

a minimum tenfold increase in efficiency in the long term. For instance, the energy efficiency of
business properties has been largely ignored in all countries because there has been no incentive
to do so. Along with residential properties, such properties form upwards of 40% of total energy
consumption.

To understand the scale, this projected transition challenges our natural resource manage-
ment and its linkages to the socio-economic system. If all this development were to occur, we
need a fundamentally different assessment approach and control system to safeguard the sustain-
ability of these transitions and investments. For this purpose, we should deploy a resource nexus
approach that comprises the interlinkages between five key natural resources (water, energy
carriers, biomass, land, minerals) in terms of extraction and consumption (see Bleischwitz et al.,
this volume). As we allow ourselves to take this more systemic view, it gives us the privilege to
understand, among other things, the conflicting patterns of resource use. The well-known case
is the use of agricultural land for growing biofuel material, replacing thus some food produc-
tion. The global biofuel production grew over sevenfold between 2000–2012 and EU’s goal
in promoting the use of biofuels in transport is related to EU target to reduce greenhouse gas
emissions (Bourguignon, 2015). However, there are lots of critical voices arguing that grow-
ing crops for biofuel consumption takes away from food production. In FAO scenario towards
2050, much more arable land is needed to cover the need for global food and fibre production
(FAO, 2009).

Thus, in keeping the target to improve radically our material and energy efficiency, all
policies should evaluated on systemic basis (Schmidt-Bleek et al., 2014). This calls for a more
integrated, interdisciplinary, nexus-like approach. For instance, the energy efficiency level of
PV panels used in northern latitudes, like in Finland, do not necessarily suffice that technol-
ogy to be major source of energy, due to low efficiency rate. Instead, the use of geothermal
energy, wind and bioenergy could have much bigger share in our energy mix. In policies, we
need to account for prohibiting factors as a part of Nexus approach. For instance, in Brazil,
hard drought heat waves in the years 2014–2016 have wrecked the performance of hydro-
electric dams in southeast Brazil, causing extensive damage to society and economy. Since
there is robust evidence about human influence on the frequency of extreme weathers, a
more integrated approach would connect and assess all the major factors and give then a more
reliable policy option scenario for taking care of national energy security. In the complex
human-environment systems, the nexus resource approach is ever more needed to provide
the sufficient analysis of the existing situation as well as providing related environment-
development related goals, expressed in more generic terms in Sustainable Development
Goals, as adopted by the UN.

The demographic factor

The rapid growth of Asia has already led to a swiftly growing consumption of raw materials, and
there is no end in sight. The growth in China in particular is unprecedented: In the course of
the next 10 years, it might even overtake the US and the EU (in terms of GDP per capita), as
Euromonitor has estimated. (Euromonitor, 2012)

The population in many countries, especially in European ones, is aging, and as the baby
boomer generation retires, the dependency ratio will change rapidly. By the year 2030, nearly
one-third of the population in some European countries will be over 65 years old, which
will be a radically different situation than the present (see Figure 13.2). In addition to slowing
down economic growth, this will also lead to a considerable change in demand. Besides add-
ing pressure on the public sector for basic services, the graying of Europe will also lead to the
Figure 13.2  Aging population in Europe, 2010–2030
Source: Prof. Wolfgang Lutz/Global Education Trend scenario, World Population Program, IIASA 2009

Figure 13.3  Key parameters in the sixth Kondratiev wave, 2010–2050

The search for resource productivity and human-focused solutions

Globalisation: decentralization of the power centers

Key megatrends

Demographic change implying aging and longevity

Key innovation platforms

The expansion of resource-efficient technologies

The rise of the bioeconomy

Web-based smart products and services (IoT)

Growth of health services

Maturing environmental concerns

Key trajectories for social change

The rise of complex societies

Web-based empowerment of the people
breakdown of the old industrial model, wherein the length of active working life was determined in detail and the structure of the welfare state was based on a sharp division between the public and the private sector.

While aging will take its toll, population growth continues in many other parts of the world, particularly in sub-Saharan Africa and Asia, which seems to lead, as stated earlier, to close to 10 billion inhabitants on Earth by 2050. The two megatrends of globalization and demographic change are together creating a world in which the key challenge will be how to increase resource productivity. At the same time, technology will advance in leaps and bounds: New, efficient energy technologies will gain ground and gradually supersede the current fossil fuel-based energy economy. Thanks to new developments in biotechnology, synthetic products can be replaced with organic materials. Nanotechnology already allows us to modify the properties of products so as to make them more durable, and it is also leading to the development of innovative new methods for diagnoses in the health care industry.

The transformational impact of the sixth Kondratiev wave on the development of our societies should not be underestimated (see Figure 13.3). Highly industrialized countries will experience a remarkable shift from manufacturing to service.

