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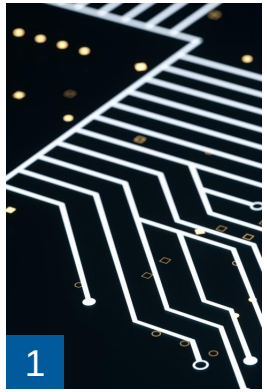
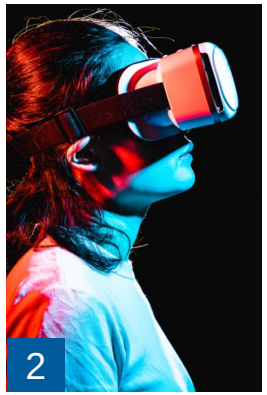
Trendbook

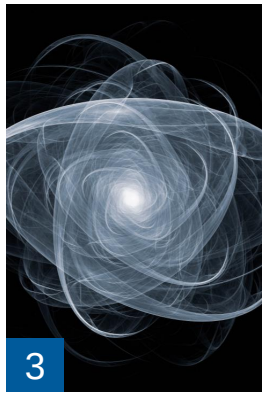
Technological trends overview



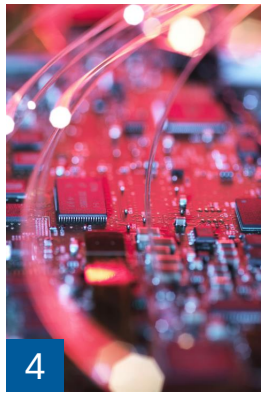
Data science and AI



Immersive technologies



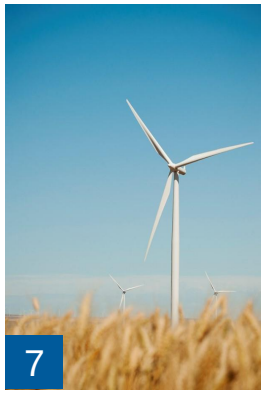
Quantum technologies



Sensor technologies

New space technologies

New materials and digital production

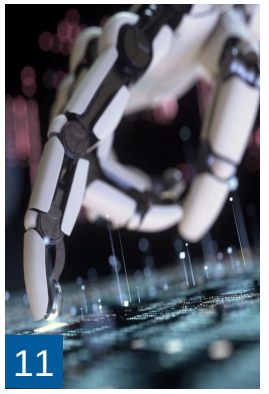


Renewable energy and resilience

Human enhancement technologies

Cyber technologies

Digital communication



Robotic and autonomous systems

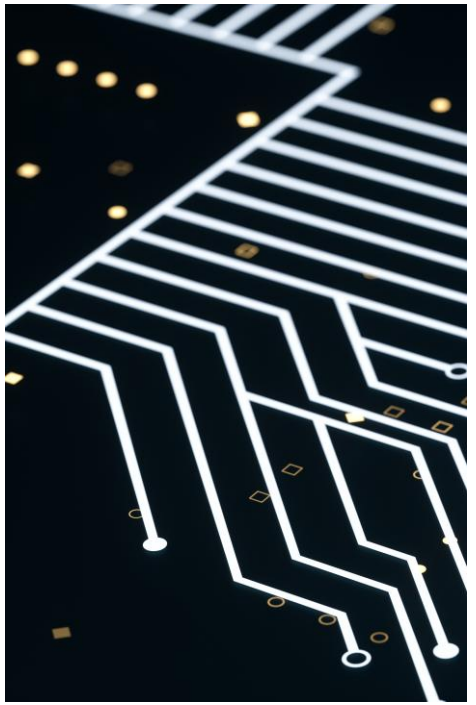
Data Science & AI

Technological trend 1 – Harnessing the power of data to emulate and overcome human intelligence

Description

Advanced data analytics uses complex methods to understand and visualise huge amounts of data.
Artificial Intelligence (AI) is about machines doing tasks that usually need human intelligence.
Data analytics methods can pull insights, sort information, and make predictions from large data sets. These data sets may be unstructured.

AI functions can be divided into two main parts. The first is parsing inputs with perception, natural language processing, and using social intelligence cues. The second part involves planning and executing outputs, called "behaviours." This includes knowledge representation, prioritisation, and planning.
Machine learning is a part of AI. It focuses on developing algorithms. These algorithms learn from input data on their own. They understand the connection between the data and our desired results, such as classifications or actions.



Key uncertainties

How can we deal with the lack of interpretability of current AI algorithms? How will current AI models be able to scale towards more advanced capabilities? How will data ownership and rights, as well as further development of AI models be regulated?

Relevance / Impact

- Economic productivity gains resulting from the automation of tasks and enhancement of labour force.
- Consumer demand increases due to enabling of personalised products and increased leisure time.
- Effect of integrating AI into daily life (e.g. chatbots, virtual assistants) on human-computer interaction and social dynamics.

Weak Signals (Proofs / Examples)

- Researchers introduce technology enabling deep learning model training on edge devices like mobile phones.
- Researchers utilise AI to accurately recognise and classify animal social behaviour.
- Startup devises predictive analytics solution, utilising data to cut freight costs by optimising transport routes, considering factors like weather, tides, and wind speed.

Immersive technologies

Technological trend 2 – Merging the physical and the virtual world to transform experiences

Description

Immersive technologies can enable a deeply engaging, multisensory, digital experience. **Augmented reality (AR)** overlays digitally created content into the user's real-world environment. **Virtual reality (VR)** creates a fully rendered digital environment that replaces the user's real-world environment.

Immersive technologies are used in various ways. In **product design and development**, they give immediate access to important information at every stage. For **collaboration and cooperation**, they help to engage with, to share information, and support colleagues in different locations. In **learning and training**, they allow trainees to experience realistic situations that are hard to recreate in real life. They also **enhance consumer experiences** by bringing potential customers closer to products and services.

Key uncertainties

Will immersive technology ideas stay as prototypes, or will they start to expand on a large scale? Are business models to support future applications viable? How can augmented reality enable new types of harm, scams, and crime? How will immersive technologies change the way we work?

Relevance / Impact

- Using immersive technologies in industrial settings, the production process can be improved through early-warning-detection mechanisms, improved quality assurance, and rapid prototyping.
- Immersive technology-assisted products and services can engage consumers in new ways and increase sales and consumption.

Weak Signals (Proofs / Examples)

- Startup aims to establish a metaverse-based "educational city" for students from grades 1 to 12.
- Researchers introduce tools to safeguard bystander privacy in real-time sensor data, by employing eye tracking, near-field microphones, and spatial awareness.

