TRANSFORMATIVE TECHNOLOGIES FOR PLANETARY HEALTH IN 2040

POLITECNICO
MILANO 1863

TECHNOLOGY FORESIGHT

Foreword

Which decisions will help safeguard health by 2040? Starting from this question, the Technology Foresight team at the Politecnico di Milano has undertaken a three-year research programme aimed at exploring the most disruptive technologies, capable of profoundly redefining the monitoring and promotion of health.

Now entering its final phase, this work focuses on identifying the key technologies that can enhance the health of the planet over a time horizon extending to 2040. Using foresight methodology, strategically relevant visions have emerged. Examining various future scenarios has highlighted the key factors necessary to build a resilient ecosystem, capable of addressing emerging challenges and guiding change.

Rebalancing the human-nature relationship is key to advancing global health and long-term planetary resilience.

Donatella Sciuto
Rector, Politecnico di Milano

TAKE-HOME MESSAGES

1 **Environments are health infrastructures**
The places we inhabit should be recognised as primary health infrastructure, shaping lifestyles, preventing disease, and hosting new models of care. From urban design to ecosystem restoration, space itself becomes a preventive and therapeutic resource. Healing the planet and healing people are increasingly one and the same act.

2 **Effectiveness requires scale**
Innovative solutions are emerging at the local level but remain fragmented and limited in reach. The real challenge ahead is not inventing new models but scaling up what already works on a global level. What remains local stays marginal; what scales up becomes transformative.

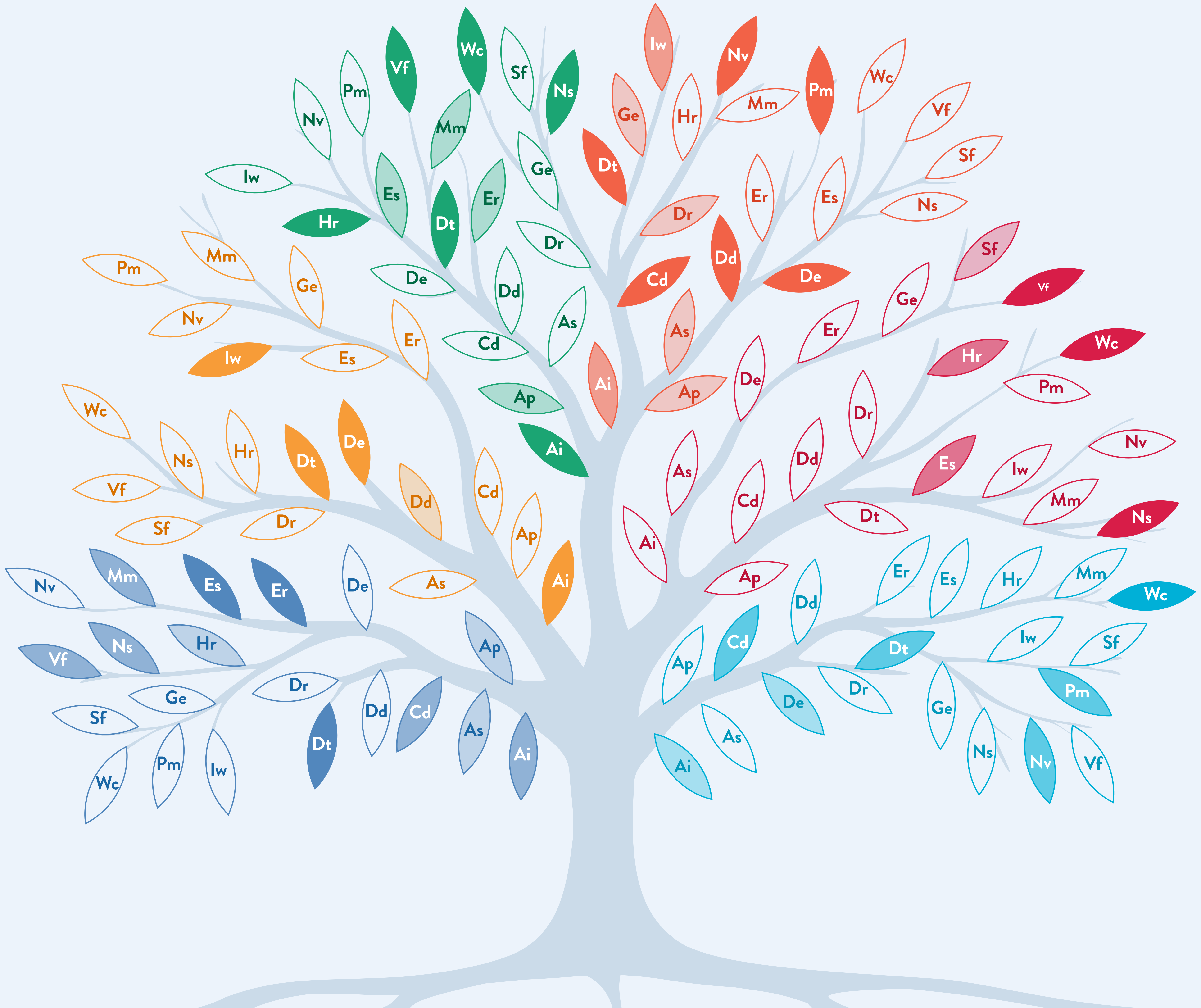
3 **Less impact, more impact?**
We have mistaken short-term efficiency for sustainability. The future demands a novel by-design paradigm, where innovations are developed with an awareness of their long-term consequences and broad-spectrum impacts beyond current understandings of sustainability. Systems and processes should adopt a life-cycle perspective, ensuring the efficient use of non-renewable resources while transforming waste and byproducts into meaningful outputs. Nothing should exist the system without generating value, for the planet and the people who inhabit it.

TRANSFORMATIVE TECHNOLOGIES FOR PLANETARY HEALTH IN 2040

STEEP Forces, Technologies and Insights

TECHNOLOGIES

- **Ai** Ambient intelligence sensors
- **Ap** Artificial photosynthesis
- **As** Agrophotovoltaic system
- **Cd** Carbon dioxide removal
- **Dd** DNA/RNA discovery
- **De** Data-driven epidemiology
- **Dr** Drones
- **Dt** Digital twin/Modelling
- **Er** Energy recovery
- **Es** Energy storage systems
- **Ge** Genetic engineering
- **Hr** Habitat restoration
- **Iw** Implantable/Wearable devices
- **Mm** Metamaterials
- **Ns** Nature-based solutions
- **Nv** Next-generation vaccines
- **Pm** Plastic metabolisation
- **Sf** Synthetic food
- **Vf** Vertical farming
- **Wc** Walkable city



INSIGHTS

- The materiality of digital health
- From WEARables to AWAREables
- Urban equiA(c)tion: health as infrastructure
- Plan(et) for health
- Health commons
- From ego-systems to eco-systems

HOW TO READ IT

Technologies

Fill style: Insight correlation strength

Weak · Moderate · High · Strong

STEEP Forces

Size: Expected impact

LOW IMPACT

HIGH IMPACT

STEEP FORCES

Social
Ageing, Non-communicable diseases, Mental health, Lifestyles, Deepening disparities, Demographic changes, Beyond gender, Migrations, Work from everywhere, Do it yourself

Technological
Med(AI)cine, Autonomous systems, Hyper-connected, Human enhancement, Extended reality, Robotics, Digital twin, Cryonics, Genetic control, Avatars

Environmental
Pandemics, Antimicrobial resistance, Global climate changes, Extreme events, Environmental degradation, Permafrost melting, Pollution, Food waste, Circular economy, Biodiversity loss

Economic
Privatisation, E-commerce, Cost of living increase, More prevention, less cure, Insurance market players, (Un)predictable instability, New spaces, new relations, Tech giants' pervasiveness, Data exploitation, Lack of skilled workers

Political
Security, Collapse of democracy, Welfare, (Trans)national identities, Information and connection, Geopolitical competition, Nuclear paths, Global commons, The rise of ethical questions, States like silos

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TECHNOLOGY FORESIGHT

Introduction

Health is increasingly approached from a holistic perspective, highlighting the deep interconnections among human, animal and environmental dimensions. In this context, health is no longer seen solely as a stand-alone element, but as a strategic factor in building resilient, sustainable and inclusive ecosystems. This shift reflects a growing awareness that safeguarding health requires addressing diverse and interconnected challenges.

The Politecnico di Milano has conducted an one-year foresight study involving 20 POLIMI researchers and professionals from the healthcare and societal sectors.

This research examines emerging technologies for the health of the planet across the fields of environmental management, infrastructure, materials, and energy resources. The aim is to develop a shared, multidisciplinary understanding of disruptive technologies affecting planetary and, consequently, our health, focusing on their potential while considering their possible impacts.