Take Finland as an example. While service currently accounts for about 65% of Finland’s GDP (a relatively low percentage compared to other European countries), in 2030 that figure will in all likelihood be well over 80%. The growing prevalence of services will alter the economic and professional structure of society. Along with other countries, Finland will gradually shift towards a production structure that is less reliant on energy and raw materials and more towards livelihoods that are based on high-value products and services, uniqueness, and locality. In fact, dematerialization has been underway in Finland since the early 1970s, where production has increased in efficiency, with fewer resources being used per unit of manufacture. At the same time, however, the benefits of improved efficiency have been offset by strong economic growth so that total consumption of energy, for example, has in fact increased. From 2006 (before the financial crisis began), however, total energy consumption in Finland started to decline. (Statistics Finland, 2015)

Entering the resource revolution through waves

In our research framework based on Kondratiev cycle analysis, we have postulated that the key driver for the impending wave we are entering is the search for resource productivity. This is largely because economic globalization has developed to the point at which raw materials and commodities have become, or are becoming, increasingly scarce. This development has and will have a particular price indication: There has been a fundamental shift from falling commodity prices into rising ones (see Figure 13.4).

It is remarkable that in the course of the 20th century, the price of commodities dropped almost by one-half. (McKinsey Global Institute, 2011, 2013) This happened at the same time that economic output went through the roof, increasing 20-fold. The reason why resource prices fell was quite obvious: New supplies were discovered in abundance, and new techniques that increased productivity were developed. Moreover, prices did not always reflect the full cost of materials. The last 10 years have been dramatically different, as prices have trend-wise been on the rise. This is particularly due to China, whose huge demand has driven prices up. When the financial crisis hit the global economy in 2008, the price surge of raw materials stopped for a while, only to continue after the most difficult phase of the crisis. From 2011 onward, the prices have been dropping or leveling out, and it is all too early to call off the rising trend.
Because our industries are still quite heavily material intensive, we are indeed running into trouble, and as a result the new battle for resources between global powers has started in earnest. Excessive use of both materials and energy sparked development in previous waves, coupled with inadequate technology for restricting the pollution that was largely caused by the use of petrochemicals. This development has now determined the agenda for the oncoming sixth Kondratiev wave, which will dominate the next 40–60 years of global progress. Increases in efficiency will be sought through the reduced use of materials—non-renewables in particular, such as metals and minerals—and from decreasing energy intensity in both production processes and in everyday life.

This quest for greater resource productivity will steer our businesses and societies and therefore set the tone for innovation. This is particularly important, because we have learned that to continue on the same growth trajectory while using resources as we do now will result in three times the use of resources by 2050. (UNEP, 2011) We have ample evidence that this is simply not possible, which means that the growth pattern will fundamentally have to change. Traditional industries must become much less materially intensive, while whole new industries will emerge, including some of which do not yet even have a name. Additionally, new professions will arise in order to facilitate these developments.

In the research and analysis side, there is clearly a need for a resource nexus approach, where interlinkages between several resources needs to be better understood in the socio-economic-ecological systems of provision. The Sustainable Development Goals adopted by UN acknowledge the fundamental role of five key resources defined by resource nexus thinking: water, energy, biomass, land and materials. Understanding the interlinkages of these key resources form the essence of any policies within the realm of these 17 SDGs.4

Above all, materials are the basis of our economy. Historically, the extraction and consumption of materials have strongly correlated with economic growth. Interestingly, however, over the course of the last decades there has been a growing decoupling5 of these two developments (Krausmann et al., 2009). On the other hand, the sheer rise in the amount of extraction has been massive: Between 1980 and 2009, the world’s domestic extraction almost doubled (Giljum...
Global change and K-waves

et al., 2014). The global production of concrete in 2012 was more than 3.5 billion tons, of which China had a share of one billion tons. Today, the total amount of rock and sand being extracted globally equals two times the volume of Mount Fuji (Bardi, 2014).

Obviously, this development has had a huge environmental impact. It has led to climate change, overexploitation of key natural resources, pollution and many other detrimental impacts. The result is that today a fairly large consensus believes that a change is needed; that is, that we need to strive for an absolute reduction in resource use in order put ourselves on the path to sustainability.

Simultaneously, our dwindling reserves have become increasingly subject to international political maneuvering, as they are not uniformly distributed across the globe. For example, 60% of the iron ore in the world comes from Australia, Brazil and China, while 83% of the world’s exploitable phosphate rock is located in Morocco, China and South Africa (Vaccari, 2009). Phosphorus is a typical example of a raw material that is becoming increasingly scarce, thus creating ample opportunities for new innovations to take over the marketplace.