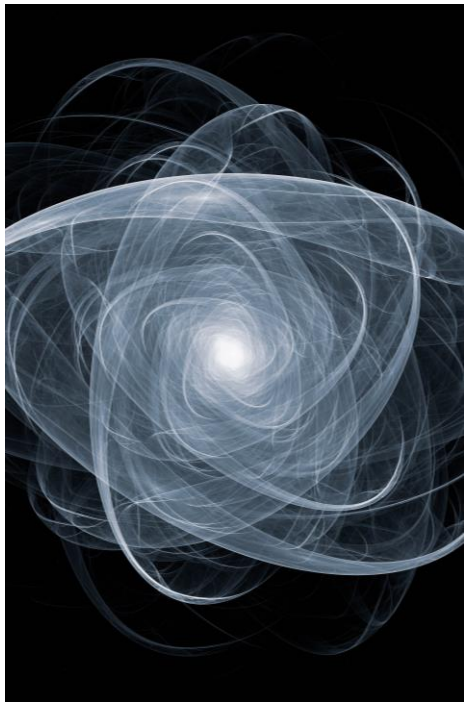
Quantum technologies

Technological trend 3 – Using quantum physics to create "magical" devices

Description

Quantum technologies harness quantum phenomena like entanglement and superposition, offering capabilities surpassing classical devices. Quantum technologies span quantum sensing, communication, and computing.

Quantum sensing increases the accuracy in measuring time, acceleration, magnetic fields, and electromagnetic radiation. This is crucial for navigating without GPS and improving reconnaissance (scouting of an area).
Quantum communication uses the quantum properties of light to enhance security and to detect eavesdropping on communications. It also enables to connect quantum sensors and computers in a network.
Quantum computing provides more computational power for encryption/decryption, optimisation, and simulations. This could render current encryption methods outdated and help create new materials through simulations.



Key uncertainties

How can the daunting technical challenges be overcome? How can the relatively narrow application scope be expanded, especially for quantum computing? How does "quantum decryption" affect privacy concerns?

Relevance / Impact

- Enable "magical" remote sensing and navigation capabilities.
- Increased security and eavesdropping detection.
- Improved computational performance for specific problems (encryption, optimisation, simulation).

Weak Signals (Proofs / Examples)

- Use of quantum technology to improve flood risk assessment, to overcome computational limitations.
- Startup unveils cloud-native service for executing conventional and quantum algorithms, simplifying development and accessibility.
- Researchers develop high-speed quantum communication.

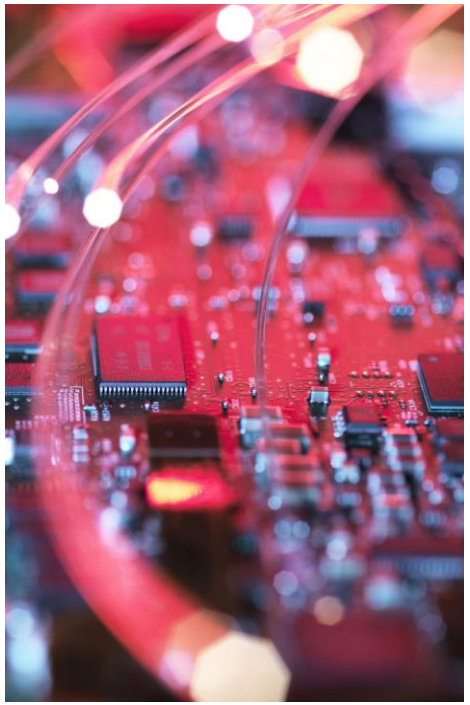
Sensor technologies

Technological trend 4 – Capturing data for smarter decisions and to enhance life's efficiency

Description

A **sensor** transforms a physical measure into a signal readable by an observer or instrument. **Sensor technologies** are advancing in three key areas: enhanced performance, miniaturisation, and distribution, with many advanced sensors improving in one or more aspects.

MEMS sensors have been the main contributor to the change in scale and functionality of sensors over the last decade.
Nanosensors take advantage of the unique properties of nanoscale materials.
Flexible sensors can withstand mechanical deformation.
Bioinspired sensors take inspiration from basic concepts behind sensory physiology.
Lab-on-chip sensors can perform various complex laboratory operations on a miniaturised scale.
Smart dust is comprised of many dust-sized smart sensors.



Key uncertainties

How will sensor performance and miniaturisation evolve? How will the secondary capabilities of smart sensors (power, communications, computing) evolve? Will novel sensor technologies be able to be produced and deployed in scale? What new data-based business models could emerge based on novel sensors?

Relevance / Impact

- Sensor technologies are enabling performance, miniaturisation, and connectivity to achieve a huge impact in many sectors.
- The vast amount of data collected can feed into a “data economy”, producing value for many stakeholders.
- Sensors can make technology personal, by being included in many everyday objects.

Weak Signals (Proofs / Examples)

- Method for mass-producing graphene-based sensors that detect lead, mercury, and E. coli in water.
- Researchers devise gravimetric sensors to detect greenhouse gases like carbon dioxide and methane, with greater sensitivity and lower energy consumption.
- Space data company about to employ hyperspectral imaging to assist precision farming.

New Space technologies

Technological trend 5 – Space Race 2.0, the next giant leap for humankind

Description

Space technologies make use of the unique conditions of space, but also must deal with the challenges that come with operating there.

In the next few years to a decade, space technology will support several groundbreaking applications. It will provide navigation for self-driving vehicles, real-time imaging of Earth for improved agriculture, and connectivity for the Internet of Things. **Looking further ahead**, the infrastructure could be established to sustainably support human life in space. This includes building habitats, research facilities, in-orbit refuelling stations, and factories.

The growing feasibility of space applications is driven by reduced launch costs, advancements in miniaturisation, standardisation, large-scale production, and the incorporation of technologies from related fields like AI, robotics, advanced manufacturing, and quantum communications.

Key uncertainties

Will the enabling technologies ever become capable enough? Will the more ambitious space applications ever become financially competitive? Will space become a field of geopolitical conflict? Will the necessary regulations for the use of space be put in place? Will there ever be a real demand for more than the practical applications of space?

Relevance / Impact

- More accurate and available positioning, navigation and timing, enables e.g. precision agriculture.
- Higher resolution Earth observation data enables advanced applications such as predictive models (with big data and AI).
- Ubiquitous and affordable communication constellations enable e.g. global internet.

Weak Signals (Proofs / Examples)

- Space suit designed by a high-fashion company.
- Development of a platform in space, to produce semiconductors, pharmaceuticals, fibre-optics.
- Use of AI methods to create Earth's digital twin based on satellite data.
- Successful testing of 3D-printed rocket engine parts.

New materials and digital production

Technological trend 6 – Transforming how things are made

Description

New materials offer unique properties like heat resistance, energy storage, and self-healing. **Digital production** aims to digitise the entire value chain, enabling real-time monitoring and optimisation. Starting with production, it involves partners, suppliers, and users to optimise designs, processes, operations, and support.