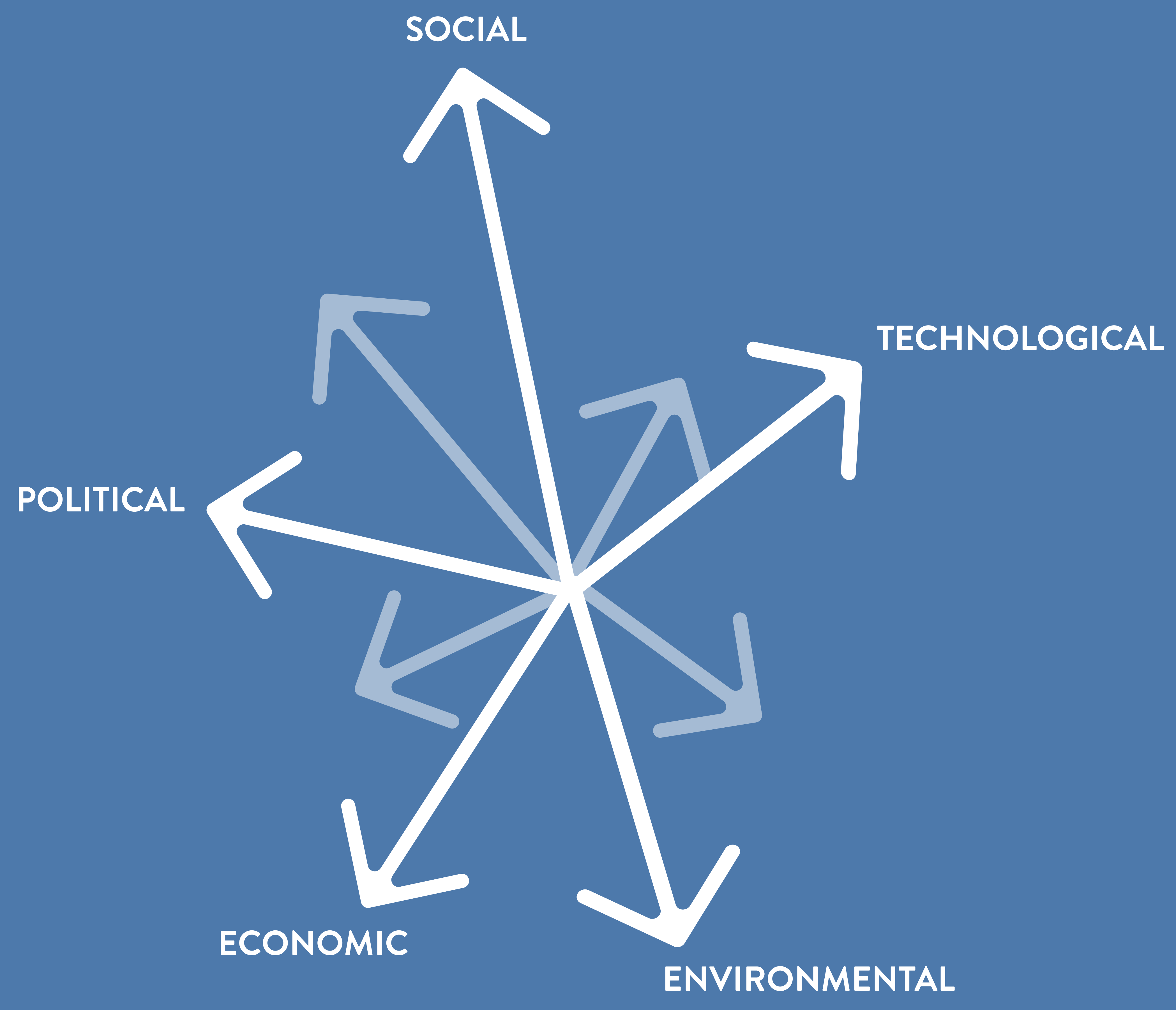
An integrated methodology has been employed, combining literature review, interviews, workshops, and surveys. Alternative future scenarios have been explored to identify opportunities, requirements, risks, and potential impacts.

This report summarises the main findings, presenting key technologies and insights to stimulate critical reflection, guide future research, and support policymaking.

What are STEEP forces

STEEP (Social, Technological, Environmental, Economic, Political) forces are typically used to gather a coherent broad vision of the past, present, and future evolution of the overall context, to try to make sense of the multitude of available data, to keep an open perspective on what is going on.

STEEP forces refer to trends that are “stable enough” to shape our future and general enough not to relate to the specific sphere of foresight. However, in this study, the ones that are expected to affect the future of health are highlighted and have been made available to generate the insights on the impact of relevant emerging technologies.



STEEP forces

SOCIAL

AGEING · DEMOGRAPHIC CHANGES · MENTAL HEALTH · **LIFESTYLES** · **DEEPENING DISPARITIES** · NON-COMMUNICABLE DISEASES · BEYOND GENDER · MIGRATIONS · WORK FROM EVERYWHERE · DO IT YOURSELF

TECHNOLOGICAL

MED(AI)CINE · AUTONOMOUS SYSTEMS · HYPER-CONNECTED · HUMAN ENHANCEMENT · EXTENDED REALITY · ROBOTICS · **DIGITAL TWIN** · CRYONICS · GENETIC CONTROL

ENVIRONMENTAL

PANDEMICS · ANTIMICROBIAL RESISTANCE · **GLOBAL CLIMATE CHANGES** · **EXTREME EVENTS** · **ENVIRONMENTAL DEGRADATION** · PERMAFROST MELTING · **POLLUTION** · FOOD WASTE · **CIRCULAR ECONOMY** · **BIODIVERSITY LOSS**

ECONOMIC

PRIVATISATION · MORE PREVENTION, LESS CURE · TECH GIANTS' PERVASIVENESS · NEW SPACES, NEW RELATIONS · (UN)PREDICTABLE INSTABILITY · INSURANCE MARKET PLAYERS · **DATA EXPOITATION** · E-COMMERCE · COST OF LIVING INCREASE · LACK OF SKILLED WORKERS

POLITICAL

SECURITY · COLLAPSE OF DEMOCRACY · WELFARE · (TRANS)NATIONAL IDENTITIES · **INFORMATION & CONNECTION** · GEOPOLITICAL COMPETITION · NUCLEAR PATHS · GLOBAL COMMONS · THE RISE OF ETHICAL QUESTIONS · STATES LIKE SILOS

The most relevant STEEP forces emerged from the participants' contributions are highlighted.

Technologies

1. **MAPPING THE LANDSCAPE: DESK RESEARCH ON THE FUTURE OF PLANETARY HEALTH** From foresight studies and scientific publications, we selected the most recurrent technologies and innovations for their transformative potential.

2. **INDIVIDUAL INTERVIEWS** We carried out an extensive assessment of a set of 20 technologies.

3. **WORKSHOPS AND SURVEY** Through group activities and a survey, the main emerging technologies were identified.

4. **TOP 9 TECHNOLOGIES** We reported the 9 technologies most closely connected to expected transformations.

WEARABLE & SENSORS

- **AMBIENT INTELLIGENCE SENSORS**
- **IMPLANTABLE/WEARABLE DEVICES**

REGENERATIVE SYSTEMS

- **PLASTIC METABOLISATION**
- NATURE-BASED SOLUTIONS
- **CARBON DIOXIDE REMOVAL**
- ARTIFICIAL PHOTOSYNTHESIS
- METAMATERIALS
- HABITAT RESTORATION

SMART CITY

- DRONES
- **WALKABLE CITY**
- VERTICAL FARMING

ENERGY SYSTEMS

- AGROPHOTOVOLTAIC SYSTEMS
- ENERGY RECOVERY
- **ENERGY STORAGE SYSTEMS**

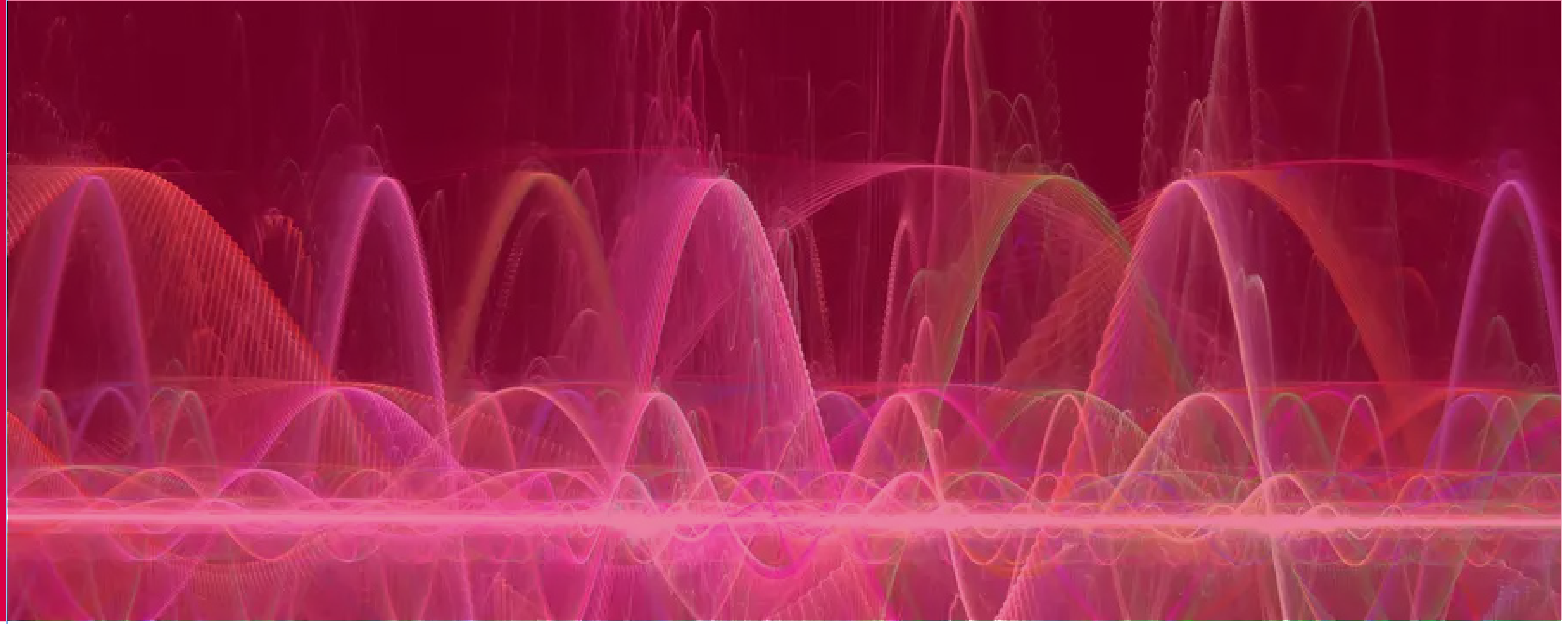
GENETICS

- GENETIC ENGINEERING
- SYNTHETIC FOOD
- **DNA/RNA DISCOVERY**
- NEXT-GENERATION VACCINES

DIGITAL

- **DIGITAL TWIN/MODELLING**
- **DATA-DRIVEN EPIDEMIOLOGY**

The process leading to the most relevant technologies and innovations expected to shape the future of planetary health.



