European Parliament

A framework for foresight intelligence

Part 1: Horizon scanning tailored to STOA's needs

STUDY

Panel for the Future of Science and Technology

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A framework for foresight intelligence

Part 1: Horizon scanning tailored to STOA's needs

The first part of the STOA study 'A framework for technology foresight intelligence', this report includes a set of five horizon scanning reports or 'radars', built with the resources of Futures Platform and covering several areas, including the world after Covid-19, disruptive futures, the Green Deal, food, and geoengineering.

Horizon scanning is a discipline that could be harnessed to inform the future activities of the Panel for the Future of Science and Technology (STOA) at both strategic and practical levels. However, as STOA does not have the working structure, human resources or expertise necessary for continuous scanning, for the horizon scans in this study it used Futures Platform.

Futures Platform is a professional trends knowledge platform that collects and analyses information on phenomena such as technology, trends and signals, using AI-based tools and a team of foresight experts to anticipate future developments. These trends and signals were used to build a set of trend radars with a view to testing the feasibility of adding horizon-scanning activities to STOA's methodological toolbox.

AUTHORS

This study was written by Lieve Van Woensel and Carl Pierer, both, at the time of writing, from the Scientific Foresight Unit, within the Directorate-General for Parliamentary Research Services (EPRS) of the Secretariat of the European Parliament, employing Futures Platform, a web-based strategic foresight platform, at the request of the Panel for the Future of Science and Technology (STOA).

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Executive summary

Horizon scanning is the systematic exploration, acquisition and use of information about events, phenomena and trends, and their mutual relationships. It is a foresight method that aims to obtain a nuanced overview of trends. It can be conducted at both macro- and micro- levels.

Horizon scanning can serve a variety of purposes: strategic, covering a broad range of topics without a specific goal, or focused on one or more megatrends (e.g. demographic change, emergence of technology, resource scarcity, climate change) or technological trends (e.g. artificial intelligence, nanotechnology, genetic engineering). In either case, it is ideally conducted on a continuous basis. This, however, can be extremely resource-intensive.

Horizon scanning activities within STOA are meant to support STOA in two ways:

1. at policy level: by assisting in strategic reflections and long-term planning of the Panel;
2. for policy analysis: by providing a mapping of phenomena to obtain a picture of technology-related issues and interconnections that might become important for European policy. Such mapping could include any kind of signals that might need attention, or mappings of areas within STOA's priorities (AI and other disruptive technologies, the Green Deal, or quality of life). At the level of practical activities (studies, events and publications), Futures Platform helped with an in-depth analysis of issues relating to the topic of investigation.

Although STOA does not have the resources or the breadth of expertise to ensure high-quality, continuous horizon scanning, it can make use of external tools that provide broad information on emerging phenomena.

Technology and trends knowledge platforms like Futures Platform are useful instruments for horizon scanning. STOA has used Futures Platform to create some horizon scanning reports on broad domains, such as future disruptors and the world after Covid-19. A number of experts in various EPRS services were also invited to use the platform and provide feedback and an evaluation.

This study began by investigating the role horizon scanning can play in STOA's work, in particular in the context of highly contested topics, and what can be learned from horizon scanning activities at other institutions. It then tested the knowledge base Futures Platform for its usefulness for fulfilling this role. In the course of this study, it was found that Futures Platform's radars and phenomena (items that make up the content of Futures Platform) are very usable as a tool for horizon scanning and can assist, but not replace, the work of the policy analyst. For this reason, they can be particularly valuable for the two purposes of horizon scanning for the work of STOA outlined above. Some examples of these radars are included in the appendix.

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1. Context

The aim of this study is to investigate an additional method to enlarge STOA's toolkit. A combination of the existing capacities at STOA and high-quality foresight-support tools, the use of collective intelligence, and the involvement of foresighters from across the world could add an extra level of foresight intelligence to STOA's toolkit.

The purpose of this is to extend STOA's practices for anticipating the future to ensure that STOA's work is 'future fit'. The focus of this study is two-fold:

1. to find a feasible way within STOA's capacities to scan events and trends that could be important, or become important in the future, in order to anticipate them in policy work; thereby, STOA's work might help minimise avoidable surprises;
2. to explore the usability of 'online stakeholder engagement' within STOA's framework of foresight intelligence.

Both parts of the project are set up so as to contribute to intelligence building for STOA.

The first part is about exploring how horizon scanning could support STOA's foresight activities. It investigates how – in a systematic way – information can be collected about possible developments in the future. It inspects possible future trends in two ways. The first does not necessarily focus on a certain field, but rather scans trends and developments that are or could become important in the future, to obtain a wider picture of new areas in which STOA is planning to conduct studies for the European Parliament.

The second way is aimed at collecting 'societal intelligence', i.e. collecting information on the societal context of the emerging technologies; the aim is to get insights into the possible concerns of the societal stakeholders regarding the possible effects of the new or emerging technologies and their future applications. This is intended to feed information about the societal context of certain emerging technologies into STOA studies and is especially necessary in the case of issues that are considered controversial in society. As such, scientific and academic evidence for a science- or technology-related topic can be complemented with information on the societal context of the technology under investigation. An assessment of evidence-based policy options on the basis of insights into societal concerns can make STOA study outcomes more functional and useful for policy-makers.

After an introduction to horizon scanning and its potential benefits for STOA, this report explains horizon scanning and its processes in more detail, describing the relationship between horizon scanning and drivers of change and megatrends, and how scanning fits in with STOA's foresight activities. The report summarises the findings regarding how horizon scanning can feed into the activities of STOA and concludes with five horizon scanning reports, exploring phenomena related to (1) the world after Covid-19; (2) disruptive futures; (3) the Green Deal; (4) food; and (5) geoengineering. These horizon scans will also be made accessible on the STOA website.

2. Introduction

Since 2015, the Panel for the Future of Science and Technology (STOA) has been involved in foresight activities. The first part of STOA's methodological study, entitled 'A framework for technology foresight intelligence', this report focuses on the development of 'trend radars' that were established to test the feasibility of adding horizon scanning activities to STOA's methodological toolbox.

This study includes a set of five horizon scanning reports, which vary in breadth and depth.

The tool employed for this purpose, Futures Platform, was appropriate for offering general overviews of upcoming areas:

1. the world after Covid-19;
2. disruptive futures, for topics within STOA's current priority areas;
3. the Green Deal, for which one radar focuses on climate change and another on environment;

one area in which STOA had already conducted some studies, namely:

4. food (including agriculture);

and one specific area that was developed further in preparation for a new publication:

5. geoengineering.

Futures Platform was selected by STOA to experiment with different levels of horizon scanning. The outcomes are presented in this report.

An overall broad horizon scan of relevant themes could be conducted on a regular basis (for instance, yearly) while a focused horizon scan might be conducted in the design phase of each new activity. To this end, STOA would benefit from a readily available professional tool. Ideally, the collection of phenomena available in such a platform is AI-based and assessed by a team of foresighters from a varied range of disciplines. Furthermore, the ideal platform would include features to download the 'scans' in a way that is useful for Members of the European Parliament as well as for the policy analysts preparing the foresight activities.

Users within the STOA unit and the European Parliamentary Research Service (EPRS) found that technology and trends knowledge platforms, such as Futures Platform are useful instruments for broad horizon scanning, both for strategic purposes, and for spotting important upcoming issues. Moreover, Futures Platform was evaluated to be most useful and time-saving when preparing new studies, especially in the design phase. In-depth analysis using the platform revealed interconnections that might have been overlooked had the tool not been used. Futures Platform was also found to be useful in reducing blind spots in STOA's analysis activities. Lastly, whereas an assessment of the quality of the evidence collected by the platform found that was no substitute for the usual research, the platform could nevertheless provide a good understanding of new topics.

3. Horizon scanning

3.1. A foresight method

Foresight activities aim to anticipate future opportunities and threats. Foresight work includes the identification of issues that are of major importance for the future and the present, and is geared towards understanding what is currently relevant for society and policy.

Horizon scanning plays an important role in foresight activities; it serves to explore the future by identifying 'emerging issues' and signals of all kinds, and to evaluate the importance of things to come. It is basically the early detection and assessment of emerging technologies or threats for policy-makers in a given domain.

For STOA, horizon scanning could be helpful, in particular by mapping:

- emerging issues, with a specific focus on possible discontinuities and changes;
- interdependencies and interconnections between emerging issues and other trends; and
- high-impact 'wild card' events that seem incredible, or are considered too unlikely to occur.

3.2. Horizon scanning as a component of foresight work

Horizon scanning is a way of systematically looking out to detect early signs of potentially important developments. These might be weak (or early) signals, trends, wild cards or other developments, persistent problems, risks, or threats, including matters at the margins of current thinking that challenge past assumptions. Horizon scanning can be completely explorative and open or a limited search for information in a specific field based on the objectives of the respective projects or tasks. It seeks to determine what is constant, what may change, and what is constantly changing in the time horizon under analysis. A set of criteria is used in the searching and/or filtering process. The time horizon can be short-, medium- or long-term.

3.3. Broad versus narrow horizon scanning

Horizon scanning can be conducted to obtain a broad overview of possible trends and connections. This type of horizon scanning does not necessarily focus on a specific area; it offers a bigger picture of what the future could bring, by mapping emerging issues, discontinuities, various kinds of signals, and interdependences between all of these. Narrow or focused horizon scanning efforts envisage the mapping of issues emerging in a specific field.

Two examples included in this study present broad horizon scanning exercises, mapping:

1. the world after Covid-19; and
2. disruptive futures.

Two examples illustrate horizon scanning that is focused on specific topics that belong to STOA's current priority areas:

3. the Green Deal, for which one radar focuses on climate change and another on environment; and
4. food (including agriculture).

One example illustrates the use of horizon scanning to obtain insights in one specific area:

5. geoengineering.

3.4. Horizon scanning processes

In 2015, the European Commission issued an in-depth report entitled Models of Horizon Scanning. This report explains that horizon scanning is often based on desk research, helping to develop the big picture behind the issues to be examined. It can also be undertaken by small groups of experts, who are at the forefront of the area of concern. They share their perspectives and knowledge with each other so as to 'scan' the ways new phenomena might influence the future. A solid 'scan of the horizon' can provide the background to develop strategies for anticipating future developments and, thereby, win lead time. It can also be a method to identify and pre-assess assumptions about the future, to feed into a scenario development process.

In its 2019 briefing on Strategic Foresight for Better Policies, the OECD explained that foresight uses a range of methodologies, such as scanning the horizon for emerging changes, analysing megatrends, and developing multiple scenarios, to reveal and discuss useful ideas about the future. The same paper identifies 'strategic foresight' as the structured and explicit exploration of multiple futures, in order to inform decision-making. It describes 'anticipatory governance' as the systematic embedding and application of strategic foresight throughout the entire governance architecture, including policy analysis, engagement and decision-making.

Horizon scanning is usually conducted as a collaborative/collective effort, combining desk research and brainstorming with a dedicated team.

STOA employs foresight for anticipatory governance in areas relating to science and technology. As general and continuous horizon scanning is a very resource-intensive activity, specific advisory bodies such as STOA have neither the range of expertise nor the human resources to set up and maintain such an activity. However, many organisations are interested in the same type of trends. In the case of STOA, horizon scanning should focus on emerging and changing issues relating to developments in science and technology and their applications. Interestingly, there exist professional support systems that offer the building blocks for this kind of horizon scanning.

Platforms of this kind focus on a variety of areas, such as: trends scanning (Shaping Tomorrow, Trend One, and Itonics), news monitoring (Meltwater, M-Brain), technological trends (Futuribles, RAND Foresight Centre), a combination of these (Futures Platform). Professional foresight associations also have their own platforms (Association of Professional Futurists, World Futures Studies Federation, and World Future Society). STOA chose Futures Platform to develop a set of trend reports, including broad scanning and narrow scanning. While this list is not exhaustive, it gives an overview of alternative solutions.

3.5. Trends, drivers of change and megatrends

Horizon scanning looks at phenomena that can be classified into three categories: *trends*, *drivers of change* and *megatrends*. Trends are triggered by drivers of change, some of which provoke change at global level. The latter can be considered to be megatrends.

A **trend** is a general direction in which something is developing or changing; it is a general tendency or direction of a development or change over time. A trend can be called a megatrend if it occurs on a global or large scale; it may be strong or weak, increasing, decreasing or stable. However, there is no guarantee that a trend observed in the past will continue in the future (see Megatrend / Trend / Driver / Issue on the European Foresight Platform (EFP) website).

Drivers of change are the forces that induce trends.

Megatrends are the eminent forces that are likely to affect the future in all areas throughout the world, over the next 10 to 15 years. They are long-term driving forces that are observable now and that will most likely have a global impact. (EEA, European Foresight Platform (EFP), JRC).

Various types of organisation analyse megatrends systematically to support foresight work in general and to help identify emerging issues and provide more input for horizon scans. The OECD describes this as exploring and reviewing large-scale changes building up in the present, at the intersection of multiple policy domains, with complex and multidimensional impacts in the future.

Because megatrends are defined as long-term driving forces that are observable now and will most likely have a global impact, they can help identify probable and preferable futures. They aid in reflecting on the future in a systemic way. Often, these drivers of change and, notably, megatrends are strongly interconnected. Population growth, for instance, could impact almost all other drivers of change.

Major / long-term drivers of change – megatrends – include:

- population growth,
- technological development,
- climate change,
- pollution,
- limited natural resources,
- migration,
- economic or financial crises.

There is a distinct methodology for the analysis of megatrends. However, the approach to outcomes of megatrend work is often the same as that applied to horizon scanning.

3.6. Examples of horizon scanning and megatrends reports

The European Strategy and Policy Analysis System (ESPAS) regularly publishes reports on megatrends such as climate change, demography, urbanisation, economic growth, energy consumption, connectivity and geopolitics.

The Joint Research Centre (JRC) continuously monitors 14 megatrends:

1. diversifying inequalities,
2. climate change and environmental degradation,
3. increasing significance of migration,
4. growing consumerism,
5. aggravating resource scarcity,
6. increasing demographic imbalances,
7. accelerating technological change and hyper-connectivity,
8. expanding influence of east and south,
9. changing nature of work,
10. diversifying education and learning,
11. shifting health challenges,
12. continuing urbanisation,
13. increasing influence of new governing systems,
14. changing security paradigm.

In its 2019 report 'Drivers of change of relevance for Europe's environment and sustainability', the European Environment Agency (EEA) clustered the drivers of change as follows:

- Cluster 1 – Growing, urbanising and migrating global population

- Cluster 2 – Climate change and environmental degradation worldwide
- Cluster 3 – Increasing scarcity of and global competition for resources
- Cluster 4 – Accelerating technological change and convergence
- Cluster 5 – Power shifts in the global economy and geopolitical landscape
- Cluster 6 – Diversifying values, lifestyles and governance approaches

Their report provides an in-depth characterisation of these clusters, their components, and interactions within and across clusters.

The World Economic Forum (WEF) has developed its strategic intelligence capabilities to facilitate easy understanding of the complex forces driving transformational change across economies, industries and global issues. The focus is on various dimensions, for instance the sustainable development goals (SDGs), global issues, industries and economies.

Various institutions publish their horizon scanning outcomes and other foresight guidelines and findings. It is worth following horizon scanning and other foresight findings from institutes all over in the world. Policy Horizons Canada, for instance, uses foresight to help the federal government build stronger policies and programmes in the face of an uncertain future. Singapore's Centre for Strategic Futures is geared towards enabling the Singapore government to navigate emerging strategic challenges and harness potential opportunities. In the UK, the Government Office for Science (GOS) helps to embed futures tools and techniques across the civil service to support policy-making.

3.7. Purpose of horizon scanning tools for STOA

For STOA, a tool that can help prepare horizon scanning reports would be useful to provide the STOA Panel with a bigger picture and help it reach decisions about new undertakings.

For the policy analysts involved in STOA activities, a horizon scan would be helpful when:

- assessing new proposals for studies or workshops, and
- exploring a new topic to paint a wider picture of all the interconnections for a certain issue; it would boost the analysts' efficiency when writing specifications for studies, preparing an event outline, or exploring a new area for a specific publication.

A horizon scan ideally provides an overview of research-relevant emerging trends. It should be presented in a structured manner. Two dimensions are particularly relevant for this structure: one can be a grouping of the emerging issues in topic clusters; the other can present the time dimension.

Even though the monitoring of horizon scanning and megatrend activities can be very useful for policy-makers, the STOA structure does not allow the undertaking of scanning as a specific activity. Nevertheless, another, more resource-efficient form of horizon scanning could definitely be useful for STOA. It could be broad as well as focused.

1. Overall, a broad horizon scan:
2. considering emerging technologies in a systemic way, e.g. for the priority areas set by STOA, could be of help in inspiring strategic thinking and planning by the STOA Panel;
3. using scanning technologies to examine phenomena that could change our lives, or influence various policies, might help in the selection of topics for STOA activities or other publications.
4. At project level, it would save the policy analysts time and enable them work with greater accuracy when designing an activity (an event, a study or a new publication).

Moreover, a horizon scan would be useful in terms of reducing blind spots and recognising interdependencies at all levels. Everyone working in the STOA environment would meanwhile benefit from other institutions' knowledge gained from tracking emerging issues, trends, drivers of change, and megatrends.

It is obvious that all scanning activities are built on collective intelligence.

4. Overall findings

For STOA, horizon scanning should not be undertaken as an activity for its own sake, but should rather be purpose-driven.

Horizon scanning could assist policy-making by identifying important needs or gaps.

It could save time and resources for the Scientific Foresight Unit (STOA), while ensuring higher quality. AI-supported trends knowledge tools, such Futures Platform, help to prevent important aspects of various subjects from being overlooked, and are especially useful when exploring new areas, for which the analysts do not necessarily possess a detailed technical background. They can also speed up the assessment of new project proposals, and improve speed and accuracy when designing new activities.

The scanning efforts of other institutions can be useful because:

5. continuous horizon scanning is extremely resource-intensive, and
6. requires collective intelligence.

Additionally, megatrends analysis of other institutions, such as the Joint Research Centre of the European Commission, the European Environment Agency or the World Economic Forum, can support horizon scanning activities; a megatrend describes the drivers of change causing the 'trends', and these trends are observed via horizon scanning.

Horizon scanning can generate many insights. However, STOA does not have the resources and broad expertise to ensure a continuous horizon scan. This would require a broader range of disciplines/expertise in the team, extra time dedicated specifically to horizon scanning, and training of the team to approaching horizon scanning in a methodologically appropriate way. Instead, STOA could conduct specific horizon scannings occasionally or on request, using a professional web- and AI-based strategic foresight tool.

5. Conclusion

Futures Platform is a suitable tool to support STOA at three levels of its activities:

1. Broad: regular horizon scanning for STOA in its main priority areas
2. Focused: for in-depth analysis when designing new activities (assessing new study requests, designing new studies, and preparing workshops), and for drawing up specifications for a project (to minimise blind spots)
3. In-depth: for analysing a new topic considered potentially important for awareness training (a typical 'what if' publication).

When it comes to serving the needs of the STOA Panel, the most obvious deliverables are one-time 'scan reports' on specific subjects, to inform analysts and policy-makers.

In addition, it might be worth investing in the development of a repository of up-to-date quality horizon scans.

6. Appendix

This appendix presents a selection of five 'radars' produced with the help of Futures Platform. The following explanations should help with reading and interpreting these radars.

Radars. Futures Platform proposes 360° radars, which give a visual structure to organise all phenomena related to a broad topic, such as 'the future of work'. These exist prefilled with phenomena by the website itself, to be modified by users, or can be created by users from scratch. The basic layout consists of three concentric circles, giving either distinct time periods or free-text fields that can be used for 'initial impact', 'response', 'adaptation', etc. The concentric circles are structured by sector, which provides additional dimensions for organising the phenomena. These sectors can be described in free text, forming the summary for the sector when the radar is downloaded. Phenomena can be added, deleted or moved around in the radar by users. The radars can be exported as PowerPoint presentations.

Phenomena. These are the items that make up the content of Futures Platform. They are made up of: a short, introductory summary of the issue (this is what can be seen in the downloaded radars in PPT), a video clip, background information, an evaluation of impacts, links to related phenomena, and links to relevant news. They also include a classification per type (see 'Phenomena types' below) and a relevant time range. The production of this content is explained in detail here; it consist essentially of three steps: (i) potential phenomena are identified by human and AI-based monitoring of publications, through advice from experts and customers, and by maintaining contacts in a futures studies network; (ii) potential topics are checked by the Futures Platform content team to satisfy certain criteria, such as significant impact, repeated mention in trustworthy publications; (iii) the actual content of phenomena is produced: a factual core is established with reference to a trusted source, then, by a repeated process of checking sources and by checking interpretations and subjective biases in the team, the additional information is put together.

Phenomena types. Phenomena are classified into one of six types: '*strengthening*' – the phenomenon's change potential lies in the future, it will become more important during its time stamp period; '*weakening*' – the phenomenon's change has mostly occurred, it will become less important; '*weak signal*' – a small phenomenon for which it is still too early to decide whether it will become important; '*wild card*' – the phenomenon or change may occur but is deemed to be unlikely; *summaries* – see themes below; *no type*. A phenomenon receives a type in a team-reviewed process by a team of Future Platforms employees.

Five horizon scanning examples are included in this report.

Two examples included in this study present broad horizon scanning exercises, mapping:

1. the world after COVID-19; and
2. disruptive futures.

Two examples illustrate horizon scanning, focusing on specific topics that are part of STOA's current priority areas, namely:

3. the Green Deal, for which one radar focuses on climate change and another on environment; and
4. food (including agriculture).

One example for which the horizon scanning was conducted to obtain focused insights in one specific area is:

5. geoengineering.

These horizon scans will also be made available on STOA's website.

The world after COVID-19

Horizon Scanning for STOA

Created from a prefilled radar of Futures Platform

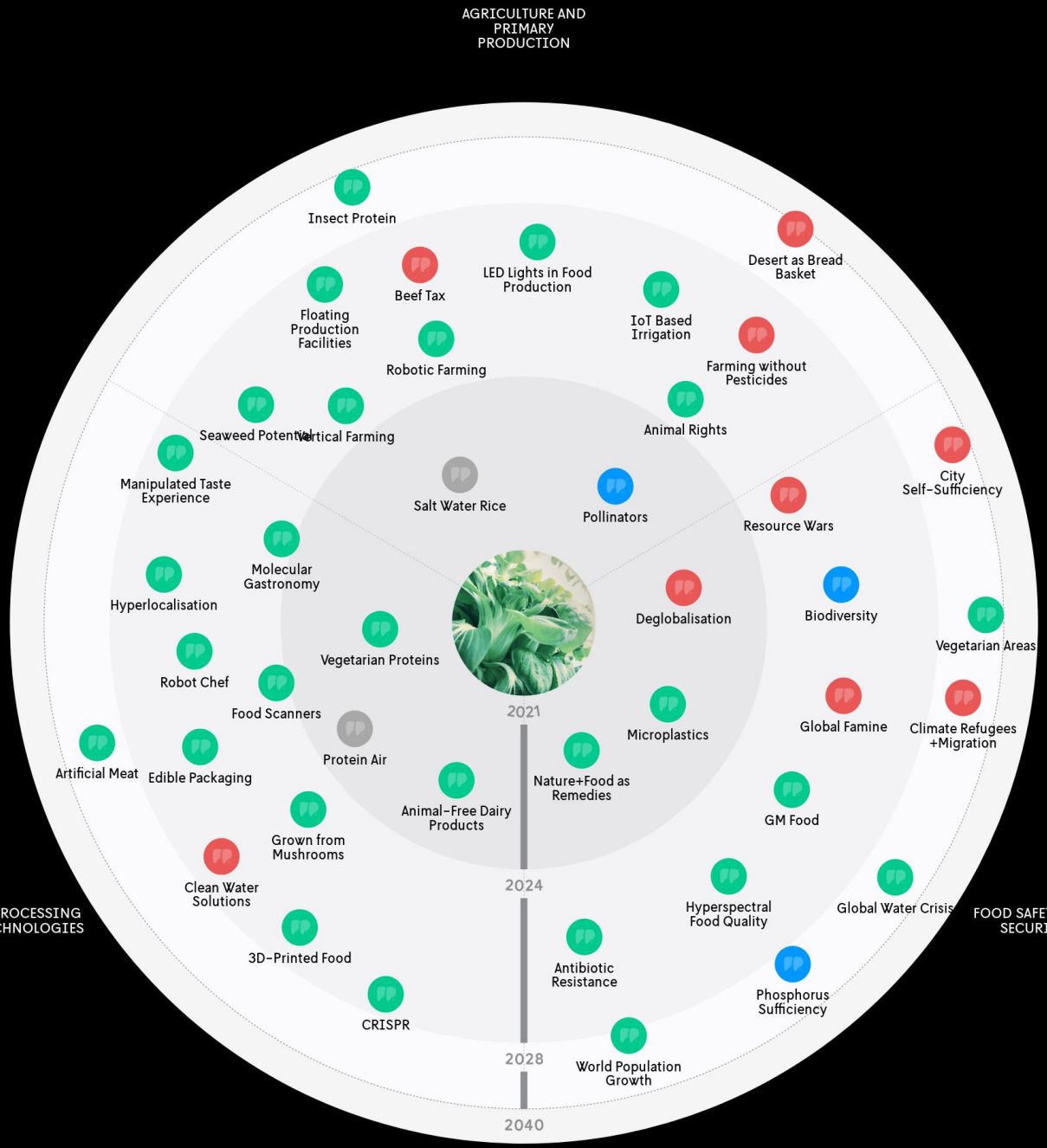
FUTURES PLATFORM

Food and agriculture, a horizon scan for STOA

Created from a prefilled radar

FUTURES PLATFORM

Food and agriculture (for final report - lvw)



Legend: Phenomena types

Strengthening (Colour: Green)
The presented issue is becoming more common or acute during the given timeframe. Most of its change potential is still ahead.