New materials focus on **enhancing performance in various aspects** such as weight, conductivity, heat resistance, and "exotic" properties. Digital production aims to **digitise the value chain**, from concept, to manufacture, use, and disposal. **Additive manufacturing** or 3D printing is a key aspect of the digital production method creating three-dimensional objects from digital models and various materials, used e.g., for rapid prototyping or on-the-spot production.

New material technologies are driven by rapid technological advances in a wide array of materials research and development fields. Digital production advancements are driven by developments in many enabling fields.

Key uncertainties

How can the several technical challenges of 3D printing be overcome? What will be the rates of adoption for digital production methods, and what will be the balance between benefits, costs and risks? How can the challenges in terms of manufacture and scalability of many new materials be addressed?

Relevance / Impact

- Continuously improving properties of new materials, e.g. metamaterials for electromagnetic cloaking.
- The digitisation of increasingly more parts of the value chain promotes technical and economic efficiency in a wide array of sectors.

Weak Signals (Proofs / Examples)

- Researchers create a non-invasive neural implant with graphene electrodes.
- Researchers achieve superconductivity at minus 23 degrees Celsius under high pressure.
- Consortium developing an "industrial metaverse", enabling digital twins and Internet of Things applications.
- Researchers employ a unique 3D printing method to create thin, curved, and resilient concrete walls.

Renewable energy and resilience

Technological trend 7 – Powering a clean and sustainable future

Description

Green or renewable energy comes from natural sources that replenish themselves faster than they're used up. These sources include solar, wind, hydropower (dams), marine (ocean-based), geothermal (underground heat), and biomass (organic materials).

Resilience in energy systems is defined as the ability to withstand threats, both natural and man-made. Green energy sources can have significant benefits to resilience, including low reliance on fuel supply and smaller, decentralised power generation.

The ultimate vision for green energy is to achieve **a low- or zero-emission economy**. This drive towards green energy comes from the need to combat climate change, improve resilience, and advancements in renewable energy technology.

Key uncertainties

What will be the net effect of the transition to green energy on the economy and on employment? How can regulations help spread the use of green energy? How will the various renewable energy technologies develop in the future?

Relevance / Impact

- Decarbonisation and electrification of sectors like manufacturing and transportation.
- Mitigation of the most severe impacts of climate change and avoidance of damages.
- Decrease in the importance of fossil and strengthening of energy resilience.

Weak Signals (Proofs / Examples)

- Fusion energy experiment produces more energy than it consumes.
- Startup combining artificial intelligence, meteorology, and data analysis to forecast electricity production and demand.
- India and the UK establish a worldwide solar grid across 140 countries.

Human enhancement technologies

Technological trend 8 – Merging human and machine

Description

Human enhancement technologies can enhance human performance beyond the limit of biological potential and can include additional capabilities beyond those innate to humans.

They aim to enhance **physical** (e.g. strength, dexterity, speed and endurance), **psychological** (cognition, emotion and motivation), and **social performance** (perceive oneself as part of a group and act as part of the team).
Core human augmentation technologies include:

- **genetic engineering** (modification of reproductive cells or cells in the grown organism),
- **bioinformatics** (computation and analysis with large sets of biological data),
- **brain interfaces** (enabling direct communication between brain and computer), and **pharmaceuticals**.

Key uncertainties

How can we study the huge amount that is not known about the brain? How to balance the effects of enhancements against the risk of undesirable consequences? How can we deal with significant, legal, ethical, and social challenges?

Relevance / Impact

- Higher productivity through labour force enhancement and increase in quality and length of human lifespan.
- Reduced health care costs due to personalised medicine and more effective preventative interventions.
- Enabling rich human-machine interfacing and enhanced interpersonal experiences via brain interfacing.

Weak Signals (Proofs / Examples)

- Company develops a neurosurgery robot capable of implanting a low-powered implant that amplifies and digitises the brain signals for broadband speed streaming.
- Researchers develop a prosthetic arm that provides a two-way interface with the user's nervous system.
- Researchers enable paralysed patient to walk again by using two wireless implants to interpret brain signals into robotic movements.

Cyber technologies

Technological trend 9 – Protecting our increasingly digital living

Description

Cyberspace can be defined as the virtual space of all information technology systems linked at the data level on a global scale. **Cyber technology is the study of the hardware, software, services, data and connections** that are cyberspace. **Cybersecurity** focuses on protecting these elements from unintended or unauthorised access, change or destruction.

Cybersecurity technologies can be broken into **attacks and defences** (e.g. malware & attack technologies, forensics), **systems security** (e.g. cryptography, authentication & authorisation), **software and platform security** (e.g. secure coding and lifecycle security), and **infrastructure security** (e.g. network security, cyber-physical systems security).

Cyberspace is foreseen to expand in the future, as more and more virtual and physical objects, or even the human body (e.g. via brain interfaces) are added to it. The importance and sophistication of cybersecurity will also increase.

Key uncertainties

What will be the “strategic balance” between offensive and defensive cyber weapons? How will the integration of AI affect cybersecurity methods? What will be the effects of quantum cryptography and computing and at what timescales?

Relevance / Impact

- Cybersecurity technologies potentially enhance the development of other key technologies, by increasing trust in data and communications security.
- The cyber domain is becoming a field of conflict in an increasingly unstable geopolitical environment.
- Cyber-attacks on the infrastructure of the future could have devastating effects.

Weak Signals (Proofs / Examples)

- Development of a platform for the quick assessment of cyber risks for insurance purposes.
- The US government issues a „Space Policy Directive“ for cybersecurity in space.
- Researchers develop a method to evaluate cybersecurity strategies by analysing the probability of overcoming weaknesses and stealing secret information.

Digital communication

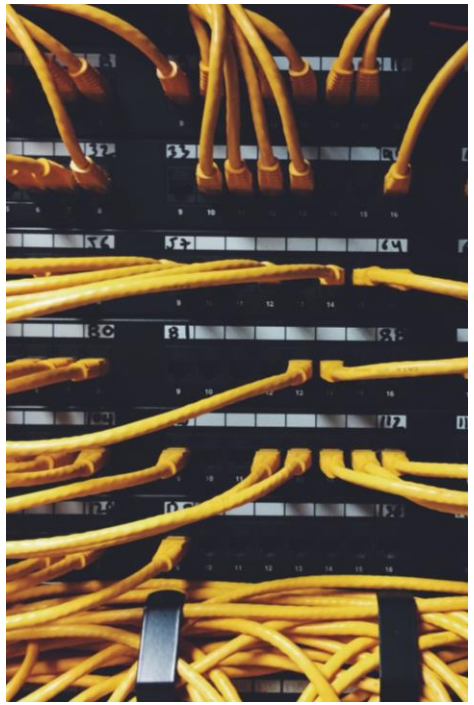
Technological trend 10 – Enhancing connectivity, enabling seamless communication globally

Description

Digital communication/connectivity encompasses digital networks, from mobile and fixed structures to the internet, including cables and satellites.