AMBIENT INTELLIGENCE SENSORS

Ambient Intelligence (AmI) sensors are technologies designed to detect environmental and physiological data. They are deployed within or around the monitored environment and its animals, operating through sensors supported by specific processing and communication systems.
AmI sensors typically use transducers and transceivers to capture, process, and transmit the collected information. These systems aim to interpret large volumes of data and to adapt the environment both responsively and predictively, enabling the effective understanding of contextual information.
An AmI system is generally characterised by context awareness, personalisation, predictive capability, adaptability, ubiquity, and transparency.
For example, AmI technology can be used to monitor air quality, biodiversity loss, and pollution levels, supporting sustainable resource management and preventing environmental degradation. It can also assist different professionals in their daily work by providing innovative tools for communication and monitoring.

OPPORTUNITIES

→ Use of environmental data to support climate adaptation strategies
→ A more equitable distribution of resources

REQUIREMENTS

→ Data interoperability
→ Clear rules for data management

RISKS

→ High costs and technologies not accessible to all
→ Cybersecurity vulnerabilities

IMPACTS

→ More effective resource management using continuous feedback

EXAMPLES OF POTENTIAL FIELDS OF APPLICATION

Monitoring urban air quality

Sensors powered by radio waves and light

Precision agriculture systems to increase crop yields

CARBON DIOXIDE REMOVAL

Carbon Dioxide Removal (CDR) technologies remove carbon dioxide (CO_2) from the atmosphere and ensure its long-term storage. They capture CO_2 using chemical filters or absorbent materials, while fans and pumps circulate air through the capture systems. The captured CO_2 is transported via pipes and valves to storage or conversion sites, where chemical reactors allow its storage or transformation. Finally, sensors and transducers monitor the process, while software and algorithms optimise its operation and detect any anomalies.
CDR technologies are characterised by large-scale carbon sequestration, permanence of storage, and adaptability to different ecosystems.
They differ according to the CO_2 capture processes employed and the storage methods adopted. For example, in Direct Air Capture systems, air passes through filters or chemical solvents, and the captured CO_2 is subsequently compressed and either stored in deep geological formations or converted into stable substances. In contrast, Biochar technologies convert organic matter into charcoal for soil storage.
CDR technologies support long-term environmental sustainability by limiting the rise in global temperatures and can be applied in industrial, agricultural, and marine environments.

OPPORTUNITIES

→ Alternative to conventional fossil fuels

REQUIREMENTS

→ Site selection and characterizations

RISKS

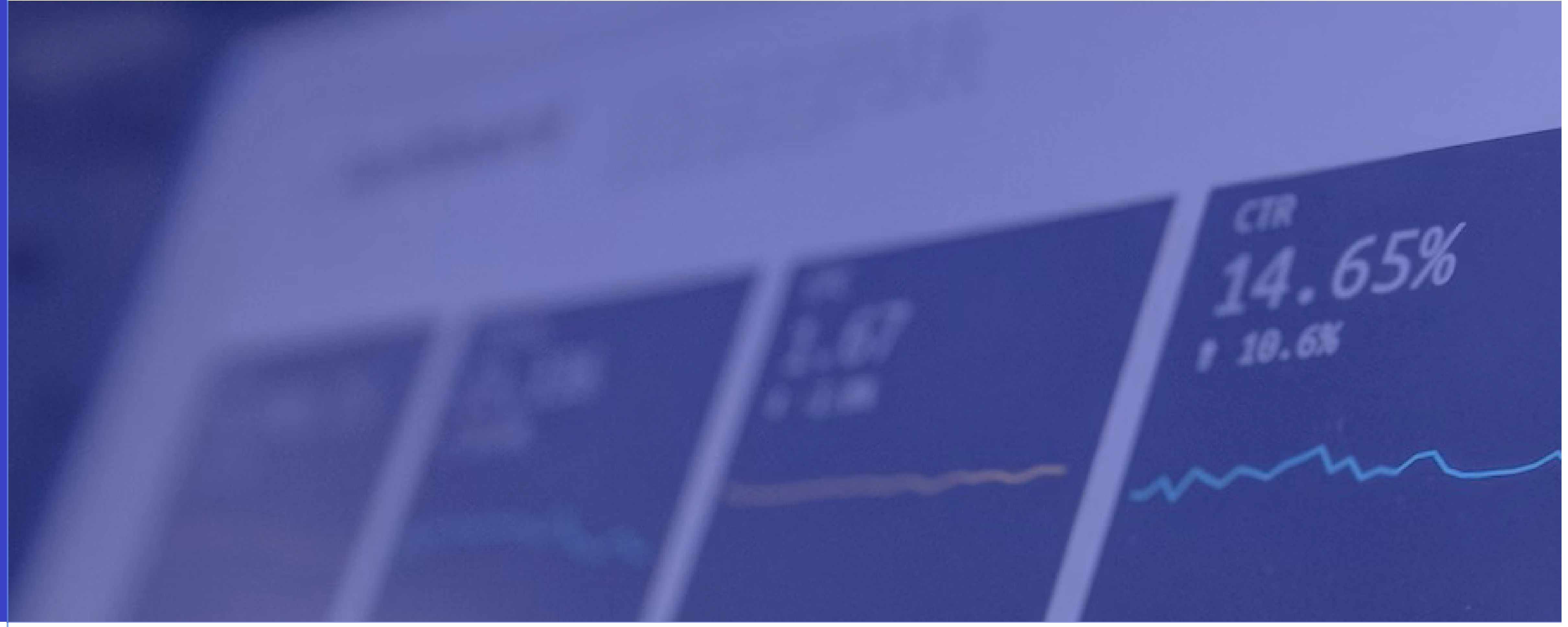
→ High costs
→ Scalability challenges

IMPACTS

→ Reduction of atmospheric carbon dioxide concentrations and containing of the effects of climate change

EXAMPLES OF POTENTIAL FIELDS OF APPLICATION

- Direct air capture with geological CO_2 storage
- Biochar in agriculture to improve soil fertility
- Moisture swing: remove CO_2 from the air and generate energy
- Accelerated basalt weathering converts CO_2 into soil minerals



DATA-DRIVEN EPIDEMIOLOGY

Data-driven epidemiology is based on continuous and integrated analysis of multidimensional and heterogeneous data. It uses statistical algorithms, predictive computational models, and artificial intelligence tools to strengthen public health management.
It involves collecting data from diverse sources, ensuring database interoperability, processing and analysing the data using statistical techniques and machine learning models, performing predictive modelling for scenario simulation, and visualising results through dashboards.
This technology relies on health databases, environmental sensors, geographic information systems, geolocation tools, cloud platforms, and deep learning algorithms.
Predictiveness, adaptability, scalability, multidisciplinary integration, and sustainability are its core features. These elements enable the generation of dynamic simulations and reliable forecasting scenarios across the health, environmental, urban, and climate sectors.
Data-driven epidemiology enables timely responses to complex health emergencies, forecasts extreme climate events, and supports evidence-based intervention planning, thereby strengthening public decision-making processes.

OPPORTUNITIES

→ Possibility of anticipating and monitoring sedentary lifestyles and health risks

REQUIREMENTS

→ Data quality
→ Multidisciplinary expertise

RISKS

→ Mismanagement of sensitive data
→ Inaccurate analysis
→ An overly deterministic approach can reduce decision-making autonomy

IMPACTS

→ Improvement of public health
→ Policy evaluation

EXAMPLES OF POTENTIAL FIELDS OF APPLICATION

Epidemic outbreak tracking

Wastewater surveillance

Environmental risk analysis

Satellite data to predict disease spread

DIGITAL TWIN/MODELLING

A Digital Twin is a set of virtual informational constructs that replicate the structure, context, and behaviour of a natural, engineered, or social system, continuously updated through real-time data.
It is characterised by predictiveness, adaptability, scalability, and bidirectional synchronisation between the physical and digital dimensions.
Data are collected through sensors, IoT devices, and information systems, transmitted and aggregated into cloud platforms or edge-computing systems, and subsequently processed using algorithms, statistical models, and artificial intelligence techniques.
Digital twins can be applied in the industrial sector to optimise production processes, in smart cities to monitor urban infrastructures, and in research centres to simulate the effects of environmental risks.
Digital twins and modelling are key tools for promoting innovation, as they enable advanced simulations and support decision making processes that are more transparent, informed, and efficient.