Weakening (Colour: Blue)
The presented issue is becoming more unusual. During the given timeframe, most of its change potential or value has already occurred.

Weak signal (Colour: Grey)
A small emerging issue in the present. At the given timeframe, it is still hard to say whether it will become a trend.

Wild card (Colour: Red)
A possible but not probable event or change. Early information about a potential emerging risk or opportunity. The probability within the given timeframe is between 5% to 30%.

Time ranges are set indicatively by the Futures Platform futurist team.
The timing indicates the expert-assessed timeframe within which the phenomenonis believed to either accelerate in change speed or start to decline in importance.

Food and agriculture

1. Food Processing and Technologies
2. Agriculture and Primary Production
3. Food Safety and Security

1. Food Processing and Technologies

Early 2020s

Accelerating improvements in various sciences rapidly change manufacturing technologies and practices. For instance, advances in automation, robotics, and big data are powerful transformation drivers. Furthermore, broadening energy and material solutions are pivotal in a world of increasing demands on efficiency. Also, machine learning, the internet of things and real-time monitoring are gradually becoming part of processes in some pioneering sectors of manufacturing industry.

Late 2020s

In the medium term, the key drivers in the manufacturing industry will be machine learning, sensing, monitoring, and processes automatized and optimized by the internet of things. At the same time, control over the entire supply chain will become more critical. Additionally, bio- and nanotechnology, circular economy, and demand for zero-energy and utilization of solutions provided by augmented reality will drive the industry towards new practices. Local manufacturing, rapid recycling and fast transportation of goods from manufacturing plant to the end user will also gradually become visible in industrial operations.

2030s and beyond

In the long run, all of the industrial processes and manufacturing practices will undergo a profound transformation, which may be characterized as an industrial revolution. The basis for this change will emerge from interconnected devices and inter-machine communication, which perhaps is best represented by a smart electrical grid. As a whole, a wide-ranging and systemic shift is taking place, in which physical devices, digital programs, energy, raw materials, and organic systems are being linked to each other, producing a significant increase in both efficiency and productivity. The entire value chain of production, distribution, sales, and purchasing, will be replaced by a new model, in which the role of humans will be thoroughly altered.

1. Food Processing and Technologies (1/5)

Vegetarian Proteins

Strengthening 2020-2023

The growing world population needs to be fed both sustainably and healthily. This will likely lead to increased consumption of vegetarian proteins.

Animal-Free Dairy Products

Strengthening 2020-2023

Several start-ups employing synthetic biology are creating new types of totally animal-free dairy products. For example, a biotech start-up Perfect Day has developed a limited run, animal free-dairy ice cream. The company focused on the biotech innovation of making animal proteins from whey and casein without using animals. Animal-free dairy products will be more environmentally friendly than traditional dairy and surpass the plant-based products in terms of taste and texture.

Protein Air

Weak signal 2020-2023

Scientist from the joint project of the Lappeenranta University of Technology and the VTT Technical Research Centre have been able to make a batch of single cell protein out of air and electricity. Their ground-breaking method is based on growing microbes by using renewable energy and carbon dioxide extracted from air. As unbelievable as it may sound, this kind of method could help us harvest food and animal feed from air anywhere without restrictions related to traditional agriculture and the environment.

1. Food Processing and Technologies (2/5)

Food Scanners

Strengthening 2024-2028

Food scanners are hand-held devices that are able analyse food composition with a simple "point and shoot". These small devices could provide valuable information prior to selling, preparing, feeding, or ingesting a piece of food by revealing its exact composition, nutritional values, and potential warning signs of contamination. Food scanners, whether they come in the form of scanning apps or scanning devices, could provide a lot of potential value for several industries and/or people who wish to control their diets.

Molecular Gastronomy

Strengthening 2024-2028

Molecular gastronomy is increasingly used to develop and manufacture new dishes of food. In practice, this means using natural sciences to gain knowledge of food, cooking and the pleasure eating brings. Molecular gastronomy will probably influence new dishes and eating trends in the future, with a potential of fundamentally changing the entire food culture.

Grown from Mushrooms

Strengthening 2024-2028

Advancements in synthetic biology have brought increasing variety to available production materials. Mushroom-based materials have already been successfully used to grow three-dimensional objects. In the futures, fungus-based products and materials will become more common, because these natural products have the advantages of low energy consumption, low emissions, and recyclability.

1. Food Processing and Technologies (3/5)

Robot Chef

Strengthening 2024-2028

In homes and kitchens, automatics and robotics are increasingly deployed to make life easier. Many manufacturers have introduced robot chefs that are designed to help with cooking. Robot chefs are often made of one arm, mimicking a human arm, that has been combined with technologies such as artificial intelligence, machine vision and voice control. In a professional kitchen, robot chefs can replace humans when it comes to carrying out tasks that require repetition, speed and an extremely high level of hygiene.

Edible Packaging

Strengthening 2024-2028

In 2050, there could be more plastic than fish in the oceans. Growing packaged goods consumption increases the demand for biodegradable packaging solutions. Made of hyper-compostable edible materials such as seaweed and milk protein, edible packaging may provide a sustainable alternative to plastic. However, high costs, regulatory requirements, and the less durable properties of edible materials make the widespread adoption of edible packaging difficult.

Hyperlocalisation

Strengthening 2024-2028

Hyperlocalisation means the desire to produce everything locally and by oneself, be it food, services, consumer goods, news, culture, or energy. More and more people are looking for chances to fulfil their daily needs with locally produced alternatives that serve the values and goals they deem important.

1. Food Processing and Technologies (4/5)

3D-Printed Food

Strengthening 2024-2028

3D printing technologies are expected to revolutionise personal and professional food preparation techniques. 3D printing makes not only creative food designs possible but also allows precise customisation of food according to individual preferences and nutritional needs. According to Research Nester, the 3D-printed food market is expected to grow to USD 400 million by 2024.

Clean Water Solutions

Wild card 2029-2041

Clean water shortage is one of the world's pressing problems and requires urgent solutions as the population grows, and climate change evolves. Various innovative tech and material solutions are continuously being developed to address this problem. If these technologies can make a breakthrough and be implemented at a large scale, clean water might one day become abundantly available.

Manipulated Taste Experience

Strengthening 2023-2028

As the humankind is forced to utilise new forms of food in the future, our need for manipulating taste experience is becoming more common. For instance, miraculin, which can be extracted from fruits or manufactured artificially, makes sour taste like sweet. Manipulating the sense of taste may prove to be a viable option in turning healthy, eco-friendly and nutritious foodstuffs into delicious alternatives to ordinary food.

1. Food Processing and Technologies (5/5)

CRISPR

Strengthening 2024-2028

CRISPR is a tool to engineer genetic information that was discovered by studying bacterial activity. The method is advanced and studied all over the world, because it enables the cheap and quick manipulation of human, animal, plant, virus, or bacteria genome.

Artificial Meat

Strengthening 2029-2039

Products intended to mimic meat are sold in many supermarkets and restaurants, but artificial meat made from animal cells in the laboratory is not yet found on the shelves of any shop. It is hoped that artificial meat, which has been in development for years, will solve some of the climate-related challenges associated with food production. The growing popularity of products that mimic meat has also raised criticism from those who call for more research into the safety of artificial meat products before they enter the market, and some people even actively oppose meat substitutes.

2. Agriculture and Primary Production

Early 2020s

The recycling of raw materials and waste, adhering to the principles of sustainable development, and various kinds of environmental thinking will continue to increase. Numerous NGOs and political parties will pressure governments to commit themselves and to foster international climate agreements, restrictions on the use of dangerous chemicals, and bans on items such as plastic bags. At the same time, nature and natural resources will be seen as enablers of economic and social growth and development, which will decrease the area of unspoiled nature year by year.

Late 2020s

Governments will boost the demand for cleantech also in the medium term by increasing environmental regulation and financial incentives. New groundbreaking cleantech solutions, such as self-healing buildings, LED lighting in food production and turning landfills into mines for raw materials, will progress rapidly, expanding the markets in the sector. It is expected that cleantech markets will continue their long-term annual growth of more than 10 percent. For example, the German government estimates that the value of cleantech markets will reach €4.4 trillion around 2025. In recent years, the growth in the markets has shifted from Europe towards developing countries.

2030s and beyond

The use of new sustainable technologies will start to bring demonstrably significant resource and cost savings to governments, organisations and individuals. In 2030s, adhering to the principles of sustainable development, recycling raw materials and waste, and utilising innovations such as an intelligent electricity network and turning carbon dioxide back into fuel will begin to be commonplace – these will not be regarded as special environmental efforts but as a reasonable and economically sound way of operation. For example, the utilisation of biology in the growing of packaging material and in the production of low-CO2 protein is becoming commonplace by necessity rather than due to ideological reasons.

2. Agriculture and Primary Production (1/5)

Salt Water Rice

Weak signal 2020-2023

Chinese scientists have managed to develop a strain of rice that can be grown in salt water. The invention could allow a significant amount of land, previously unsuitable for cultivating rice due to lack of fresh water, to be taken into agricultural use. Even though salt water rice is remarkably more expensive than traditional strains, it is still believed to have the potential of feeding hundreds of millions of people in the future. Besides China, also Dubai has taken great interest in the invention.

Pollinators

Weakening 2020-2023

Up to 40 % of all Apidae (apid bees) and butterflies are endangered in certain areas and up to 16.5 % of all vertebrate pollinators face extinction. The wide disappearance of pollinators is a grave challenge to biodiversity, food production, and many other fields using plants that rely on biotic pollination.

Animal Rights

Strengthening 2024-2028

More and more people aim to promote and advance animal rights by donating funds to various organisations and projects and by making conscious consumption decisions. This increases pressure on societies and businesses who need to take the ethical demands related to the treatment of animals more thoroughly into consideration.

2. Agriculture and Primary Production (2/5)

Vertical Farming

Strengthening 2024-2028

In vertical farming, plants are not grown horizontally on the fields but indoors, on several layers on top of each other. It is believed, that vertical agriculture enhances both the quality and quantity of the crops. This is due to a controlled environment optimized for the plants.

Robotic Farming

Strengthening 2024-2028

Farming is believed to be one of the next fields which will undergo a large scale robotisation. New robots are being developed, e.g., to pick fruits and berries. The drivers to develop farming robots are related to both labour shortages and new technological possibilities.

Seaweed Potential

Strengthening 2024-2028

Seaweed farming can be considered as one of the most natural and economical solution to solve global challenges, such as climate change, nutrition, and malnourishment. Yet, the biggest hope on seaweed cultivation is put on the development of a variety of high-value sustainable products like biofuels, medicines and food supplements. For example, super-foods such as seaweed snacks and other readily available ‘sea vegetables’ are slowly gaining momentum in markets.

2. Agriculture and Primary Production (3/5)

IoT Based Irrigation

Strengthening 2024-2028

Irrigation systems are becoming digitalized and tailored with optimal operations, making it more efficient and cost-effective. The implementation of IoT technologies for irrigation systems helps to minimize water consumption and increase crop production. The IoT based irrigation systems, coupled with an artificial intelligence-powered algorithm, machine-to-machine communication, and machine-learning applications, enable precision irrigation.

Farming without Pesticides

Wild card 2024-2028

Mass death of bees has led to loss of productivity in farmed crops as they do not pollinate the way they used to. Recent studies show that a chemical cocktail from farming including pesticides and insecticides has spread to wild flora as well. It is possible that future farming will have to become pesticide free to continue.

Beef Tax

Wild card 2024-2028

In the future, beef may be subject to pigovian taxes. Traditional meat may become a food only for the rich and the less wealthy have to make do with other sources of protein. With the growing climate awareness and the increased interest in plant-based diets and meat substitutes, beef taxes would further curb meat consumption and significantly disrupt the traditional meat industry. In an extreme scenario, this may even bring the end of mass-scale meat production.

2. Agriculture and Primary Production (4/5)

LED Lights in Food Production

Strengthening 2023-2028

LED lights can be used for efficient and competitive food production indoors. The benefits of vertical indoor farming include efficient and steady production rates, independence from location and weather conditions, and lack of pests. The indoor farming with LED lights could help tackle the challenges of the growing demand for food, water scarcity, and the rising carbon footprint.

Floating Production Facilities

Strengthening 2024-2028

Solar-powered, floating constructions may solve the challenges of food and energy production in the future. Plantations and power plants built on water can also provide sustainable food and energy in areas where land is scarce or conditions are challenging. Floating construction has the potential to make production more environmentally friendly, efficient and local.

Insect Protein

Strengthening 2028-2040

FAO has estimated that protein demand will increase up to 70 % by the year 2050. This increasing demand cannot be met with traditional meat production methods. Thus, the use and industrial production of insect proteins will likely see a significant increase in the next 30 years.

2. Agriculture and Primary Production (5/5)

Desert as Bread Basket

Wild card 2029-2039

Because of climate change and population growth, the future of the world's food production may increasingly depend on harnessing new areas for growing food and on adopting innovative farming technologies. It is possible that thanks to the new farming technologies the deserts may turn into food production areas.

3. Food Safety and Security

Early 2020s

The population of the world will continue to grow for a few decades, but population growth is no longer based solely on an increasing birth rate, but on the fact that people live longer than previous generations. In other words, the population is both growing and growing older. At the same time, humankind is also increasingly urbanising at an accelerating pace. With only 3% of people in the world living in urban areas in 1800, the share has currently already reached approximately 55%. Every day, the number of urban residents increases by roughly 200,000. In 1990 there were only 10 megacities in the world, with a population of more than 10 million people, whereas now, there are more than thirty megacities.

Late 2020s

As urbanisation accelerates, especially in Asia and Africa, the number of megacities with more than 10 million residents will increase to around forty. Currently, population growth due to an increase in the birth rate is mainly occurring in Sub-Saharan Africa. Almost the entire generation of so-called ‘baby boomers’ born in Western countries after the wars will reach their retirement age in the medium term. More and more representatives of the millennial ‘generation Y’ are beginning to take on leading roles in business, politics and market-defining companies. In emerging countries, absolute poverty and wars are declining and the middle class is on the rise, but in the western world the middle class is shrinking and the overall polarisation of society is accelerating.

2030s and beyond

Life expectancy is growing rapidly almost everywhere. However, the development has been most rapid in the West. Due to the increase in life expectancy, in particular, WHO estimates that population growth will continue until the year 2050, when the population is expected to be around 9.8 billion. As a result of accelerating urbanisation, a record 66% of humanity, or 6.5 billion people in total, are expected to live in cities. The continued growth in prosperity and population is overshadowed by the prospect of a major international war and the collapse of states, the increase in displacement due to climate change and migration, risk of pandemics, and the blatant inequality of the population, which can lead to unrest and terrorism, or at least weaker health and shorter life expectancy among the poor.

3. Food Safety and Security (1/5)

Nature+Food as Remedies

Strengthening 2020-2023

Healthcare is moving from a medicinal, disease-curing focus into a holistic management of human wellbeing. New health approaches highlight the importance of prevention and acknowledge the importance of nature and nutrition in improving and maintaining physical and mental health.

Deglobalisation

Wild card 2020-2023

The era of globalisation may be coming to an end, disintegrating the world's complex interdependencies as a consequence. Reasons for deglobalisation include a widespread rise in nationalism, a serious weakening of the liberal hegemony driven above all by the US, as well as the need for different countries to ensure their own security of supply by reshoring critical production.

Microplastics

Strengthening 2020-2023

Microplastics are plastic fragments or particles that are five millimetres or less in length. These minuscule particles often end up in the nature. An increasing amount of evidence shows that they can be found in animals, plants and humans. Sources of microplastics include the clothing industry, cosmetics and industrial waste. Even though there is no evidence at present to prove that microplastics pose a threat to the well-being of humans or the nature, long-term accumulation of plastic may have unknown consequences for an organism.

3. Food Safety and Security (2/5)

Resource Wars

Wild card 2024-2028

Several natural resources are non-renewable and available only in limited quantities. For this reason, it is possible that at some point the struggle for their control will intensify significantly. The possibility of armed conflicts cannot be ruled out entirely.

GM Food

Strengthening 2023-2028

The genetic manipulation (GM) of food crops has raised a lot of concern and doubts among the consumers. However, many of the scientists who have researched the issue, agree that the GM foods, which have passed the safety assessments and are sold on the global market, cannot be shown to be harmful to humans. Use of GMOs (genetically modified organisms) can bring multiple benefits to agricultural practices and may play a vital role in addressing climate change and the growing global food crisis.

Antibiotic Resistance

Strengthening 2024-2028

Antibiotic resistance develops through natural processes, but medicating humans and animals unnecessarily with antibiotics accelerates the growth of antibiotic-resistant bacteria. If effective new antibiotics cannot be developed, diseases that had earlier been almost defeated and modest infectious diseases could become life-threatening. Phage therapies, in which viruses are used to destroy bacteria, may also prove useful.

3. Food Safety and Security (3/5)

Biodiversity

Weakening 2024-2028

On a global level, biodiversity is weakening fast. This is entirely because of human-made reasons like agriculture, pollution and climate change. In the coming decades, the decline may reach a point where it starts threatening certain food industries or even global food security.

Hyperspectral Food Quality

Strengthening 2024-2028

Hyperspectral imaging works across several bands of light that the human eye cannot capture. Using super sensitive cameras and AI algorithms, hyperspectral imaging can detect quality and decay of fresh food products. This process can add reliability to production and quality to the end products sold to consumers.

Global Famine

Wild card 2040-2120

As the world population and the middle class grow, the need for food production will also keep increasing. At the same time, climate change, erosion, wars and other crises are having a significant impact on food production and distribution chains. For these reasons, the world market price of food is likely to rise sharply in the future, which will directly increase famine in the poorest countries. If the development of the world economy becoming replaced by regional economic blocs accelerates at the same time, food may become a geopolitical weapon and the world food market may come to a partial halt. The requirements for food self-sufficiency are likely to become significantly higher in the future.

3. Food Safety and Security (4/5)

World Population Growth

Strengthening 2029-2039

According to the UN calculations, the global population grows by about 83 million annually. Population growth is mainly occurring in developing countries, the fastest growing areas being located in Africa and Asia. The forecast estimates that the population of the world will be 8.6 billion in 2030, and rise to 9.8 billion by 2050.

Phosphorus Sufficiency

Weakening 2045-2055

Phosphorus-based fertilizers are vital for modern agriculture. Depletion of easily mineable phosphorus could cause disastrous consequences by halving the current rate of food production. Because phosphorus is a non-renewable natural resource, new technologies and ways of operating are invented continuously to develop the way it is being collected and re-used. In addition, scientists are trying to find alternative fertilizers to replace the mineral-based phosphorus.

Climate Refugees +Migration

Wild card 2029-2039

Many currently inhabited areas may become unliveable in the future due to climate change. This would lead to massive waves of climate refugees, forcing countries to rethink their immigration and refugee policies. The current estimates of potential climate refugees range from 25 million to 1.5 billion by 2050.

3. Food Safety and Security (5/5)

Global Water Crisis

Strengthening 2024-2029

Lack of drinking and irrigation water is shutting down many sustainable areas for living and eroding agricultural areas that were only recently productive. Resulting political unrest may confirm the saying: water is the next oil. The crises threatening the global economy are significant– already in 2013, The World Economic Forum considered the water crisis to pose a considerable risk to the modern world.

Vegetarian Areas

Strengthening 2024-2028

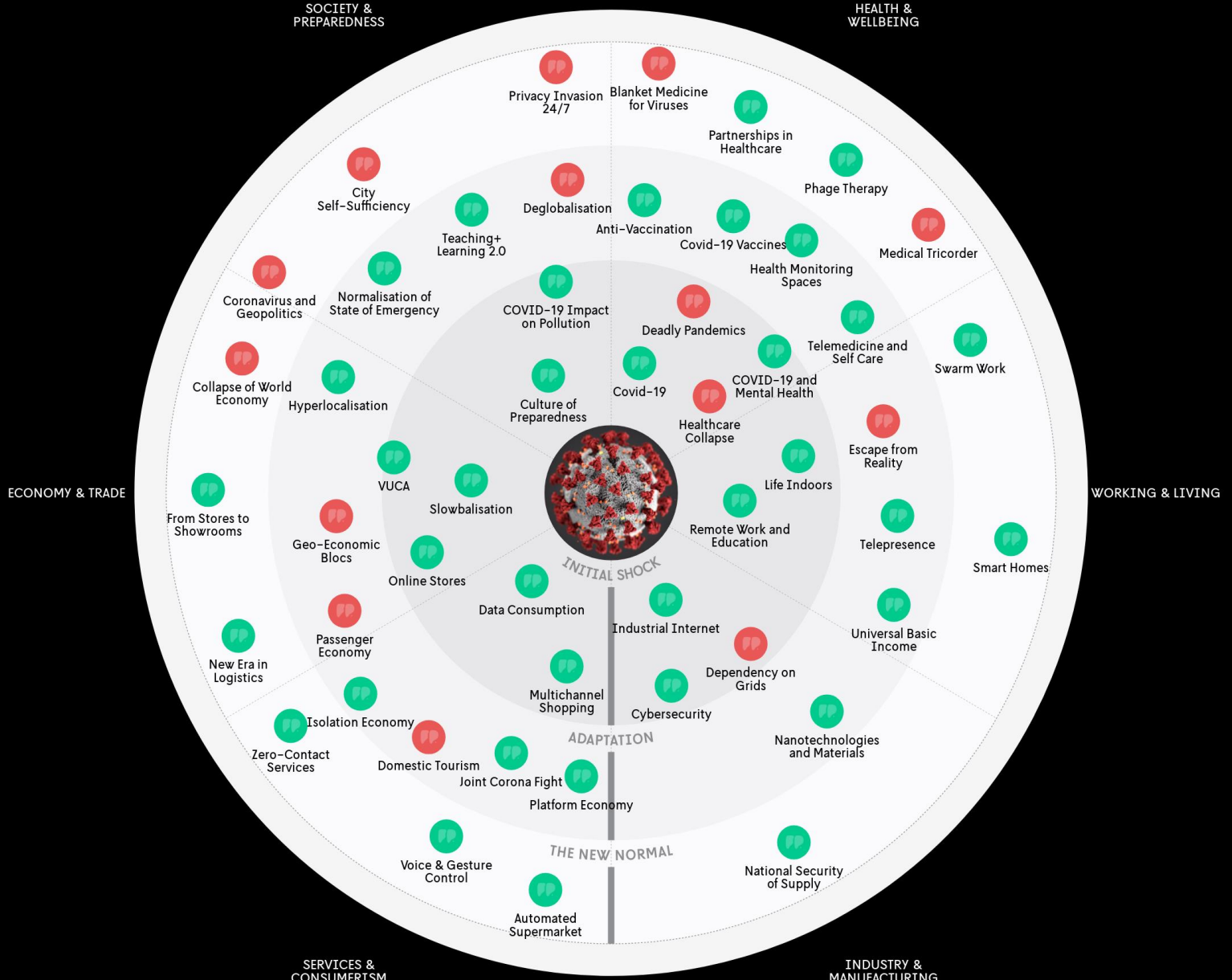
The popularity of vegetarian and vegan food and the stores, restaurants, and events offering them is rising significantly. Although people with vegetarian and vegan diets are still a minority of now, plant-based diets are becoming more common, especially among the younger generations. In the future, we will probably find whole areas that concentrate on vegetarian food.

City Self-Sufficiency

Wild card 2029-2039

Future cities may develop towards greater self-sufficiency. In that case, most of the food, energy, and clean water production, as well as recycling would take place within the city, utilising various new technologies.

The world after COVID-19



Legend: Phenomena types

Strengthening (Colour: Green)
The presented issue is becoming more common or acute during the given timeframe. Most of its change potential is still ahead.

Weakening (Colour: Blue)
The presented issue is becoming more unusual. During the given timeframe, most of its change potential or value has already occurred.

Weak signal (Colour: Grey)
A small emerging issue in the present. At the given timeframe, it is still hard to say whether it will become a trend.

Wild card (Colour: Red)
A possible but not probable event or change. Early information about a potential emerging risk or opportunity. The probability within the given timeframe is between 5% to 30%.

Time ranges are set indicatively by the Futures Platform futurist team.
The timing indicates the expert-assessed timeframe within which the phenomenonis believed to either accelerate in change speed or start to decline in importance.

The world after COVID-19

1. Services & Consumerism
2. Economy & Trade
3. Society & Preparedness
4. Health & Wellbeing
5. Working & Living
6. Industry & Manufacturing

1. Services & Consumerism

Early 2020s

Platform economy will remain a dominant change driver in the service industry, dismantling rapidly several existing service production and delivery related value chains. At the same time, it joins together both conventional operators of the industry with a network of prosumers. Sharing economy, made possible by platform economy, creates new kinds of business models which, to some extent, reduce the profitability of conventional businesses but, on the other hand, offer better visibility, strong co-operation channels, and a chance to utilize the benefits of scalability.

Late 2020s

Customers' expectations for uniqueness, tailorability, automation, and smartness of service, are continually growing. An increasing number of service providers join larger alliances and business ecosystems, which, in the best case, will gradually develop into new areas of business. Good examples of this are the passenger economy, and holistic service packages aimed at homes. These are based on a smart platform providing reachability, ease of use, trust, and on which numerous private service providers offer their products.

