Emerging Grand Challenges and Megatrends for the Future of Europe

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Abstract: Megatrends are cross-sectional and lasting developments creating grand challenges. This study investigates the interlinkages of 14 megatrends and their consequences using cross-impact and emerging issues analyses. The results map out interlinkages and long-term implications for Europe's future, underscoring the importance of involving broader perspectives in policy making to uncover wider issues. This study contributes to defining grand challenges and connecting futures studies with socio-technical transitions literature. Results discuss the advent of eco-awareness as a megatrend, and it identifies five emerging challenge areas. Further research is essential for a more comprehensive understanding of these intersections.

Keywords: Grand challenges, emerging issues, megatrends, anticipation, European Union.

1 Introduction

This study explores the complex interactions between megatrends and the emergence of grand challenges. Megatrends are long-term and global developments that have a cross-cutting impact on society (Kuosa & Stucki,

2021). Grand challenges on the other hand, are issues that become large-scale or global problems (George et al., 2016). Megatrends can oftentimes be found to be framed as grand challenges, such as changing demographics and climate change (see e.g., Brown, 2021; Kuiper & Brady, 2023). However, megatrends give rise to many challenges and even though grand challenges appear to share a lot of characteristics with megatrends, they are different concepts, with distinct differences in framing and connotations (OECD, 2016). When considered in isolation, megatrends present a challenge, seemingly grand, yet in combination more emerge. In scenario development and policy making, a first task is to combine different trends and potential disruptions to derive plausible scenarios and in doing so, a selection of trends is chosen (Whyte, J., personal communication, 2024 June 25; Wiebe et al., 2018). In doing so, there is a risk that certain consequences are omitted from consideration since marginalized trends are excluded from the analysis and those which act as threat multipliers by exacerbating other challenges (Bremberg, 2018).

Current goals, objectives, and policy aim at addressing current societal, environmental, and technological challenges. It is therefore evident that interventions to solve these challenges can risk exacerbating other issues or creating new ones entirely (Ferraro et al., 2015). Therefore, in addressing these, we must also have our eye on the horizon and beware the challenges of the next century. The intention here is not to divert focus from current challenges being addressed, but to enlighten these potential challenges so that innovations tackling challenges of today avoid exacerbating future challenges and to contribute to systemic resilience through anticipation (Brown, 2021). Previous research often states the complexity of megatrends interlinkages as fact, research holistically and systematically investigating these relationships, however, is scarcer. The Joint Research Centre (2020) focused on five megatrends' impact on the security climate, revealing challenges such as increasing resource conflicts and climate change displacements which shows the need to consider these interlinkages. Marmier et al., (2022) applied a text-mining approach to explore the interlinkages within the megatrend of accelerating technological change and hyperconnectivity, the authors propose that similar approaches can be applied to assess the interlinkages between different megatrends rather than

just within. Lichtenthaler (2021) takes a conceptual approach to delve into the positive and negative interdependencies between two megatrends, sustainability and digitalization, showing how they share both positive and negative effects on one another. It is worth noting, however, that Cross-impact analyses on trends provide ample basis for scenario development (Alizadeh et al., 2016; Weimer-Jehle, 2005). As such, there may be a plethora of literature to be uncovered hidden in scenario reports. Nonetheless, since grand challenges and megatrends are complex and highly interconnected, they require prospective theorizing to support anticipatory policymaking (Funtowicz & Ravetz, 1993; Gümüsay et al., 2022; Marmier et al., 2022). Therefore, this study combines a systems- and futures thinking approach, to treat them not in isolation but rather explore their interconnectedness and how they can give rise to the emerging grand issues of the next century (OECD, 2016). Our focus and frame of reference is guided by our broad disciplines of innovation, design, and technology; wherein we combine our perspectives and disciplines using design-, resilience-, futures-, and analytical thinking (Bühring & Liedtka, 2018).

The problem, purpose, and question

Foresight in EU policymaking serves the purpose of prioritising issues, future proofing policy, and anticipating future challenges (Van Woensel, 2024). Understanding the complexity of trend interlinkages, however, is a long-term challenge for policy design (Panula-Ontto et al., 2018). Whilst the policies of today attempt to resolve contemporary issues, they risk exacerbating the problems of tomorrow. It is therefore important to anticipate and monitor these developments and their potential for emerging issues. The purpose of this study is to shed light onto these complexities and their potential challenges to contribute to anticipatory policymaking. Answering the research question: *What are the interlinkages of megatrends and their potential consequences?* The scope of this inquiry is the European Union (EU) as a meso-level of analysis and time horizon of around 2050.

2 Literature review

The following sections reviews literature on futures studies and foresight, the multi-level perspective (MLP), and grand challenges.

Futures studies and foresight

Foresight research, generally, attempts to theorize when, where, how, and why inquiries into the future work (Fergnani & Chermack, 2020). Whereas futures studies constitute a systematic inquiry into the future (Dator, 2019). As such, we view foresight as the process, and futures as the product of the process (Öner, 2010). Consequently, there are many epistemological underpinnings and assumptions that make such an inquiry possible, from a positivistic reality which can be foreseen provided enough data or a constructivist point of view as the future being something which resides in the minds of people or aggregated to collectively held imaginaries (Jasanoff, 2021; Piirainen & Gonzalez, 2015). As such, the field has largely progressed from positivistic predictions (Kristóf, 2024). Ravetz et al., (2021) describe the evolution of foresight as moving from predictions to identifying opportunities and understanding the non-linear dynamics and multi-domain dependencies, towards a co-evolutionary understanding of emergence, synergies, and collective inquiry (Ravetz et al., 2021). Whilst we acknowledge that the future cannot be accurately predicted, we support the idea of exploring trends, emerging issues and alternative futures to build a better future (Minkkinen, 2020). In EU policymaking, foresight has manifested itself and plays a crucial role through several institutions and influenced policy design and decision-making through continuous horizon scanning, scenario planning, and risk assessments amongst others (Van Woensel, 2024).