OPPORTUNITIES

→ Strengthened management of emergencies

REQUIREMENTS

→ Clear regulatory framework on data protection
→ Data interoperability
→ Advanced digital infrastructures

RISKS

→ Bias due to incomplete or non-representative data
→ Excessive reliance on predictive models at the expense of human judgement
→ Vulnerability to cyberattacks

IMPACTS

→ Continuous monitoring
→ Event simulation and risk assessment

EXAMPLES OF POTENTIAL FIELDS OF APPLICATION

City digital twin for pollution monitoring

Sun digital twin for solar storm predictions

DNA/RNA DISCOVERY

This expression refers to technologies that enable the partial or complete analysis of DNA, genome structure, gene expression levels, and epigenetic modifications. These approaches allow a detailed examination of biological processes and the mechanisms controlling gene activity.
Genome analysis relies on single nucleotide polymorphism chips and second- and third-generation DNA sequencing technologies. Transcriptome analysis is primarily based on microarrays and RNA sequencing. Microarrays use oligonucleotide probes to bind specific RNA transcripts, whereas RNA sequencing allows the direct sequencing of RNA molecules without the need for predefined probes. These technologies are characterised by high precision, the ability to generate large volumes of data, automated processing, and integration with advanced bioinformatics systems. They support detailed studies of biological processes, gene regulation, disease monitoring, early diagnosis, and stimulate research across the pharmaceutical, agricultural, and food science sectors. For these reasons, DNA and RNA analysis technologies are considered to have significant transformative potential.

OPPORTUNITIES

→ Species conservation
→ Early identification of epidemic imbalances
→ Promotion of healthy lifestyles

REQUIREMENTS

→ Data integration and bioinformatics
→ Regulatory and ethical compliance

RISKS

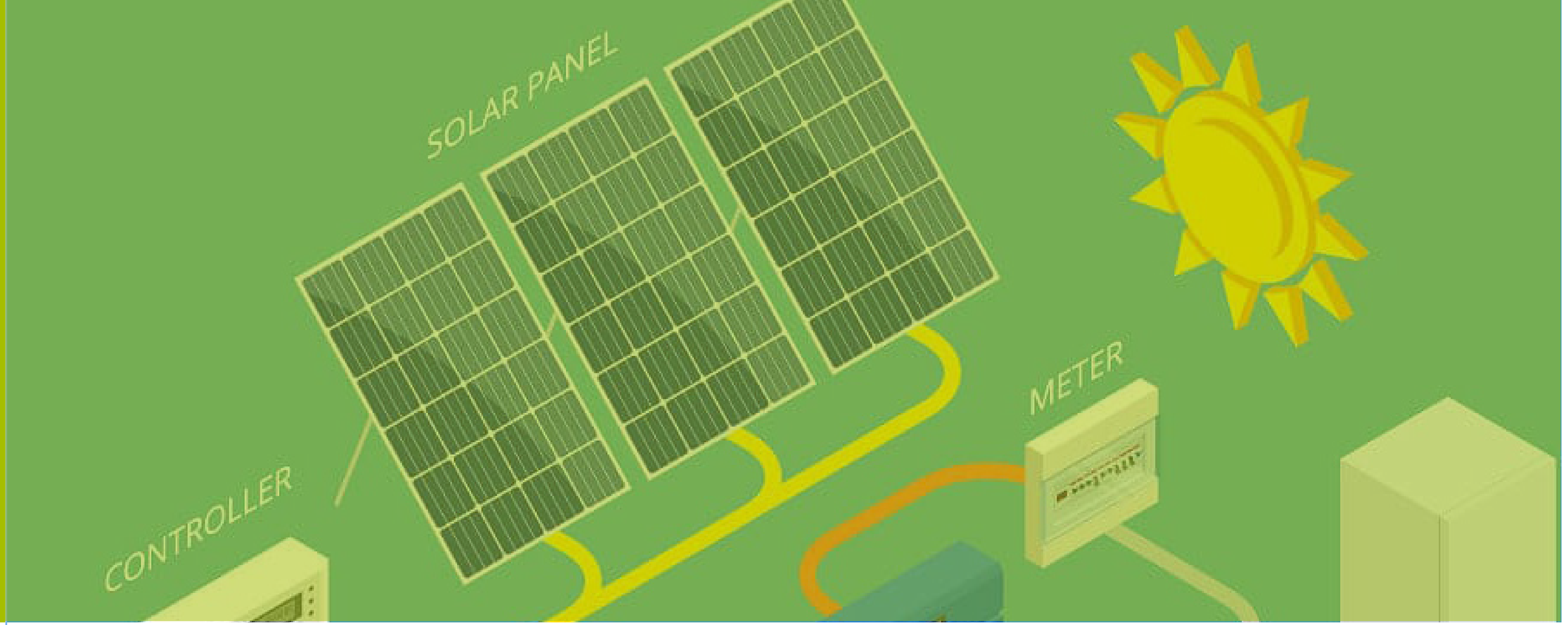
→ Data protection
→ Bioethical issues
→ Misuse findings to implement discriminatory practices

IMPACTS

→ Transformation of biomedical research

EXAMPLES OF POTENTIAL FIELDS OF APPLICATION

- Single-cell transcriptomics
- Pills capable of blocking the spread of influenza viruses



ENERGY STORAGE SYSTEMS

An Energy Storage System (ESS) stores the energy produced and makes it available when required. This technology helps reduce emissions, manage peak demand, and ensure energy supply in the event of power outages.
The main storage technologies include pumped hydro storage, electrochemical batteries, flywheels, compressed air energy storage systems, hydrogen storage, and thermal energy storage. These solutions incorporate essential components such as sensors, actuators, management software, algorithms, and transducers, while differing in terms of operating principles, storage methods, and storage duration.
ESS technologies are adaptable to different energy sources, offer predictive capabilities using algorithms, contribute to sustainability by reducing waste, and can be applied across a wide range of contexts.
Overall, these systems facilitate the transition to a more reliable and flexible energy system.

OPPORTUNITIES

→ Development of new markets
→ Improving safety and autonomy in transport systems

REQUIREMENTS

→ Planning and strategic capabilities

RISKS

→ High recycling costs
→ Encouraging energy wasting behaviors

IMPACTS

→ Energy planning
→ Energy market stability
→ Greater electricity grid stability

EXAMPLES OF POTENTIAL FIELDS OF APPLICATION

Hydroelectric reservoirs used to store renewable energy

Solid-state thermal battery

Lithium-air battery with WSe_2 catalyst

Use of heated sand for energy storage

IMPLANTABLE/WEARABLE DEVICES

Implantable and wearable devices support an integrated approach to human, animal and environmental health, as they allow the real-time collection of data on various biological and environmental parameters. Wearable devices are applied externally to the body, whereas implantable devices are inserted within the organism, enabling even more precise monitoring.
These technologies use advanced sensors, wireless connectivity, and data analysis systems to ensure continuous monitoring of animal welfare, air quality, and urban environments, facilitating a proactive and coordinated approach to ecosystem health management.
They are characterised by miniaturised components, highly sensitive sensors, the capability for continuous monitoring, and the biocompatibility of the materials used.
In the future, these technologies are expected to enable the adoption of more effective health and environmental policies, contributing to the creation of more sustainable and informed communities.

OPPORTUNITIES

→ Continuous data updating
→ Integrated management of public and environmental health

REQUIREMENTS

→ Standardisation

RISKS

→ Data management and protection challenges
→ Measurement and/or data interpretation errors
→ Unequal access to technologies

IMPACTS

→ Integration across different systems

EXAMPLES OF POTENTIAL FIELDS OF APPLICATION

Urban air quality sensors
Motorised hand mobility glove
Wearable for animal health monitoring
Wearable neurotech

PLASTIC METABOLISATION

Plastic metabolisation uses bacteria and fungi to biodegrade plastic polymers (such as PET, PUR, and PE) or convert them into energy or biomass. The effectiveness of these processes depends on environmental conditions and the physicochemical characteristics of different types of plastic. It promotes the recovery and reuse of plastic materials and encourages a circular approach to waste management.
This technology relies on specific enzymes (through bioprocesses and bioreactors), advanced synthetic biology approaches, metabolic engineering, and co-metabolism mechanisms. It is characterised by high enzymatic selectivity, efficient polymer conversion, the ability to operate at moderate temperatures, and reduced energy consumption compared with traditional chemical processes.
Plastic metabolisation has a significant impact on ecosystem health, affecting organisms exposed to plastics, disrupting food chains, and contributing to the release of microplastics into the environment. At the same time, it contributes to a reduction in carbon dioxide emissions and supports sustainable recycling processes.