2030s and beyond

Eventually, customers start to take the tailorability, uniqueness, automation, and smartness of service for granted. The functionality of a concept, which increasingly means offering the customer at once something original and helpful, will quickly separate the service providers into winners and losers. Trying to stand out from the crowd, service providers will more and more compete for attention, hoping to hook the customers with game-like and multisensory means.

1. Services & Consumerism (1/3)

Data Consumption

Strengthening 2020-2023

The coronavirus epidemic has caused a spike in data consumption. With the proliferation of streaming and cloud services, data consumption will increase at an unprecedented rate even after the pandemic is over. The skyrocketing demand may put an extreme strain on the data infrastructure and cause disruptions in the long run.

Multichannel Shopping

Strengthening 2020-2023

The internet, social media and mobile technology have already changed the purchasing behaviour of consumers significantly. Customers want to consider and complete their purchases in a place and time that best suits them. The pressures from new kinds of demands cause immense changes and challenges to actors who have concentrated on traditional sales and service channels.

Joint Corona Fight

Strengthening 2020-2023

The fight against coronavirus may boost interest in the development of health technologies worldwide. In the future, increasing resources and establishing deeper collaboration between different actors can accelerate health innovations in areas such as artificial intelligence, big data and robotics. This will create better conditions for future healthcare.

1. Services & Consumerism (2/3)

Platform Economy

Strengthening 2020-2023

Platform economy especially refers to service innovations built on external online ecosystems and made publicly available to consumers. These platform-based services are easily scalable and therefore endlessly replicable, creating huge growth potential for companies that succeed in their marketing efforts.

Domestic Tourism

Wild card 2020-2023

Tourism and business travel have been suffering from a significant decrease in travellers due to worldwide quarantines and travel restrictions. In the future, this development may be accelerated by the worsening economic situation everywhere, the rising plane ticket prices, the general awareness of the risk of infection associated with travelling, a newly awakened interest in domestic travel and nature as well as the new opportunities provided by remote work and virtual tourism. If the new ways of operating become the norm, it is possible that the previous trend of mass tourism will be replaced with a new trend of domestic and nature travel.

Isolation Economy

Strengthening 2020-2023

In the isolation economy, people travel less, and most things can be handled from home. As face-to-face social interaction and travel decrease due to fear, necessity or personal choice, the need for technology-based communication channels and internet-based services increases. Remote work innovations, streaming services and online marketplaces thrive and make people's lives easier. Some disadvantages of long-standing isolation may be the formation of atomic echo chambers and mounting mistrust towards outsiders.

1. Services & Consumerism (3/3)

Voice & Gesture Control

Strengthening 2023-2028

Voice and gesture control is already here, even if not yet in the mainstream. In the near future, smart devices and intelligent built environments may be operated almost unnoticeably with voice and gestures. Voice or gesture control operated technologies will also help dispel concerns regarding hygiene in public spaces, such as airports or shopping malls.

Zero-Contact Services

Strengthening 2021-2024

Zero Contact services are rapidly becoming more common as a result of the COVID-19 pandemic. Companies are feverishly looking for ways to provide service without customers having to come in contact with employees or equipment. Restaurants, transport services, shops and numerous other actors have had to think of new ways to avoid the risk of infection during a pandemic. It is likely that many of the new practices will persist even after the pandemic has subsided, as contact involves the potential for a wide range of other microbes to spread.

Automated Supermarket

Strengthening 2024-2028

Supermarkets will experience a tremendous increase in the level of automation. First of its kind, Amazon Go works already without any sales personnel using a mobile app, artificial intelligence and sensors. This model could be soon adopted by retail stores, responding to the need for quicker, more convenient and customer-centric experiences.

2. Economy & Trade

Early 2020s

The global economy is expected to grow by about four percent annually for the next couple of years. This growth is sustained mainly by the developing economies with their 5% growth rate. The developed economies, currently growing 2,5% per year, are anticipated to slow down to a circa 1,7%. At the moment, the global economy is facing many threats, most significant of which are the rise of protectionism, trade wars and economic sanctions, pandemics, the crisis in the Middle-East escalating to a great power conflict, and, at least a temporary, end of globalisation and strengthening of deglobalisation.

Late 2020s

Numerous international economic authorities estimate the global economy to continue on a 4% growth path in the medium term also. Nevertheless, the requirement for this development is that protectionism, trade wars, and other risks will fail to materialize. The US presidential elections will continue to have a significant impact on the global economy. It is likely, China will continue its rise toward being the largest economy in the world, and it will take the lead at least in the global control of world's basic raw materials, Africa's economic progress, military development, but also in the advancement of various new technologies, such as green tech, AI and IoT, and their commercialisation.

2030s and beyond

In the long term, the global economy is encountering many notable uncertainties, of which at least some will materialize as large-scale shocks. According to some views, a transitional phase toward a new world order has been ongoing since the end of Obama's second term. The current global order, based on agreements, democracy, and individual freedom, will be succeeded by a still unknown structure. The most reliable signs for the beginning of this transformation have been Brexit, the election of Trump, the rise of populism, protectionism and the far-right, Russia's hybrid war against the West, the rise of China's influence, the policies of Erdogan, Duterte and Orban, and the rise of nationalism, for example, in Brazil, India and France.

2. Economy & Trade (1/3)

Slowbalisation

Strengthening 2020-2023

Slowbalisation is a word to describe the slowing down of globalization – most importantly, the perceived slowdown in the strengthening of the connections between different nation-states and their economies. In 2019, world trade growth fell short of expectations and, according to the WTO's estimates, 2020 can also become challenging. However, despite slowing down, globalization is not about to grind to a halt. Still, the slowdown of globalization may be of permanent nature. This can lead to the emergence of stronger regional economic areas.

Online Stores

Strengthening 2020-2023

On a global level, e-commerce is moving from a state of linear growth to a state of exponential growth. Due to the pandemic, many people have started shopping online for the first time. The food delivery market especially is expected to have a major breakthrough with growth at up to 16% annually, at least until 2025. A large proportion of the new customers may find the services easy and necessary even when the situation changes again, continuing or even increasing their use in the future.

VUCA

Strengthening 2020-2023

VUCA refers to a volatile, uncertain, complex, and ambiguous operational environment, where anticipating coming events is extremely difficult. The ability of individuals and organisations to function in the rapid changes of a VUCA world is the key to success in the future.

2. Economy & Trade (2/3)

Geo-Economic Blocs

Wild card 2020-2023

The world may divide into geo-economic blocs. Economic and technological competition and the need to ensure the resilience of one's own supply chains may drive the great powers to repatriate critical manufacturing functions. This would weaken globalisation and create largely economically self-sufficient zones, such as the EU, North America, and China-led East Asia.

Passenger Economy

Wild card 2040-2050

The "passenger economy," a term coined by the American technology company Intel, refers to the full economic and societal value stemming from fully autonomous, pilotless vehicles. According to their study, the global proliferation of self-driving vehicles will begin by 2040, and the value of products and services created from their use, including the indirect savings in both time and resources, could be worth US$7 trillion by 2050.

Hyperlocalisation

Strengthening 2024-2028

Hyperlocalisation means the desire to produce everything locally and by oneself, be it food, services, consumer goods, news, culture, or energy. More and more people are looking for chances to fulfil their daily needs with locally produced alternatives that serve the values and goals they deem important.

2. Economy & Trade (3/3)

Collapse of World Economy

Wild card 2024-2028

It is possible that the global economy based on virtual money, leverage, various futures contracts, speculative financial instruments, and stocks with freely floating values will collapse one day. If this happened, almost immediate shortages of imports and many basic goods would be experienced all around the world. In that case, many states would not be able to collect enough taxes to continue their operations, which would lead to shutting down most public services.

New Era in Logistics

Strengthening 2029-2039

The manufacturing and delivery of products from the manufacturing site to the consumer is changing perhaps more than ever before in history. Along with the logistics itself, the role of the retail as well as the need for intermediate storage, ports, forklifts, trucks, container ships, container cranes and even the need for containers may substantially decrease from what it is at the present.

From Stores to Showrooms

Strengthening 2024-2028

The Internet and mobile technologies are changing consumer behaviour in physical stores. In the future, brands must invest more and more into a comprehensive and easy customer experience, which will require a more efficient combining of physical and digital service channels. As online shopping becomes the norm, physical stores, perhaps excluding groceries, may even stop selling products entirely and transform into showrooms where customers experience products before purchasing them online.

3. Society & Preparedness

Early 2020s

In the near future, an increasing number of people will become dissatisfied with the present regulations because they feel that the legislation controls their lives excessively and that some of the laws are may even be detrimental, for example, to the formation of the tax base, and to the competitiveness of the country's innovation environment. Also, demands to lighten old administrative practices will probably increase in most states. It is very likely that we will experience several initiatives to root out different forms of discrimination, dishonest pricing, and fraud, as well as efforts to experiment with new kinds of decision-making and income formation models.

Late 2020s

Numerous regulations concerning public administration itself and its practices will most likely change in the medium term. Naturally, the changes will vary from country to country, but it is very probable that the most adjustments will have something to do with leveraging digitalisation, increasing the transparency of decision-making, lightening the regulations, utilizing the AI, big data and IoT, as well as real-time information production and decision-making based on it. The changes will also be strongly related to reducing bureaucracy and administration, cost cuts, degree requirement modifications, favouring a client-centred approach instead of a system-centred one, and also in many countries to corruption and nepotism prevention.

2030s and beyond

In the long run, several societal operations and services will become automated, and entirely or partly monitored and coordinated by the AI. Numerous public spaces will become smart and interactive, which improves both the user experience and the feeling of security. Use of cash will decrease or cease altogether, health monitoring will become continuous, and we will be scored, assessed, and categorised several times a day. At the same time, new technology will offer a vast amount of previously unknown applications to both criminals and terrorists. To respond to these challenges, public administration, political decision-making, and judicial system have to change their procedures to be unprecedentedly anticipatory and flexible.

3. Society & Preparedness (1/3)

Culture of Preparedness

Strengthening 2024-2028

Culture of preparedness refers to a conscious and planned effort by the government to help various local communities to build up their resilience in the face of disasters. The community resilience is based on the utilization of local resources which enable the residents to be prepared to withstand shocks also in situations in which government help is not immediately available. Culture of preparedness includes both the local capacities and networks, as well as a sense of urgency about maintaining them.

COVID-19 Impact on Pollution

Strengthening 2020-2023

The coronavirus pandemic is triggering a considerable decrease in air pollution in major cities as roads and skies are cleared, and industrial activities are suspended. However, the reduction in overall emissions is likely to be temporary. Once this pandemic is over, researchers and policymakers may obtain new knowledge from this sudden change for handling the climate crisis.

Deglobalisation

Wild card 2020-2023

The era of globalisation may be coming to an end, disintegrating the world's complex interdependencies as a consequence. Reasons for deglobalisation include a widespread rise in nationalism, a serious weakening of the liberal hegemony driven above all by the US, as well as the need for different countries to ensure their own security of supply by reshoring critical production.

3. Society & Preparedness (2/3)

Teaching+ Learning 2.0

Strengthening 2020-2023

The rapidly changing and insecure operational environments of the globalizing world pose new kind of challenges for education. Changes in teaching methodology are also strongly linked to technological development, which essentially changes future competence requirements as well as alters learning tools, methods, and environments.

Normalisation of State of Emergency

Strengthening 2020-2023

The states of emergency that come into effect all over the world due to national crises such as epidemics or conflicts, may at least partially and at least in certain places remain in effect permanently. The extended rights of the government, practices of citizen surveillance and limits of gatherings may, therefore, stay in place even if the crisis goes away. This is one of the ways the COVID-19 pandemic will make an impact in many countries.

Coronavirus and Geopolitics

Wild card 2020-2023

The new coronavirus will change the geopolitical balance of the world. China's position as the other leading power in the world is likely to be cemented due to the pandemic, and the role of the United States will be weakened. In Europe, the future of the European Union may be at risk. The world is more and more likely to be divided into blocs.

3. Society & Preparedness (3/3)

City Self-Sufficiency

Wild card 2029-2039

Future cities may develop towards greater self-sufficiency. In that case, most of the food, energy, and clean water production, as well as recycling would take place within the city, utilising various new technologies.

Privacy Invasion 24/7

Wild card 2029-2039

In the future, if both the built environment and devices attached to it are permanently and almost without exception connected to the internet, it may cause a practically complete loss of privacy. In that case, small and unnoticeable sensors, which would follow and record our every move, would be ubiquitous.

4. Health & Wellbeing

Early 2020s

The more affluent part of society is displaying a rising interest in their health and the various means of health and well-being improvement. Their requirements on health get steadily higher, and they are more prepared to use the money for sustaining their fitness. Also, they are proactively adopting a diverse range of devices monitoring their physical functions and shape. Meanwhile, the prospects for the less health-aware part of the population are deteriorating, and it is possible that some of them cannot expect to live as long and healthy life as their parents.

Late 2020s

In the medium term, responsibility for the maintenance and care of one's health will become more critical. The treatment will gradually become customer-centred and reliant on automation. Nursing staff will take the role of a sparring partner, coach, and supporter. At the same time, the augmentation of the capabilities of the human body through technological and electrical attachments starts becoming feasible. This will cause a significant ethical discussion and possibly later a grouping of people into organic-humans, who perceive the body as "sacred," and techno-humans, who treat the body as a user interface.

2030s and beyond

In the long run, tremendous advancements, akin even to the discovery of microbes or the invention of vaccines, are to be anticipated in the field of healthcare. The most prominent ones will be the stopping of aging, genome design, stem cell treatments, human spare parts, universal cancer drug and blanket medicine for viruses. At the same time, there are copious and mounting risks in the healthcare, which may turn the course to an entirely different direction. For example, some of the severest risks are antibiotic resistance, depletion of fresh water, new illnesses related to the emerging technologies, eco-catastrophes, and pandemics.

4. Health & Wellbeing (1/4)

Covid-19

Strengthening 2020-2023

The Covid-19 spreads rapidly from person to person, causing respiratory infections, among other things. The mortality rate among the elderly is high, even several percents. Those infected can spread the virus before any noticeable symptoms appear, which makes limiting the spread of the pandemic challenging. The pandemic has spread to all continents, excluding Antarctica, and the virus may stay with us for years.

Healthcare Collapse

Wild card 2020-2023

Surprising and considerable increase in patients and care needs may in the worst-case lead to the paralysis and even collapse of the healthcare system. Contributing factors to the failure are, for example, the exhaustion of healthcare workers, depletion of supplies, and the logistical problems created by masses of patients. Unexpected epidemics and pandemics pose to healthcare possibly the most significant risk of collapse.

Deadly Pandemics

Wild card 2024-2029

In the era of the climate crisis, urbanisation, and hyper-connected world, a pandemic can cause tremendous damage across the globe. The Covid-19 pandemic has opened up an opportunity to increase preparedness and develop long-term strategies for potential public health crises. Unpreparedness for future epidemics and other emerging health threats, such as bioterrorism, might lead to pandemics with significant magnitude in the not-so-distant future.

4. Health & Wellbeing (2/4)

COVID-19 and Mental Health

Strengthening 2020-2023

Experts have expressed concern about the effects of the coronavirus on people's mental health. Quarantine measures, worrying about the future and economic uncertainty can increase fear, stress and anxiety. In the face of ever-changing circumstances and a prolonged virus epidemic, both medical staff and ordinary citizens need mental coping methods.

Anti-Vaccination

Strengthening 2020-2023

The growing anti-vaccination movement has led to a worldwide drop in vaccination rates and caused previously eradicated diseases to re-emerge. Anti-vaccination rhetoric usually centres around a mistrust in science and governments, and spreads misinformation about the purposes and side-effects of vaccines. Social media has amplified the volume of vaccine misinformation among public, and the Covid-19 pandemic has further heightened the debates on the topic.

Covid-19 Vaccines

Strengthening 2021-2024

Several vaccines have been developed against coronavirus (SARS-CoV-2) in order to help humanity to gain control of the Covid-19 pandemic, but their development and deployment rates vary by country and vaccine. It will probably take years for the entire world population to gain immunity, but effective vaccination programmes will allow even large countries to vaccinate a significant portion of the population in just a few months. In developed countries, the majority of people are expected to receive the vaccine by the end of 2021.

4. Health & Wellbeing (3/4)

Telemedicine and Self Care

Strengthening 2020-2023

Telemedicine encompasses a broad variety of technologies and tactics to deliver virtual medical, health, and education services. Telehealth is not a specific service, but a collection of means to enhance care and education delivery. With a growing need for an advanced and more efficient form of clinical care, online health care is increasingly becoming an integral part of healthcare systems.

Health Monitoring Spaces

Strengthening 2024-2028

Health monitoring spaces mean health-promoting areas that provide equipment for comprehensive self-care and health monitoring. This equipment could be found at home, at work, or in public places.

Phage Therapy

Strengthening 2028-2040

Because antibiotic-resistant bacterial strains are spreading and increasing, new therapies to replace antibiotics are currently very sought after in medicine. One promising method is phage therapy, in which the pathogenic bacterium is destroyed by the virus, or phage, that affects that bacterium. Bacteriophages can also be engineered to be effective against more than one type of bacterium.

4. Health & Wellbeing (4/4)

Partnerships in Healthcare

Strengthening 2024-2028

Public-private partnerships are seen as an effective way to capitalize on the relative strengths of the public and private sectors to address problems that neither could tackle adequately on its own, in particular in respect of quality, access, financial optimization and innovation in the health sector. A significant advantage of public-private partnerships is that governments can notably save money, while patients with less money or healthcare coverage have access to superior care.

Medical Tricorder

Wild card 2045-2055

Tricorder is a portable medical scanner appearing in the sci-fi series Star Trek. It can be used to diagnose patients conveniently without a need for blood tests or X-rays. The device only needs to be brought into the proximity of the patient, and it will carry out the analysis and display the results. A real-life tricorder has been under development for a long time. Only very recently, however, there has been enough progress to suggest the invention has a chance of becoming a reality. A functional tricorder would have a massive impact on the health care industry.

Blanket Medicine for Viruses

Wild card 2029-2039

Several medicines capable of curing and preventing most of the viral diseases are currently under development. If a safe and effective solution is found to defeat even the most common viruses, the consequences for general health and life expectancy could be significant.

5. Working & Living

Early 2020s

A constant change is taking place in working life which manifests, for example, as flexibility and lean-thinking, holacracy, i.e., favouring low hierarchy pop-up teams, crowdsourcing and dividing a task to micro and macro assignments, rising significance of inner motivation and autonomy as the primary models of completing chores, as well as an effort towards continuous evaluation and monitoring. For example, flexible and active cooperation with others, continuous learning, the ability to master the larger picture and foresight skills, as well as team coordination, are all skills which are required more and more often.

Late 2020s

In the medium term, the regulations concerning working life become more flexible in most cases, and old structures and hierarchies are dismantled. In many places, also the achieved benefits, and the subsidies and protection given to particular professions or companies, are likely to be reduced, and the power of markets increased. Unemployment, employment, and retirement will be dealt with in a more flexible manner, which materialises as experiments in basic income and citizen's accounts, as well as re-evaluations of retirement benefits and models, and their funding. At the same time, the AI will become further linked with new services, vehicles, and production processes, thus increasing the capabilities of individual persons and teams and reducing routine tasks and eliminating overlaps.

2030s and beyond

The long-term effects of AI, automatisation, and robotisation on employment are exceedingly hard to estimate. In principle, it is entirely possible that the advancements of AI and the industrial revolution 4.0 liberate humans from routine tasks and the necessity of earning a livelihood. As in the series Star Trek, money is not discussed but the basic needs of everyone are met, and each can choose whether to be a spaceship officer, musician or something else altogether. It is also possible that states collapse as tax revenues decline, and the robot-owning elite takes over. Also, all of the models located somewhere between these two extremes are plausible.

5. Working & Living (1/3)

Remote Work and Education

Strengthening 2020-2023

Both working and studying over the internet are continuously increasing in popularity. Advancing communications technology is in many professions making the physical location of the employee irrelevant. Similarly, many institutions of higher education, and recently even primary schools, are making it possible to take courses and classes online. Over time, remote work, or telework, and distance education will have impacts on, e.g., real estate markets.

Life Indoors

Strengthening 2029-2039

In the process of societies becoming wealthier, more and more people learn to see urban outdoors as overcrowded, filthy, surrounded by unsocial behaviour, and being on the mercy of harsh weather. As people seek a better quality of life, services, leisure, and the entire city life are steadily relocated into well-controlled, airconditioned, and more pleasant interiors.

Escape from Reality

Wild card 2029-2039

It is likely, that virtual and augmented reality as well as social media solutions will consume a growing share of our work and free time as technologies advance and as services and game-like alternative realities take shape. This may cause various health problems and a weakening sense of reality amongst the population.

5. Working & Living (2/3)

Telepresence

Strengthening 2024-2028

Telepresence means creating a feeling of presence through various technologies, even though the person is not physically present. For example, video conferencing is one common form of telepresence. The increasing acceptance of telepresence, e.g., in remote work and distance education, and the development of communication technologies help people to seize opportunities that in the previous times would have necessitated travelling or even relocating to another area.

Universal Basic Income

Strengthening 2029-2039

Universal basic income means that every citizen is regularly given money to ensure his/her livelihood. In recent years, different kinds of basic income models have found their way to political discussion and societal experiments, particularly in Europe. With the COVID-19 pandemic's negative impact on economies, discussions on the topic gained momentum. Spain has introduced a basic income model, which also prompted discussions of a pan-EU minimum income.

Swarm Work

Strengthening 2024-2028

Swarm work means splitting up a task to tiny assignments, either directly or through a platform, for a high number of subcontractors whom the creator of the job may not even know. Micro- and macro-tasking are areas of swarm work and crowdsourcing, which refer to the scope and requirements of the task.

5. Working & Living (3/3)

Smart Homes

Strengthening 2024-2028

Increasingly comprehensive solutions, where smartness is integrated into buildings and furniture, may become an essential part of homes within the coming decade. With automation and optimization enabled by the Internet of Things (IoT), artificial intelligence (AI), and robotics, smart homes will enhance productivity and efficiency of the user’s lifestyle and contribute towards sustainable energy use.

6. Industry & Manufacturing

Early 2020s

Accelerating improvements in various sciences rapidly change manufacturing technologies and practices. For instance, advances in automation, robotics, and big data are powerful transformation drivers. Furthermore, broadening energy and material solutions are pivotal in a world of increasing demands on efficiency. Also, machine learning, the internet of things and real-time monitoring are gradually becoming part of processes in some pioneering sectors of manufacturing industry.

Late 2020s

In the medium term, the key drivers in the manufacturing industry will be machine learning, sensing, monitoring, and processes automatized and optimized by the internet of things. At the same time, control over the entire supply chain will become more critical. Additionally, bio- and nanotechnology, circular economy, and demand for zero-energy and utilization of solutions provided by augmented reality will drive the industry towards new practices. Local manufacturing, rapid recycling and fast transportation of goods from manufacturing plant to the end user will also gradually become visible in industrial operations.

2030s and beyond

In the long run, all of the industrial processes and manufacturing practices will undergo a profound transformation, which may be characterized as an industrial revolution. The basis for this change will emerge from interconnected devices and inter-machine communication, which perhaps is best represented by a smart electrical grid. As a whole, a wide-ranging and systemic shift is taking place, in which physical devices, digital programs, energy, raw materials, and organic systems are being linked to each other, producing a significant increase in both efficiency and productivity. The entire value chain of production, distribution, sales, and purchasing, will be replaced by a new model, in which the role of humans will be thoroughly altered.

6. Industry & Manufacturing (1/2)

Industrial Internet

Strengthening 2020-2023

Industrial Internet, or the Industrial Internet of Things (IIoT), means connecting industrial processes with intelligent devices, analytics, and information systems. The industrial internet comprises practically all the same issues as the Internet of Things, but it is used in reference to all things industry. The applications are focused on greater efficiency and workforce productivity across the value chain manufacturing process.

Cybersecurity

Strengthening 2020-2023

The significance of cybersecurity increases continually at state, company and individual levels. The cybercriminals seek to take advance of both software and human-related vulnerabilities for, e.g., economic gains or stealing information. The annual losses caused by cybercrime are counted in billions.

Dependency on Grids

Wild card 2029-2039

If a large-scale malfunction would shut down electric grids and data networks for a long period of time, the modern society completely dependent on them could descend into chaos or even collapse. Certain radical natural phenomena, military strikes and cyber-attacks could all damage grids or even completely destroy them regionally or even globally. Repairing large-scale damages could turn out to be impossible or at least it would cost hundreds of billions and take years.

6. Industry & Manufacturing (2/2)

Nanotechnologies and Materials

Strengthening 2023-2028

Nanotechnologies and materials provide significant improvements to objects, equipment, and processes that are in everyday use. Advancements on the nano level improve efficiency and accuracy in many fields of industry and science.