As implied, the key drivers of innovation for the next Kondratiev wave will be material scarcity stemming from the anticipated shortage of metal and mineral resources in the next few decades. Simply put, material scarcity is controlled by two factors: the supply of the material versus its demand. With a growing world population and growing consumption, the demand for material resources already far exceeds the supply. In the past century, the exploration of new locations and technological innovations in mining and extraction kept material reserves in balance with the demand, helping the price levels stay moderate. However, present knowledge indicates that this balance will not continue into the 21st century, as the production of a number of material resources has already peaked. (UNEP, 2013)

The most precious resources on our planet are food and water. In the decades to come, there will be a tremendous challenge concerning the sufficiency of these resources. In the food markets, we are already seeing the results of scarcity as food prices are rising. FAO food price index has risen 61% from 2004. Global food production is under severe constraints, for reasons varying from the overuse of fertilizers and other harmful farming practices to the growing needs of the global middle class. One thing seems certain: The crisis will severely affect those countries that are ill-equipped to manage the situation.

According to Professors Harald Sverdrup and Vala Ragnarsdottir, experts in the study and modeling of the cycles of minerals and other natural resources, every year we are using 3,700 million tons of cement; 1,300 million tons of wood; 2,200 million tons of iron and steel, of which 1,500 tons comes from mines; and we produce 110 million tons of aluminum, 50 million of it from mines. The annual global output of copper, zinc and lead is 35 million tons, of which 16 million comes from within the earth. The other metals account for 50 million tons, 35 million of which are extracted from mines. (Sverdrup and Ragnarsdottir, 2014)

After examining the circulation of raw materials and assessing the use of natural resources in the future, they have arrived at the following conclusions. First, there will not be any serious shortage of copper, aluminum or iron for a long time. Iron production will peak around 2030, with serious scarcity emerging around 2080, which will in turn lead to a serious economic crisis, as iron is such a vital part of all infrastructure.

Second, there will be a serious crisis with respect to phosphorus — a crucial ingredient in modern fertilizers — but it will be due to erosion. In Sverdrup’s and Ragnarsdottir’s estimation, soil erosion due to phosphorus overuse will probably be the greatest threat to civilization in the long run. Without healthy soil, we have no hope of feeding the growing population on Earth. According to the Food and Agriculture Organization of the UN, we already saw the peak of arable soil around the year 2000.
Third, problems will escalate and eventually blow up in our faces with regard to the use of fossil fuels, the inefficiency and costs of our systems of production, and the scarcity of nickel and other metals needed for high-tech products. We must adapt our economies to these radically new circumstances. Our taxation system must shift from taxing the work towards taxing the use of scarce and polluting materials. There is promise of a new economic system in which the principles of three R’s will reign – reduce, reuse and recycle – called circular economy. Now being adopted by EU, circular economy simply holds that the massive plundering of the earth's precious resources should stop. (European Commission, 2016) In the sixth wave, we simply must be much more intelligent in how we run our economies.

As new types of policies are gaining ground, a nexus approach to manage resources will be ever-more needed in the future since it emphasizes synergies in natural resource governance and emphasizes resource-related stress multipliers (see Bleischwitz et al., this volume). Moreover, to understand the challenges in the emerging sixth wave, we need such modeling that provides us with new business-as-usual scenarios that are based on better understanding of interactions between bio-physical and socio-economic systems. Only then can we expect fully informed policies facing the real challenges of the next decades.

Conclusion
We are entering a new socio-economic cycle – the sixth wave. This is an era for which we truly need a balance sheet for the planet. (Wijkman and Skånberg, 2014) It is a phase in our societies and economies (extending to the middle the century) in which we need to focus on becoming aware of both looming deficits and potential assets. Any serious attempt to make forecasts for the middle of the century cannot avoid asking what resources we might be living on in that time. Jörgen Randers determined that we most likely will experience a world where substantially less is being consumed by the typical Western citizen. The path to the future will be tumultuous and full of conflict. (Randers, 2012) However, as the Sustainable Development Goals should guide the agenda for international and national policies, the resource nexus approach, comprising critical natural resources and analyzing human-environment relationship, should provide us a more realistic and comprehensive research and policy agenda.

On country level, the real question is: Which country has the capacity to become a trendsetter? We can all probably contribute to making that happen. The most important thing, however, is that we must ourselves understand what it takes to promote the achievement of such a goal. We must all become responsible consumers and promote lifestyles and solutions that further this idea. What an enormous opportunity this is for any country, particularly when considering that the change in direction is inevitable in the next few decades. We are still looking for the country or group of countries that will start to redefine their legislation, taxation and overall policies – something we have earlier referred to as “system policies.” (Schmidt-Bleek et al., 2014) This should serve as a model for how the social regime of the country will be transformed during the sixth Kondratiev cycle in order to both reflect and respond to the great challenges of our age.

Notes
1 The model, called World3, utilized the following parameters: investments, population, pollution, natural resources and food.
3 See: https://sustainabledevelopment.un.org/sdgs
4 See: www.un.org/sustainabledevelopment/sustainable-development-goals/
5 UNEP’s International Resource Panel (IRP) has applied the concept of ‘decoupling’ to this challenge. While the term has been applied to everything from electronics to physical cosmology to linear algebra, in the sense used here decoupling means using less resources per unit of economic output and reducing the environmental impact of any resources that are used or economic activities that are undertaken.  


---

**References**