Multi-level perspective

Grand societal challenges require transformative innovations (Geels, 2020), to understand which, the author lays forth the MLP as a conceptual framework for understanding the transitions thereof (Geels, 2019). In combination with a futures perspective, the MLP provides a well-

established framework for navigating the complex dynamics of change and the different ways in which the socio-technical regime may reconfigure through different horizons of change (Vähäkari et al, 2020).

The MLP describes three levels of change, see Figure 1. The niche (*micro*) level describes the weak signals of change, including developing technologies, products, and movements in protected spaces. The *meso*-level encompasses the multiple domains of the system in question, herein the EU. It is comprised of dominant technology, culture, science, markets, users and preferences, industry, and policy. Above the regime resides the *macro*-level landscape developments which are the dominant forces shaping societies (i.e., megatrends) on a global level in addition to shorter term shocks such as pandemics and wars (Geels, 2019; Vähäkari et al., 2020). The MLP depicts the transition of the regime from the current dominant system, towards a more fit for context future system and the more turbulent transitory phase of H2 in between, much akin to the three horizons framework (Sharpe et al., 2016).
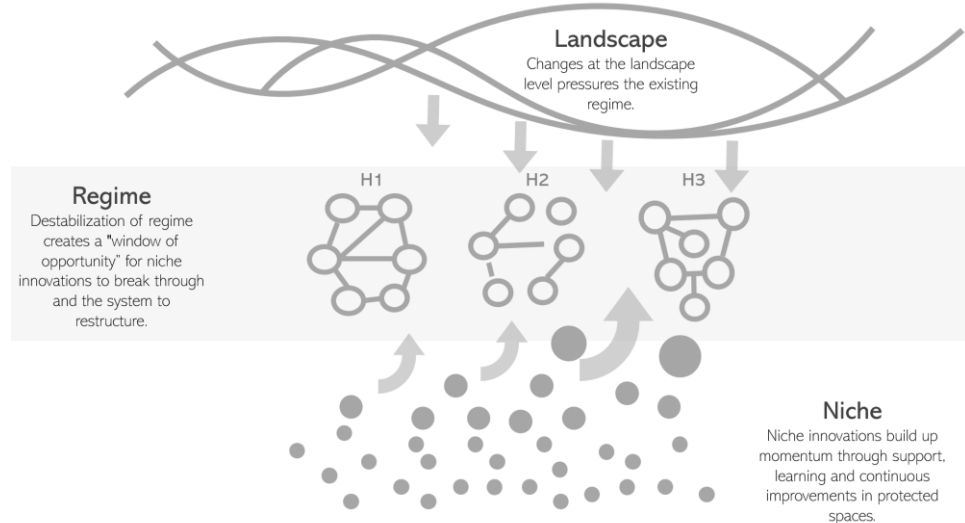

Figure 1. Multi-level Perspective, adapted from Systems Innovation Network (n.d.) and Geels (2004). Light grey arrows indicate grand challenges and H1-3 represents different horizons of change (Sharpe et al., 2016).

Megatrends are part of the external environment to the meso-level regime. They exert pressure onto the socio-technical regime allowing emerging

niches to enter and get a footing in the system (Geels, 2004). Niches may present both threats and opportunities and they are difficult to spot and project as they have yet to come to fruition (Dator, 2018). Megatrends are the result of a range of drivers which are grouped and framed to support high-level policy discussions on current and emerging challenges (Wilkinson, 2016). They are largely uncontrollable, have cross-sectoral impact and last anywhere around 10-30 years (van Dorsser & Taneja, 2020). Since these megatrends are the aggregation of underlying drivers, they can be framed ambiguously as evident by the vast repository of online megatrend reports providing different but related accounts of megatrends. For the purposes of this paper, we draw from the European Commission's (2022) knowledge for policy platform, the Megatrends hub. The hub contains a set of 14 megatrends and a description of underlying trends which are relevant for the future of Europe. The megatrends are all built on a rigorous process of research and deliberation to support EU policymaking process. Since its conception, is has been periodically kept up to date and relies on continuous contributions as a form of collective intelligence (European Commission, 2019).

In Molitor's model of change (2010), the first step of the emergence of an issue is the external environment (i.e., landscape). Molitor considers more aspects of the socio-technical regime as part of the environment, however, the general idea aligns, since it includes aspects such as wars and megatrends. Stemming from developments in this environment, issues emerge which can be framed. This is a creative process as problems go from ill-defined and abstract to more specified and defined (*ibid*). Axelsson (2022) suggests that once an emergent phenomenon has been identified, understanding whether it is a good or bad and for whom is necessary. Ideas may die at their infancy, whilst more sound ideas emerge and do so over longer time spans.