Connectivity technologies cover various types. These include **fibre optic networks**, which offer high throughput. **Wi-Fi 6** provides higher performance and security, making it suitable for industrial use. **5G/6G** mobile cellular networks are smart, reliable, scalable, and secure for various applications. **Low-power wide-area networks** are specifically designed for Internet of Things devices. **Low Earth orbit satellites** offer global coverage with relatively lower latency.

The future of digital connectivity will mainly focus on cloud computing and the Internet of Things. Cloud computing involves hosting applications on remote network servers. The Internet of Things connects everyday objects to the internet.



Key uncertainties

What use cases should be addressed by advanced connectivity methods (5G, 6G, space), and what use cases can be satisfied by more cost-efficient legacy approaches (e.g. 4G)? How will the capital intensiveness of some advanced connectivity methods (e.g. 5G, 6G, space) affect their economic viability?

Relevance / Impact

- Digital connectivity enables the Internet of Things, and cloud and edge computing.
- First internet access enabled for many globally due to new connectivity technologies.
- Self-driving connected vehicles could be enabled by high-quality network access, even in remote locations.

Weak Signals (Proofs / Examples)

- Startup introduces a thin, portable modem offering fast internet anywhere.
- Car and telecom industry equip vehicle models with 5G to enhance transmission speeds for improved software performance, navigation, and media streaming.
- Consortium to offer internet connectivity in rural USA and Brazil via spacecraft constellation.

Robotic and autonomous systems

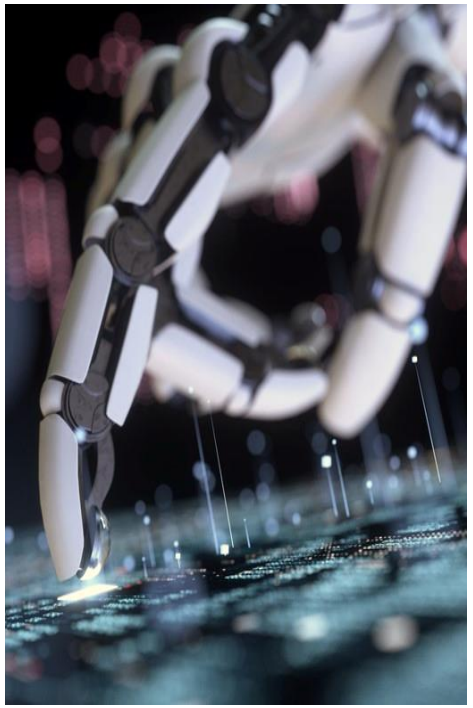
Technological trend 11 – Smart machines working for and with humans

Description

An **autonomous system** makes decisions based on the understanding of the world, itself, and the situation, responding to uncertainties. **Robotics** involves creating and developing these autonomous systems, which can range from being fully controlled by humans to operating independently.

Robotic and autonomous systems are designed to tackle tasks falling within the four D's of robotisation:
dull (repetitive and tiring), **dirty and dangerous** (humans at risk) and **dear** (where mistakes are costly).
Depending on the mission, these systems can operate with different levels of autonomy, considering factors like technical capabilities, legal considerations, and mission requirements.

The increasing growth of robotic and autonomous systems is driven by cheaper and smaller sensors, more agile, capable, small, and cheaper actuators (turn energy into physical motion), and advances in computing, autonomy and AI.



Key uncertainties

Will the necessary very high reliability be achieved for specific applications? What is the net impact that robotic and autonomous systems will have on employment? What is the net environmental impact of robotic and autonomous systems? How can we tackle the challenges of human-robot collaboration?

Relevance / Impact

- Reduced labour costs and increased flexibility in production, such as in manufacturing and agriculture.
- Reduced human error and risk to human life, such as in medical procedures.

Weak Signals (Proofs / Examples)

- A Company implements a trial system to assist with emergencies during flights.
- Startup creates and tests automated robots for building houses.
- Researchers develop and test autonomous robotic needles for medical use.

Megatrends overview

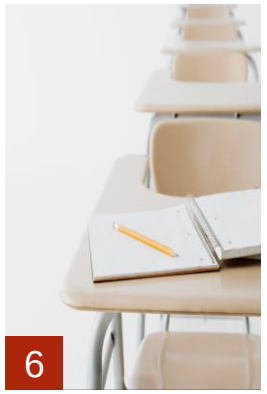
Aggravating resource scarcity

Changing nature of work

Changing security paradigm

Climate change and environmental degradation

Continuing urbanisation

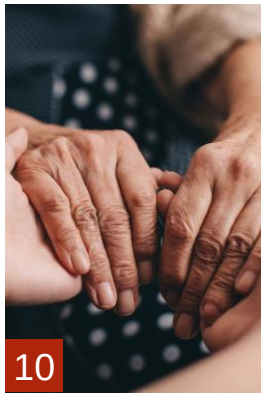


Diversification of education and learning

Widening inequalities

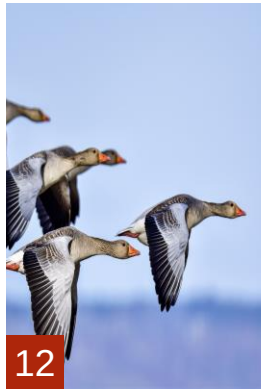
Expanding influence of East and South

Growing consumption



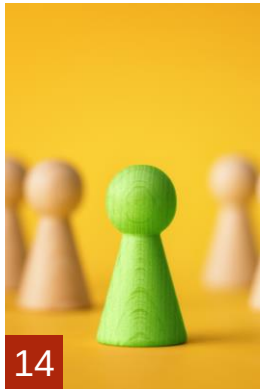
Increasing demographic imbalances

Increasing influence of new governing systems



Increasing significance of migration

Shifting health challenges



Diversity-aware society

Aggravating resource scarcity

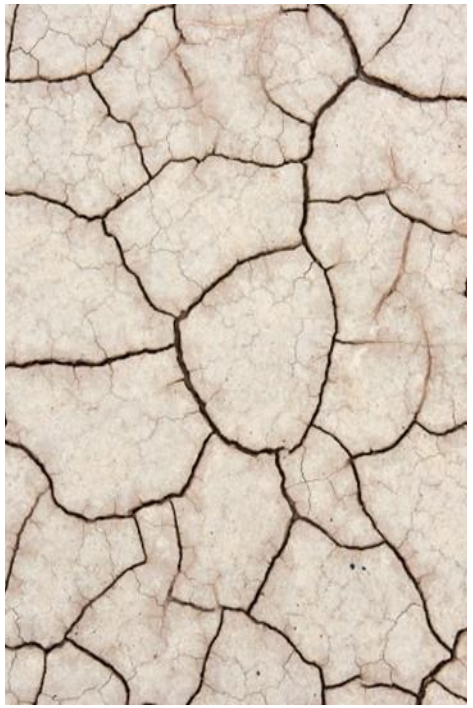
Megatrend 1 – Disconnect between human consumption and the planet's finite resources

Description

Demand for water, food, energy, land, and minerals is increasing significantly. This is causing **natural resources to become scarcer and more expensive**. This is due to several factors, including population growth, growing economies, and climate change.