OPPORTUNITIES

→ New biodegradable materials
→ New industrial opportunities in advanced recycling
→ Stimulation of scientific research

REQUIREMENTS

→ Risk management regulations
→ Research enabling innovation

RISKS

→ Complexity in managing mixed
→ Potential release of toxic metabolites
→ Risk of engineered species dissemination

IMPACTS

→ Energy production from plastic
→ Reduction of microplastic pollution
→ Increased plastic production

EXAMPLES OF POTENTIAL FIELDS OF APPLICATION

Enzyme engineered to degrade polyurethane

Microbiabiofilms used to degrade polyolefins

Trichoderma converts plastic to energy

WALKABLE CITY

The walkable city is an urban model in which smart technologies make urban spaces more accessible, safer, and sustainable.
This approach enhances the urban experience by enabling the real-time circulation of information on routes, traffic conditions, events, and services. Furthermore, it places people at the heart of urban planning while improving safety, responsiveness, and the overall quality of public spaces.
The model integrates a range of technologies that make infrastructure more intelligent, including smart pavements, pedestrian crossings, lighting systems, and connected urban furniture. Traffic flows and mobility management are supported through IoT sensors, edge-ai cameras, and adaptive traffic lights. In addition, innovative solutions facilitate the planning of multimodal journeys and pedestrian-friendly routes, while algorithms and urban platforms contribute to more efficient and sustainable city management.
Overall, this model has a significant impact on several dimensions of urban life, helping to improve mobility, social well-being, public health, and social inclusion. It encourages a rethink of how urban centres are designed, built, and experienced, recognising pedestrian mobility as a key element of contemporary urban policy.

OPPORTUNITIES

→ Urban safety
→ Increased physical activity
→ Proximity and use of shared spaces

REQUIREMENTS

→ High investment
→ Education for sustainable mobility
→ Integrated planning

RISKS

→ Dependence on digital infrastructures
→ Cybersecurity threats
→ Alienation
→ Rising inequality

IMPACTS

→ Emission reductions
→ More efficient space management
→ Healthier lifestyles

EXAMPLES OF POTENTIAL FIELDS OF APPLICATION

Urban design guided by simulations

Platforms offering real-time summaries of public services

INSIGHTS

The following narratives emerged from the insight phase, shaped by reflections on alternative futures for planetary health. These explorations aimed to imagine diverse trajectories, highlighting opportunities, critical issues, and the conditions necessary to steer change in a desirable direction.

This includes considering the perspectives of various stakeholders (institutions, providers medical, doctors, researchers, etc.) while remaining attentive to potential risks and systemic barriers.

THE MATERIALITY OF DIGITAL HEALTH

The health of the planet and collective well-being are entangled in the **physical resources** that sustain technology, energy, water, and raw materials. The expansion of data centres and tech infrastructures, especially in urban areas, creates direct competition for these finite resources, potentially undermining environmental resilience.

A paradigm shift is needed: technological progress must align with planetary boundaries, prioritising circularity, resource efficiency, and equitable access over pure performance. Without an **integrated governance of resource** use, the digital race risks deepening social inequalities, turning health into a privilege tied to economic access to Earth's resources.

In this context, an opportunity emerges to pursue a widespread of more efficient systems for **resource management and sharing**.

Resource unavailability, together with **infrastructure failures and disruptions**, may represent significant risks to the implementation of such a governance model, highlighting the fragility of digital systems.

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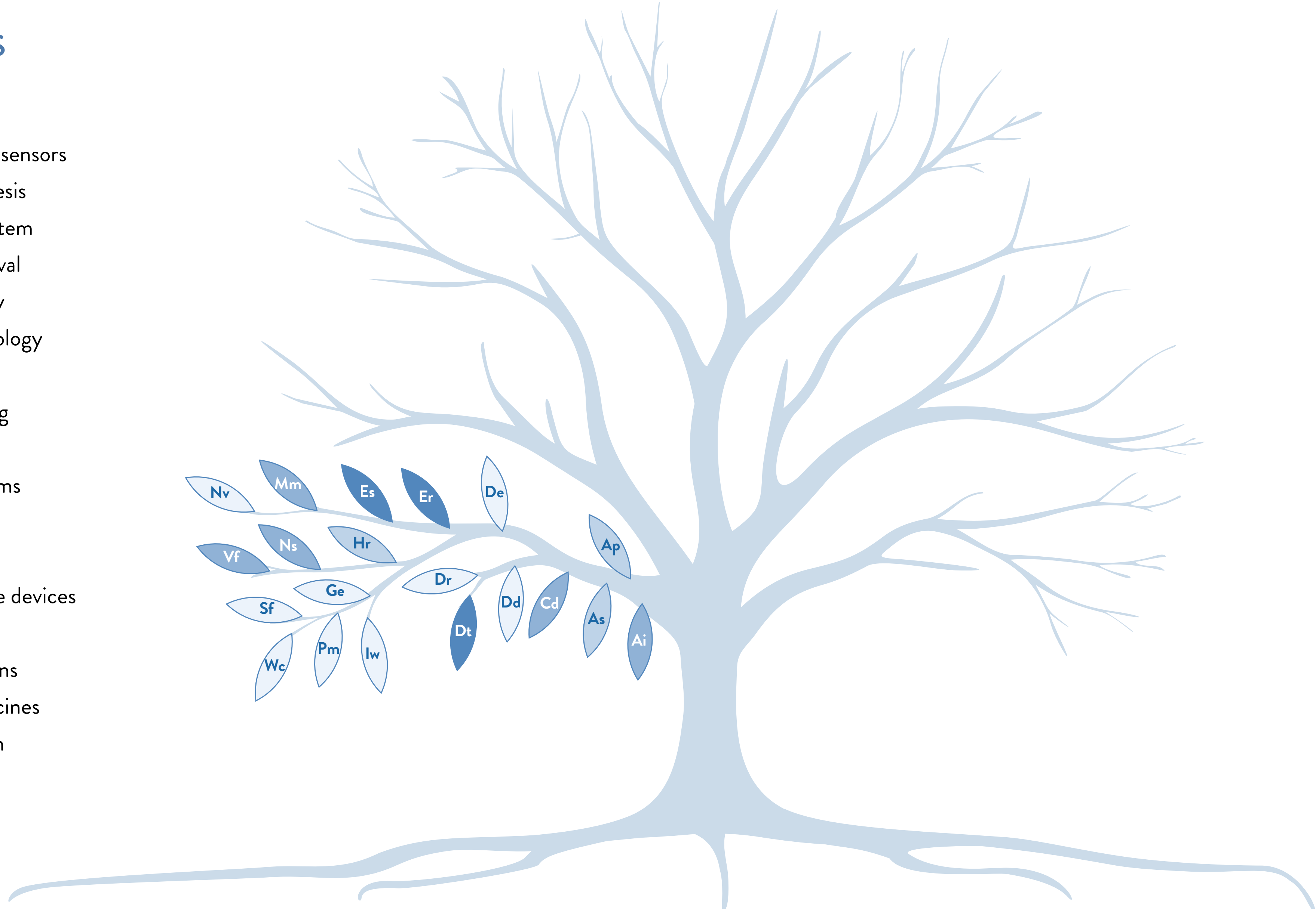

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FROM **WEAR**ABLES TO **AWARE**ABLES

The convergence of ambient sensing, animal wearables, and digital twins is reshaping health prevention beyond the individual, expanding the concept of the “wearable” to encompass entire ecosystems, where people, animals, infrastructure, and environment become interconnected nodes of a single intelligent monitoring architecture.

This shift holds genuine promise for community resilience and early-warning prevention, but this hyper-awareness triggers a resilience paradox: without **ethical data governance** and **universal literacy**, the question is who can afford it, who gets to listen, and in whose interest.

An intelligent monitoring architecture can amplify risks such as the **loss of privacy**, **health inequalities**, and the concentration of **data power** in the hands of a few actors.

Nevertheless, wearable devices offer a significant opportunity to enhance both **physical and mental health**, enabling new forms of **health prevention**. They promote behavioural changes **towards more active and preventative lifestyles** and allow for the **early detection of epidemics** and communicable diseases.

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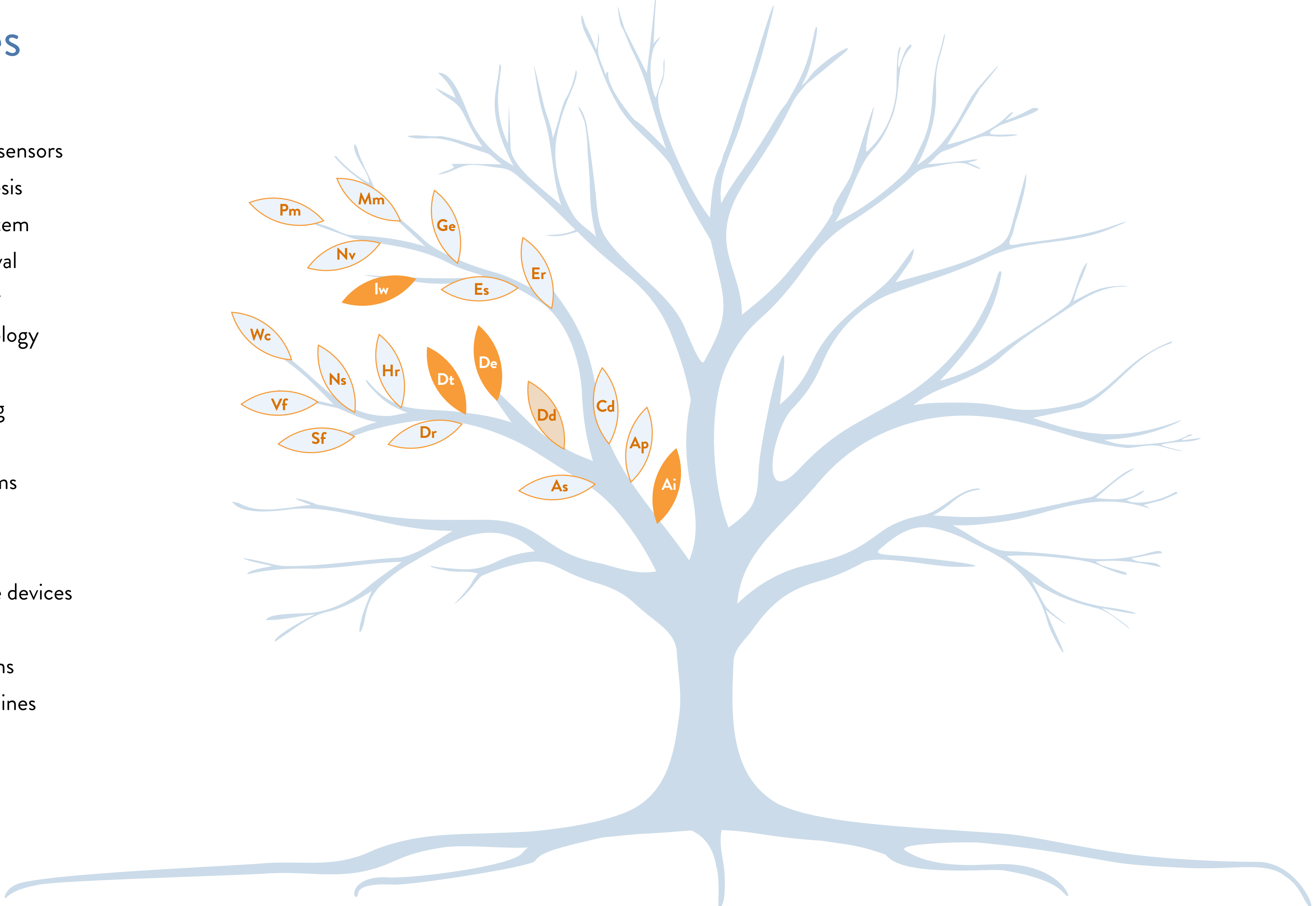