Integrating the concepts above, using the MLP as a theoretical framework, we outline our conceptualization and definition of what constitutes a grand challenge and the emergence thereof, also separating the concept from that of megatrends. In doing so, we deal with the issues of degrees of complexity, issues of scale, and temporal scope which otherwise can create

a broad and non-specific concept (Seelos, Mair, & Traeger, 2023). Megatrends are impactful, large-scale, and long-lasting developments, whereas grand challenges are the consequences of such trends. Grand challenges are thereby defined as the pressures exerted upon the regime from landscape developments. They can come in the form of shocks or stresses and are pervasive, as in their effects are largely homogeneously felt throughout the system. This imposes a stronger distinction between megatrends and challenges as it is the effects of such events and trends that impose challenges rather than the trends themselves. Global or grand challenges from another perspective constitute not only problems to address, but also scientific, technological, ecological, and social goals or ambitions which can unlock new abilities for the progression of human and planetary development (Kaldewey, 2018). We view such challenges as the development and integration of niches into the regime, i.e., the bottom-up societal advancements as shown in figure 1. As such, we can thereby view grand challenges as existing on a spectrum of intricacy, from complicated to complex, between the simple and wicked (Martí, 2018). This view then includes scientific advances as more complicated grand challenges concern the development of niches and them breaking into the regime, they are non-persistent and of relative scale to the system in question. Whereas the more complex problems stem from the pressure exerted upon the system from the landscape (Brown, 2021). Grand challenges in the form of achievements, such as major advancements in technology, medicine, or mathematics, still constitute a grand challenge however of a simpler complexity.

Challenges of the 21st century

The challenges faced by the EU during this century are many and cannot possibly be fully covered in neither depth nor breadth. However, this section attempts to provide an overview of recent accounts thereto as a baseline depiction of what is anticipated. Kuiper & Brady (2023) focusing on health within the EU discuss *challenges* (not referring to them as grand but treated in an equivalent manner). They mention several megatrends as challenges and acknowledge their interconnectedness, including but not limited to the Russian aggression on Ukraine, the cost-of-living crisis, changing demographics and climate change. Framed as global, grand, and thorny

challenges, Brown (2021) outline two challenges: The first concerns multi-crises in already vulnerable communities that inhibits their core functionality, the challenge therein is for their governments to provide security during prolonged and multiple crises. The second is the widening inequalities on multiple scales from global to local, in how power, resources, and emissions are distributed. Drawing from more popular literature, we find extensive lists of grand challenges for the future of the 21st century. Lufkin (2017a; 2017b) outline many challenges for the BBC:s future column, beginning with the ethics of genetic modification; dealing with an ageing population; sinking cities and their populations; the spread of social media and its effects on society; global security as new geopolitical tensions rise; transitioning to driverless vehicles; resource scarcity; interplanetary travel and colonization; neural enhancements and their effect on inequality; and the rising concern over AI's influence. These grand challenges are however both scientific advancements and problems to manage, for a more extensive list, see Lufkin (2017b).

More rigorous sources of grand challenges on the other hand can be drawn from The Millennium Project (2024), a private think tank which provides a framework for 15 global challenges which are continuously monitored and updated using a vast repository of expert knowledge (Glenn & Gordon, 2001). Published around the turn of the century 15 global issues and opportunities were merged into 15 global challenges standing before us at the time, along with a normative scenario on the 2050 horizon (*ibid*). By merging issues and opportunities, The Millenium Project frames each challenge as a question of how, and thereby manages to combine the problems perspective and societal-scientific advancement perspective. These global challenges include a comprehensive range of areas: Achieving sustainable development for all, ensuring sufficient clean water without conflict, balancing population growth and resources, creating genuine democracy from authoritarian regimes, and making policy decisions sensitive to long-term and global issues. Additional challenges include ensuring information and communications technologies work for the benefit of everyone, promoting ethical market economies to reduce wealth disparities, combating new and reemerging diseases, enhancing decision-making capacities amidst changing work and institutional landscapes, and

developing new security strategies to curb ethnic conflicts and terrorism. Furthermore, they address improving the status of women to better the human condition, preventing organized crime from gaining more power, meeting growing energy demands safely and efficiently, accelerating scientific and technological advancements for societal benefit, and incorporating ethical considerations into global decision-making processes (Glenn & Gordon, 2001). Finally, these challenges are accompanied by suggested actions to address said challenges as well as regional considerations taking into account the more nuanced contexts around the world (See, The Millennium Project, 2024). These challenges represent long-lasting challenges which have been around for a long time and will continue to for the foreseeable future.

3 Methodology

Conventional trend analysis focuses on one trend in isolation (Puglisi, 2001). As megatrends are characterized by an ambiguous and interconnected nature (Marmier et al., 2022), we explore them in relation to one another through a cross-impact analysis (Weimer-Jehle, 2005). Cross-impact analysis was initially developed by Theodore Gordon and Olaf Helmer in 1966 to assess the probability of an event occurring and the impact this had on other events occurring (Gordon, 1994; Helmer, 1977). From which different policy interventions could be introduced and analysed to assess their impact on this probability or consequence of the event (Gordon, 1994). Focusing on the consequences of the combined developments of megatrends, this study analyses the impact of megatrends on each other in terms of events or forces that could be a consequence of their interaction, described in more detail in the following sections. This analysis is then followed by an emerging issues analysis, developed in the 70s by Graham Molitor to forecast changes in public-policy, EIA has reached extensive use as a futures method (Dator, 2018; Molitor, 2018). In combination these two methods contribute to the purpose of exploring the complex interlinkages of megatrends and anticipating their conceived challenges. Figure 2 shows an overview of the research design and flow

between the input, analysis and outputs including the number of items processed in each stage.
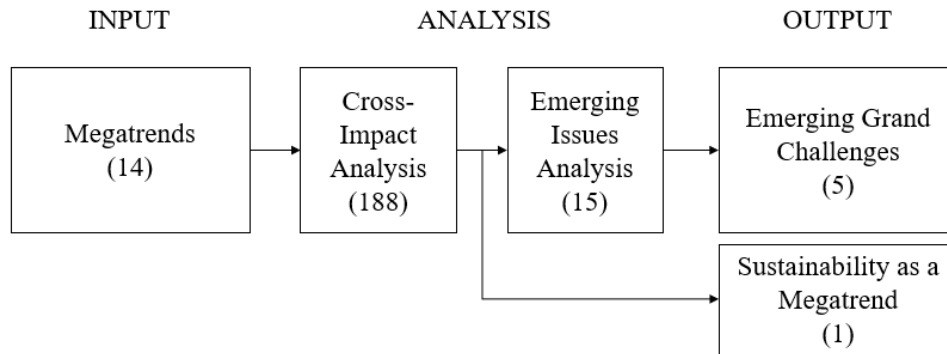
INPUT   ANALYSIS   OUTPUT