The problems scarcity causes can be felt worldwide. These include **water shortages**, **unstable food access**, and **energy crises**. The consequences of resource scarcity are far-reaching and include environmental degradation, economic instability, and social unrest.

Addressing this megatrend requires a comprehensive approach. **Consumption behaviour change** must be encouraged. Innovative ways to manage resources more sustainably with the use of emerging technologies need to be established.



Key uncertainties

How will societal values evolve in response to escalating resource scarcity? What impact will technological advancements have on resource demand and availability? How will economic systems adapt to address the growing scarcity of resources? How will international governance structures evolve to manage resource challenges effectively?

Relevance / Impact

- Shifts in societal values from excess towards mindful consumption.
- Need for sustainable business models and use of innovative materials.
- Efforts to achieve energy independence and fair global resource distribution shape geopolitical strategies.

Weak Signals (Proofs / Examples)

- Rising costs of crucial resources like water, food, and energy cause challenges for businesses and consumers.
- Rising awareness among the public about the consequences of resource scarcity.
- Businesses are increasingly focusing on Environmental, Social, and Governance factors in their operations.
- State-initiated transformation towards renewable energy.

Changing nature of work

Megatrend 2 – Upskilling and reskilling for a technology-driven workplace

Description

The world of work is undergoing a thorough transformation. New generations, **digitally native and purpose-driven**, are entering the workforce, while older generations are extending their careers. The demographic shift is changing job markets, career paths, and organisational structures. This change is also influenced by technology, globalisation, and economic uncertainties.
The **future of work is not just digital, but also purposeful**. Workers increasingly seek careers that align with their values and contribute to a positive impact. Work is becoming more **flexible and spread out**. Remote work policies are changing how we understand jobs. The **increase in freelance or gig work** is blurring the lines between having a regular job and running a business.

The **skills gap** between employers' needs and workers' qualifications is widening. To stay competitive in a labour market that is technologically advancing, **continuous upskilling and reskilling** are necessary.

Key uncertainties

What role will societal attitudes play in embracing workplace automation? How fast will technology change jobs and needed skills? How will the gig economy affect income and businesses? How will remote work and advanced technology use in labour impact the environment? What policies can balance innovation with fair labour practices?

Relevance / Impact

- Altered expectations around work-life balance call for flexible, autonomous employment models.
- Technology shapes and creates new job positions and makes up- or reskilling a necessity.
- Negative impacts on labour market, state welfare system and tax revenues through the exchange of human labour for automation.

Weak Signals (Proofs / Examples)

- Change in remote work policies in firms and the growing demand from new generations entering the workforce.
- Growing investments in automatisation in major industries.
- Easy up- or reskilling of individuals with online learning platforms.
- Use of online platforms by individuals to offer freelance services in the sense of a gig economy.

Changing security paradigm

Megatrend 3 – Safeguarding tomorrow: Navigating the evolving security landscape

Description

The global security landscape is changing significantly. Previously focused on military threats between nations, it now includes **cyber threats**, **climate change-induced disasters**, and **terrorism**. With the increasing frequency of security-relevant events, the perception of security among the population decreases.

Military threats are becoming hybrid, employing varied tactics. Politically motivated **cyber-attacks are on the rise**, alongside an **increasing militarisation of space**.

Countries like China, Russia, and India are heavily investing in space programs, leading to more powerful players in space. Advanced technologies like artificial intelligence, big data analytics, quantum technologies, autonomous weapons, biotechnologies, and hypersonic glide vehicles are **transforming power structures and global relations**.

Key uncertainties

How will technological advancements shape the tactics used in warfare? How will economic shifts impact defence spending? What possible disasters will be induced by climate change in the future, and how can they be prevented? How do shifting alliances influence security strategies?

Relevance / Impact

- Adjustments in societal perceptions and values regarding security.
- Necessity of maintaining technological superiority and innovation in defence strategies.
- Need for industrial resilience and self-sufficiency to mitigate vulnerabilities.
- Reshape and reassessment of alliances and geopolitical strategies.

Weak Signals (Proofs / Examples)

- State and non-state actors are actively advanced military technologies with increasing spending.
- Technology used in both, space exploration and military, points to blurred lines between civil and defence sectors.
- Utilisation of hybrid warfare tactics in the war in Ukraine.
- Almost daily incidents of cyberattacks on governmental and non-governmental entities.

Climate change and environmental degradation

Megatrend 4 – Earth on the brink, from crisis to transformation

Description

Greenhouse gas emissions and global temperatures are rising. Urgent action is needed to **mitigate the harmful impacts of climate change**. The broad spectrum of challenges includes **biodiversity loss and destroying living spaces**. It also covers **extreme weather events** and resulting **resource scarcity**.

Societal attitudes are changing because of these challenges. People now want **eco-friendly products**. They are also encouraged to make **green investments**. However, uncertainties remain regarding how well mitigation efforts work and **how severe future climate impacts will be**. These unknowns make achieving environmental resilience challenging.

Policymakers face the challenge of balancing immediate economic needs with future sustainability goals. To do this, they are using tools like **carbon pricing** and **emissions trading**. These tools are designed to encourage companies to reduce their emissions. They also aim to promote investments in sustainable production and energy supply.

Key uncertainties

Can societal values and norms evolve to prioritise sustainability? What technologies emerge to address environmental challenges? What implications has a low-carbon economy on businesses? How do geopolitical tensions impact international cooperation on climate action?

Relevance / Impact

- Economic aftermaths of transitioning to a sustainable, low-carbon economy.
- Social shifts towards eco-conscious consumer behaviour and green investments.
- Political challenges in implementing effective climate policies.
- Environmental degradation and loss of biodiversity threaten ecosystem health and human well-being.

Weak Signals (Proofs / Examples)

- Rising frequency of extreme weather events.
- Adoption of renewable energy sources like solar and wind power on a global scale.
- Implementation of carbon pricing mechanisms and emissions trading schemes in various countries.
- Development and deployment of innovative technologies for carbon capture and sustainable agriculture.