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URBAN EQUI**A(C)TION**: HEALTH AS INFRASTRUCTURE

The **urban environment** is a **key factor for public health**, functioning as a system of interconnected variables.

The transition towards regenerative urban ecosystems, aimed at mitigating pollution, heat islands, and noise, represents a strategic variable in territorial governance, primary prevention, and overall well-being. In this context, "walkability" directly influences physical activity levels and stress loads across the population. In short, a city that thrives makes its inhabitants thrive too.

The transition towards regenerative urban systems enables the development of more **resilient energy infrastructures**, the integration of monitoring and **prevention systems across social, healthcare and environmental domains**, as well as a more efficient and **shared management of resources**. At the same time, the design of walkable cities produces immediate effects on individual behaviour, encouraging the adoption of more active **lifestyles and health-oriented preventive practices**.

However, this process is not without risks. It may exacerbate **health inequalities**, reinforce forms of **social exclusion** embedded in urban planning models, and increase the **vulnerability of infrastructure to failures or disruptions**, with potential impacts on the continuity of essential services.

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Nv	Next-generation vaccines
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Vf	Vertical farming
Wc	Walkable city

STEEP Forces

SOCIAL: AGEING · DEMOGRAPHIC CHANGES · MENTAL HEALTH · LIFESTYLES · DEEPENING DISPARITIES · NON-COMMUNICABLE DISEASES · BEYOND GENDER · MIGRATIONS · WORK FROM EVERYWHERE · DO IT YOURSELF

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PLAN(ET) FOR HEALTH

Health is no longer just one policy area among many, but it is becoming a **shared infrastructure** built on the **convergence** of medicine, urban planning, and public governance.

It connects human health with the ecosystem: environmental contexts, climate, biodiversity, mobility, and public health feed into a single, unified system. This enables prevention, risk prediction, and smarter governance of the relationship between people, cities, and ecosystems.

In this framework, several key opportunities emerge, including the development of **resilient energy infrastructures**, the **early detection of epidemics** through integrated data systems and predictive analytics, the promotion of **shared resource management models** and the pursuit of a **neutral environmental footprint**.

At the same time, this transformation raises a number of potential risks. The **concentration of data power** in the hands of a few actors give rise to concerns regarding equity and control. **Infrastructure failures and systemic disruptions** could trigger cascading effects across interconnected domains. Moreover, **poor policy coordination** may undermine the effectiveness of integrated approaches, while **rebound effects in resource consumption** risk offsetting sustainability gains if not properly managed.

Technologies

Ai Ambient intelligence sensors
Ap Artificial photosynthesis
As Agrophotovoltaic system
Cd Carbon dioxide removal
Dd DNA/RNA discovery
De Data-driven epidemiology
Dr Drones
Dt Digital twin/Modelling
Er Energy recovery
Es Energy storage systems
Ge Genetic engineering
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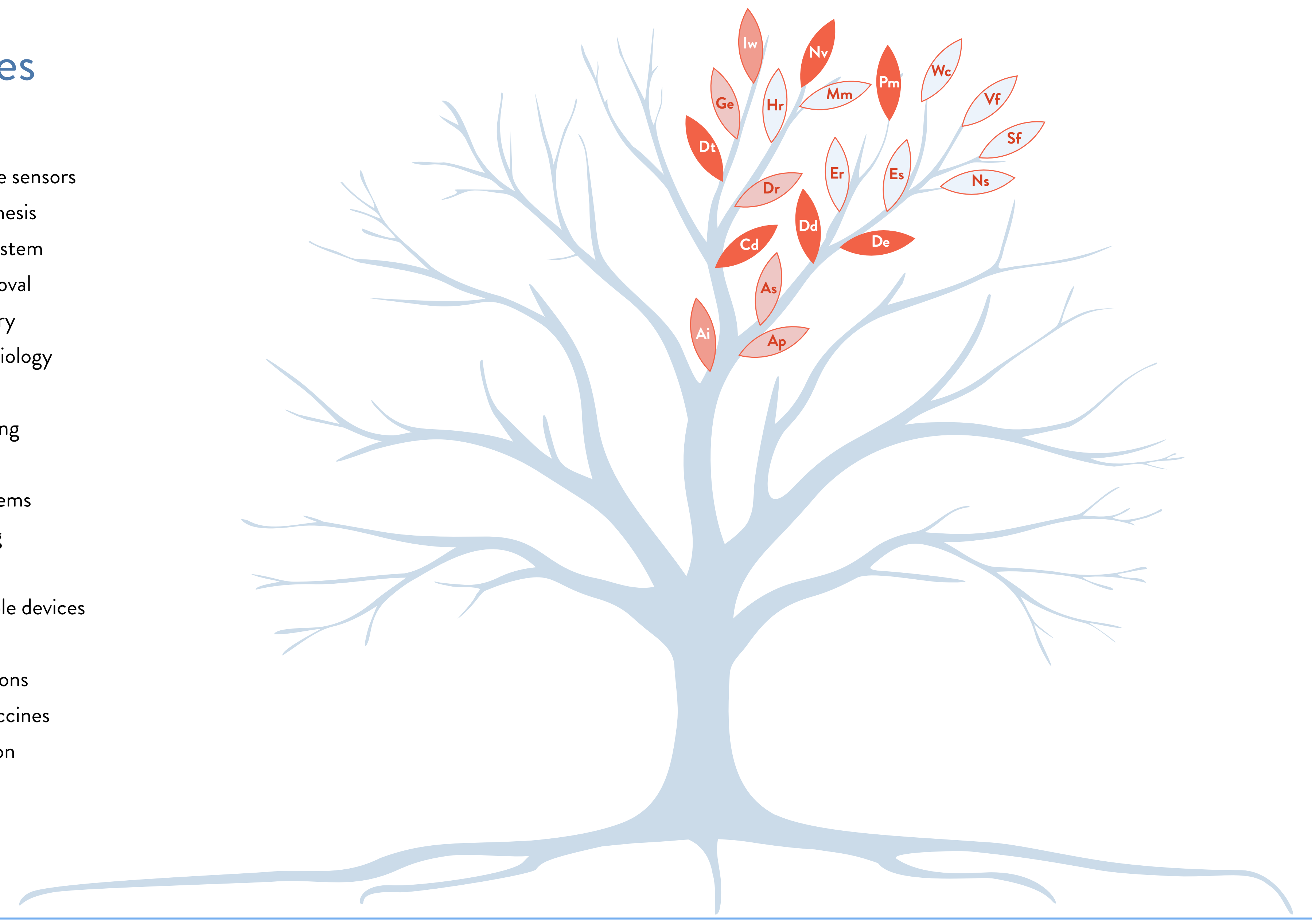

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HEALTH COMMONS

Well-being is not merely an individual matter, but a **social process** that requires the active participation of a community in managing the resources that make a healthy life possible.

Collective health and environmental sustainability can be threatened by the current socio-economic divide, where access to healthy lifestyles, prevention, and technological innovation is a privilege tied to income rather than a universal right. Sharing economy and proximity-based solidarity can help reduce the structural inequalities that turn "time for health" into a luxury for the few: lifestyle can be redefined not as a series of high-end consumer choices but as a **community resource supported by accessible local services**.

Recognising well-being as a social process opens up important reflections in terms of opportunities, starting with the development of a more inclusive approach to **physical and mental health**, the **strengthening of community networks**, as well as a broader behavioural shift towards **active and preventive lifestyles** and a more **shared management of resources**.

Health commons risk deepening **health inequalities** when differences in resources, capabilities, and participation across communities translate into systematically uneven acess to benefits and outcomes.