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┌──────────────┐   ┌──────────────┐ ┌──────────────┐   ┌──────────────────┐
│              │   │   Cross-     │ │  Emerging    │   │ Emerging Grand   │
│  Megatrends  │──▶│   Impact     │▶│  Issues      │──▶│   Challenges     │
│    (14)      │   │  Analysis    │ │  Analysis    │   │      (5)         │
│              │   │   (188)      │ │   (15)       │   └──────────────────┘
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                                                        ┌──────────────────┐
                                                        │ Sustainability as a│
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Figure 2. Overview of research design.

Cross-impact analysis

To understand the interlinkages between megatrends, this study employs a cross-impact analysis using soft-system knowledge and intuitive logics (Weimer-Jehle, 2005). The method has seen extensive use as a futures methodology, e.g., Panula-Ontto et al. (2018) applied the method for the purpose of identifying emerging challenges in the Finnish energy system. As megatrends can by definition be assumed to affect each other, this study takes a more qualitative approach to assessing their impact on one another rather than assessing the severity thereof. Drawing from the 14 megatrends as outlined by the European Commission's (2022) Megatrends hub, interlinkages between trends were assessed in terms of driving forces and potential consequences. The interlinkages of the megatrends were systematically reviewed, totalling 182 potential combinations which were surveyed and discussed amongst the three researchers. For each possible link we asked what impact Y on a global level had on X in the EU by 2050 and if this posed a significant challenge beyond the trend itself based on the combined expertise of the authors. The matrix found in the appendix was tagged with a +, -, ±, or '?' depending on the directionality and uncertainty of the impact. The causal reasoning was based on trend cards procured through the Megatrends hub which included a description and underlying trends, combined with complementary expertise and backgrounds (van

Woensel, 2024). Certain assumptions are imposed regarding the megatrends reach in time, space, and impact, all assumed to be comparatively equal and constant. Considering that these megatrends are based on the same dataset and are rigorously framed, we can consider them to operate within the same scope (van Dorsser & Taneja, 2020). Regarding any perceived uncertainties, the impact would be tabled for further research and consideration, meaning that a brief literature review was conducted, and the impact was discussed again at a later stage as the matrix was reassessed. Through this iterative and systematic assessment, previous assumptions could also be questioned, allowing for new insights to emerge and allowing for a second chance to identify any previously missed impacts. This process resulted in 127 impacts, 15 of which were identified as potential challenges to be analysed further and framed as part of the Emerging Issues Analysis (EIA). The novelty of challenges that emerged as a result of this analysis varied. Some were more prevalent such as the ensuing climate crisis, others less apparent such as generational inequality.

Emerging issues analysis

An EIA is used to understand potential threats and opportunities in their early stages of emergence (Dator, 2018; Inayatullah, 2008). This allows for monitoring developments in anticipation of them and provide early warnings (Wildman, 2001). Typically, emerging issues are detected through bottom-up scanning, searching for weak signals which may pose issues as they grow to become trends or even megatrends (Schultz, 2006). However, defining challenges as the pressures exerted on the European regime from megatrends, challenges were identified based on the combined impact of two megatrends. Thereby, rather than assessing the impact of niche technologies, social movements, or policies, this approach uncovers challenges stemming from a more aggregate level.

The model as shown in figure 3 describes three phases of development as an issue goes from developments in the external environment, to be (I) identified and framed, (II) advanced into consideration, and (III) finally into resolution. The method was employed to assess the emergence of each of the identified potential challenges, navigating the space between the external environment and the ideas which emerge to frame them. This process relied heavily on soft data, requiring intuitive judgement (Helmer, 1977).

Figure 3. Simplified Molitor Model of Change adapted from Molitor (2018).

Challenges were thereby selected based on perceived novelty by screening traditional and grey literature, including policy documents and for their mention. Issues high on the model of change i.e., phases II or III were excluded from further assessment. Taking a step back and viewing the bigger picture of impacts, the challenges were grouped based on emergent themes that were further developed through literature review and are presented as such in the following results section.

For validation of the approach and findings, we utilized an extended peer community (Funtowicz & Ravetz, 1993). Utilizing internal review functions, conference presentation and discussion to elicit feedback, and disseminated and discussed the findings with the Joint Research Centre of the European Commission (Whyte, J., personal communication, 2024 June 25).
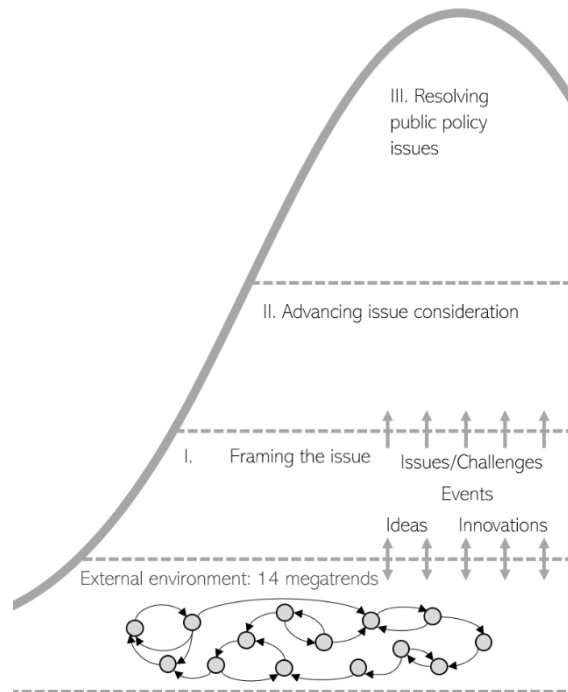
4 Results

This section presents a description of the emerging challenge areas, the underlying cross-impact matrix can be found in the appendix showing ideated impacts. While megatrends can largely be assumed to affect each other, these impacts are based on our combined expertise and ability to identify potential challenges. This means that this framing is not unambiguous nor exhaustive. Where there is a connection missing, it is due to us not being able to reason out a significant impact and not due it not potentially existing one.