Continuing urbanisation

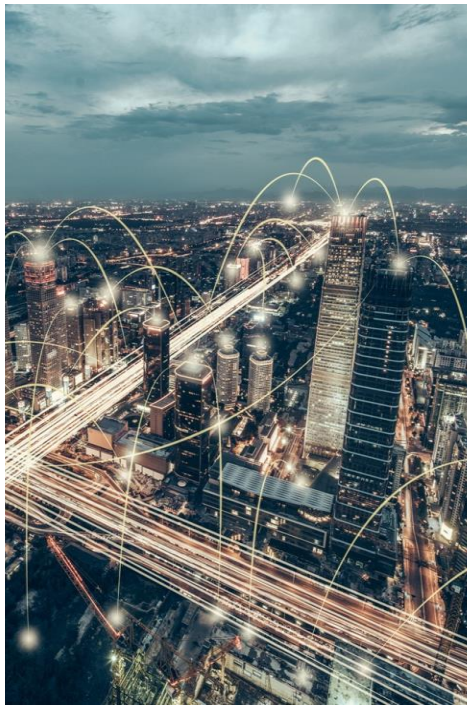
Megatrend 5 – Cityscape shift, from concrete jungles to sustainable hubs

Description

Urbanisation is the ongoing **migration of people from rural to urban areas** in search of better opportunities. This movement is transforming the global landscape. As cities continue to grow and evolve, they become **epicentres** of economic activity, innovation, and cultural exchange.

However, rapid urbanisation also poses significant challenges, including environmental degradation, social inequalities, and infrastructural strain. Cities need to **make housing affordable**, **reduce traffic jams** and ensure everyone can **access vital services**.

Digitalisation and technological advancements offer opportunities for sustainable urban development, enabling **data-driven decision-making** and **citizen engagement**.



Key uncertainties

Can technological innovations address environmental pressures and socioeconomic disparities? How will economic factors impact the development and affordability of urban infrastructure? How to prioritise sustainability and resilience amidst rapid urban growth?

Relevance / Impact

- Clean energy and resilient infrastructure promote economic growth and job creation in cities.
- Smart city technologies can optimise resource use, improve service delivery, and enhance disaster preparedness.
- Green spaces, and the availability of healthcare and education in cities unlock higher quality of life and social mobility.

Weak Signals (Proofs / Examples)

- Community-driven co-housing projects offering affordable and sustainable living options.
- Smart city pilot projects testing innovative solutions for mobility, energy management and waste reduction.
- Sharing economy platforms promoting resource optimisation and shared consumption in cities.

Diversification of education and learning

Megatrend 6 – Unleashing learning potential: The traditional concept of education needs tutoring

Description

The diversification of education and learning megatrend highlights how education changes. It responds to **new generations' needs and quickly advancing technology**. This megatrend redefines the purpose and structure of **21st-century education**.

Traditional educational models are shifting towards more **personalised**, **flexible**, and **lifelong learning experiences**. This covers several areas. First, there is an increase in **informal and peer-to-peer learning**. Second, technology is becoming a bigger part of education. **Personalised learning** services fuelled by artificial intelligence and new possibilities of Virtual Reality and Augmented Reality are on the rise.

Society understands that learning new skills continuously is important. So, educational institutions are changing. They are becoming **centres for learning** instead of only knowledge providers.

Key uncertainties

What are the societal and cultural norms' impact on new educational paradigms? How is the future of learning shaped by technology? What are the economic challenges from education diversification, are disparities addressed? What are the required political policies/regulations for evolving education?

Relevance / Impact

- Fosters inclusivity and empowers individuals to pursue personalised learning paths.
- Addresses the demand for adaptable skills in a rapidly evolving job market.
- Promotes sustainability and global citizenship through environmental education initiatives.
- Requires policy frameworks that support lifelong learning and educational equity.

Weak Signals (Proofs / Examples)

- Rise of alternative education models, such as peer-to-peer learning platforms and massive open online courses.
- Increasing emphasis on socioemotional learning in educational curricula.
- Adoption of blended learning approaches combining online or immersion and traditional classroom methods.

Widening inequalities

Megatrend 7 – Bridging the gap: Socio-Economic disparities

Description

Widening inequalities highlight the **growing gap between the affluent and marginalised segments of society**, despite efforts to alleviate poverty.

These differences appear in many areas of life. They include education, employment, healthcare, and how wealth is distributed. Gender, ethnicity, social class, and where a person lives greatly affect their chances and resources. The COVID-19 pandemic has exacerbated existing inequalities, underscoring the urgency for equitable policies and interventions. **Tackling structural barriers is crucial**. It is also important to encourage social cohesion. Additionally, inclusive economic growth must be fostered. These steps are key to fighting growing inequalities.

Failure to address these disparities could jeopardise societal stability and hinder sustainable development.

Key uncertainties

How will attitudes towards inequality evolve, and will action be taken to address it? Which technology advancements worsen/improve access to wealth, education and healthcare? Which economic policies could lessen salary inequalities? How does climate change impact resource inequalities and vulnerability? How will political efforts reduce inequalities?

Relevance / Impact

- Inequalities breed political unrest and instability.
- Economic growth suffers from barriers to marginalised groups in education and jobs.
- Unequal healthcare access worsens health disparities.
- Environmental degradation hits vulnerable communities the hardest.

Weak Signals (Proofs / Examples)

- Grassroots movements for social justice and equity.
- Growing public discourse on income inequality and wealth distribution.
- Corporate efforts on diversity and inclusion, like gender pay gap reporting and diversity quotas.
- Policy experiments tackling systemic disparities, like universal basic income trials and progressive taxation.

Expanding influence of East and South

Megatrend 8 – The rising economic powerhouses: Shifting global dynamics

Description

East and South are becoming more influential in the world economy. This marks a big change. Economic power is moving from Western countries and Japan to rising areas. These areas include **Asia, Africa, and South America**.

China, India, Indonesia, and Brazil are experiencing **strong economic growth**. This growth comes from industrialisation, technological progress, and changes in demographic trends. These developments **reshape global trade patterns**, investment flows, and geopolitical alliances.

Asia is expected to generate **more than half of the world's economic output by 2050**. This highlights the emergence of **new economic powerhouses** and a broader variety of global markets. New trade unions, like **BRICS**, try to counter the power of established Western economic forces. This leads to geopolitical tensions and difficulties in finding the right balance between competition and cooperation across country borders.

Key uncertainties

How will countries growing in influence affect societies and global trends? Who will win the technology innovation race? What is the impact of environmental challenges on emerging market growth? How will new trading unions impact economic development? What are policies for inclusive growth and reduced disparities?

Relevance / Impact

- Reshape of global economic power, creating new economic leaders.
- Altering trade patterns and boosting regional collaboration.
- Promoting innovation and infrastructure growth in emerging markets.
- Shaping and disrupting geopolitical alliances with implications for global governance.

Weak Signals (Proofs / Examples)

- Rising foreign direct investment in emerging markets, especially in infrastructure and technology.
- Increased global demand for goods and services from Asia, Africa, and South America.
- Growth of innovation hubs and tech startups boosts entrepreneurship and job creation in emerging economies.
- Growth of regional trade agreements and economic blocs, promoting intra-regional cooperation and integration.