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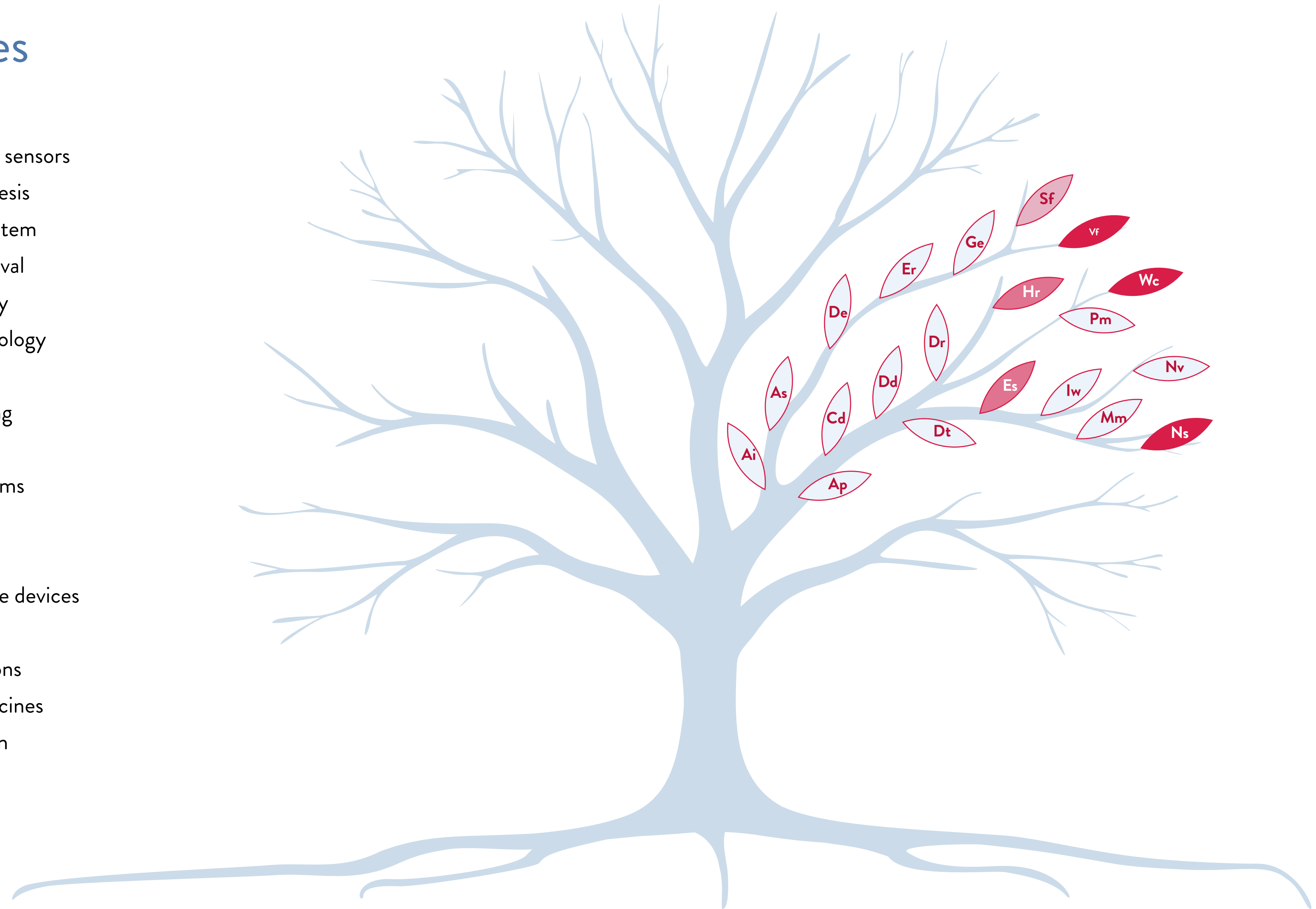

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FROM EGO-SYSTEMS TO ECO-SYSTEMS

The interdependence of our ecosystem is being severely challenged by climate change, resource scarcity, and growing inequalities. To respond to this complexity, it is imperative to move beyond siloed approaches in favour of **interconnected governance**. Although the most effective solutions often emerge at the local level, their systemic impact depends on their ability to integrate into global networks.

Ethically coordinated leadership is required, capable of orchestrating collaboration between public and private actors to steer technological and environmental transitions towards an equitable and resilient model.

This context fosters more efficient and **shared resource management**, **strengthens community networks**, and promotes models oriented towards **environmental footprint neutrality**. In this way, it becomes possible to overcome fragmented approaches and particularistic interests, adopting a truly global perspective.

The emergence of interconnected and coordinated governance also reveals a key vulnerability: **insufficient political coordination** can compromise the alignment and implementation of collective efforts, ultimately limiting their overall impact.

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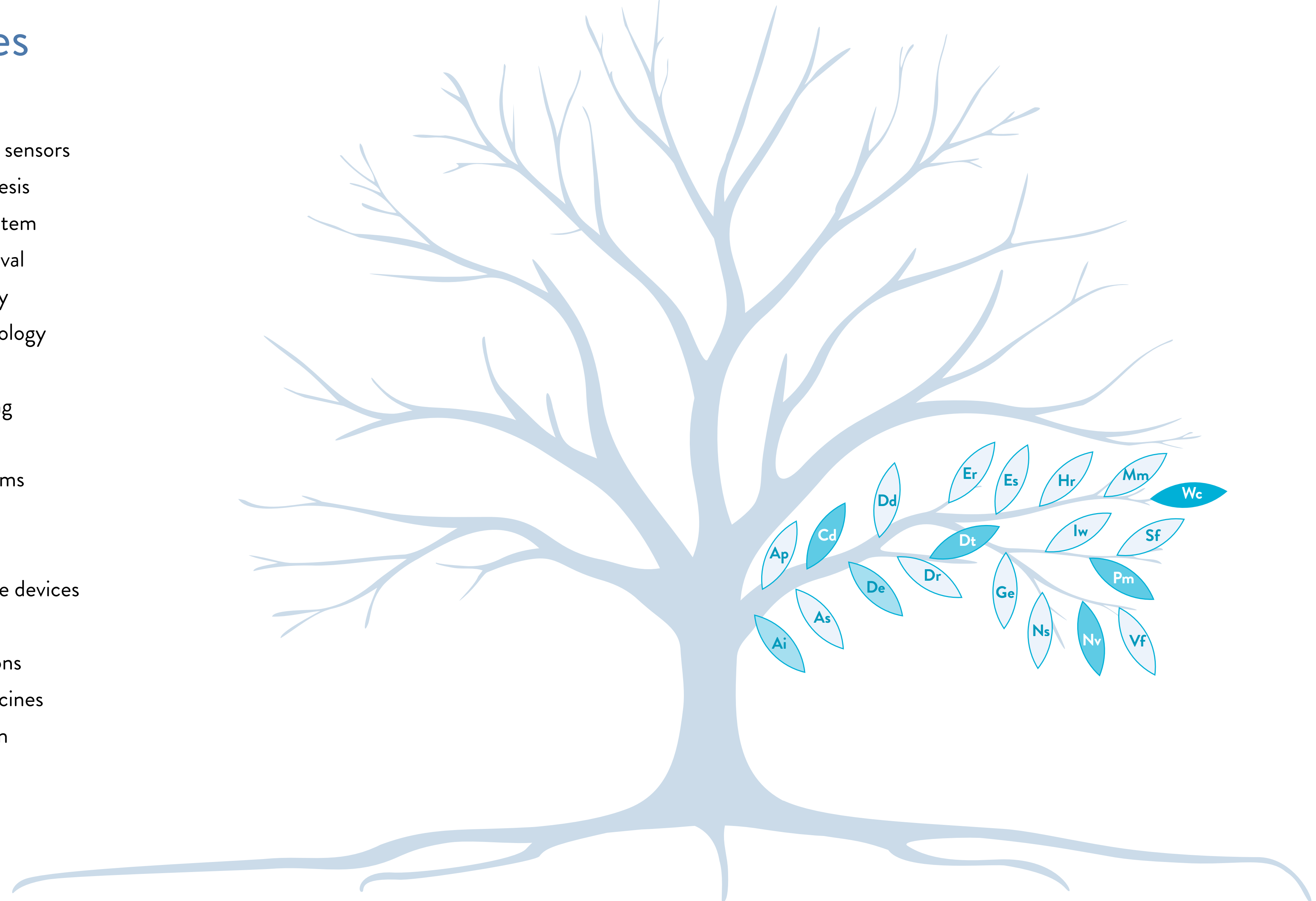