National Security of Supply

Strengthening 2020-2023

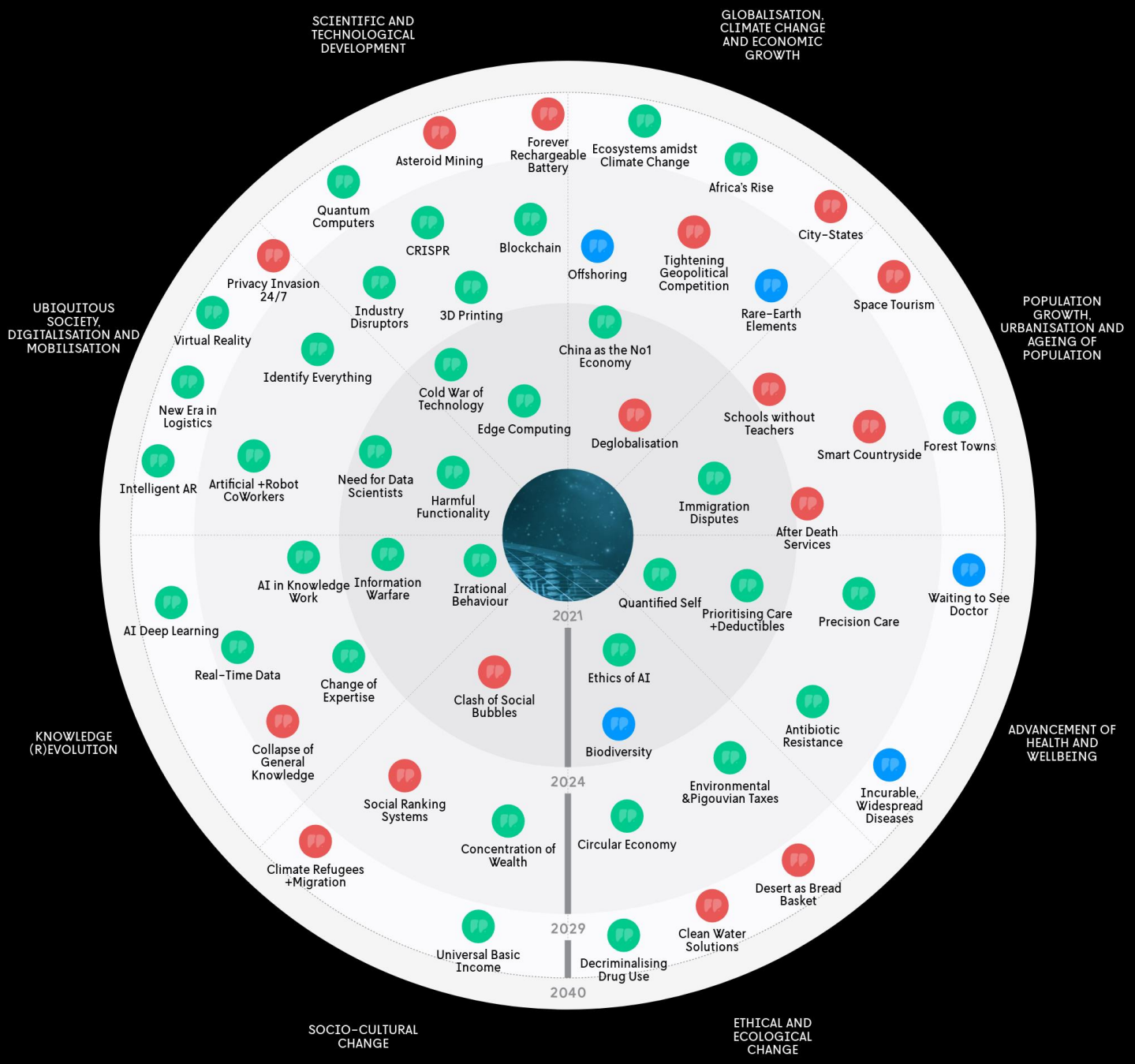
The world is becoming more unpredictable. This unpredictability is increasing the risk that in the future, nation-states will have to endure an increasing amount of different kind of crises. All over the world, this may increase the nation-states' interest to ensure the security of supply on a national level. In practice, this means they will increasingly invest in domestic production, decrease dependency on international supply chains and start maintaining extensive emergency supply storages.

Future disruptors, a horizon scan for STOA

Created from a prefilled radar of Futures Platform

FUTURES PLATFORM

Clone of Future Disruptors – a Horizon Scan



Legend: Phenomena types

Strengthening (Colour: Green)
The presented issue is becoming more common or acute during the given timeframe. Most of its change potential is still ahead.

Weakening (Colour: Blue)
The presented issue is becoming more unusual. During the given timeframe, most of its change potential or value has already occurred.

Weak signal (Colour: Grey)
A small emerging issue in the present. At the given timeframe, it is still hard to say whether it will become a trend.

Wild card (Colour: Red)
A possible but not probable event or change. Early information about a potential emerging risk or opportunity. The probability within the given timeframe is between 5% to 30%.

Time ranges are set indicatively by the Futures Platform futurist team.
The timing indicates the expert-assessed timeframe within which the phenomenonis believed to either accelerate in change speed or start to decline in importance.

Future Disruptors - a Horizon Scan

From eight perspectives

1. Socio-Cultural Change
2. Knowledge (R)evolution
3. Ubiquitous Society, Digitalisation and Mobilisation
4. Scientific and Technological Development
5. Globalisation, Climate Change and Economic Growth
6. Population Growth, Urbanisation and Ageing of Population
7. Advancement of Health and Wellbeing
8. Ethical and Ecological Change

1. Socio-Cultural Change

The socio-cultural change affecting developed countries involves a wide range of issues that are fundamental to our daily lives, values, ways of working, educational needs, commerce, service offering, hobbies and our ways of communicating and being with others. simultaneous socio-cultural changes often also have unpredictable multiplier effects.

BACKGROUND

Communication has changed from communicating information one way to an enriching dialogue that takes place on the social channels of the internet. This has been influenced by blogs, which have accelerated civic journalism, and the rapid development of social media. Technological progress is one of the major drivers of socio-cultural change. Mobile devices and cloud services have made the consumption and sharing of information easy and uninterrupted. Sharing has become part of work and culture, whether it's personal photos and videos or sharing expert articles and speeches.

Different sharing applications and services have had a significant impact on culture, learning and teaching. The participatory and sharing economies have produced a variety of platforms that allow the sharing of goods, commodities and resources. Hyperlocalisation, which emphasizes local products and services, is one of the trends of recent years. More and more people want the food they eat to be grown locally, the products made next door and the energy produced nearby.

Besides Generation Z – people born after 1995 – entering the labour market, one of the most important socio-cultural change phenomena today is especially the transition of the Millennials to leadership positions. The Millennials – also called Generation Y – refer to the generation born in the 1980s and early 1990s. For them, life is not just about making a living; pay, and the value and identity that come from work do not matter as much as for previous generations. They are not led from above but through values, participation and rewards. Equality, the relevance of work, environmental sustainability and diversity are important values for the Millennials. This change will continue to challenge many current management practices, gender power positions, and issues related to the use of working time and leisure, and performance measurement.

IMPACTS

Working life is changing towards more flexible rules where one can partially work or retire and, for example, study while working. The drivers behind this development are the need to get more people in the labour force, to enable them to stay on the job and update their skills, and to motivate people to work on their own terms.

Another visible socio-cultural change relates to the development of individualism. On the one hand, any one of us can stand out and become a personal brand through, for example, social media. On the other hand, the Internet and social media have contributed to the emergence of new communities: people form both physical and especially virtual communities around some common interest.

The influence of the individual has increased. The modification, customisation and personalisation of products and services have been followed by prosumerism. Consumer opinions and experiences are spreading quickly online and forcing companies to respond.

The change in communication has also led to significant information security threats and privacy issues. In recent years, the opposite has also been seen. Sharing has shifted toward micro-communities and decreased in the most public channels.

1. Socio-Cultural Change (1/2)

Clash of Social Bubbles

Wild card 2020-2023

In developed countries, different parts of the population may become so estranged from each other that understanding the everyday realities of people outside your own social bubble becomes difficult or outright impossible. Contradictions between groups with differing values and traditions and between geographical areas could escalate to serious conflicts, and possibly even lead to civil wars where different social groups would demand autonomy.

Social Ranking Systems

Wild card 2023-2028

A social ranking system refers to a register, in which each customer or citizen has their own balance of points, which changes in real time based, for example, on their purchasing behaviour or adherence to laws. As the first country in the world, China is introducing a social ranking system to monitor its citizens. Similar, state-run ranking systems or a voluntary, business owned systems, may also be proposed in other countries including the west.

Concentration of Wealth

Strengthening 2024-2028

Many scientists, politicians and organisations, such as World Economic Forum, have stated their concerns over increasing economic inequality that is due to growing differences in income and highly unbalanced wealth distribution. In January 2019, Oxfam, an NGO concentrating on development aid, reported that 26 billionaires now match the wealth of half the world's population. If this trend continues, in 2030 the wealthiest 1% will control up to two-thirds of all global wealth.

1. Socio-Cultural Change (2/2)

Climate Refugees +Migration

Wild card 2029-2039

Many currently inhabited areas may become unliveable in the future due to climate change. This would lead to massive waves of climate refugees, forcing countries to rethink their immigration and refugee policies. The current estimates of potential climate refugees range from 25 million to 1.5 billion by 2050.

Universal Basic Income

Strengthening 2029-2039

Universal basic income means that every citizen is regularly given money to ensure his/her livelihood. In recent years, different kinds of basic income models have found their way to political discussion and societal experiments, particularly in Europe. With the COVID-19 pandemic's negative impact on economies, discussions on the topic gained momentum. Spain has introduced a basic income model, which also prompted discussions of a pan-EU minimum income.

2. Knowledge (R)evolution

Already some time ago, the economist assessed that in some fields as much as 90 % of usable, unique information had been created in the past two years. even though the renewal rate of relevant information isn't that breathtaking in all sectors, all fields have one thing in common: each year, more new knowledge is created than the year before.

BACKGROUND

The drivers for change in information automation and our relationship with knowledge are twofold. Firstly, the share of people who work to produce scientific knowledge or who are otherwise considered knowledge workers is increasing year by year. Second, electronic information mining and sharing tools advance at a great speed. Scientific information is not the only information group that is growing exponentially. Similar growth can be seen in all kinds of information and data. The digitalised society is continuously generating vast amounts of unstructured mass data (Big Data), which is being exploited in different ways. News items are often global and disseminated as a continuous flow to all over the world simultaneously. In the domains of hobbies or entertainment, the amount of new events is so enormous that it is impossible to stay on top of everything – unless one concentrates on specific genres or subcultures.

The drivers of this change in our relation to information include, alongside the abovementioned explosive increase in the amount of information, smart data mining and learning analytics software, and the new, democratic and crowdsourced means of use applied in social media platforms. Then again, the new mechanisms for producing information are also demanding more from people themselves. False or untrue information is more difficult to identify as information editing techniques and online propaganda strategies become more widespread.

IMPACTS

We are living in a world where information can be stored practically free of charge and without limits. At the same time, it becomes unessential to save or learn pieces of information by heart as the best information is always available. Soon, automated information production, digital registers and services as well as communal knowledge creation strongly challenge all expert occupations. In particular, the whole nature of the education sector, consulting, library services, customer service in basic health care, publishing, and the various support functions of research – such as analysis and information gathering – will change to a significant degree. Deep-learning artificial intelligence is capable of combining knowledge in a way that would not be possible for the human brain. In the future, artificial intelligence will increasingly shape the possibilities for producing information. In the development of artificial intelligence, it is necessary to identify the prevailing biases of human thought so that they are not transferred to the reasoning of artificial intelligence. As information relationships change, peer-to-peer knowledge, beliefs, and emotional stories are increasingly considered as reliable, or even more reliable than expert knowledge, and the perception of truth becomes relative. We are talking about a "post-truth period" in which trust in the truthfulness of expertise and specialist knowledge has deteriorated.

2. Knowledge (R)evolution (1/3)

Irrational Behaviour

Strengthening 2020-2023

Rational thinking and argumentation based on facts and science are losing ground to argumentation that relies on emotions, values and selective use of evidence. This trend has far-reaching impacts on national policies, geopolitics, and the future of democracy. The atmosphere of panic and uncertainty of the COVID-era has accelerated this trend. Conspiracy theories, in particular, have seen a significant rise in interest among the public.

Information Warfare

Strengthening 2020-2023

Contemporary technologies and media enable increasingly efficient manipulation of information to pressure other actors and to affect policies and warfare. Several governmental and private actors are already using these new tools and channels as parts of international power struggles and conflicts.

Change of Expertise

Strengthening 2024-2028

Experts with thorough knowledge in their fields are naturally needed also in the future, but the status of experts and the amount of value placed on an individual expert view is changing. In particular, the value of so-called gurus is decreasing due to increasing opportunities to harness the wisdom of crowds, collect big data and use intelligent applications to gain versatile knowledge.

2. Knowledge (R)evolution (2/3)

AI in Knowledge Work

Strengthening 2024-2028

AI-based systems and robots will drastically change knowledge intensive fields and professions, such as those in finance, medicine, leadership, and law. On the one hand, AI will enhance the work of experts by providing effective assistance. On the other hand, it will also make many current jobs redundant. What additional value AI can bring largely depends on how well the solutions enabled by it are integrated on an operational level.

Collapse of General Knowledge

Wild card 2024-2028

It is possible that the level of general knowledge will decline or even collapse. In the worst case, this will lead to the emergence of social bubbles within which there is hardly any knowledge about the lives of those in other bubbles. This kind of development is driven by, e.g., the algorithms used in social media and search engines which provide filtered content, whose selection is based on user's previous internet behaviour. That kind of content neither challenges nor widens the worldview.

Real-Time Data

Strengthening 2024-2029

In the future, we gain access to continuous real-time data. Numbers in real-time statistics are constantly changing. Sensor data from our environment and different processes combined with big data means that the amount of "live" data increases exponentially. We will surely see a variety of real-time data analysis tools and platforms.

2. Knowledge (R)evolution (3/3)

AI Deep Learning

Strengthening 2029-2039

With Deep learning algorithms, results of using Artificial Intelligence in software will seem genuinely surprising to the human user. What feels striking of AI in an application is either the seeming intelligence in the response, or the achievement by the software that seems to do something that a human individual could not reach.

3. Ubiquitous Society, Digitalisation and Mobilisation

World's wealthiest regions see a continuous rise of ubiquitous social development. Miniature-sized technology is embedded in our built environment, thus turning our environment and spaces increasingly digital, intelligent, and interactive.

BACKGROUND

The word 'ubiquitous' stems from ubique (Latin for 'everywhere'). This development has been given multiple names, such as ubiquitous society, ubiquitous computing, and pervasive computing. The concept is also connected to the Internet of Things (IoT), where smart devices and interfaces communicate with each other and with people. It is estimated that at the beginning of the 2020s, up to 26-100 billion devices will be connected to the internet globally. Increasingly fast information networks, such as the 5G network, allow for even more efficient and smoother networking. The increased intelligence of our environment means, for example, that a smart refrigerator notifies us during our grocery shopping what is missing or handles grocery orders automatically. The ubiquitous society may also manifest itself through smart roads and cars that significantly diminish the role of driving. In social and health care, the impacts of ubiquitousness are significant, e.g. in the form of smart and interactive surroundings or wearable intelligence and communication.

This is also linked with rapid robotisation: industry robotics find new peers in an array of service robots.

Alongside increasing intelligence and interactivity, our built environment becomes more and more mediated: any surface can become a media interface as technology is rapidly developing and prices dropping. The core of this megatrend is in the physical, virtual, social, mobile, and symbolic spaces merging to form a single experience of space for users. As regards the devices we use, we may be on the route towards a hyper-networked world where contemporary technology is replaced with tiny mobile devices that store information in the cloud and use walls of, for instance, public spaces as monitors. Thus, along with the mediated surfaces and the modifiability and adaptability, the increasing mobility is one of the core representations of the ubiquitous society.

Augmented reality technologies such as VR and AR can also bring their own dimension to different user interfaces. Augmented reality enables digital interfaces to be enriched with a variety of sensory experiences and bring to the forefront something that would otherwise be out of reach.

IMPACTS

The wealthiest areas and countries of the world are currently shifting from information societies towards ubiquitous societies. Preparedness for this development is low in the public sector and many organisations. A threat is that stakeholders who are utterly unaware of how to act in this new operational environment are engulfed and utterly exhausted by the changes. Another imminent danger is that we enter the ubiquitous future with only technology in mind and fail to recognise the opportunities ubiquitous computing has to offer regarding new services, creative contents, and human wellbeing. The potential for cyber threats and cyber-attacks is growing significantly in a deeply interconnected society, and it is essential to be prepared for them.

3. Ubiquitous Society, Digitalisation and Mobilisation (1/3)

Harmful Functionality

Strengthening 2020-2023

Data security is of supreme interest in the digital age. More and more digital products and network equipment are being barred from the market on the ground of alleged harmful functionalities. Even a hypothetical threat, proven or otherwise, could lead to the suspension of products. Products by the Chinese telecom equipment maker Huawei, for instance, are being barred from the markets in the US and several other countries for concerns of potential espionage.

Need for Data Scientists

Strengthening 2020-2023

Data and AI technologies are driving the development of our industries, creating a high demand for experts in STEM-related fields (Science, Technology, Engineering, and Math), where wages are rapidly growing in many countries. The skills gap is widening around the world, and it’s predicted that a global shortage of cybersecurity professionals alone may rise to two million very soon.

Identify Everything

Strengthening 2023-2028

Advances in AI will enable applications that can identify almost everything quickly and effortlessly. There are already a variety of smart device-oriented applications that let the user identify, for example, plants and songs, in mere seconds. In the future, the diagnosis of illnesses and identification of tastes, among other things, could be made through an application.

3. Ubiquitous Society, Digitalisation and Mobilisation (2/3)

Artificial +Robot CoWorkers

Strengthening 2024-2028

Estimations of how much of contemporary human work could be fully automated in the next few decades vary from five to 70 per cent. Just as great variation can be found in estimations of how much new work appears as a result. In the most likely future, automation and human labour form increasingly efficient teams and jobs are lost at an increasing pace and new usages for human labour are found.

Privacy Invasion 24/7

Wild card 2029-2039

In the future, if both the built environment and devices attached to it are permanently and almost without exception connected to the internet, it may cause a practically complete loss of privacy. In that case, small and unnoticeable sensors, which would follow and record our every move, would be ubiquitous.

New Era in Logistics

Strengthening 2029-2039

The manufacturing and delivery of products from the manufacturing site to the consumer is changing perhaps more than ever before in history. Along with the logistics itself, the role of the retail as well as the need for intermediate storage, ports, forklifts, trucks, container ships, container cranes and even the need for containers may substantially decrease from what it is at the present.

3. Ubiquitous Society, Digitalisation and Mobilisation (3/3)

Intelligent AR

Strengthening 2029-2039

Intelligent augmented reality (IAR) refers to a combination of augmented reality (AR) and intelligence amplification (IA). In this second generation interactive AR, artificial intelligence reads and interprets actions and needs of the users in real-time, and modifies the space and experiences accordingly.

Virtual Reality

Strengthening 2029-2039

Virtual reality stands for environments produced with computer simulation. They can either be based on the real world or be completely imaginary. Virtual reality can be used for entertainment and education, in the medical field as well as for business purposes. At the moment, most of the VR applications are based on the use of VR glasses.

4. Scientific and Technological Development

Technological and scientific development is accelerating. many new technologies have taken significant steps forward during the last few years, and development does not appear to be slowing down. there have been discussions about the fourth industrial revolution, where technology is the driving force behind radical changes in many areas of society.

BACKGROUND

Technological development has accelerated over the last twenty years. Many radical technologies can bring about major changes in many industries and areas of society in the near future. Artificial intelligence, and in particular machine learning, have taken great leaps forward. Artificial intelligence is already present in many everyday contexts and is believed to be one of the most prominent technologies shaping society in the future.

The development of robotisation and automation has accelerated and replaced many of the routine tasks previously performed by humans. Self-service checkouts and robotic aeroplanes have quickly become commonplace, and many different social robots are already on the market. Self-driving cars may also be a reality in the very near future as computer vision and artificial intelligence develop. 3D printing has provided a new way to optimise and improve industrial production. A world where consumer goods, spare parts, and other necessary items can be printed at home in an instant completely changes the logic of industrial production and logistics. The 5G network is making data processing even faster, further accelerating the development.

Blockchain technology, the foundation cryptocurrencies are based on, has been loaded with high expectations, but also with hype which may not meet those expectations. However, it is possible that technology can have a significant impact on the financial world and e-commerce giants, for example. It could also solve information security challenges and transfer data to be controlled by the network users themselves. Augmented reality technologies such as VR and AR are increasingly being used for entertainment, educational and simulation purposes.

Furthermore, healthcare and medicinal technology are advancing fast. Use of robotics in surgery is continually increasing, people’s health can soon be monitored and problems treated from afar and with the help of preventive medicine. Nanomedicine offers new possibilities (and threats) – not even to mention the opportunities offered by gene therapy. Recent developments suggest that spare parts such as new organs can be grown in the near future.

IMPACTS

The current technological shift has been compared to the early days of the industrial revolution, and this comparison is not without merit. The ongoing change is accelerated by the development of artificial intelligence, machine learning, robotics, automation, bio- and nanotechnology, rapid 3D printing, and mobile technology. Many of the new technologies may be revolutionary in the future, but equally, the promises they make may not materialise, at least not exactly as one would expect. The relationship between man and technology will transform due to touch screens, voice and gesture control, augmented reality, mobility and self-monitoring. Rapid technological development creates confidence in the ability of technology to solve large and complex problems, which can also lead to unnecessary optimism. Then again, in an increasingly technological world, there is also a growing desire to reduce the role of technology in life, at least in social communication. Decision-making that is excessively tied to traditions or the current moment constitutes a severe threat to the development of technology. On the other hand, we view new ways of exploiting technology in product and service development as an opportunity. On the societal level, the forerunner role is up for grabs: who will develop and utilise the newest technology in ways that focus on the environment and human needs and wellbeing?

4. Scientific and Technological Development (1/3)

Edge Computing

Strengthening 2020-2023

Edge computing refers to the processing and storing of data near its point of origin. The data is not transferred to an external data centre but a server located, for example, next to a base station will take care of the handling and warehousing. This reduces latency, improves data security and possibly also lowers costs.

Cold War of Technology

Strengthening 2020-2023

Competition over which one is the dominant superpower is becoming more intense between the US and China. This also impacts the field of technology. The US is trying to prevent technological brain drain to China and make global technological production chains more favorable to itself, for example by returning production back home. At the same time, China is working to become the technological leader over the US. Thus, the cold war of technology is escalating.

3D Printing

Strengthening 2024-2028

3D printing is expected to make prototyping and product customisation cheaper and quicker than any previous technology. Spare parts can be printed for machines, weapons, the human body and the international space station alike. 3D printing combined with AI, new materials and the advancing robotics will significantly change the innovation and manufacturing processes of many industries.

4. Scientific and Technological Development (2/3)

Industry Disruptors

Strengthening 2024-2028

The markets are merging, splitting and uniting again at an unprecedented pace. The main reason for this is that new competitors are entering the markets with procedures and visions quite unlike the traditional ones. For example, streaming services like Netflix have replaced video rental shops almost completely. With rapid technological developments, more and more industries will undergo changes due to disruptive competitors in the future.

Blockchain

Strengthening 2023-2028

Blockchain, the technology behind the cryptocurrency Bitcoin, is a system of recording information in a way that makes changing or hacking the data extremely difficult. It is one form of Distributed Ledger Technology (DLT) where records of transactions are stored in public digital ledgers distributed across the network. Blockchain technology is not confined to the cryptocurrency world, and it can bring about a technological revolution as big as the Internet.

CRISPR

Strengthening 2024-2028

CRISPR is a tool to engineer genetic information that was discovered by studying bacterial activity. The method is advanced and studied all over the world, because it enables the cheap and quick manipulation of human, animal, plant, virus, or bacteria genome.

4. Scientific and Technological Development (3/3)

Quantum Computers

Strengthening 2045-2055

Quantum computers can use simultaneously binary digits in forms of zeros and ones. That allows a real quantum computer to conduct simultaneously tasks and operations that amount to all existing calculation power of today.

Forever Rechargeable Battery

Wild card 2029-2039

In the future, rechargeable batteries may last so long that they will never need to be replaced. A scientist at the University of California managed to develop a battery that lasts for 200,000 recharges instead of the standard 300 to 500. If this invention can be implemented on a wider scale, it will cause a revolution within the battery manufacturing industry as well as in the development of battery technology.

Asteroid Mining

Wild card 2075-2085

Within just a few decades, mining asteroids may become not only technically possible but also economically viable. Multiple companies are working towards expanding the resource base into space and making asteroid mining a regular part of Earth’s economy. Claiming the untapped resources waiting in space may, however, become a frantic and disorganised race not completely unlike the American frontier or Klondike Gold Rush.

5. Globalisation, Climate Change and Economic Growth

Globalisation refers to the multifaceted way the world is becoming more networked and economies, information, cultures and identities are becoming more interconnected. the key drivers of globalisation are the rapid development of technology, transportation, and media, the increase of multilateral financial dependencies, and a huge socio-cultural shift in values.

BACKGROUND

Globalisation is not an entirely new phenomenon. The Age of Discovery and the Silk Road, for instance, both represent what globalisation meant in the past. Counting only by the extent of world trade, globalisation was at its peak in the 1910s, before World War I. However, if we look at globalisation from the socio-cultural perspective, the contemporary world of information networks and social media has taken the interdependencies of the humankind to a whole new level. This on-going development is only gaining strength as time passes.

The socio-cultural value shift enabling globalisation has included the acceptance of internationalisation and tolerance of diversity instead of narrow-mindedness, individualist mindset instead of emphasising traditional values, and economic growth instead of zero-sum economy. Further, it contains the ideas of highlighting the importance of democracy, human rights, and ethics instead of ensuring the privileges of the elites and, instead of considering wars as a natural part of life, it holds a strong anti-war position.

Globalisation is also related to the feeling of the increasingly accelerating pace of work and life in general. This feeling is real in the sense that product and service development cycles have continuously shortened, more and more new information is created every day, and there is increasing pressure for participation and sharing.

In the long term, climate change as a global megatrend will change the natural and human ecosystems in fundamental ways.