Growing consumption

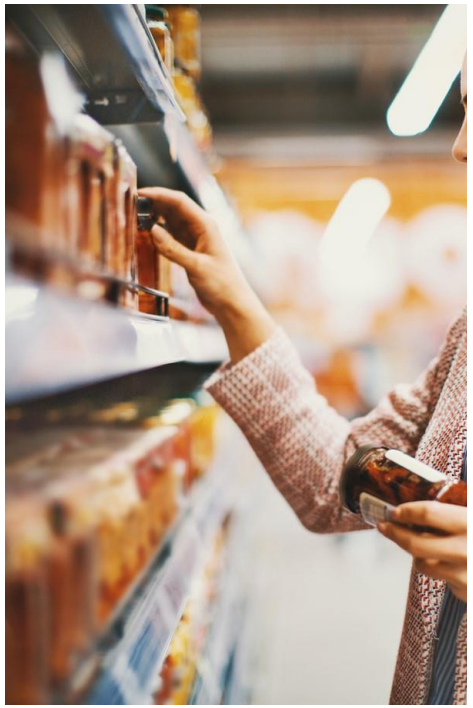
Megatrend 9 – From clicks to conscious choices

Description

Growing consumption reflects **the escalating consumption globally**. Driving factors are changes in middle-class populations, technological advancements, and shifting societal values towards sustainability. It also covers a rise in digital shopping experiences. These experiences are both personalised and immersive.

Consumers, particularly in affluent regions, are seeking **eco-friendly alternatives**. They are closely examining the environmental and social effects of what they buy. Resulting business models like shared economy, circular economy and upcycling gain in traction. Moreover, the **digital transformation of commerce** is reshaping the way businesses interact with customers, offering convenience and personalisation.

These shifts are poised to **impact traditional business models** and regulatory frameworks. It is questionable if the change in consumption behaviour mitigates the effects of the rising middle-class population in emerging countries.



Key uncertainties

How will changing societal values influence consumption? What impacts will technological advances have on (sustainable) consumption? What economic factors will impact purchasing power and spending habits? Are increasing consumption and sustainability incompatible? How will geopolitical dynamics affect supply chains and trade contracts?

Relevance / Impact

- Drives innovation and economic growth of green industries, as well as shared- and circular economy possibly mitigating resource depletion.
- Impact on the need for global supply chains and trade agreements.
- Steadily rising consumption, with no turning point in sight.

Weak Signals (Proofs / Examples)

- Rise of eco-friendly brands and products in the market, by growing consumer demand for sustainable and ethically sourced goods.
- Adoption of shared and circular economy by businesses and governments.
- Shift towards purpose-driven marketing, deep engagement strategies, personalised experiences and immersive consumer interactions.

Increasing demographic imbalances

Megatrend 10 – The demographic divide: Balancing growth and decline

Description

As the world's population burgeons towards an estimated 9.7 billion by 2050, significant **demographic imbalances** are becoming increasingly apparent.

Rapid population growth, notably in Sub-Saharan Africa, contrasts starkly with stagnation or even decline in many developed nations. This **shift in demographics** reflects intricate interplays between factors such as fertility rates, mortality rates, migration patterns, and ageing populations. Such demographic disparities are poised to **shape economies**, **societies**, and **geopolitical landscapes** in profound ways.

These challenges could lead to issues such as **declining youth in the workforce**, **sustainability concerns for pension- and healthcare systems**, **reduced family support for the elderly**, and **increased political influence of older demographics**.

Key uncertainties

Will healthcare technology mitigate effects of ageing populations? How do ageing patterns affect labour markets? How will economic policies handle regional population differences and effects? What are the political effects of demographic imbalances on international relations and migration policies?

Relevance / Impact

- Use of new technologies for the healthcare of the ageing population.
- Ageing populations strain healthcare systems and social welfare programs.
- Demographic shifts impact consumer markets and the age composition of the workforce.

Weak Signals (Proofs / Examples)

- Emerging discussions on pension reform and healthcare financing.
- Increasing interest in workforce diversity and intergenerational equity.
- Shifts in migration policies in ageing countries highlight the need for young talents in the labour force.
- Technological innovations in healthcare and eldercare services.

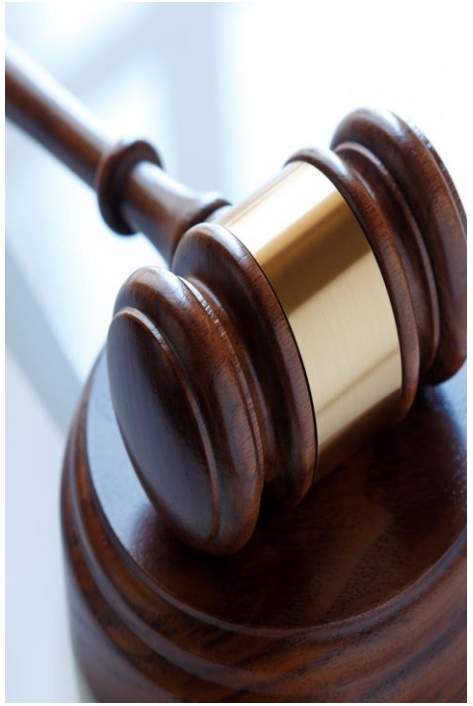
Increasing influence of new governing systems

Megatrend 11 – From top-down to grassroots: Empowering diverse voices

Description

In today's rapidly evolving world, traditional governance structures are undergoing a profound transformation. Non-state actors, fuelled by global awareness and enabled by digital platforms, are exerting **increasing influence on decision-making processes**. This shift is leading to the emergence of **multi-layered governing systems**, characterised by a diverse array of stakeholders and participatory mechanisms. The rise of **social media** has further disrupted conventional channels of communication, amplified voices and facilitated **grassroots engagement** in governance.

However, alongside these opportunities come challenges, including the **erosion of trust** in traditional institutions and the **polarisation of society**. As technology continues to advance, questions arise regarding the role of automation in decision-making and its implications for **accountability and transparency**.
Nevertheless, the trend towards new governing paradigms offers the potential for more inclusive, responsive, and effective forms of governance in the future.



Key uncertainties

Will participatory governance help to overcome socio-economic disparities and environmental degradation? Will technology enable automatic decision-making, e.g. without human involvement? What is the impact on industries reliant on old governance structures? What political dynamics shape emerging governance frameworks?

Relevance / Impact

- Empowerment of non-state actors and grassroots movements in decision-making processes.
- Disruption of traditional media and communication channels by social media platforms.
- Challenges to the legitimacy and authority of established governance institutions.
- Opportunities for greater transparency and accountability through digital technologies.

Weak Signals (Proofs / Examples)

- Increasing use of digital platforms for citizen engagement and activism.
- Rise of alternative forms of governance at local and regional levels.
- Growing demand for participatory democracy and collective intelligence approaches.
- Shifts in media consumption patterns towards online and social media platforms.