Emerging grand challenges

The following are the identified and framed challenges as interpreted and further developed through literature review, backing up the interlinkages and exploring their possible development.

Generational inequality and retirement crisis

Widening inequality and demographical change drive each other in a potentially vicious circle. Demographical change imposes greater inequality between generations, and widening inequality increase already prevalent gaps between generations. Weighing in new forms of work such as the gig economy these developments are rendering workers future retirement at stake as fewer contribute to their pension savings potentially leading to a pension crisis, as pension and welfare systems are not able to cover this gap if gig economies continue to grow (Allchin, 2024; Swedish Pension Agency, 2021). Meanwhile growing fears that pension systems resemble Ponzi schemes as they rely on continual growth and throughout of a productive population threaten the integrity and legitimacy of such systems. In the wake of increasing relative voting power amongst the elderly, potential reform may be increasingly difficult as short- and long-term interests become unaligned.

Climate crisis, migration, and resource scarcity.

The effects of continued climate degradation, growing resource scarcity, and resulting climate refugees will constitute a grand challenge. It is of the outmost interest to avoid such a crisis in the first place (Noonan & Rusu, 2022). However, with current global policies, the possibility of limiting warming to even 2°C is looking grim (IPCC, 2023). Besides physical resources such as food, water, energy, and land, as megatrends are progressing and reinforcing each other, time is yet another resource becoming scarce as complexity and urgency are perpetually increasing. With more exposed nations increasingly looking towards the 'developed' world for remedy and compensation, a future with increasing climate refugees will place an immense burden and strain on European systems. It

will become increasingly pressing to find levels of sufficiency which lead to stable populations and systems to support them, with adequate levels of consumption which ensures levels of quality of life without inflicting upon planetary boundaries (Jungell-Michelsson & Heikkurinen, 2022).

Urban systems under pressure

Continuing urbanization and climate change and environmental degradation is putting pressure on an already strained resource scarcity (He et al., 2021). This problem can already be seen manifesting in megacities such as Mexico City, especially with the development of informal settlements where access to water and waste management is a growing challenge (Gutierrez, 2019). Such settlements are scarcer in high income areas such as the EU, however, without affordable and adequate housing, a rise in such housing may be on the horizon for European countries (Kuffer, Proietti, & Siragusa, 2023). More prevalent infrastructure congestion can be seen in electricity systems around Europe, with a projected need to double cross-border transmission infrastructure by 2030 (European Commission, 2023). Although this is both a supply and demand issue, changing weather patterns will continue to exacerbate these strains by crippling power production capacity, reducing transmission capacity through overheating, and increasing power demand through heating and cooling. Under normal operation this is oftentimes manageable, however, during peak demand, issues become more apparent (Sherman, Lin, & McElroy, 2022). These developments will come to affect infrastructure such as fresh- and wastewater, transportation, and energy, in the long-term causing outages, congestion, and other systemic issues. Therefore, we see a growing demand to flattening daily consumption curves through both technological and social means, in addition to conventional infrastructure development. However, changing behaviour and daily consumption patterns imposes a grand challenge of redesigning practises and society. Using the theory of social practice, Smale, van Vliet and Spaargaren (2017) analyse the barriers and opportunities to sustainable domestic energy consumption by looking at the interaction between household practices and smart grids. The process of realising smart grid interventions can conflict with existing daily routines as it requires a fundamental shift in how and when resources are consumed. Such a change

imposes a readjustment and flexibility in daily routines and behaviour. While some practices are easier to stretch and reconfigure, other practices such as cooking, can pose obstacles, causing further social injustices. Technological advancements and growth of certain sectors is poised to mitigate this challenge by increasing efficiency, scaling up systems to create more headroom, and eliminating bottlenecks. However, in doing so most likely also creating induced demand through rebound effects and therefore also requires behavioural change (Giampetro & Mayumi, 2018).

Detachment from reality

Following technological advancements, a changing security paradigm, increasing influence of new governing systems – The challenge of distinguishing between real and fake news, and between the physical, virtual, and augmented realities, will most likely continue to grow, which in turn feeds into misinformation, insecurity, and distrust posing further threats to democracy (Vaccari & Chadwick, 2020). Perceptions of reality will grow increasingly subjective and multiple as there will be trustworthy experiences that become personal truths (Suiter, 2016). Competing narratives of techno-utopic and dystopic visions of society as new technologies constitute both threats and opportunities. Potentially parallel societies in the digital realm, building on already existing isolation, depression, and loneliness, creating a social detachment from reality; and others seeking to disconnect from hyperconnectivity altogether. Further social lock-in is created through algorithmic filter bubbles which limits ones' worldview (Maati et al. 2023). New laws are coming into place that mandate that artificially generated photos and films of people be branded as such, however, this does not stop bad actors from disregarding such rules. Early-stage examples of this can already be witnessed to an extent through misinformation campaigns (Government Offices of Sweden, 2023), growing corruption (Directorate-General for Migration and Home Affairs, 2023), and direct sabotage leading to conspiracy theories as there may be distrust behind official truths (Guhl, 2024). However, these are possibly merely early signals of a much greater challenge in the long-term. Future challenges in this cohort of issues include validating the source or truth of material, which will be an immense technical and social challenge. There is

a possibility that this challenge can be mitigated by a diversification of education and learning, making younger generations better able to suss out misinformation and artificially generated content; and older generations to acquire this ability further down the road. Some technological advancements may also subdue this risk by being able to flag artificially generated content and potentially misleading information, however, this creates a perpetual arms race between those trying to influence and those trying to detect.