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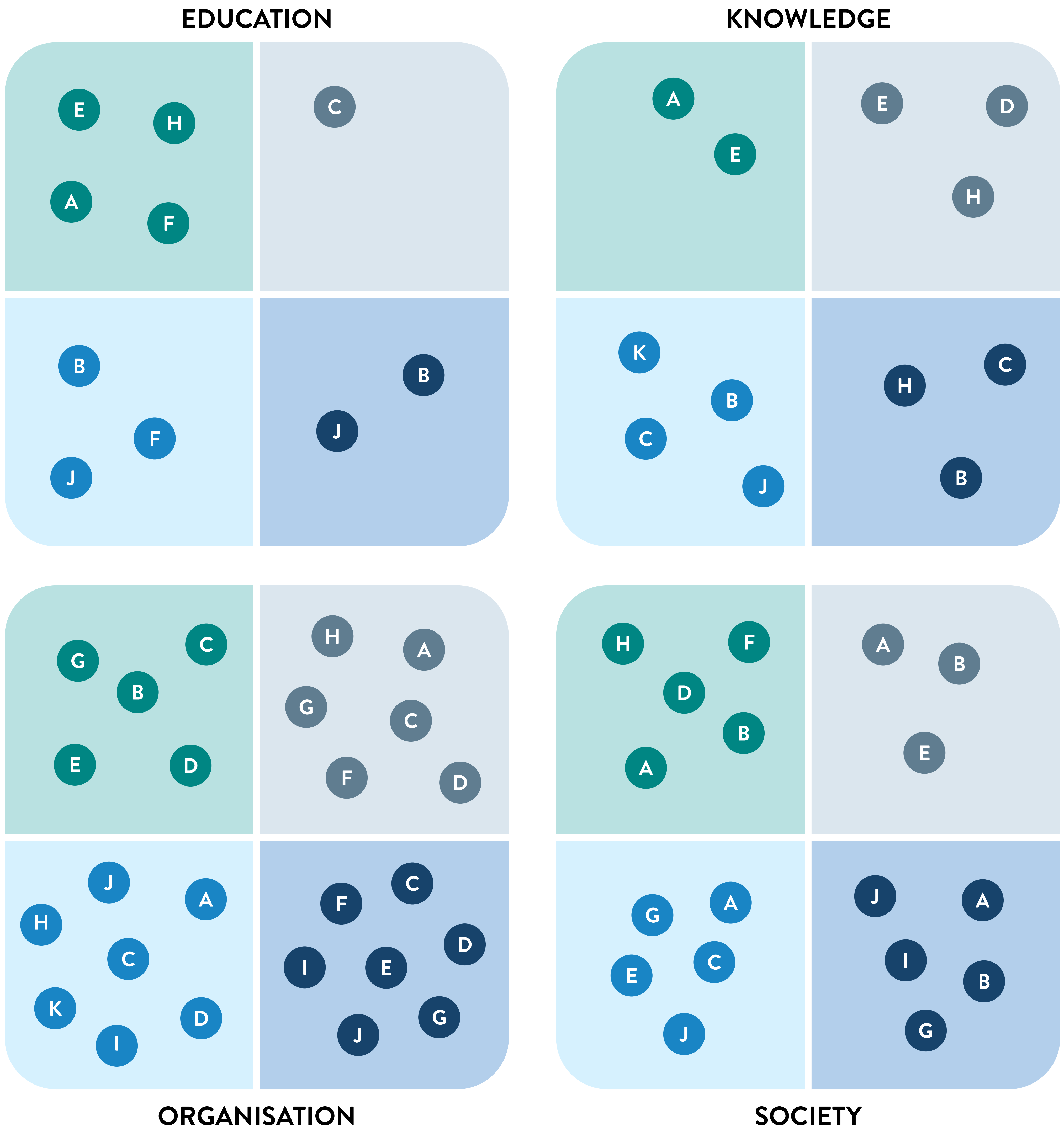
Opportunities, Requirements, Risks, and Impacts

Several recurrent factors emerged in the conversations exploring how the future of planetary health might look like in 2040. These factors are associated with the technologies and their transformative potential, enablers, and barriers, as well as their prospective effects. We identified and grouped key elements into four main perspectives: education, knowledge, organisation, and society.



OPPORTUNITIES

- A Inclusive physical and mental health
- B Strenghtened community networks
- C Resilient energy infrastructures
- D Social, healthcare, and environmental surveillance and prevention
- E Early detection of epidemics
- F Neutral environmental footprint
- G Shared resource management
- H Behavioural shift toward active and prevention lifestyles

RISKS

- A Resource unvailability
- B Health inequality
- C Social exclusion by design
- D Concentration of data power
- E Loss of privacy
- F Infrastructure failures and disruptions
- G Poor policy coordination
- H Rebound effect in resources consumption

REQUIREMENTS

- A Universal accessibility and inclusive design principles
- B Integrated technical and managerial competencies
- C Lifecycle-oriented resource reduction and reuse
- D Crisis-resilient and future-proof infrastructure networks
- E Local implementation and global coordination alignment
- F Widespread health, digital, and data literacy
- G Balanced and long-term political and regulatory commitment
- H Stable, long-term political and regulatory commitment
- I Integreated governance frameworks
- J Education and civic engagement for shared priorities
- K Secure and interoperable data infrastructure systems

IMPACTS

- A Extension of healthspan expectancy
- B Integrated mind-body health as a societal standard
- C Predictive management of epidemic risks
- D Decarbonised urban system
- E Restoration of natural ecosystems in urban areas
- F Clean air/water/soil transition
- G Climate-resilient and cohesive communities
- H Improved environmental quality
- I Universal access to preventive health
- J Shift towards a circular economy

Conclusions

Planetary health makes clear that human health is inseparable from the integrity of natural systems: environmental degradation, climate change, and resource depletion directly translate into risks for individual and collective well-being.
Ensuring planetary health therefore requires not only mitigating these pressures but also rethinking how innovation is conceived and deployed.

Technologies can act as powerful enablers, improving monitoring, prevention, and resource efficiency, provided they are guided by principles of sustainability, equity, and systemic integration.
This implies aligning technological development with environmental limits, strengthening governance and cross-sector collaboration, and ensuring inclusive access and responsible use.
Under these conditions only innovation can effectively contribute to safeguarding both ecosystem resilience and human health in the long term.

More information available at: https://www.foresight.polimi.it/health/

Participants

Participants to interviews and workshops are listed below. We thank them for their invaluable contributions and insights.

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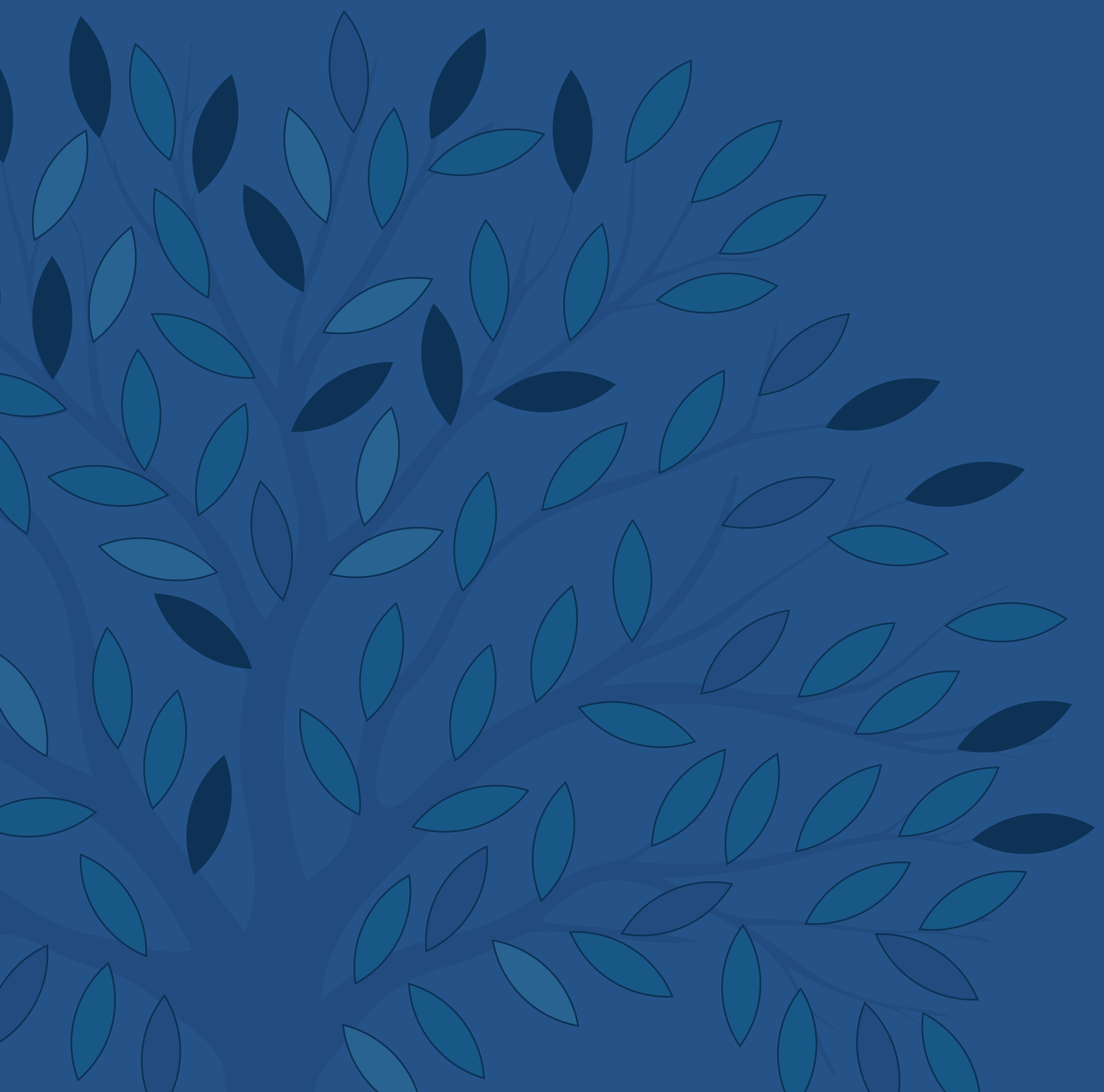

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