IMPACTS

Globalisation constitutes a complicated morass of challenges, including issues such as contradictions between cultural identities and economic dependencies or the free movement of labour and goods – both of which some consider straightforward problems at least from the viewpoint of nation-states. Environmental changes and climate change policies to control it can transform the operational environment of businesses and lifestyles of people radically. Anti-globalisation is a parallel development of globalisation, which has recently appeared increasingly in the form of nationalist and protectionist voices. As these attitudes become stronger, they may threaten or reverse the course of globalisation. Alongside globalisation, there is also the development of localisation, where local communities are seen as more and more important. On the other hand, globalisation also contains many possibilities. Examples include the shortening product and service development cycles, the increased and quickened dissemination of knowledge, or the increased pressure to engage end-users in production and development and sharing and disseminating knowledge more openly. Climate change alters the living conditions of humans and other species in many ways, affecting, for instance, migration and the conditions in which different industries operate. Measures aimed at mitigating climate change are also shaping the boundaries and limits of human activities.

5. Globalisation, Climate Change and Economic Growth (1/3)

Deglobalisation

Wild card 2020-2023

The era of globalisation may be coming to an end, disintegrating the world's complex interdependencies as a consequence. Reasons for deglobalisation include a widespread rise in nationalism, a serious weakening of the liberal hegemony driven above all by the US, as well as the need for different countries to ensure their own security of supply by reshoring critical production.

China as the No1 Economy

Strengthening 2020-2023

China is currently either the world's largest or the second-largest economy, depending on the way of measuring. In the future, it is reasonably likely that China's economy will continue to grow faster than that of the US and other first-world countries, meaning it is in the process of eclipsing the US as the world's number one economy. However, there are several trends and events that could steer China off this path.

Offshoring

Weakening 2024-2028

Industrial automation is likely to slow down offshoring industries from developed to developing countries. Also, it may slow down growth of developing regions, since cheap labour is no longer the main rationale for establishing industry's locations.

5. Globalisation, Climate Change and Economic Growth (2/3)

Rare-Earth Elements

Weakening 2024-2028

Rare-earth elements are used for virtually all modern electronics, from cell phones to wind turbines. The production of rare earth elements is currently primarily concentrated in China.

Tightening Geopolitical Competition

Wild card 2023-2028

The global geopolitical dynamics are changing. The unipolar system led by the USA is crumbling, mainly due to the rise of China. At the same time, Europe is seeking to become more independent of the USA, and Russia is actively pursuing its own interests. The world could face a new era of geopolitical power competition in the near future.

Africa's Rise

Strengthening 2029-2041

Despite its persistent image of being an impoverished continent afflicted by disease and war, Africa is, at least partly, developing into an active economic region. If the positive development continues, in the future, Africa will be a significant market area thanks to its natural resources and growing population. The interest from nations outside the continent may also accelerate economic development in the area. However, there are still several obstacles which can stall the development considerably.

5. Globalisation, Climate Change and Economic Growth (3/3)

Ecosystems amidst Climate Change

Strengthening 2029-2039

According to the majority of experts, climate change is accelerating and will potentially threaten even the existence of humans. In the last 20 years, Earth's average temperature has been at the highest levels since 1880. Also, the record temperatures are from recent years. Climate change affects the living conditions of both animals and plants and changes the ecosystems in significant ways.

City-States

Wild card 2029-2039

As the megacities constitute an ever-growing share of the global economic activity, it is possible that some of them will strive to become independent states. For example, the desire to avoid funding the less developed parts of the country can form the basis for the drive toward independence. National policies perceived as harmful to the city may also act as contributing factors in the background.

6. Population Growth, Urbanisation and Ageing of Population

The growth of the world population is no longer based on higher birth rates but on the fact that younger generations' life expectancy exceeds that of the older ones. in other words, the human race is both becoming more populous and ageing. at the same time, humans are concentrated in densely populated areas due to urbanisation.

BACKGROUND

For now, the continuous increase in the wellbeing of the humankind that has followed industrialisation has meant explosive growth in the world population. After a lengthy period of slow growth, the world population finally leapt over the 1 billion mark in 1820 and reached 7 billion in 2011. The UN estimates that the population growth continues until 2050, with an expected total population of 9.7 billion at that point.

Population growth is no longer based on increasing birth rates. Instead, growth happens because people live longer than before. In fact, in developed countries, birth rates have started to decline, increasing the proportion of the elderly in the population. The demographic change will take place in all states at some point. UN estimates that the share of people over 65 in the whole world population reaches 16% by 2050. At the same time, it is estimated that two-thirds of the world's population lives in urban areas. Reasons for urbanisation include the mechanisation of the countryside, overpopulation of the rural regions in developing countries, and the livelihood opportunities available in cities and towns.

The global life expectancy has rapidly risen. The average life expectancy at birth of the global population is around 73 years already. However, there are contrary opinions. For example, in the United States, estimates have been drawn stating that, due to worsening dietary habits, this century is the first when life expectancy decreases. There may be a rift in life expectancy: the well-educated, healthy, and enlightened live significantly longer, and the uneducated, less health-aware and unprivileged often live shorter lives than their parents.

IMPACTS

Even if only a fraction of the promises related to health care and health technology become a reality, we will live in a world where the majority of people are over a hundred years old. Without a doubt, rapidly ageing populations cause many kinds of social and societal problems. In many countries, extending careers and rising retirement age are necessary and urgent measures to maintain the dependency ratio at a tolerable level.

Demand for employees in care and services for the elderly is increasing in all areas of the society even though tele- and self-care solutions balance this development to some degree, particularly in developed countries. At the same time, the demand for work in maintaining basic infrastructure is bound to increase. Due to economic, demographic and structural reasons, the number of employees in the municipal sector is decreasing in many Western countries. At the same time, the need for work is increasing. Challenges can also be sought in increasing employment-based immigration as well as in strengthening the role of the third sector in the production of public services. Urbanisation accelerates inequality and global environmental problems, but also, for example, creates more opportunities for jobs and education.

6. Population Growth, Urbanisation and Ageing of Population (1/2)

Immigration Disputes

Strengthening 2020-2023

The previous European migrant crisis, the expectations of emerging new population migrations, and an increasing occurrence of acts of terrorism in Western countries have sparked political discussion with some campaigning for more nationalist policies and less immigration. The rise of these far right-wing movements has highlighted the polarisation of opinions among countries and citizens bringing the debate to the forefront.

After Death Services

Wild card 2024-2028

The rising individualism and increasing wealth may soon also be reflected in the number of services, which deal with the wishes people have regarding their death and the time after that. After death services could become so popular, that also the public sector starts to offer them.

Schools without Teachers

Wild card 2024-2028

The programming schools Ecole 42, Hive, and Mitra's online school, are the first examples of new types of schools with virtually no real teachers. It is possible that the model based on utilising the internet and solving real-life problems in informal teams will become so popular that it even ultimately replaces the current teacher-centric model in vocational education.

6. Population Growth, Urbanisation and Ageing of Population (2/2)

Smart Countryside

Wild card 2024-2028

The development of smart technologies and networks will create new opportunities to bring life to rural communities. If the technologies can improve livelihood conditions, access to services and the efficiency of logistics, the countryside may become vitalized in a completely new way instead of continuing to die out. However, this is unlikely to happen without bold strategy as well as long-term investment to support it.

Forest Towns

Strengthening 2029-2040

The idea of forest-like, yet smart, dense, and self-sufficient urban residential areas are gaining momentum. The reason for this development is three-fold: It is better understood that humans thrive best in natural habitats with little or no visible machinery, that the living needs to become more sustainable, and that smart can enhance green. For example, Singapore's government has a bold plan where utilities, parking, and roads are pushed to the underground, and the ground level is designed as a car-free town centre with abundant greenery, public gardens, and community farms.

Space Tourism

Wild card 2029-2039

Space tourism may become very popular in the future. Hundreds of people have already bought tickets for vacations that have not even been scheduled yet. Mass space tourism may yet grow into a significantly large industry.

7. Advancement of Health and Wellbeing

In developed countries, health care, science and technology have progressed alongside economic growth. this has led to continuously better health, hygiene, nutrition, and well-being of people.

BACKGROUND

The most evident direct outcomes of the continuous development of health care, science, and technology are rapid decreases in mortality among infants and the constant increases in life expectancy and standard of living. Other significant areas where the rise of wellbeing can be seen, particularly in the West, include the considerable advancement of safety in general, positive developments in the rule of law, and widening understanding of human rights. It has been estimated that the probability of violent death was a hundred times greater in the Middle Age than today and that the situation may have been even worse in the times of prehistoric tribal wars. At the time, there was also no guarantee of the integrity of property and body. From today's perspective, this can be difficult to comprehend.

The recent rapid development of health technology may offer many unprecedented opportunities for the prevention and treatment of serious diseases. For example, gene therapy makes it possible to replace cells or influence their function in a controlled manner. Nanotechnology can enable effective targeted treatments, and better use of patient data, for example, with the help of artificial intelligence, can lead to even earlier diagnoses and more individualised treatment. The concept of health is becoming more comprehensive, and its focus is on disease prevention. The so-called preventive medicine can lower health care costs when it is possible to intervene earlier or prevent the onset of the disease altogether.

IMPACTS

Due to advancements in medical science, people will live, on average, healthier and longer lives, although the need for health services is growing everywhere as the population ages. However, the developing world will suffer from a scarcity of proteins, which will have an impact on health. In the West, the divide between the health aware and the disinterested will probably widen. The increasing need and cost of health services can also lead to the situation where the wealthy have access to highly personalised and excellent care, while the poor need to settle for clearly worse alternatives. In more prosperous nations, the demand for labour in the health sector is likely to find a steady level in basic health care in the next few years as tele- and self-care as well as crowdsourced health care services advance. This development gives rise to whole new kinds of needs regarding care and treatment; ones that cannot be met with current educational standpoints or combinations of existing professional competences.

7. Advancement of Health and Wellbeing (1/2)

Quantified Self

Strengthening 2020-2023

As a consequence of digitalisation, real-time health data monitoring is increasingly becoming available to consumers. Our bodily and mental functions and states are measured, analysed and stored with the help of sensors, devices and applications. Self-observation and measurement of personal health will become promising tools to enhance both physical and mental wellbeing.

Prioritising Care +Deductibles

Strengthening 2020-2023

As the population ages, countries offering public healthcare have to prioritise and ration publicly funded health care services. Often the alternative for eliminating certain services is to increase the patients' deductible, i.e. the price the patients have to pay for themselves.

Antibiotic Resistance

Strengthening 2024-2028

Antibiotic resistance develops through natural processes, but medicating humans and animals unnecessarily with antibiotics accelerates the growth of antibiotic-resistant bacteria. If effective new antibiotics cannot be developed, diseases that had earlier been almost defeated and modest infectious diseases could become life-threatening. Phage therapies, in which viruses are used to destroy bacteria, may also prove useful.

7. Advancement of Health and Wellbeing (2/2)

Precision Care

Strengthening 2029-2039

Genetics and nanomedicine are fields that have taken gigantic leaps forward in recent years. These developments enable transforming healthcare into anticipatory, individualised, and precise treatments that, in turn, can defeat an increasing number of serious diseases.

Incurable, Widespread Diseases

Weakening 2029-2039

Medical science has advanced enormously in the last hundred years. At an accelerating speed, efficient means are being discovered to prevent and treat many widespread diseases thus far considered incurable. In the coming decade, breakthroughs in nano and biotechnology will bring significant advances to the treatment of common diseases. Discovering new treatments will mean both increasing life expectancy and improved quality of life for the elderly.

Waiting to See Doctor

Weakening 2024-2028

The healthcare sector is currently going through widespread digitalisation and automation in the areas of monitoring and diagnostics. As telehealth technologies and artificial intelligence develop, it is possible that preventive healthcare will improve further and reduce the need for consultation with doctors, speed up visits to the doctor and help anticipate health changes when planning on discharging patients. The increased use of artificial intelligence and health technology may also mean a change in industry policies and labour needs.

8. Ethical and Ecological Change

Ethical and ecological values and ways of thinking are strongly interlinked. Together they form a significant aspect of our lives and there's nothing on the horizon that would seem to lessen the impact of this megatrend. in fact, the situation seems quite the contrary.

BACKGROUND

In the developed world, the 1990s and 2000s can be considered an era of ecological considerations. A key driver of the environmental value change has been scientific research supporting the interpretation of climate change and the human-caused devastation of nature caused.

Studies and media interest have, for their part, affected the search for alternative energy sources, creation of new inventions, and development of hybrid and electric cars. Emissions have become questions addressed by international discussions and agreement negotiations. At the same time, appreciation of nature and naturalness has been on the rise. Increasing concern for the wellbeing of our natural environment is characteristic of the 90s and the 00s. In the 2010s, this concern has only increased as the visible effects of climate change have become a part of everyday life throughout the world.

In the Western world, the 2010s have also been a decade of climate change concerns and ethical concerns. In addition to the carbon footprint, typical themes discussed today include the moral of financial institutions, equality and diversity, animal rights, the size of executives' salary and option programs, and increasing wage differences. For businesses, the increased significance of ethical considerations has meant, among other things, a higher requirement for transparency in production, ethical treatment of employees, and greater interest in impact investing. There has also been an active debate regarding the sustainability and safety of services. Besides companies' community relations, social and societal entrepreneurship that can solve societal and global problems have been discussed actively. Similarly, an ever-increasing share of the population has demanded greater transparency from governmental decision-making processes.

IMPACTS

Due to changes in consumers' values, the goal of practising ethical and responsible business will have an increasing impact on the everyday activities of companies. Consumers are demanding that products and services are green, have a low carbon footprint and follow ethical standards. Ethical values and experience of significance also guide the choice of the workplace more and more. This has led to a notable increase in more ethical and ecological consumption options.

End-users' participation in the design of the products and services at their disposal (prosumerism) will continue to increase. The impact of this trend is accelerated by, for example, crowdsourcing and DIY (Do It Yourself) culture. Small investors are also increasingly interested in responsible investments. Value shifts and changes can also be seen in the increased popularity of services and general attitudes in life (slow food, slow travel, slow fashion, etc.). The ethical-ecological worldview extends to issues such as hyperlocalisation: local food and locally produced services are valued. An ever-growing part of the public finds it essential to know who is behind a given product, what the carbon footprint of it is, where the money goes, and whether the local community is to benefit from a potential purchase.

8. Ethical and Ecological Change (1/3)

Ethics of AI

Strengthening 2020-2023

Advancements in artificial intelligence bring about new kinds of technology-related, ethical questions that receive increasing attention in the future. We can expect that moral debate, legislation and practical guidelines regarding the development and utilisation of AI are becoming increasingly topical issues during the ongoing decade.

Biodiversity

Weakening 2024-2028

On a global level, biodiversity is weakening fast. This is entirely because of human-made reasons like agriculture, pollution and climate change. In the coming decades, the decline may reach a point where it starts threatening certain food industries or even global food security.

Environmental &Pigouvian Taxes

Strengthening 2024-2028

Climate change, limited natural resources and pollution are forcing societies to find ways to steer production and consumption in a sustainable direction. Environmental and Pigouvian taxes, e.g., such as the proposed flight tax, are important tools used by nation-states to discourage actions that damage the environment, or at least accumulate funds to prevent and mitigate those damages.

8. Ethical and Ecological Change (2/3)

Circular Economy

Strengthening 2024-2028

Circular economy is a rising production mode aiming to reduce waste and pollution by following the principles of sustainable development in the design of material flows. The efficient use and recycling of all raw materials benefit both the environment and the economy. A shift to a circular system also benefits human beings directly by allowing us to sustain our lifestyles, creating new job opportunities, and improving our health through reduced air pollution.

Clean Water Solutions

Wild card 2029-2041

Clean water shortage is one of the world's pressing problems and requires urgent solutions as the population grows, and climate change evolves. Various innovative tech and material solutions are continuously being developed to address this problem. If these technologies can make a breakthrough and be implemented at a large scale, clean water might one day become abundantly available.

Desert as Bread Basket

Wild card 2029-2039

Because of climate change and population growth, the future of the world's food production may increasingly depend on harnessing new areas for growing food and on adopting innovative farming technologies. It is possible that thanks to the new farming technologies the deserts may turn into food production areas.

8. Ethical and Ecological Change (3/3)

Decriminalising Drug Use

Strengthening 2029-2039

The fight against drugs has for long concentrated on forbidding and punishment. Now the example of a few nations and expert recommendations show that drug-related problems could be addressed in completely opposite tools in the future. In particular, it seems that criminal sentences for the use of mild drugs may become history almost all around the world.

Green Deal
Part 1 - Climate Change

Horizon scan for the STOA Panel

Created from a prefilled radar

FUTURES PLATFORM

Climate Change
cp

Legend: Phenomena types

Strengthening (Colour: Green)
The presented issue is becoming more common or acute during the given timeframe. Most of its change potential is still ahead.

Weakening (Colour: Blue)
The presented issue is becoming more unusual. During the given timeframe, most of its change potential or value has already occurred.

Weak signal (Colour: Grey)
A small emerging issue in the present. At the given timeframe, it is still hard to say whether it will become a trend.

Wild card (Colour: Red)
A possible but not probable event or change. Early information about a potential emerging risk or opportunity. The probability within the given timeframe is between 5% to 30%.

Time ranges are set indicatively by the Futures Platform futurist team.
The timing indicates the expert-assessed timeframe within which the phenomenonis believed to either accelerate in change speed or start to decline in importance.

Climate Change - List of Areas within the horizon scan

1. Society and Values
2. Nature and Ecosystems
3. Science and Technologies

1. Society and Values

Early 2020s

The recycling of raw materials and waste, adhering to the principles of sustainable development, and various kinds of environmental thinking will continue to increase. Numerous NGOs and political parties will pressure governments to commit themselves and to foster international climate agreements, restrictions on the use of dangerous chemicals, and bans on items such as plastic bags. At the same time, nature and natural resources will be seen as enablers of economic and social growth and development, which will decrease the area of unspoiled nature year by year.

Late 2020s

Governments will boost the demand for cleantech also in the medium term by increasing environmental regulation and financial incentives. New groundbreaking cleantech solutions, such as self-healing buildings, LED lighting in food production and turning landfills into mines for raw materials, will progress rapidly, expanding the markets in the sector. It is expected that cleantech markets will continue their long-term annual growth of more than 10 percent. For example, the German government estimates that the value of cleantech markets will reach €4.4 trillion around 2025. In recent years, the growth in the markets has shifted from Europe towards developing countries.

2030s and beyond

The use of new sustainable technologies will start to bring demonstrably significant resource and cost savings to governments, organisations and individuals. In 2030s, adhering to the principles of sustainable development, recycling raw materials and waste, and utilising innovations such as an intelligent electricity network and turning carbon dioxide back into fuel will begin to be commonplace – these will not be regarded as special environmental efforts but as a reasonable and economically sound way of operation. For example, the utilisation of biology in the growing of packaging material and in the production of low-CO2 protein is becoming commonplace by necessity rather than due to ideological reasons.

1. Society and Values (1/7)

Climate Anxiety

Weak signal 2020-2023

Climate anxiety might become a phenomenon that can, at its worst, lead to an increase in mental health issues. Climate anxiety is currently not recognized as an official medical condition and it is partly seen as an understandable reaction to the threat an endangered ecosystem poses to humans. On an individual level, however, if a person does not find a constructive way to cope with their anxiety, it may start severely impacting their ability to function.

Anti-Environmentalism

Strengthening 2020-2023

Efforts to protect the environment and curb climate change have caused a backlash all over the world. Conservative politicians and industrial businesses are usually behind it, as they tend to consider protective measures to save the environment or climate either overexaggerated or even completely misguided. Additionally, some people feel that the restrictions environmentalists and climate change advocates demand are mostly just ideological and pose unnecessary limits to their personal freedom.

Oil Price War

Strengthening 2020-2023

The latest oil price war broke out when OPEC and its allies failed to agree on reducing oil production due to the coronavirus-induced collapse in oil demand and prices. Russia rejected the deal. Saudi Arabia, which wanted cuts, consequently announced it would increase production and sell oil at lower prices. As a result, the price of crude oil continued to fall. The single-day drop in price was the highest since 1991.

1. Society and Values (2/7)

COVID-19 Impact on Pollution

Strengthening 2020-2023

The coronavirus pandemic is triggering a considerable decrease in air pollution in major cities as roads and skies are cleared, and industrial activities are suspended. However, the reduction in overall emissions is likely to be temporary. Once this pandemic is over, researchers and policymakers may obtain new knowledge from this sudden change for handling the climate crisis.

Slowbalisation

Strengthening 2020-2023

Slowbalisation is a word to describe the slowing down of globalization – most importantly, the perceived slowdown in the strengthening of the connections between different nation-states and their economies. In 2019, world trade growth fell short of expectations and, according to the WTO's estimates, 2020 can also become challenging. However, despite slowing down, globalization is not about to grind to a halt. Still, the slowdown of globalization may be of permanent nature. This can lead to the emergence of stronger regional economic areas.

Leadership Crisis

Strengthening 2023-2028

The global leadership crisis is deepening due to the alarmingly weak correspondence between power and competency to handle the fast-paced challenges organisations are facing. If leaders fail to embrace diversity, remove ego, and strengthen morality, organizations may experience hindered growth and face unforeseen risks. Economy, large-scale health risks, geopolitics, counterterrorism, climate change, and corporate management are examples of areas in danger facing severe leadership problems.

1. Society and Values (3/7)

Animal Rights

Strengthening 2024-2028

More and more people aim to promote and advance animal rights by donating funds to various organisations and projects and by making conscious consumption decisions. This increases pressure on societies and businesses who need to take the ethical demands related to the treatment of animals more thoroughly into consideration.

Resource Wars

Wild card 2024-2028

Several natural resources are non-renewable and available only in limited quantities. For this reason, it is possible that at some point the struggle for their control will intensify significantly. The possibility of armed conflicts cannot be ruled out entirely.

Better World

Strengthening 2024-2028

Instead of focusing solely on growth, profits, and financial success, more and more organizations build their strategies and projects on values that stress the importance of striving towards a better, more sustainable world. Though many organizations have participated in these types of activities for the sake of marketing or to improve their corporate image, there is a new wave of businesses with a genuine desire to seek solutions for the most significant challenges facing humanity and the environment.

1. Society and Values (4/7)

Environmental &Pigouvian Taxes

Strengthening 2024-2028

Climate change, limited natural resources and pollution are forcing societies to find ways to steer production and consumption in a sustainable direction. Environmental and Pigouvian taxes, e.g., such as the proposed flight tax, are important tools used by nation-states to discourage actions that damage the environment, or at least accumulate funds to prevent and mitigate those damages.

Circular Economy

Strengthening 2024-2028

Circular economy is a rising production mode aiming to reduce waste and pollution by following the principles of sustainable development in the design of material flows. The efficient use and recycling of all raw materials benefit both the environment and the economy. A shift to a circular system also benefits human beings directly by allowing us to sustain our lifestyles, creating new job opportunities, and improving our health through reduced air pollution.

Vegetarian Areas

Strengthening 2024-2028

The popularity of vegetarian and vegan food and the stores, restaurants, and events offering them is rising significantly. Although people with vegetarian and vegan diets are still a minority of now, plant-based diets are becoming more common, especially among the younger generations. In the future, we will probably find whole areas that concentrate on vegetarian food.

1. Society and Values (5/7)

Collapse of World Economy

Wild card 2024-2028

It is possible that the global economy based on virtual money, leverage, various futures contracts, speculative financial instruments, and stocks with freely floating values will collapse one day. If this happened, almost immediate shortages of imports and many basic goods would be experienced all around the world. In that case, many states would not be able to collect enough taxes to continue their operations, which would lead to shutting down most public services.

Impact Investments

Strengthening 2024-2028

Impact investment intends to generate positive, measurable social and environmental impacts alongside financial returns. The volume of impact investment is expected to start growing quite rapidly in the coming years. Impact investment is linked to other similar ideas such as conscious capitalism, sustainable investment, and ethical investment.

Eco-socialism

Wild card 2023-2028

Socialism, Marxism and green values that combine eco-socialism and the green left may become the new political mainstream. The supporters of this movement consider the capitalist system to be the main reason behind many of the current social and environmental problems. This ideology was earlier focused on dismantling capitalism and advancing the ecological cause, but is now concerned more with climate change, and, for example, poverty, gender equality and racism.

1. Society and Values (6/7)

Climate Refugees +Migration

Wild card 2029-2039

Many currently inhabited areas may become unliveable in the future due to climate change. This would lead to massive waves of climate refugees, forcing countries to rethink their immigration and refugee policies. The current estimates of potential climate refugees range from 25 million to 1.5 billion by 2050.

Colonising Mars

Wild card 2085-2095

Besides the interests of finding a safe haven in case of a doomsday scenario, the cost of going to space has decreased significantly over the last few years. As necessary technology emerges and financial incentives become clearer, it will be hard to find arguments against the progress that colonising other planets seems to bring. It is possible that we are not too many decades away from finally beginning to make Mars our new home.

World Population Growth

Strengthening 2029-2039

According to the UN calculations, the global population grows by about 83 million annually. Population growth is mainly occurring in developing countries, the fastest growing areas being located in Africa and Asia. The forecast estimates that the population of the world will be 8.6 billion in 2030, and rise to 9.8 billion by 2050.

1. Society and Values (7/7)

Global Citizenship

Strengthening 2029-2039

More and more people consider themselves global citizens and no longer build identity based on their country of birth or residence. These people believe they belong to a global community and feel at home in an international environment.