Labor displacement

A stagnating European population growth, a booming population in developing economies, increasing adversities from climate change and a desperate need for a skilled workforce. These developments present an immense ethical challenge, characterized by a disparity between climate contra skill migration. Countries are shutting down their borders to refugees whilst calling for a skilled workforce to help abate their growing pension and productivity crisis, yet migrants are oftentimes de-skilled and exploited to work low-paying and low-skilled jobs (Purkayastha et al., 2023). We see a future, where migrant populations are forced to, or otherwise required to upskill themselves using their own educational infrastructure or one imposed on them from the developed world, in order to have the chance of receiving a working permit. Much akin to the older concept of brain drain, the phenomena of emigrating skilled labour seeking opportunities elsewhere, whereas this (re)emerging form of more exploitative nature. Competition for qualified students has been a long-standing trend in higher education (Bennell & Pearce, 2003). National higher education in developing countries has suffered at the hand of private and overseas institutions that are able to attract top candidates (ibid) and may continue to do so. Shaping educational policy in developing countries according to the needs and wants of the developed world imposes significant cultural clashes and questionable sustainability at both ends of the equation, becoming a form of colonization of education (See also Silova, Rappleye, & Auld, 2020). Overcoming these multifaceted issues in a sustainable, just, and ethical way reveals a significant grand challenge of the future significant change in systems of education, migration, and labour around the world.

Although this may to an extent be mitigated by diversification of education and learning, allowing people to reskill to suit changing needs, it does not address the larger challenge of labour scarcity. Whilst technological improvements and automation may subvert some demand, future concern for physical labour are still prevalent. In a recent policy briefing by the OECD (2023) they describe how the EU energy transition will generate 2.5 million jobs and the importance of migration to that end. Since potential migrants might not possess the adequate skillset, it is proposed that this be matched with development modules in the origin countries. Concurrently, emerging fears of white-collar work being displaced as a consequence of increasing technological advancements such as artificial intelligence introduces further uncertainties of the future, potentially serving as a remedy or further exacerbating these challenges.

5 Discussion and concluding remarks

This study contributes to the understanding of interlinkages between megatrends, providing a holistic outlook on emerging grand challenges 2050 and beyond that should be continuously counteracted. In doing so, we emphasise the importance of considering the breadth of developments as they can strengthen the consequence of others and create otherwise unanticipated consequences (Bremberg, 2018). Going beyond the global challenges of previously published literature, these emerging grand challenges contribute to the continued outlook for anticipatory governance. As opposed to the global challenges of The Millenium Project as described by Glenn & Gordon (2001), we propose a distinction between grand challenges of a scientific and advancement nature to that of a more complex challenge. In doing so, this study also contributes to the integration of futures studies with the Multi-level Perspective (see also, Vähäkari et al., 2020).

Lastly, we propose that sustainability/eco-awareness become a megatrend as a fifteenth megatrend in the Competence Centre on Foresight as it would serve to balance the impacts of several trends, acting as a 'threat divider'. However, in doing so we must not assume that sustainability is an

unstoppable force, more effort is needed to accelerate this trend and thereby ease the burden on the others. The trend of eco-awareness or sustainability in general, is sometimes viewed as a megatrend (see e.g., Mittelstaedt et al., 2014), however, not in the Megatrends hub. It is however mentioned as part of the growing consumption megatrend that more eco-conscious consumption is increasing, this does not align with the overall megatrend nor covers the additional effects of evo-awareness. Furthermore, it is stipulated in megatrend (5) that the effects of climate change are affecting behaviour. Though this may be explained as climate change and environmental degradation impacting the cultural and preferential nature of the socio-technical regime, broad cultural changes may also constitute landscape developments (Geels, 2004). Therefore, we argue that this has developed steadily enough to necessitate it as a stand-alone megatrend and is required to fill some missing links in the mapping process. For instance, eco-awareness is contributing to peoples' reproductive choices thereby increasing demographic imbalances (Dillarstone, Brown, & Flores, 2023); and climate change and environmental degradation should have an indirect negative effect on growing consumption through a megatrend of eco-awareness. There is also a missing link here between how climate change and degradation affect consumption patterns from fossil-fuels towards other resources changing the influence of e.g., oil states.

Limitations and future(s) research

Due to our holistic perspective, we miss out on the depth of analysis within each development and the challenges. Therefore, further research can choose to focus on particular relationships and their potential consequences, however, with the remainder thereof still in consideration. Furthermore, as we deal with these issues on a systemic level, certain more niche challenges are overlooked, whose implications can be of great significance in the long-term. Therefore, a more bottom-up perspective of investigating the emerging grand challenges stemming from the development of niche innovations is warranted.

There are several methodological limitations to this research. First and foremost, our outlook of challenges is non exhaustive and is subject to our

areas of expertise and biases as it served to explore and exemplify the complexity of interlinkages. Therefore, further research and practise should take similar approaches utilizing wider range of expertise and perspectives. Secondly, future research can consider different weights of linkages through expert judgement. Lastly, the pace at which these megatrends develop has not taken into account and can differentiate greatly between trends. We use some form of presumption regarding their coevolution which therefore also can be more quantitatively compared. Although the relationships between these trends are multiple, they may also be changing (De Smedt, Borch, & Fuller, 2011). Therefore, there is room for additional uncertainty as their relationships may transform in the future.