Increasing significance of migration

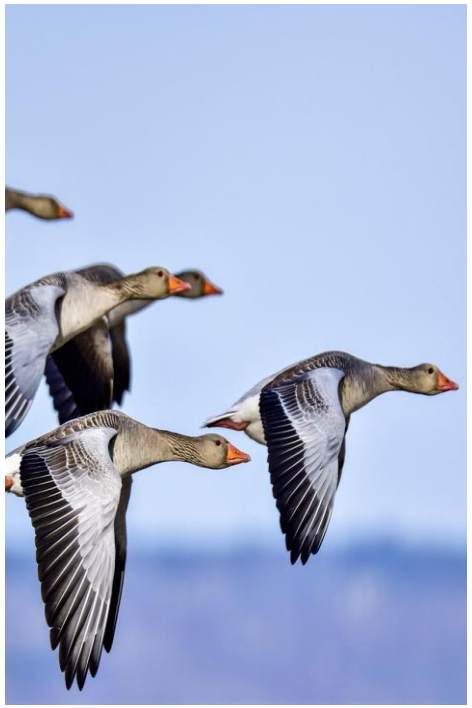
Megatrend 12 – A world on the move: From displacement to integration

Description

Migration, the movement of people across borders, has emerged as a pivotal societal and political phenomenon in an interconnected world. By 2020, over 281 million individuals were residing outside their country of birth, reflecting a significant increase since 1990.

This trend encompasses not only voluntary migration but also includes millions displaced across borders due to conflict and persecution. Migration dynamics are shaped by a myriad of factors, including **economic disparities**, **social aspirations**, and **geopolitical tensions**.

The impact of migration extends beyond demographic shifts, influencing **cultural integration**, **labour markets**, and **political discourse**. However, managing migration poses complex challenges. These vary from **border security** to **social cohesion**, requiring comprehensive and inclusive approaches.



Key uncertainties

How to handle cultural integration in diverse societies? What is the role of technology in shaping migration patterns? What are the economic implications of labour migration for both sending and receiving countries? How will climate change impact migration dynamics? What is the influence of political ideologies on migration policies?

Relevance / Impact

- Migration shapes cultural diversity and challenges social norms within host societies.
- Effects on labour markets, economic growth, and welfare systems in sender and receiver nations.
- Climate change contributes to displacement.
- Migration policies reflect political ideologies and international relations.
- Solving migration issues demands comprehensive and inclusive governance and cooperation.

Weak Signals (Proofs / Examples)

- Increasing global mobility and migration flows due to geopolitical events and humanitarian crisis.
- Shifts in public perceptions towards migration and migrants, as well as border control reintroduction.
- Technological advancements facilitating communication, movement, but also surveillance.

Shifting health challenges

Megatrend 13 – From viral to vital: Adapting to the new norms of health challenges

Description

Health challenges are undergoing a significant shift, influenced by a combination of factors such as **advances in science**, **improved living standards**, and **environmental changes**.

Infectious diseases, once dominant, have been mitigated, but **new health burdens emerge** from unhealthy lifestyles, pollution, and other anthropogenic causes. The **ageing population**, coupled with **non-communicable diseases** like cancer and mental health issues, pose new complexities to global health. Additionally, the COVID-19 pandemic highlighted the need for better preparedness and response to emerging health threats.

Digitalisation and **personalised medicine** offer promising solutions but also raise questions about data privacy and accessibility. Advances in **CRISPR-Cas9 gene editing** could enhance humans to be unaffected by specific incurable diseases. **Nanomedicines** could autonomously target disease-relieving effects only where it is necessary.

Key uncertainties

How will societies react in the face of possible outbreaks of diseases? What ethical issues arise with use of technology in healthcare? What economic disparities will emerge due to uneven healthcare access? How does environmental decline affect human health? How will governments handle global health management amid geopolitical tensions?

Relevance / Impact

- Increasing healthcare costs due to the rising burden of non-communicable diseases.
- Challenges in healthcare infrastructure and workforce management.
- Heightened awareness of environmental factors influencing health.
- Need for international collaboration and policy coordination to address global health challenges.

Weak Signals (Proofs / Examples)

- Rising prevalence of obesity and mental health disorders.
- Emergence of new infectious diseases and antimicrobial resistance.
- Technological innovations in telemedicine, wearable devices, and AI diagnostics.
- Growing public interest in holistic approaches to health, e.g. physical, mental, and emotional aspects.

Diversity-aware society

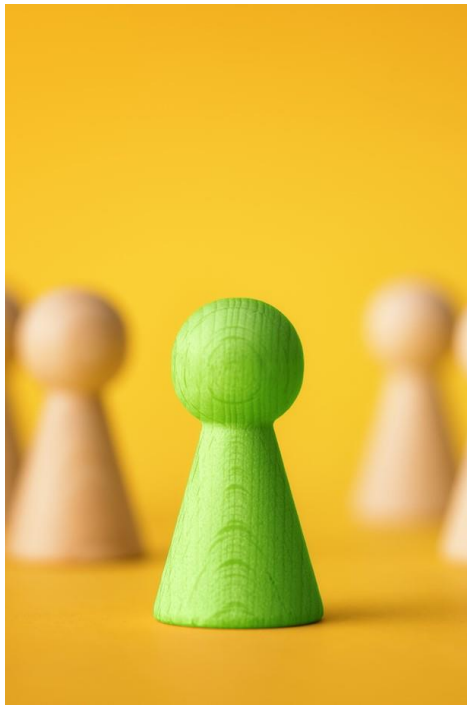
Megatrend 14 – A new era of social awareness

Description

Diversity-awareness indicates a change in society. This change means more people are speaking up. They understand social problems better and support groups with less power.

Fuelled by digital connectivity and global awareness, individuals are **asserting their identities and challenging traditional norms**. This megatrend is characterised by a growing emphasis on authenticity, inclusivity, and social justice. From grassroots activism to corporate diversity initiatives, woke culture is reshaping societal values and power dynamics. It is particularly prevalent among younger generations who prioritise empathy, equity, and social responsibility. However, the **spread of misinformation** and echo chambers challenge the authenticity of online activism.

This trend affects many areas of life. These areas include education, business practices, and governance structures. It helps create a fairer and more inclusive society.



Key uncertainties

How will political polarisation impact the progression of diversity-aware culture? How will technological advancements influence the dissemination of woke ideologies? Will diversity-aware branding lead to genuine change, or will it be perceived as superficial? How will diversity-aware culture intersect with environmental activism?

Relevance / Impact

- Social media platforms amplify marginalised voices and foster community-building.
- Businesses embracing diversity could experience improved innovation and consumer trust.
- Embracing diversity fosters social cohesion and challenges discriminatory norms.
- Individualism of opinion but also opinion-making.

Weak Signals (Proofs / Examples)

- Increased representation of marginalised groups in mainstream media and entertainment.
- Grassroots activism and social movements advocating for systemic change.
- Generation Z's embrace of identity politics and social justice causes.
- Cultural shifts towards inclusivity and acceptance of diverse perspectives.