2. Nature and Ecosystems

Early 2020s

The sphere of untouched nature is diminishing year by year because of human actions, and numerous species and entire ecosystems in many places will have to adapt to smaller habitats, or they will become endangered. Especially the ecosystems of rainforests have suffered from the intensive use of forests. The chemicalisation of the environment has affected the fertility, living conditions, and, possibly, genome of many animal populations. The acutest example of this has been the massive death of bee colonies.

Late 2020s

In the near future, the overfished fish populations are in danger of collapsing, and the ecosystems of coral reefs are at risk of being destroyed. A significant part of all the liquid water of the world is already, at least to some degree, polluted by microplastics. The plastic waste problem of the world's oceans is getting worse, but already there have been some international actions to moderate the issue and to fix it later on. There have also been various actions to prevent the chemicalisation of the environment, but binding international treaties regarding many hazardous chemicals do not exist yet. Neonicotinoids are an example of this: they have been connected to the bees' colony collapse disorder.

2030s and beyond

In the long-term, global climate is changing, and ecosystems will have to adapt to significantly. Several species will not survive the coming developments, at least not without human intervention. As examples of the new means to preserve species are transportations to new habitats, bans on hazardous chemicals, and genome manipulation so that the species will survive in a deteriorating climate. In recent decades, there have been many cases of successful international binding decisions to stop the use of harmful chemicals. The most notable ones are the bans on genome-affecting DDT and ozone-damaging CFC, which have resulted in a gradual recovery of ecosystems.

2. Nature and Ecosystems (1/6)

Pollinators

Weakening 2020-2023

Up to 40 % of all Apidae (apid bees) and butterflies are endangered in certain areas and up to 16.5 % of all vertebrate pollinators face extinction. The wide disappearance of pollinators is a grave challenge to biodiversity, food production, and many other fields using plants that rely on biotic pollination.

Untouched Nature

Weakening 2020-2023

Wilderness areas have become more and more rare on Earth in the last 25 years and this trend continues in the near future. Researchers fear that without drastic preservation policies, most of remaining wilderness will be utilised before the end of the century.

Global Greening

Strengthening 2020-2023

Global green leaf area has grown by approximately 5 percent after the start of the millennium. Earlier on, the biggest drivers for global greening were thought to be climate change and the increase of carbon dioxide in the air, however recent research indicates direct human actions to be the central factor. The largest countries to contribute to global greening are China and India. The two have invested in rejuvenating their forests and improving their agricultural practices, with impressive results.

2. Nature and Ecosystems (2/6)

Biodiversity

Weakening 2024-2028

On a global level, biodiversity is weakening fast. This is entirely because of human-made reasons like agriculture, pollution and climate change. In the coming decades, the decline may reach a point where it starts threatening certain food industries or even global food security.

Wild Animals

Weakening 2024-2028

Both UN and the WWF have released scientific reports warning that human activities are causing a rapid decline in the population of many wild animal species. There is even a growing scientific consensus that the Earth is at the early stages of a 6th mass extinction event. The final outcome and its impact on humans, however, still remain unclear.

Farming without Pesticides

Wild card 2024-2028

Mass death of bees has led to loss of productivity in farmed crops as they do not pollinate the way they used to. Recent studies show that a chemical cocktail from farming including pesticides and insecticides has spread to wild flora as well. It is possible that future farming will have to become pesticide free to continue.

2. Nature and Ecosystems (3/6)

Weakening Gulf Stream

Wild card 2065-2075

Melting polar ice caps may not only lead to significantly higher sea levels but could also disrupt the flow and strength of ocean currents. As a result, the Gulf Stream could weaken or even stop, which would lead to a colder climate in Northern and Western Europe.

Global Water Crisis

Strengthening 2024-2029

Lack of drinking and irrigation water is shutting down many sustainable areas for living and eroding agricultural areas that were only recently productive. Resulting political unrest may confirm the saying: water is the next oil. The crises threatening the global economy are significant– already in 2013, The World Economic Forum considered the water crisis to pose a considerable risk to the modern world.

Seaweed Potential

Strengthening 2024-2028

Seaweed farming can be considered as one of the most natural and economical solution to solve global challenges, such as climate change, nutrition, and malnourishment. Yet, the biggest hope on seaweed cultivation is put on the development of a variety of high-value sustainable products like biofuels, medicines and food supplements. For example, super-foods such as seaweed snacks and other readily available ‘sea vegetables’ are slowly gaining momentum in markets.

2. Nature and Ecosystems (4/6)

Forestation

Strengthening 2024-2028

Sustainable forestry, including planting trees and other measures to increase forest coverage, is becoming more commonplace everywhere in the world. New governments, organizations, companies and individuals constantly join the efforts to fight deforestation. Despite this, there is still a long way to go before the net global forest loss can be stopped.

Aerial Reforestation

Strengthening 2024-2028

Several companies are developing more efficient and environmentally friendly solutions to plant and sustain trees with drones. Since there is an urgent need to restore forests as soon as possible, these intelligent aerial alternatives provide faster and more cost-efficient means to improve precision forestry, mitigate the risks of deforestation, and maximise biodiversity.

Hothouse Earth

Wild card 2085-2095

If the world doesn’t manage to stop climate change, there is a growing chance that in the mid- to long-term future, it will trigger runaway warming far beyond the current climate models. At worst, this could destroy the entire ecosystem and render the Earth partially or completely uninhabitable.

2. Nature and Ecosystems (5/6)

Permafrost

Weakening 2065-2075

Permafrost is ground which stays below the freezing point for two or more years. At least in Siberia, permafrost is currently melting, other permafrost areas are also likely to follow this pattern.

Melting Antarctica

Wild card 2040-2120

A new study states the outcomes of melting Antarctic ice sheets could be much quicker and more drastic than what has been estimated. If global warming cannot be controlled, sea levels could rise over a metre before the current century is over, and several metres by 2300. This could have far-reaching consequences beyond an environmental problem. Economic, social, and political instability would be inevitable across coastal regions that are extremely vulnerable to future sea-level rise.

Solar Satellites

Wild card 2065-2075

It is possible that solar panels installed on satellites will meet most of the future energy needs. In space, the amount of solar radiation to the panels will not be affected by the atmosphere, changes in weather or the time of the day. This would make a space-based power plant very efficient. Currently, utilizing solar panels for energy is not feasible because of the massive amount of investments required as well as issues with the technology for electric power transmission. Different solutions for wireless power transmission, such as microwaves, are currently under active research.

2. Nature and Ecosystems (6/6)

Ecosystems amidst Climate Change

Strengthening 2029-2039

According to the majority of experts, climate change is accelerating and will potentially threaten even the existence of humans. In the last 20 years, Earth's average temperature has been at the highest levels since 1880. Also, the record temperatures are from recent years. Climate change affects the living conditions of both animals and plants and changes the ecosystems in significant ways.

3. Science and Technologies

Early 2020s

Science, by nature, is self-correcting which means that discoveries change and supplement previous interpretations continuously. Science is also cumulative, indicating that all previously confirmed findings give a basis for new ones. A novel technology, like AI, or a remarkable scientific breakthrough on some field, may provide an explanation, or even a shortcut to a whole new level, for some other area of study. Additionally, the processing power of computers and the number of researchers is currently unmatched in human history. For these reasons, science will keep up its accelerating rate in the future also.

Late 2020s

In the short and medium term, there will be an enormous demand for new highly skilled specialists, particularly data scientists, coders, cybersecurity professionals, and AI researchers and developers. In the medium term, demand for know-how and expertise on so-called STEM-fields (Science, Technology, Engineering, and Mathematics) will likely grow considerably. A central reason for this is that virtually all fields of production will become smarter, more networked and complicated, which means that productivity cannot rise further without the latest knowledge of STEM-fields.

2030s and beyond

In the longer term, several large-scale scientific breakthroughs are to be anticipated, which will revolutionize their respective disciplines. Examples of this include, among others, industrial revolution 4.0, quantum technology, the next generation of AI, gene, and biomedicine 2.0, nanotechnology, renewable energy and circular economy revolution, graphene revolution, DNA-data storing, space economy, and electrification and automatisation of transportation, as well as using hydrogen as a fuel in vehicles. Also, in the conventional hard sciences, e.g., physics, radical findings are likely to take place, which, once realized, have the potential to transform the world and human possibilities in a fundamental way. Such revolutionary developments could be, for instance, the discovery of dark energy and matter, detection of the fourth dimension, multiverse, or fifth fundamental interaction of nature, quantum teleportation of physical objects becoming feasible, artificial wormhole, warp drive, or antigravitation.

3. Science and Technologies (1/6)

AI That Writes Itself

Weak signal 2020-2023

Microsoft and the University of Cambridge have published an Artificial Intelligence software called DeepCoder that writes code by copying existing segments that it can find. DeepCoder is a radical innovation, a software robot creating software. This fast copy (and paste) cat can replace human coding labour and act as a model for other types of software.

Protein Air

Weak signal 2020-2023

Scientist from the joint project of the Lappeenranta University of Technology and the VTT Technical Research Centre have been able to make a batch of single cell protein out of air and electricity. Their ground-breaking method is based on growing microbes by using renewable energy and carbon dioxide extracted from air. As unbelievable as it may sound, this kind of method could help us harvest food and animal feed from air anywhere without restrictions related to traditional agriculture and the environment.

Formic Acid Fuel

Weak signal 2020-2023

Researchers at Rice University have discovered a new method for transforming carbon dioxide into liquid formic acid fuel. A conventional purification process uses salts to generate formic acid, which has a drawback of cost and energy inefficiency due to the need of the desalting process. Consequently, the team utilized solid electrolytes, which eliminates the use of salts. In tests, the process has been shown to reach about 42% energy conversion efficiency. It is expected to reduce greenhouse gas in an effective and environmentally friendly way when combined with renewable electricity. Furthermore, the fuel could one day be used by hydrogen fuel-cell cars.

3. Science and Technologies (2/6)

Biochar

Strengthening 2024-2028

Biochar is charcoal produced from biomass by pyrolysis. Biochar can be used as a soil amendment and fuel. Its potential uses for combatting climate change are currently also researched. Biochar is a stable and efficient way of storing carbon on the ground. There is not, however, a scientific consensus on the benefits of biochar when it comes to combatting climate change.

GM Food

Strengthening 2023-2028

The genetic manipulation (GM) of food crops has raised a lot of concern and doubts among the consumers. However, many of the scientists who have researched the issue, agree that the GM foods, which have passed the safety assessments and are sold on the global market, cannot be shown to be harmful to humans. Use of GMOs (genetically modified organisms) can bring multiple benefits to agricultural practices and may play a vital role in addressing climate change and the growing global food crisis.

CRISPR

Strengthening 2024-2028

CRISPR is a tool to engineer genetic information that was discovered by studying bacterial activity. The method is advanced and studied all over the world, because it enables the cheap and quick manipulation of human, animal, plant, virus, or bacteria genome.

3. Science and Technologies (3/6)

Solar Power

Strengthening 2024-2028

Solar power is rapidly gaining popularity. The decrease in production costs has made it one of the most important forms of renewable energy. According to some estimates, solar power may become the largest single source of electricity by 2050.

Small Nuclear Power Plants

Strengthening 2024-2028

Within just a few years, new kinds of small, safe and relatively inexpensive nuclear reactors will arrive to the market. The plants are made ready at a factory and transported as one piece on a lorry. They are expected to offer a fast solution for reducing emissions in several countries. The power of one small reactor varies from a few dozens of megawatts to 300 megawatts, which is enough to meet the energy needs of a medium-sized city.

Cleantech

Strengthening 2024-2028

There is a growing demand to reduce waste, pollution, and energy consumption while still increasing operational performance and productivity. Green and clean technologies, also known as cleantech, are constantly developed to answer this challenge and to support the creation of efficient and environment-friendly products, services, and processes.

3. Science and Technologies (4/6)

Cyborg Plants

Strengthening 2029-2039

Scientists are not only trying to enhance human abilities with new technologies, but also to create plants with superpowers. Cyborg plants have already a capability to monitor their environment, communicate with us, and function as a rechargeable energy storage. The field of engineered plants is developing rapidly, and it's expected to bring new solutions for multiple sectors, such as electronics, defence, and farming.

Out of Batteries

Wild card 2029-2039

Demand for electricity off the grid and during peak hours is going up. While batteries have a huge market potential, they bear the risk of becoming a major disruptor in case some of their raw materials like lithium becomes too rare and expensive. Without a massive growth of energy storage, a new energy crisis could become a possibility.

Algorithmic Biology

Strengthening 2023-2028

When biology is studied using algorithms, a whole new kind of understanding regarding the functioning of natural systems and species can be reached. Powerful computers, artificial intelligence, and big data continuously create new possibilities for biological research. This could enable breakthrough discoveries and answer various types of biological questions in a way that human brains by themselves cannot achieve.

3. Science and Technologies (5/6)

Hydrogen Economy

Strengthening 2024-2028

The pollution-free hydrogen may become the most important fuel as well as the main form of storing energy in the future. Hydrogen economy means a situation where hydrogen has replaced liquid fuels for vehicles as well as heating systems and replaced batteries as the primary form of energy storage. The biggest challenges of the hydrogen economy are related to economic and technological questions.

CO2 Capture and Repurposing

Strengthening 2024-2028

Innovations related to capturing, storing and repurposing carbon are one way of reducing CO2 emissions. New technological and biological solutions for carbon capture from industrial processes and the air are continually being explored. The key challenge of this development is to make innovations cost-effective and globally scalable as quickly as possible.

Biofuels

Strengthening 2024-2028

Biofuels are fuels made out of biomass. Trees, plants and different types of waste are some examples of suitable raw materials to make biofuel. The raw material can be used either directly by burning or it can be further processed into other materials, such as motor fuels.

3. Science and Technologies (6/6)

Artificial Photosynthesis

Strengthening 2029-2039

Artificial photosynthesis is one of the most promising ways to produce biofuels in the future. This technology that mimics one of nature's most powerful phenomena solves two issues at once: it inexhaustibly creates pure energy while capturing carbon dioxide from the atmosphere.

Solar Radiation Management

Wild card 2045-2055

Solar radiation management (SRM) refers to solutions to reduce the impact of climate change by reflecting a part of inbound sunlight back out into space. SRM techniques are only just being developed, but at best they could potentially greatly help to combat climate change, at least in the short term. In the long term, however, using SRM techniques could have unpredictable and even irreversible consequences for the Earth.

New Era in Logistics

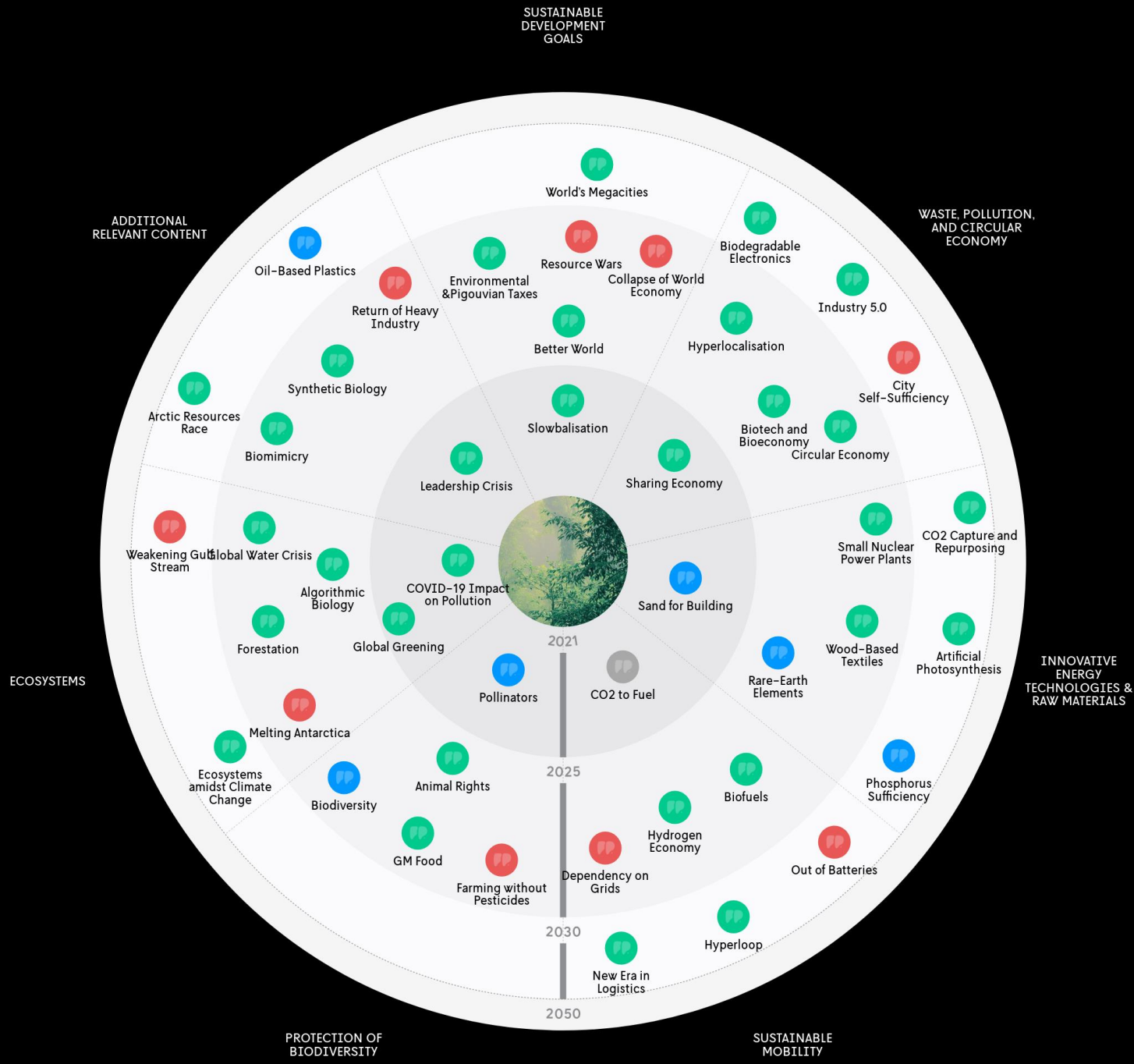
Strengthening 2029-2039

The manufacturing and delivery of products from the manufacturing site to the consumer is changing perhaps more than ever before in history. Along with the logistics itself, the role of the retail as well as the need for intermediate storage, ports, forklifts, trucks, container ships, container cranes and even the need for containers may substantially decrease from what it is at the present.

Green Deal
Part 2 – Environment
A horizon scan for STOA

FUTURES PLATFORM

Green deal-environment-incl. circular economy (for final report - cp/lvw)



Legend: Phenomena types

Strengthening (Colour: Green)
The presented issue is becoming more common or acute during the given timeframe. Most of its change potential is still ahead.

Weakening (Colour: Blue)
The presented issue is becoming more unusual. During the given timeframe, most of its change potential or value has already occurred.

Weak signal (Colour: Grey)
A small emerging issue in the present. At the given timeframe, it is still hard to say whether it will become a trend.

Wild card (Colour: Red)
A possible but not probable event or change. Early information about a potential emerging risk or opportunity. The probability within the given timeframe is between 5% to 30%.

Time ranges are set indicatively by the Futures Platform futurist team.
The timing indicates the expert-assessed timeframe within which the phenomenonis believed to either accelerate in change speed or start to decline in importance.

Green deal, part 2: Environment, incl. circular economy

1. Protection of Biodiversity
2. Ecosystems
3. Sustainable Development Goals
4. Waste, pollution, and circular economy
5. Innovative energy technologies & raw materials
6. Sustainable Mobility
7. Additional Relevant Content

1. Protection of Biodiversity

Inner circle

The sphere of untouched nature is diminishing year by year because of human actions, and numerous species and entire ecosystems in many places will have to adapt to smaller habitats, or they will become endangered. Especially the ecosystems of rainforests have suffered from the intensive use of forests. The chemicalisation of the environment has affected the fertility, living conditions, and, possibly, genome of many animal populations. The acutest example of this has been the massive death of bee colonies.

Middle circle

In the near future, the overfished fish populations are in danger of collapsing, and the ecosystems of coral reefs are at risk of being destroyed. A significant part of all the liquid water of the world is already, at least to some degree, polluted by microplastics. The plastic waste problem of the world's oceans is getting worse, but already there have been some international actions to moderate the issue and to fix it later on. There have also been various actions to prevent the chemicalisation of the environment, but binding international treaties regarding many hazardous chemicals do not exist yet. Neonicotinoids are an example of this: they have been connected to the bees' colony collapse disorder.

Outer circle

In the long-term, global climate is changing, and ecosystems will have to adapt to significantly. Several species will not survive the coming developments, at least not without human intervention. As examples of the new means to preserve species are transportations to new habitats, bans on hazardous chemicals, and genome manipulation so that the species will survive in a deteriorating climate. In recent decades, there have been many cases of successful international binding decisions to stop the use of harmful chemicals. The most notable ones are the bans on genome-affecting DDT and ozone-damaging CFC, which have resulted in a gradual recovery of ecosystems.

1. Protection of Biodiversity - related phenomena

- Wild Animal Species
- Seaweed Potential
- Biodiversity
- Global Greening
- Coronal Mass Ejection of the Sun
- Permafrost
- Forestation
- Animal Rights
- Weakening Gulf Stream
- Melting Antarctica & Rising Sea Levels
- Ecosystems amidst Climate Change
- Destruction of Biosphere Reserves
- Supervolcano Eruption Leads to Nuclear Winter
- Pollinators
- Untouched Nature

1. Protection of Biodiversity (1/1)

Pollinators

Weakening 2020-2023

Up to 40 % of all Apidae (apid bees) and butterflies are endangered in certain areas and up to 16.5 % of all vertebrate pollinators face extinction. The wide disappearance of pollinators is a grave challenge to biodiversity, food production, and many other fields using plants that rely on biotic pollination.

Animal Rights

Strengthening 2024-2028

More and more people aim to promote and advance animal rights by donating funds to various organisations and projects and by making conscious consumption decisions. This increases pressure on societies and businesses who need to take the ethical demands related to the treatment of animals more thoroughly into consideration.

Farming without Pesticides

Wild card 2024-2028

Mass death of bees has led to loss of productivity in farmed crops as they do not pollinate the way they used to. Recent studies show that a chemical cocktail from farming including pesticides and insecticides has spread to wild flora as well. It is possible that future farming will have to become pesticide free to continue.

1. Protection of Biodiversity (2/2)

GM Food

Strengthening 2023-2028

The genetic manipulation (GM) of food crops has raised a lot of concern and doubts among the consumers. However, many of the scientists who have researched the issue, agree that the GM foods, which have passed the safety assessments and are sold on the global market, cannot be shown to be harmful to humans. Use of GMOs (genetically modified organisms) can bring multiple benefits to agricultural practices and may play a vital role in addressing climate change and the growing global food crisis.

Biodiversity

Weakening 2024-2028

On a global level, biodiversity is weakening fast. This is entirely because of human-made reasons like agriculture, pollution and climate change. In the coming decades, the decline may reach a point where it starts threatening certain food industries or even global food security.

2. Ecosystems

Inner circle

All indicators show that the global warming is accelerating. Between 1906 and 2005, the average temperature of both land and sea rose by 0,74°C altogether. Within this timespan, the increase in temperature has virtually doubled since the 1950s. After 1979, if only the temperature of the lower atmosphere is considered, there has been an increase of 0,12°C during each decade of the period of examination.

Middle Circle

In the near future, the increase in earth's temperature will accelerate still. In the Paris climate treaty, it was agreed to limit the temperature rise under 2 °C regarding pre-industrial levels and to take action which would restrict the increase under 1,5 °C. In addition to the emission reduction aims, there is a long-term objective in the Paris agreement to balance human-caused greenhouse emissions with the carbon sinks by the latter part of the current century and to direct funding toward low-carbon and climate-sustainable development.

Outer Circle

By 2030s, climate as a whole has not changed dramatically, but in particular areas, such as the Mediterranean and the Caribbean, the impact of the increase in extreme weather phenomena will have become apparent. In the long term, the entire global climate will change with all its by-products and multiplicative effects. In the model of 22nd century commissioned by Intergovernmental Panel on Climate Change (IPCC), the most optimistic estimate predicts "only" a 0,3 – 1,7 °C (0,5 –3,1 °F) increase in temperature. In the worst-case scenario, the temperature increase will be up to 2,6 – 4-8 °C (4.7 – 8.6 °F), which, among other things, would jeopardize the world's food production.

2. Ecosystems - related phenomena

- Super Hurricanes
- Climate Anxiety
- Climate Refugees and Migration
- Zero-Emission Countries
- Uninhabitable Hothouse Earth
- Biodiversity
- Global Greening
- Environmental and Pigouvian Taxes
- Permafrost
- Forestation
- CO2 Capture and Repurposing
- Weakening Gulf Stream
- Melting Antarctica & Rising Sea Levels
- Ecosystems amidst Climate Change

2. Ecosystems (1/3)

COVID-19 Impact on Pollution

Strengthening 2020-2023

The coronavirus pandemic is triggering a considerable decrease in air pollution in major cities as roads and skies are cleared, and industrial activities are suspended. However, the reduction in overall emissions is likely to be temporary. Once this pandemic is over, researchers and policymakers may obtain new knowledge from this sudden change for handling the climate crisis.

Global Greening

Strengthening 2020-2023

Global green leaf area has grown by approximately 5 percent after the start of the millennium. Earlier on, the biggest drivers for global greening were thought to be climate change and the increase of carbon dioxide in the air, however recent research indicates direct human actions to be the central factor. The largest countries to contribute to global greening are China and India. The two have invested in rejuvenating their forests and improving their agricultural practices, with impressive results.