Pertaining the discussed challenges, further research can establish indicators to monitor their development to see whether they emerge on the agenda. More work can also go into framing and understanding the problems per se. Due to the uncertainty given this time scope, establishing indicators to track the emergence of these challenges can give a continuous indication of their accuracy and the efficacy of means to address them. This paper does not predict what will happen, however, implores the reader to beware and anticipate them as potential developments. To assess their progression in policy, text mining approaches can be utilized in policy discourse and reports. (Marmier et al., 2022).

Data declaration

All working data will be made available upon request.

Appendix. Table a. Cross-impact analysis, showing noted tensions/challenges in orange.

	1. Accelerating technological change and hyperconnectivity	2. Aggravating resource scarcity	3. Changing nature of work	4. Changing security paradigm	5. Climate change and environmental degradation	6. Continuing urbanization	7. Diversification of education and learning	8. Widening inequalities	9. Expanding influence of East and South	10. Growing consumption	11. Increasing demographic imbalances	12. Increasing influence of new governing systems	13. Increasing significance of migration	14. Shifting health challenges
1. Accelerating technological change and hyperconnectivity		(+) Efficiency gains are reducing resource intensity, however, shifting scarcity towards critical materials and inducing rebound effects.	(+) Enabling remote work, AI is altering white collar jobs, automization affects blue collar work. Cross-cutting effects on creativity and productivity.	(+) New vulnerabilities and criticalities increase need for independence, cybersecurity and desinformation.	(+) Rebound effects of efficiency gains and new tech drives further need for material and energy extraction.	(-) Enables people to live and work in rural areas.	(+)Enables and drives micro-learning, hybrid teaching, and requiring life-long learning.	(±) Enabling transparency and access to knowledge, yet access to emerging tech and its benefits are mainly afforded by the wealthy.	(+) Enabling a global society.	(+) Creating more directed and personalised advertisements, and influencers can push products.	(+) Tech displaces jobs and reduces opportunity for new generations, and new technology can replace desires for having children.	(+) Creates new governing systems such as AI, participatory modes of governance, and information technology.	(-) Remote work can be offshored, information can flow without the flow of people.	(-) Negative due to long-term possibilities for biohacking, decreasing screening time, and early detection
2. Aggravating resource scarcity	(-) Hinders further development, but to a möderate extent also drives new innovation.		(+) Possible challenge as scarcity may neccesitate changing demand patterns through work routines.	(+) Needs to secure supply-chains reduces globalism.	(+) Scarcity leads to furhter intensity in extraction, shifting to new areas of environmental degradation.	(-) Urban challenges may drive people towards rural self-sufficiency.		(+) Inequality in access to resources and externalities of extraction.	(+) able to leverage access to in demand resources, however, also more subjected to scarcity increasing restorative claims.	(-) Scarcity decreases consumption.	(+) Further driving reduced birthrates.	(+) Increasing need for demand-side management whcih can govern over peoples daily lifes.	(+) Migration may become a growing issue as local resouces are already under constraint.	(+) Scarcity affects health challenges by limiting access to affordable clean water, energy, and food.
3. Changing nature of work	/	/		/	/	(-) Increases ability for remote work and thereby rural settlement.	(+) Education is strongly linked to the demands of work.	(+) Makes certain jobs more attractive and beneficial for highly educated, whilst others are left with less job security.	(±) Uncertain trajectory, shifting from industrial to service economy may drive increased or decreasaed influence.	(±) Reduces some consumption such as travelling, yet increases other forms of consumption.	(-) Remote working, 4-day work week, gig-work, and other forms of work increase work-life balance and supports the creation of families.	(+) Creates need for new forms of governance.	(+) Migration changes form and neccesity.	(+) May reduce movement and creates social health challenges.
4. Changing security paradgim	(+) Driving technological arms race.	(+) Supply chains may be tightened. Resulting in a possible challenge as resource conflicts will emerge.	(-) May limit the change in work as security concerns increases.		/	(-) Urban environments become targets for attack driving people towards rural homesteads.	(?) Potential challenge if education and learning does not keep up with the changing security paradigm.	(+) Potential challenge as social cohesion is threatened through polarization and inequality of security.	(+) Shifting paradigm leads to more strategic consideration of South and East partnerships.	(+) Potentially increasing resource consumption in defence industries.	(+) Concerns for stability decreases birthrates.	(+) Will create new security and governance systems. EU and NATO will increase its influence.	(+) Significance increases in consequence of growing security concerns.	(+) Insecurity can lead to mental and emotional distress.
5. Climate change and environmental degradation	(+) Strong driver of innovation.	(+) Affects access to water, energy, and food.	(+) Drives a permeation of sustainability principles throughout the working environment.	(+) National interests are threatened, creating new security dynamics.		(+) People may flock to urban environemnts in hopes of resource provisions and to escape effects of climate change.	(+) Shifts need for education in skills for sustainable development.	(+) Less fortunate are more affected by effects of climate change.	(+) More subjected to climate adversities increasing punitive claims to developing from developed nations.	(-) Through changing social paradigm, consumption is decreased. Whilst consumption of 'sustainable' products increases.	(+) Leads to climate anxiety which affects birthrates. Young and old are more at risk.	(+) Increases need for multi-level and multi-domain governance.	(+) Climate migration becomes an emerging challenge.	(+) Effects of climate change imposes new health issues related to quality of water and food, heat waves, and floodings.
6. Continuing urbanization	(+) Increased urbanization increases technology push as new technologies are needed to manage denser populations.	(+) Denser populations create tensions on infrastructure and resource systems.	(+) Denser populations create the need for more round-the-clock services.	(+) Civil prepardness is affected as populations migrate to cities.	(+) Although more efficient, consumption is more concentrated leading to environmental degradation.		(±) More equal education, negative effect on diversification as it changes into more industrialized ways of learning.	(+) Unequal distribution of resources and services, where more resources are directed to urban areas, gentrification.	/	/	(+) Creates geographic demographic imbalances as more young people move into urban environments.	(+) Alters democracies as greater voting power emanates from urban areas.	(+) Population deficits in rural environments may pull for migrating populations to contribute to their growth and wellfare.	(+) Denser populations creat new health challenges. Centralized healthcare may give unequal access to healthcare.
7. Diversification of education and learning	(+) Ed-tech drives innovation, and access to learning may also contribute to driving technological innovation.	/	(+) New skills are being taught which change how work is done in the future, from productive machines to critical thinkers.	(+) Unstructured and informal learning enables questionable knowledge to affect learners.	/	/		(+) A diversified, informal, and less homogenous education can worsen inequalities if not recognized.	(+) Massive access to education globally, as well as questionable forms of education may increase the influence of East & South in the EU.	/	(-) Can decrease imbalances due to reschooling & life long learning.	(+) More norm-breaking and informal education can contribute to the influence of new governing systems, both good and bad.	(±) Some forms of migration may increase in significance but decrease in others.	/

Table a continued.

	1. Accelerating technological change and hyperconnectivity	2. Aggravating resource scarcity	3. Changing nature of work	4. Changing security paradigm	5. Climate change and environmental degradation	6. Continuing urbanization	7. Diversification of education and learning	8. Widening inequalities	9. Expanding influence of East and South	10. Growing consumption	11. Increasing demographic imbalances	12. Increasing influence of new governing systems	13. Increasing significance of migration	14. Shifting health challenges
8. Widening inequalities	/	/	/	(+) contributes to a changing security paradigm by creating unrest and injustice.	/	/	(+) Leads to both the growth of unofficial sources through distrust, and educational intervention, diversifying formal education.		/	/	(+) The gap between the rich and the poor increase already existing demographic imbalances.	(+) Poses a threat to democracy and social cohesion enabling new governing systems.	(+) In an inequal society, the significance of migration increases, which would otherwise be more equally distributed.	(+) Affects inequality of health and healthcare, exacerbating shifting health challenges.
9. Expanding influence of East and South	(+) Creating competition in technological development.	(+) Growing demand in East and South may increase resource scarcity in the EU as less can be imported.	/	(+) Drives changes in security paradigm as influence grows.	(+) Increased quality of life and growth might increase climate change and environmental degradation.	/	(+) May lead to a greater diversification of learning through the teaching of more perspectives and worldviews.	/		(+) May increase consumption in the EU through cheap and competitive products.		(+) Growing influence contributes to the influence of new governing systems.	(+) Attracting workforces may become a more competitive landscape	/
10. Growing consumption	(+) Drives incremental innovation to optimize systems.	(+) Growing consumption's impact on resource scarcity is already a strong link and a grand challenge.	(+) Increased consumption of certain goods and services creates new forms of work.	(+) Increased consumption and dependance thereto creates greater vulnerabilities to disturbances.	(+) Growing consumption's impact on climate change and environmental degradation is a prevalent challenge.	/	/	(+) Being poor is expensive, middle- and upper-class consumption increases the divides between social groups.	(+) Consumption of certain goods that are primarily made in certain parts of the world are increasing the influence of the East and South.		/	/	(+) Growing consumption in certain areas leads to demand for more migrant workforces.	(+) Growing consumption of certain foods creates health challenges.
11. Increasing demographic imbalances	/	/	(+) Older populations working imposes changes on the nature of their work.	(+) Elderly people are increasingly targeted for scams.	/	/	(+) Elderly people are incentivized to life long learning due to longer work-life.	(+) Creates inequalities between different age groups. Future of pension systems is a challenge for generational equality.	/	/		(+) Demographic imbalance create democratic challenges due to potentially different political interests.	(+) Increases the need for workforce migration.	(+) Ageing population creates challenges in providing healthcare.
12. Increasing influence of new governing systems	(+) Tech giants are afforded power to shape the future, towards their envisioned technoutopia.	/	(+) New governing systems can alter the nature of work in terms of decision making.	(+) Potential lack of transparency causes uncertainty in terms of influences, biases, and values.	/	/	(+) Introducing new influences and demands.	(-) Systems with built-in fairness may reduce inequalities.	/	(+) Personalized and directed advertisments and influencers pushing products.	/		/	/
13. Increasing significance of migration	/	/	/	(+) Foreign influence can create unease and decrease the feeling of safety.	/	/	(+) Off-shoaring education to ensure workforce migration suited to the needs of EU interests.	(±) Wealth could be a criterion if allowed to migrate. Migrating workforces risk being exploited in destination country.	(+) EU reliance on migration becomes a leverage point for East and South.	/	(±) May benefit age demographics but alter ethnicity demographics.	(+) New governing systems and metrics are introduced to manage migration.		/
14. Shifting health challenges	(+) Health issues are a strong driver for continued technological development	/	(+) Shifting health challenges, such as pandemic have a large impact on our ways of working as evident på Covid-19.	(+) Creates new forms of security concerns as new threats and vulnerabilities emerge.	/	/	(+) Altered health prerequisites changes how education is conducted. E.g., increase in attention deficite disorders.	(+) Causes concern for affordability and access to care, and private forms of health enhancements may increase such disparities.	/	/	(+) Child mortatliy and longer lifespans create imbalance in age distribution.	/	(+) Growing need for healthcare workers.	

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