Algorithmic Biology

Strengthening 2023-2028

When biology is studied using algorithms, a whole new kind of understanding regarding the functioning of natural systems and species can be reached. Powerful computers, artificial intelligence, and big data continuously create new possibilities for biological research. This could enable breakthrough discoveries and answer various types of biological questions in a way that human brains by themselves cannot achieve.

2. Ecosystems (2/3)

Melting Antarctica

Wild card 2040-2120

A new study states the outcomes of melting Antarctic ice sheets could be much quicker and more drastic than what has been estimated. If global warming cannot be controlled, sea levels could rise over a metre before the current century is over, and several metres by 2300. This could have far-reaching consequences beyond an environmental problem. Economic, social, and political instability would be inevitable across coastal regions that are extremely vulnerable to future sea-level rise.

Forestation

Strengthening 2024-2028

Sustainable forestry, including planting trees and other measures to increase forest coverage, is becoming more commonplace everywhere in the world. New governments, organizations, companies and individuals constantly join the efforts to fight deforestation. Despite this, there is still a long way to go before the net global forest loss can be stopped.

Global Water Crisis

Strengthening 2024-2029

Lack of drinking and irrigation water is shutting down many sustainable areas for living and eroding agricultural areas that were only recently productive. Resulting political unrest may confirm the saying: water is the next oil. The crises threatening the global economy are significant– already in 2013, The World Economic Forum considered the water crisis to pose a considerable risk to the modern world.

2. Ecosystems (3/3)

Ecosystems amidst Climate Change

Strengthening 2029-2039

According to the majority of experts, climate change is accelerating and will potentially threaten even the existence of humans. In the last 20 years, Earth's average temperature has been at the highest levels since 1880. Also, the record temperatures are from recent years. Climate change affects the living conditions of both animals and plants and changes the ecosystems in significant ways.

Weakening Gulf Stream

Wild card 2065-2075

Melting polar ice caps may not only lead to significantly higher sea levels but could also disrupt the flow and strength of ocean currents. As a result, the Gulf Stream could weaken or even stop, which would lead to a colder climate in Northern and Western Europe.

3. Sustainable Development Goals

Inner circle

The global economy is expected to grow by about four percent annually for the next couple of years. This growth is sustained mainly by the developing economies with their 5% growth rate. The developed economies, currently growing 2,5% per year, are anticipated to slow down to a circa 1,7%. At the moment, the global economy is facing many threats, most significant of which are the rise of protectionism, trade wars and economic sanctions, pandemics, the crisis in the Middle-East escalating to a great power conflict, and, at least a temporary, end of globalisation and strengthening of deglobalisation.

Middle circle

Numerous international economic authorities estimate the global economy to continue on a 4% growth path in the medium term also. Nevertheless, the requirement for this development is that protectionism, trade wars, and other risks will fail to materialize. The US presidential elections will continue to have a significant impact on the global economy. It is likely, China will continue its rise toward being the largest economy in the world, and it will take the lead at least in the global control of world's basic raw materials, Africa's economic progress, military development, but also in the advancement of various new technologies, such as green tech, AI and IoT, and their commercialisation.

Outer circle

In the long term, the global economy is encountering many notable uncertainties, of which at least some will materialize as large-scale shocks. According to some views, a transitional phase toward a new world order has been ongoing since the end of Obama's second term. The current global order, based on agreements, democracy, and individual freedom, will be succeeded by a still unknown structure. The most reliable signs for the beginning of this transformation have been Brexit, the election of Trump, the rise of populism, protectionism and the far-right, Russia's hybrid war against the West, the rise of China's influence, the policies of Erdogan, Duterte and Orban, and the rise of nationalism, for example, in Brazil, India and France.

3. Sustainable Development Goals - related phenomena

- Rise of Global Oligarchs
- China as the World’s No1 Economy
- Dependency on Electric Grids and Data Networks
- BRICS Countries
- Africa Continental Free Trade Area
- China’s Foreign Acquisitions
- Collapse of Russia
- Industry Disruptors
- Africa’s Rise
- Collapse of Eurozone
- New Era in Logistics
- Business Ecosystem Customership
- Deglobalisation
- Collapse of World Economy
- Collapse of China

3. Sustainable Development Goals (1/2)

Slowbalisation

Strengthening 2020-2023

Slowbalisation is a word to describe the slowing down of globalization – most importantly, the perceived slowdown in the strengthening of the connections between different nation-states and their economies. In 2019, world trade growth fell short of expectations and, according to the WTO's estimates, 2020 can also become challenging. However, despite slowing down, globalization is not about to grind to a halt. Still, the slowdown of globalization may be of permanent nature. This can lead to the emergence of stronger regional economic areas.

Better World

Strengthening 2024-2028

Instead of focusing solely on growth, profits, and financial success, more and more organizations build their strategies and projects on values that stress the importance of striving towards a better, more sustainable world. Though many organizations have participated in these types of activities for the sake of marketing or to improve their corporate image, there is a new wave of businesses with a genuine desire to seek solutions for the most significant challenges facing humanity and the environment.

Environmental &Pigouvian Taxes

Strengthening 2024-2028

Climate change, limited natural resources and pollution are forcing societies to find ways to steer production and consumption in a sustainable direction. Environmental and Pigouvian taxes, e.g., such as the proposed flight tax, are important tools used by nation-states to discourage actions that damage the environment, or at least accumulate funds to prevent and mitigate those damages.

3. Sustainable Development Goals (2/2)

Collapse of World Economy

Wild card 2024-2028

It is possible that the global economy based on virtual money, leverage, various futures contracts, speculative financial instruments, and stocks with freely floating values will collapse one day. If this happened, almost immediate shortages of imports and many basic goods would be experienced all around the world. In that case, many states would not be able to collect enough taxes to continue their operations, which would lead to shutting down most public services.

Resource Wars

Wild card 2024-2028

Several natural resources are non-renewable and available only in limited quantities. For this reason, it is possible that at some point the struggle for their control will intensify significantly. The possibility of armed conflicts cannot be ruled out entirely.

World’s Megacities

Strengthening 2028-2040

The term "megacity" refers to a metropolitan area with over 10 million inhabitants. Currently, there are 34 megacities in the world, Tokyo being the largest. In the coming decades, urbanisation will have the most substantial impact on Asia and Africa, both of which still have large rural populations.

4. Waste, pollution, and circular economy

Inner circle

The recycling of raw materials and waste, adhering to the principles of sustainable development, and various kinds of environmental thinking will continue to increase. Numerous NGOs and political parties will pressure governments to commit themselves and to foster international climate agreements, restrictions on the use of dangerous chemicals, and bans on items such as plastic bags. At the same time, nature and natural resources will be seen as enablers of economic and social growth and development, which will decrease the area of unspoiled nature year by year.

Middle circle

Governments will boost the demand for cleantech also in the medium term by increasing environmental regulation and financial incentives. New groundbreaking cleantech solutions, such as self-healing buildings, LED lighting in food production and turning landfills into mines for raw materials, will progress rapidly, expanding the markets in the sector. It is expected that cleantech markets will continue their long-term annual growth of more than 10 percent. For example, the German government estimates that the value of cleantech markets will reach €4.4 trillion around 2025. In recent years, the growth in the markets has shifted from Europe towards developing countries.

Outer circle

The use of new sustainable technologies will start to bring demonstrably significant resource and cost savings to governments, organisations and individuals. In 2030s, adhering to the principles of sustainable development, recycling raw materials and waste, and utilising innovations such as an intelligent electricity network and turning carbon dioxide back into fuel will begin to be commonplace – these will not be regarded as special environmental efforts but as a reasonable and economically sound way of operation. For example, the utilisation of biology in the growing of packaging material and in the production of low-CO2 protein is becoming commonplace by necessity rather than due to ideological reasons.

4. Waste, pollution, and circular economy - related phenomena

- Circular Economy
- Climate Anxiety
- Zero-Emission Countries
- Concrete Out of Waste
- Environmental and Pigouvian Taxes
- City Self-Sufficiency
- Phosphorus Sufficiency
- Cleantech
- Protein Out of Air & Electricity
- Farming without Pesticides
- CO2 Capture and Repurposing
- Recycling Robots
- Dumps to Mines
- CO2 to Fuel through Solar Power
- Rapid Recycling

4. Waste, pollution, and circular economy (1/3)

Sharing Economy

Strengthening 2020-2023

Sharing economy stands for a system of sharing, renting, or borrowing goods instead of owning them. Digital platforms are essential to the sharing economy, as they enable the owners and potential users of goods to connect with each other. At its best, the sharing economy can lead to full utilisation of resources that are currently underutilised.

Biotech and Bioeconomy

Strengthening 2024-2028

Biotech refers to technology, research, and processes aimed at growing and refining organic or living material to be utilized as resources, energy, or products. Advancements in biotechnology will accelerate the shift from fossil fuels towards a bioeconomy built on renewables.

Hyperlocalisation

Strengthening 2024-2028

Hyperlocalisation means the desire to produce everything locally and by oneself, be it food, services, consumer goods, news, culture, or energy. More and more people are looking for chances to fulfil their daily needs with locally produced alternatives that serve the values and goals they deem important.

4. Waste, pollution, and circular economy (2/3)

Circular Economy

Strengthening 2024-2028

Circular economy is a rising production mode aiming to reduce waste and pollution by following the principles of sustainable development in the design of material flows. The efficient use and recycling of all raw materials benefit both the environment and the economy. A shift to a circular system also benefits human beings directly by allowing us to sustain our lifestyles, creating new job opportunities, and improving our health through reduced air pollution.

Biodegradable Electronics

Strengthening 2028-2040

The growing amount of electronic waste, as well as the massive number of devices themselves, are major environmental problems which are being addressed by developing biodegradable electronics. The increasing integration of technology into the human body is also driving up the demand for organic, toxin-free and safe devices, as various kinds of body-implanted gadgets, e.g., for health monitoring, are being developed.

City Self-Sufficiency

Wild card 2029-2039

Future cities may develop towards greater self-sufficiency. In that case, most of the food, energy, and clean water production, as well as recycling would take place within the city, utilising various new technologies.

4. Waste, pollution, and circular economy (3/3)

Industry 5.0

Strengthening 2024-2029

The next wave of the industrial revolution, Industry 5.0, will turn our focus back to humanity. It will be a revolution where robots help humans work better, faster, and safer by leveraging cognitive computing power. Contrary to the accelerated automation and dehumanisation seen in the previous tier of the industrial revolution, Industry 5.0 aims to generate the highest benefits from better collaboration between machine and humans.

5. Innovative energy technologies & raw materials

Inner circle

The rapid development of material technology will continue. The features and application possibilities of numerous elements, raw materials, and organic materials, like wood, will be more and more discovered. The thousands of different components of wood can be used by the chemical industry also. Other renewable raw materials will increasingly replace, for example, oil, glass, concrete, plastic and various metals. At the same time, nanotechnology is opening a whole new dimension of material utilisation.

Global energy consumption has more than doubled in the past 50 years, and it is going to keep growing. Of annual global demand for energy, comparable to roughly 14 billion tons of oil, up to 81% is being met by fossil fuels. In the short run, there will be an increase in the consumption of the fossil fuels and other non-renewable energy sources. At the same time, renewable energy sources are gaining ground. Solar, wind, and hydropower, as well as bioenergy and geothermal heat, are currently undergoing a rise in popularity. A gradual, more comprehensive introduction of the electric car is going to influence the energy supply too. In the coming years, green energy will still have only a minor market share, but further down the line, it is assumed to surpass the fossil fuels.

Middle circle

In the medium term, the available reserves of several critical raw materials, like phosphorus, and some rare metals vital to the electronics industry, e.g., rhodium, tellurium and platinum and some less common minerals, will slowly start becoming depleted, which will likely lead to a price increase. Given that China controls circa a 90 % market share of the rarest metals, mainly because of the labour-intensive mining process and China's low labour costs, there is a growing risk that it will decide to halt exporting them.

The supply of energy production will diversify in the future. A leading global certification establishment, DNV GL, estimates that green electricity and especially wind power will most likely become cheaper than coal already by 2020s. Also, the solar cell technology is assumed to undergo an increase in efficiency and experience a rapid decrease in price, as well as to become usable in varied ways. Crucial for the price reduction is substituting silicon with perovskite materials. The most significant obstacle for the broader introduction of solar and wind power is not the production price, but society's continuous need for energy. For this reason, energy storage solution, i.e., the development of hydrogen and battery technologies, will be essential for the competitiveness of renewable energy sources against fossil fuels and nuclear power.

Outer circle

In the long run, the available reserves of some rare metals and minerals will become depleted, and their prices will likely rise. The recycling level of minerals is probably going to increase from the present. At the same time, especially in the electronics industry and battery technology, novel metals and minerals are continuously being discovered, with which previously indispensable components can be replaced. Meanwhile, a new demand for elements which have not seen extensive use this far, like thorium, is to be expected. Space mining is likely to start, too. Metal asteroids and Moon-based helium-3 reserves have been estimated to be economically most promising.

According to an assessment from Stanford University, renewable energy sources could potentially cover up to 80% of the world’s energy consumption by 2030 and 100% by 2050. One cornerstone of this development will be electrification of cars which can, with excellent efficiency, cut 42,5% of present energy need. Biofuels may present a second potential cause for an energy revolution. Third significant opportunity is connected to the possibilities of the hydrogen economy. Pressure, voltage, and temperature differences, when tapped into through miniature thermo- and piezoelectric generators, present fourth possible area for an energy revolution. After the 2060s, an even more thorough revolution in energy generation is to be anticipated, as proper thorium and fusion plants probably become available, conceivably combined with wireless power transfer from sun-orbiting satellites.

5. Innovative energy technologies & raw materials - - related phenomena

- Formic Acid Fuel
- Dependency on Electric Grids and Data Networks
- Biofuels
- Small Nuclear Power Plants
- Solar Satellites
- Electricity-Producing Bacteria
- Hydrogen Economy
- Fusion Power – Helium 3
- Microgrids
- Energy Blackmail
- Smart Grids
- Use of Wind Power
- Use of Fossil Fuels
- Solar Power
- Wireless Power Transmission

5. Innovative energy technologies & raw materials (1/3)

Sand for Building

Weakening 2020-2023

The demand of sand that is suitable raw material for concrete and glass as well as electronics has been on the increase for a long time. There is no end to this development at least in the near future. Sand is the world's third most-consumed natural resource after air and water. Billions of tons are mined every year.

Rare-Earth Elements

Weakening 2024-2028

Rare-earth elements are used for virtually all modern electronics, from cell phones to wind turbines. The production of rare earth elements is currently primarily concentrated in China.

Wood-Based Textiles

Strengthening 2024-2028

New types of wood-based fibres offer a sustainable alternative to the widely-used cotton, viscose and oil-based materials. Many technologies are already ready for commercial production, and their uptake can revolutionise the entire textile and clothing industry. By shifting production towards the circular economy, the sector will be able to reduce its CO2 emissions, the chemical load on the environment and humans as well as to mitigate the growing waste problem.

5. Innovative energy technologies & raw materials (2/3)

Small Nuclear Power Plants

Strengthening 2024-2028

Within just a few years, new kinds of small, safe and relatively inexpensive nuclear reactors will arrive to the market. The plants are made ready at a factory and transported as one piece on a lorry. They are expected to offer a fast solution for reducing emissions in several countries. The power of one small reactor varies from a few dozens of megawatts to 300 megawatts, which is enough to meet the energy needs of a medium-sized city.

Phosphorus Sufficiency

Weakening 2045-2055

Phosphorus-based fertilizers are vital for modern agriculture. Depletion of easily mineable phosphorus could cause disastrous consequences by halving the current rate of food production. Because phosphorus is a non-renewable natural resource, new technologies and ways of operating are invented continuously to develop the way it is being collected and re-used. In addition, scientists are trying to find alternative fertilizers to replace the mineral-based phosphorus.

Artificial Photosynthesis

Strengthening 2029-2039

Artificial photosynthesis is one of the most promising ways to produce biofuels in the future. This technology that mimics one of nature's most powerful phenomena solves two issues at once: it inexhaustibly creates pure energy while capturing carbon dioxide from the atmosphere.

5. Innovative energy technologies & raw materials (3/3)

CO2 Capture and Repurposing

Strengthening 2024-2028

Innovations related to capturing, storing and repurposing carbon are one way of reducing CO2 emissions. New technological and biological solutions for carbon capture from industrial processes and the air are continually being explored. The key challenge of this development is to make innovations cost-effective and globally scalable as quickly as possible.

6. Sustainable Mobility

Inner circle

Traffic will become more energy-efficient, and its emissions per kilometre will gradually decrease. Most car manufacturers will strive to launch their first battery-powered electric cars in the near future, or, at least to produce a rechargeable hybrid model. In order to attract those who need to charge their electric cars, petrol stations will begin to compete, not only among themselves, but also with the new type of battery charging stations about to be introduced. MaaS, i.e., Mobility as a Service type services, which enable the transportation of people anywhere for a fixed monthly fee without the need to own a means of transport or purchase separate services, will become available for forward-looking customers.

Middle circle

Transport and travel will change significantly already in the medium term. For example, a sizable portion of cars will become electric. This has a significant impact on the energy efficiency of traffic, since, for instance, a vehicle running on gasoline utilizes only 20% of its fuel's energy, whereas an electric car transforms 80% of the electricity into movement. Partly autonomous hydrogen and electric cars, various small flying devices which operate in the urban environment, and the first prototypes of the significant future modes of transport, such as large airships and supersonic Hyperloop vacuum tubes, will increasingly enter the market. For the new modes of transport, the actual breakthrough will, however, take place later.

Outer circle

In 2030s, the movement and travel of people will change significantly. The options to be considered will no longer concern the owning or renting of a single means of transport, but the alternative logistical solutions to travelling. The most promising new technologies that facilitate the transportation of people and enable versatile MaaS solutions include robot cars or modules which move on the ground, trams which move above urban traffic, flying vehicles, such as drones (i.e., quadcopters and gyroplanes) which transport people, supersonic Hyperloop vacuum tubes, and rocket aeroplanes which travel through space. A multi-billion passenger economy is estimated to emerge based on these innovations.

6. Sustainable Mobility - related phenomena

- Space Tourism
- SkyPod Elevator
- Car-Free City Centres
- Passenger Cabins on Robot Platforms
- Robot Cars and Taxis
- Electric Cars
- Hyperloop as a Connector of the World
- Flying Cars
- High Speed Travel
- Car Ownership
- Road Deaths and Car Repairs
- Bicycle Highways
- Driving and Driver's License
- Road Traffic as Software

6. Sustainable Mobility (1/3)

CO2 to Fuel

Weak signal 2020-2023

A test facility the size of a shipping container was built in Finland as a pilot project to produce renewable fuels through solar power. In the test facility, solar power is transformed into gas and liquid fuels by using carbon dioxide and water extracted from air.

Hydrogen Economy

Strengthening 2024-2028

The pollution-free hydrogen may become the most important fuel as well as the main form of storing energy in the future. Hydrogen economy means a situation where hydrogen has replaced liquid fuels for vehicles as well as heating systems and replaced batteries as the primary form of energy storage. The biggest challenges of the hydrogen economy are related to economic and technological questions.

Biofuels

Strengthening 2024-2028

Biofuels are fuels made out of biomass. Trees, plants and different types of waste are some examples of suitable raw materials to make biofuel. The raw material can be used either directly by burning or it can be further processed into other materials, such as motor fuels.

6. Sustainable Mobility (2/3)

Dependency on Grids

Wild card 2029-2039

If a large-scale malfunction would shut down electric grids and data networks for a long period of time, the modern society completely dependent on them could descend into chaos or even collapse. Certain radical natural phenomena, military strikes and cyber-attacks could all damage grids or even completely destroy them regionally or even globally. Repairing large-scale damages could turn out to be impossible or at least it would cost hundreds of billions and take years.

New Era in Logistics

Strengthening 2029-2039

The manufacturing and delivery of products from the manufacturing site to the consumer is changing perhaps more than ever before in history. Along with the logistics itself, the role of the retail as well as the need for intermediate storage, ports, forklifts, trucks, container ships, container cranes and even the need for containers may substantially decrease from what it is at the present.

Out of Batteries

Wild card 2029-2039

Demand for electricity off the grid and during peak hours is going up. While batteries have a huge market potential, they bear the risk of becoming a major disruptor in case some of their raw materials like lithium becomes too rare and expensive. Without a massive growth of energy storage, a new energy crisis could become a possibility.

6. Sustainable Mobility (3/3)

Hyperloop

Strengthening 2028-2040

Hyperloop is a next-generation ultra-high-speed mode of transportation currently under development with potential route ideas around the world. It aims to compete with traditional forms of road and rail traffic as well as air transport by offering significantly reduced travel times and mitigating the negative environmental impact. It will not only revolutionise mobility but also redefine the development of dense urban areas and remote locales.

7. Additional Relevant Content

Inner circle

Accelerating improvements in various sciences rapidly change manufacturing technologies and practices. For instance, advances in automation, robotics, and big data are powerful transformation drivers. Furthermore, broadening energy and material solutions are pivotal in a world of increasing demands on efficiency. Also, machine learning, the internet of things and real-time monitoring are gradually becoming part of processes in some pioneering sectors of manufacturing industry.

Food means very different things to poor and developing populations compared to rich people living in an overabundance of nutrition. Others suffer from constant hunger and nutrient-poor food, while others are overweight. In Western countries, the proportion of people whose identity is built on food is on the rise, but for the vast majority, the price of food remains a decisive factor, even though consumers are much more aware of the ecological and ethical aspects of food as well as the self-expression and health-consciousness that can be experienced through food. Comparing the price of food is constantly on the increase, especially in the media, but digital development also supports it. Prices are continually made more comparable, and more and more retailers are trying to guarantee that their prices are the cheapest on the market.

Middle circle

In the medium term, the key drivers in the manufacturing industry will be machine learning, sensing, monitoring, and processes automatized and optimized by the internet of things. At the same time, control over the entire supply chain will become more critical. Additionally, bio- and nanotechnology, circular economy, and demand for zero-energy and utilization of solutions provided by augmented reality will drive the industry towards new practices. Local manufacturing, rapid recycling and fast transportation of goods from manufacturing plant to the end user will also gradually become visible in industrial operations.

Food needs to be increasingly responsible and functional and have versatile characteristics to enable self-expression in Western countries. It is becoming more common to build a personal brand through food choices, much like clothing and hairstyle choices. At the same time, food waste is beginning to be seen as a major societal problem, which is leading to the mainstreaming of collecting food waste for recycling. A bigger trend is the increased local production of food, which is being driven by three major changes. First of all, the various forms of urban farming, food snobbery, and demand for freshness and responsibility are on the increase. Secondly, urban supply chains and food recycling are becoming more effective. Thirdly, automation, such as 3D printing of food, robotic chefs, laboratory farming, and automatic recycling will become an even more integral part of food production and its processing and distribution.

Outer circle

In the long run, all of the industrial processes and manufacturing practices will undergo a profound transformation, which may be characterized as an industrial revolution. The basis for this change will emerge from interconnected devices and inter-machine communication, which perhaps is best represented by a smart electrical grid. As a whole, a wide-ranging and systemic shift is taking place, in which physical devices, digital programs, energy, raw materials, and organic systems are being linked to each other, producing a significant increase in both efficiency and productivity. The entire value chain of production, distribution, sales, and purchasing, will be replaced by a new model, in which the role of humans will be thoroughly altered.

Due to climate change, many regions, such as the Mediterranean, are expected to become dry deserts, while in many areas, heavy rainfall and storms will increase to an extent that impedes food production. The world's phosphorus reserves and drinking water resources will be depleted. According to FAO estimates, protein production will change dramatically, as by 2050 it will not be possible to meet 70% of the world’s increasing demand for protein, by traditional meat production methods. Therefore, the use of insect-based, algae-based and laboratory-grown protein and industrial production in the urban environment will inevitably increase significantly. Food cultures will be fragmented in a new way. The differences between increasingly self-sufficient cities and rural areas, as well as between different districts, income groups and age groups, will increase.

7. Additional Relevant Content - related phenomena

- Vegetarian Proteins
- Molecular Gastronomy
- 3D-Printed Food
- Moringa Tree as a Food Source
- Growing Rice in Salt Water
- Robotic Farming
- Vertical Farming
- Robot Chef
- Food Scanners
- Protein Out of Air & Electricity
- Farming without Pesticides
- LED Lights in Food Production
- GM Food
- Desert as Bread Basket
- Artificial Meat

7. Additional Relevant Content (1/2)

Leadership Crisis

Strengthening 2023-2028

The global leadership crisis is deepening due to the alarmingly weak correspondence between power and competency to handle the fast-paced challenges organisations are facing. If leaders fail to embrace diversity, remove ego, and strengthen morality, organizations may experience hindered growth and face unforeseen risks. Economy, large-scale health risks, geopolitics, counterterrorism, climate change, and corporate management are examples of areas in danger facing severe leadership problems.

Synthetic Biology

Strengthening 2024-2028

Synthetic biology is considered one of the newest, rapidly growing, and promising fields of biotechnology. Innovations of the field provide new alternatives for e.g. materials and fuels and new solutions to enhance medicine and food production.

Biomimicry

Strengthening 2024-2028

The most endurable system on our planet is nature. It has had the whole of Earth’s existence to refine its systems and strategies. Biomimicry is a promising field that studies natural solutions in order to find new ideas for products, processes, and policies. Nature’s inspiring innovativeness can be used to support sustainable development and to spark new tools to solving our global challenges.

7. Additional Relevant Content (2/2)

Return of Heavy Industry

Wild card 2024-2029

It is possible that the western world could experience the return of the heavy industry. If the digital and immaterial services were to decrease in importance, it could lead to capital moving back to manufacturing industry, which will undergo productivity leaps through automation, AI-robotics, and, for example, 3D printing. The present low-cost manufacturing countries may, in the future, experience changes which could fundamentally reduce their competitiveness in relation to production which takes place near the consumer markets.

Arctic Resources Race

Strengthening 2024-2028

As the Arctic keeps melting, the exploitation of its resources is becoming increasingly widespread. For example, it has been estimated that approximately 22% of the world's undiscovered oil and gas is located in this area. Several states have already expressed interest in exploiting these resources, and this could lead to both political tensions and ecological risks.

Oil-Based Plastics

Weakening 2028-2040

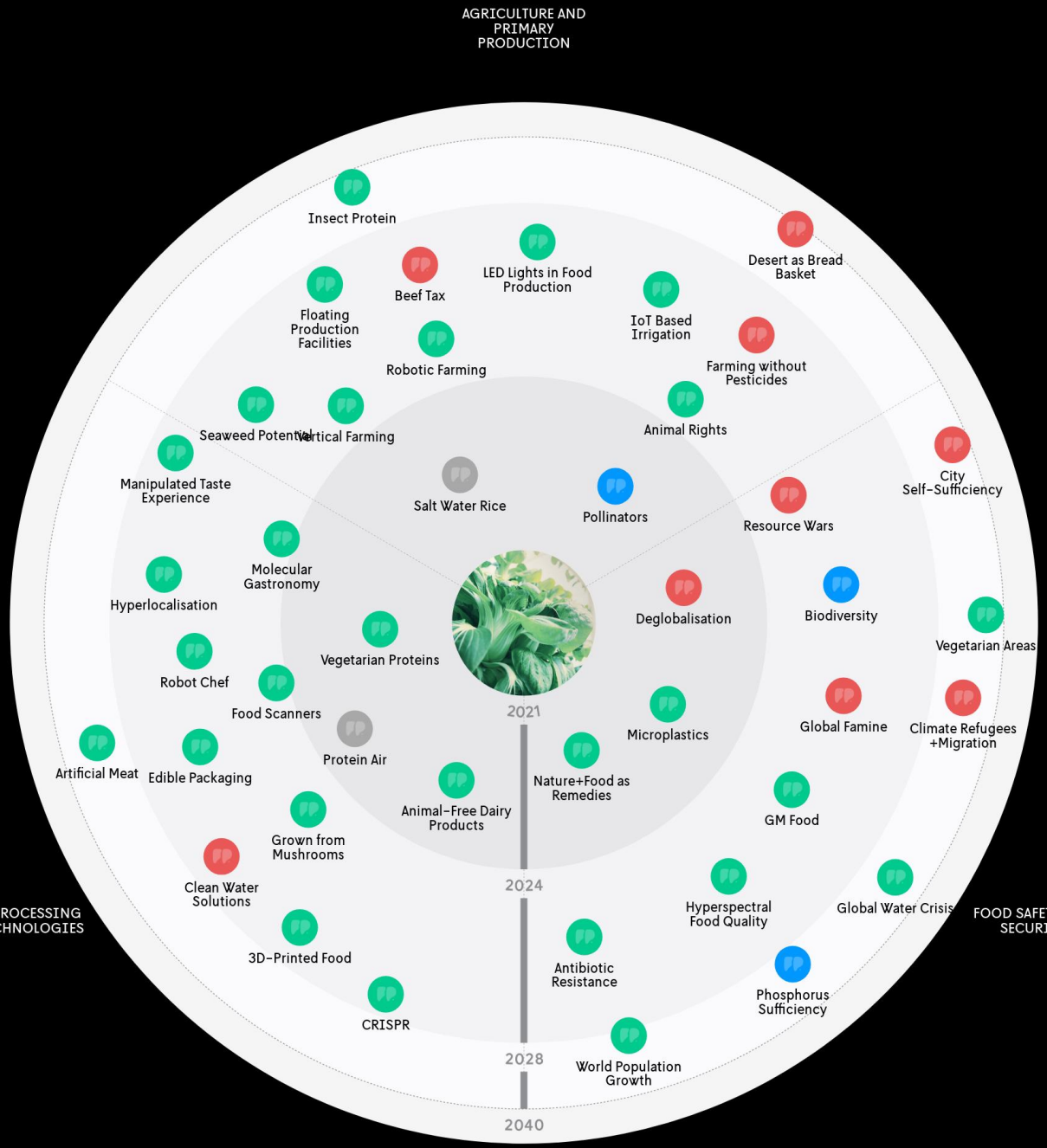
The use of traditional oil-based plastics is continuing to decline because their use is environmentally challenging. Decreased availability of natural resources, efficient recycling, and new material solutions drive change towards use of renewable materials in plastics production. The switch to a circular plastic economy is expected to bring new innovative packaging solutions, drive business opportunities and create new green jobs.

Food and agriculture, a horizon scan for STOA

Created from a prefilled radar

FUTURES PLATFORM

Food and agriculture (for final report - lvw)



Legend: Phenomena types

Strengthening (Colour: Green)
The presented issue is becoming more common or acute during the given timeframe. Most of its change potential is still ahead.

Weakening (Colour: Blue)
The presented issue is becoming more unusual. During the given timeframe, most of its change potential or value has already occurred.

Weak signal (Colour: Grey)
A small emerging issue in the present. At the given timeframe, it is still hard to say whether it will become a trend.

Wild card (Colour: Red)
A possible but not probable event or change. Early information about a potential emerging risk or opportunity. The probability within the given timeframe is between 5% to 30%.

Time ranges are set indicatively by the Futures Platform futurist team.
The timing indicates the expert-assessed timeframe within which the phenomenonis believed to either accelerate in change speed or start to decline in importance.

Food and agriculture

1. Food Processing and Technologies
2. Agriculture and Primary Production
3. Food Safety and Security

1. Food Processing and Technologies

Early 2020s

Accelerating improvements in various sciences rapidly change manufacturing technologies and practices. For instance, advances in automation, robotics, and big data are powerful transformation drivers. Furthermore, broadening energy and material solutions are pivotal in a world of increasing demands on efficiency. Also, machine learning, the internet of things and real-time monitoring are gradually becoming part of processes in some pioneering sectors of manufacturing industry.

Late 2020s

In the medium term, the key drivers in the manufacturing industry will be machine learning, sensing, monitoring, and processes automatized and optimized by the internet of things. At the same time, control over the entire supply chain will become more critical. Additionally, bio- and nanotechnology, circular economy, and demand for zero-energy and utilization of solutions provided by augmented reality will drive the industry towards new practices. Local manufacturing, rapid recycling and fast transportation of goods from manufacturing plant to the end user will also gradually become visible in industrial operations.

2030s and beyond

In the long run, all of the industrial processes and manufacturing practices will undergo a profound transformation, which may be characterized as an industrial revolution. The basis for this change will emerge from interconnected devices and inter-machine communication, which perhaps is best represented by a smart electrical grid. As a whole, a wide-ranging and systemic shift is taking place, in which physical devices, digital programs, energy, raw materials, and organic systems are being linked to each other, producing a significant increase in both efficiency and productivity. The entire value chain of production, distribution, sales, and purchasing, will be replaced by a new model, in which the role of humans will be thoroughly altered.

1. Food Processing and Technologies (1/5)

Vegetarian Proteins

Strengthening 2020-2023

The growing world population needs to be fed both sustainably and healthily. This will likely lead to increased consumption of vegetarian proteins.

Animal-Free Dairy Products

Strengthening 2020-2023

Several start-ups employing synthetic biology are creating new types of totally animal-free dairy products. For example, a biotech start-up Perfect Day has developed a limited run, animal free-dairy ice cream. The company focused on the biotech innovation of making animal proteins from whey and casein without using animals. Animal-free dairy products will be more environmentally friendly than traditional dairy and surpass the plant-based products in terms of taste and texture.

Protein Air

Weak signal 2020-2023

Scientist from the joint project of the Lappeenranta University of Technology and the VTT Technical Research Centre have been able to make a batch of single cell protein out of air and electricity. Their ground-breaking method is based on growing microbes by using renewable energy and carbon dioxide extracted from air. As unbelievable as it may sound, this kind of method could help us harvest food and animal feed from air anywhere without restrictions related to traditional agriculture and the environment.

1. Food Processing and Technologies (2/5)

Food Scanners

Strengthening 2024-2028

Food scanners are hand-held devices that are able analyse food composition with a simple "point and shoot". These small devices could provide valuable information prior to selling, preparing, feeding, or ingesting a piece of food by revealing its exact composition, nutritional values, and potential warning signs of contamination. Food scanners, whether they come in the form of scanning apps or scanning devices, could provide a lot of potential value for several industries and/or people who wish to control their diets.

Molecular Gastronomy

Strengthening 2024-2028

Molecular gastronomy is increasingly used to develop and manufacture new dishes of food. In practice, this means using natural sciences to gain knowledge of food, cooking and the pleasure eating brings. Molecular gastronomy will probably influence new dishes and eating trends in the future, with a potential of fundamentally changing the entire food culture.

Grown from Mushrooms

Strengthening 2024-2028

Advancements in synthetic biology have brought increasing variety to available production materials. Mushroom-based materials have already been successfully used to grow three-dimensional objects. In the futures, fungus-based products and materials will become more common, because these natural products have the advantages of low energy consumption, low emissions, and recyclability.

1. Food Processing and Technologies (3/5)

Robot Chef

Strengthening 2024-2028

In homes and kitchens, automatics and robotics are increasingly deployed to make life easier. Many manufacturers have introduced robot chefs that are designed to help with cooking. Robot chefs are often made of one arm, mimicking a human arm, that has been combined with technologies such as artificial intelligence, machine vision and voice control. In a professional kitchen, robot chefs can replace humans when it comes to carrying out tasks that require repetition, speed and an extremely high level of hygiene.

Edible Packaging

Strengthening 2024-2028

In 2050, there could be more plastic than fish in the oceans. Growing packaged goods consumption increases the demand for biodegradable packaging solutions. Made of hyper-compostable edible materials such as seaweed and milk protein, edible packaging may provide a sustainable alternative to plastic. However, high costs, regulatory requirements, and the less durable properties of edible materials make the widespread adoption of edible packaging difficult.

Hyperlocalisation

Strengthening 2024-2028

Hyperlocalisation means the desire to produce everything locally and by oneself, be it food, services, consumer goods, news, culture, or energy. More and more people are looking for chances to fulfil their daily needs with locally produced alternatives that serve the values and goals they deem important.

1. Food Processing and Technologies (4/5)

3D-Printed Food

Strengthening 2024-2028

3D printing technologies are expected to revolutionise personal and professional food preparation techniques. 3D printing makes not only creative food designs possible but also allows precise customisation of food according to individual preferences and nutritional needs. According to Research Nester, the 3D-printed food market is expected to grow to USD 400 million by 2024.

Clean Water Solutions

Wild card 2029-2041

Clean water shortage is one of the world's pressing problems and requires urgent solutions as the population grows, and climate change evolves. Various innovative tech and material solutions are continuously being developed to address this problem. If these technologies can make a breakthrough and be implemented at a large scale, clean water might one day become abundantly available.

Manipulated Taste Experience

Strengthening 2023-2028

As the humankind is forced to utilise new forms of food in the future, our need for manipulating taste experience is becoming more common. For instance, miraculin, which can be extracted from fruits or manufactured artificially, makes sour taste like sweet. Manipulating the sense of taste may prove to be a viable option in turning healthy, eco-friendly and nutritious foodstuffs into delicious alternatives to ordinary food.

1. Food Processing and Technologies (5/5)

CRISPR

Strengthening 2024-2028

CRISPR is a tool to engineer genetic information that was discovered by studying bacterial activity. The method is advanced and studied all over the world, because it enables the cheap and quick manipulation of human, animal, plant, virus, or bacteria genome.

Artificial Meat

Strengthening 2029-2039

Products intended to mimic meat are sold in many supermarkets and restaurants, but artificial meat made from animal cells in the laboratory is not yet found on the shelves of any shop. It is hoped that artificial meat, which has been in development for years, will solve some of the climate-related challenges associated with food production. The growing popularity of products that mimic meat has also raised criticism from those who call for more research into the safety of artificial meat products before they enter the market, and some people even actively oppose meat substitutes.

2. Agriculture and Primary Production

Early 2020s

The recycling of raw materials and waste, adhering to the principles of sustainable development, and various kinds of environmental thinking will continue to increase. Numerous NGOs and political parties will pressure governments to commit themselves and to foster international climate agreements, restrictions on the use of dangerous chemicals, and bans on items such as plastic bags. At the same time, nature and natural resources will be seen as enablers of economic and social growth and development, which will decrease the area of unspoiled nature year by year.

Late 2020s

Governments will boost the demand for cleantech also in the medium term by increasing environmental regulation and financial incentives. New groundbreaking cleantech solutions, such as self-healing buildings, LED lighting in food production and turning landfills into mines for raw materials, will progress rapidly, expanding the markets in the sector. It is expected that cleantech markets will continue their long-term annual growth of more than 10 percent. For example, the German government estimates that the value of cleantech markets will reach €4.4 trillion around 2025. In recent years, the growth in the markets has shifted from Europe towards developing countries.

2030s and beyond

The use of new sustainable technologies will start to bring demonstrably significant resource and cost savings to governments, organisations and individuals. In 2030s, adhering to the principles of sustainable development, recycling raw materials and waste, and utilising innovations such as an intelligent electricity network and turning carbon dioxide back into fuel will begin to be commonplace – these will not be regarded as special environmental efforts but as a reasonable and economically sound way of operation. For example, the utilisation of biology in the growing of packaging material and in the production of low-CO2 protein is becoming commonplace by necessity rather than due to ideological reasons.

2. Agriculture and Primary Production (1/5)

Salt Water Rice

Weak signal 2020-2023

Chinese scientists have managed to develop a strain of rice that can be grown in salt water. The invention could allow a significant amount of land, previously unsuitable for cultivating rice due to lack of fresh water, to be taken into agricultural use. Even though salt water rice is remarkably more expensive than traditional strains, it is still believed to have the potential of feeding hundreds of millions of people in the future. Besides China, also Dubai has taken great interest in the invention.

Pollinators

Weakening 2020-2023

Up to 40 % of all Apidae (apid bees) and butterflies are endangered in certain areas and up to 16.5 % of all vertebrate pollinators face extinction. The wide disappearance of pollinators is a grave challenge to biodiversity, food production, and many other fields using plants that rely on biotic pollination.

Animal Rights

Strengthening 2024-2028

More and more people aim to promote and advance animal rights by donating funds to various organisations and projects and by making conscious consumption decisions. This increases pressure on societies and businesses who need to take the ethical demands related to the treatment of animals more thoroughly into consideration.

2. Agriculture and Primary Production (2/5)

Vertical Farming

Strengthening 2024-2028

In vertical farming, plants are not grown horizontally on the fields but indoors, on several layers on top of each other. It is believed, that vertical agriculture enhances both the quality and quantity of the crops. This is due to a controlled environment optimized for the plants.

Robotic Farming

Strengthening 2024-2028

Farming is believed to be one of the next fields which will undergo a large scale robotisation. New robots are being developed, e.g., to pick fruits and berries. The drivers to develop farming robots are related to both labour shortages and new technological possibilities.

Seaweed Potential

Strengthening 2024-2028

Seaweed farming can be considered as one of the most natural and economical solution to solve global challenges, such as climate change, nutrition, and malnourishment. Yet, the biggest hope on seaweed cultivation is put on the development of a variety of high-value sustainable products like biofuels, medicines and food supplements. For example, super-foods such as seaweed snacks and other readily available ‘sea vegetables’ are slowly gaining momentum in markets.

2. Agriculture and Primary Production (3/5)

IoT Based Irrigation

Strengthening 2024-2028

Irrigation systems are becoming digitalized and tailored with optimal operations, making it more efficient and cost-effective. The implementation of IoT technologies for irrigation systems helps to minimize water consumption and increase crop production. The IoT based irrigation systems, coupled with an artificial intelligence-powered algorithm, machine-to-machine communication, and machine-learning applications, enable precision irrigation.

Farming without Pesticides

Wild card 2024-2028

Mass death of bees has led to loss of productivity in farmed crops as they do not pollinate the way they used to. Recent studies show that a chemical cocktail from farming including pesticides and insecticides has spread to wild flora as well. It is possible that future farming will have to become pesticide free to continue.

Beef Tax

Wild card 2024-2028

In the future, beef may be subject to pigovian taxes. Traditional meat may become a food only for the rich and the less wealthy have to make do with other sources of protein. With the growing climate awareness and the increased interest in plant-based diets and meat substitutes, beef taxes would further curb meat consumption and significantly disrupt the traditional meat industry. In an extreme scenario, this may even bring the end of mass-scale meat production.

2. Agriculture and Primary Production (4/5)

LED Lights in Food Production

Strengthening 2023-2028

LED lights can be used for efficient and competitive food production indoors. The benefits of vertical indoor farming include efficient and steady production rates, independence from location and weather conditions, and lack of pests. The indoor farming with LED lights could help tackle the challenges of the growing demand for food, water scarcity, and the rising carbon footprint.

Floating Production Facilities

Strengthening 2024-2028

Solar-powered, floating constructions may solve the challenges of food and energy production in the future. Plantations and power plants built on water can also provide sustainable food and energy in areas where land is scarce or conditions are challenging. Floating construction has the potential to make production more environmentally friendly, efficient and local.

Insect Protein

Strengthening 2028-2040

FAO has estimated that protein demand will increase up to 70 % by the year 2050. This increasing demand cannot be met with traditional meat production methods. Thus, the use and industrial production of insect proteins will likely see a significant increase in the next 30 years.

2. Agriculture and Primary Production (5/5)

Desert as Bread Basket

Wild card 2029-2039

Because of climate change and population growth, the future of the world's food production may increasingly depend on harnessing new areas for growing food and on adopting innovative farming technologies. It is possible that thanks to the new farming technologies the deserts may turn into food production areas.

3. Food Safety and Security

Early 2020s

The population of the world will continue to grow for a few decades, but population growth is no longer based solely on an increasing birth rate, but on the fact that people live longer than previous generations. In other words, the population is both growing and growing older. At the same time, humankind is also increasingly urbanising at an accelerating pace. With only 3% of people in the world living in urban areas in 1800, the share has currently already reached approximately 55%. Every day, the number of urban residents increases by roughly 200,000. In 1990 there were only 10 megacities in the world, with a population of more than 10 million people, whereas now, there are more than thirty megacities.

Late 2020s

As urbanisation accelerates, especially in Asia and Africa, the number of megacities with more than 10 million residents will increase to around forty. Currently, population growth due to an increase in the birth rate is mainly occurring in Sub-Saharan Africa. Almost the entire generation of so-called ‘baby boomers’ born in Western countries after the wars will reach their retirement age in the medium term. More and more representatives of the millennial ‘generation Y’ are beginning to take on leading roles in business, politics and market-defining companies. In emerging countries, absolute poverty and wars are declining and the middle class is on the rise, but in the western world the middle class is shrinking and the overall polarisation of society is accelerating.

2030s and beyond

Life expectancy is growing rapidly almost everywhere. However, the development has been most rapid in the West. Due to the increase in life expectancy, in particular, WHO estimates that population growth will continue until the year 2050, when the population is expected to be around 9.8 billion. As a result of accelerating urbanisation, a record 66% of humanity, or 6.5 billion people in total, are expected to live in cities. The continued growth in prosperity and population is overshadowed by the prospect of a major international war and the collapse of states, the increase in displacement due to climate change and migration, risk of pandemics, and the blatant inequality of the population, which can lead to unrest and terrorism, or at least weaker health and shorter life expectancy among the poor.

3. Food Safety and Security (1/5)

Nature+Food as Remedies

Strengthening 2020-2023

Healthcare is moving from a medicinal, disease-curing focus into a holistic management of human wellbeing. New health approaches highlight the importance of prevention and acknowledge the importance of nature and nutrition in improving and maintaining physical and mental health.

Deglobalisation

Wild card 2020-2023

The era of globalisation may be coming to an end, disintegrating the world's complex interdependencies as a consequence. Reasons for deglobalisation include a widespread rise in nationalism, a serious weakening of the liberal hegemony driven above all by the US, as well as the need for different countries to ensure their own security of supply by reshoring critical production.

Microplastics

Strengthening 2020-2023

Microplastics are plastic fragments or particles that are five millimetres or less in length. These minuscule particles often end up in the nature. An increasing amount of evidence shows that they can be found in animals, plants and humans. Sources of microplastics include the clothing industry, cosmetics and industrial waste. Even though there is no evidence at present to prove that microplastics pose a threat to the well-being of humans or the nature, long-term accumulation of plastic may have unknown consequences for an organism.

3. Food Safety and Security (2/5)

Resource Wars

Wild card 2024-2028

Several natural resources are non-renewable and available only in limited quantities. For this reason, it is possible that at some point the struggle for their control will intensify significantly. The possibility of armed conflicts cannot be ruled out entirely.

GM Food

Strengthening 2023-2028

The genetic manipulation (GM) of food crops has raised a lot of concern and doubts among the consumers. However, many of the scientists who have researched the issue, agree that the GM foods, which have passed the safety assessments and are sold on the global market, cannot be shown to be harmful to humans. Use of GMOs (genetically modified organisms) can bring multiple benefits to agricultural practices and may play a vital role in addressing climate change and the growing global food crisis.

Antibiotic Resistance

Strengthening 2024-2028

Antibiotic resistance develops through natural processes, but medicating humans and animals unnecessarily with antibiotics accelerates the growth of antibiotic-resistant bacteria. If effective new antibiotics cannot be developed, diseases that had earlier been almost defeated and modest infectious diseases could become life-threatening. Phage therapies, in which viruses are used to destroy bacteria, may also prove useful.

3. Food Safety and Security (3/5)

Biodiversity

Weakening 2024-2028

On a global level, biodiversity is weakening fast. This is entirely because of human-made reasons like agriculture, pollution and climate change. In the coming decades, the decline may reach a point where it starts threatening certain food industries or even global food security.

Hyperspectral Food Quality

Strengthening 2024-2028

Hyperspectral imaging works across several bands of light that the human eye cannot capture. Using super sensitive cameras and AI algorithms, hyperspectral imaging can detect quality and decay of fresh food products. This process can add reliability to production and quality to the end products sold to consumers.

Global Famine

Wild card 2040-2120

As the world population and the middle class grow, the need for food production will also keep increasing. At the same time, climate change, erosion, wars and other crises are having a significant impact on food production and distribution chains. For these reasons, the world market price of food is likely to rise sharply in the future, which will directly increase famine in the poorest countries. If the development of the world economy becoming replaced by regional economic blocs accelerates at the same time, food may become a geopolitical weapon and the world food market may come to a partial halt. The requirements for food self-sufficiency are likely to become significantly higher in the future.

3. Food Safety and Security (4/5)

World Population Growth

Strengthening 2029-2039

According to the UN calculations, the global population grows by about 83 million annually. Population growth is mainly occurring in developing countries, the fastest growing areas being located in Africa and Asia. The forecast estimates that the population of the world will be 8.6 billion in 2030, and rise to 9.8 billion by 2050.

Phosphorus Sufficiency

Weakening 2045-2055

Phosphorus-based fertilizers are vital for modern agriculture. Depletion of easily mineable phosphorus could cause disastrous consequences by halving the current rate of food production. Because phosphorus is a non-renewable natural resource, new technologies and ways of operating are invented continuously to develop the way it is being collected and re-used. In addition, scientists are trying to find alternative fertilizers to replace the mineral-based phosphorus.

Climate Refugees +Migration

Wild card 2029-2039

Many currently inhabited areas may become unliveable in the future due to climate change. This would lead to massive waves of climate refugees, forcing countries to rethink their immigration and refugee policies. The current estimates of potential climate refugees range from 25 million to 1.5 billion by 2050.

3. Food Safety and Security (5/5)

Global Water Crisis

Strengthening 2024-2029

Lack of drinking and irrigation water is shutting down many sustainable areas for living and eroding agricultural areas that were only recently productive. Resulting political unrest may confirm the saying: water is the next oil. The crises threatening the global economy are significant– already in 2013, The World Economic Forum considered the water crisis to pose a considerable risk to the modern world.

Vegetarian Areas

Strengthening 2024-2028

The popularity of vegetarian and vegan food and the stores, restaurants, and events offering them is rising significantly. Although people with vegetarian and vegan diets are still a minority of now, plant-based diets are becoming more common, especially among the younger generations. In the future, we will probably find whole areas that concentrate on vegetarian food.

City Self-Sufficiency

Wild card 2029-2039

Future cities may develop towards greater self-sufficiency. In that case, most of the food, energy, and clean water production, as well as recycling would take place within the city, utilising various new technologies.

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The first part of the STOA study 'A framework for technology foresight intelligence', this report includes a set of five horizon-scanning reports or 'radars', built with the resources of Futures Platform and covering several areas, including the world after Covid-19, disruptive futures, the Green Deal, food, and geoengineering.

Horizon scanning is a discipline that could be harnessed to inform the future activities of the Panel for the Future of Science and Technology (STOA) at both strategic and practical levels. However, as STOA does not have the working structure, human resources or expertise necessary for continuous scanning, for the horizon scans in this study it used Futures Platform.

Futures Platform is a professional trends knowledge platform that collects and analyses information on phenomena such as technology, trends and signals, using AI-based tools and a team of foresight experts to anticipate future developments. These trends and signals were used to build a set of trend radars with a view to testing the feasibility of adding horizon scanning activities to STOA's methodological toolbox.

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