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Article

Charting public health horizons: Hybrid SMEs and the X.0 Wave Theory in post-COVID governance

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Abstract: The COVID-19 pandemic has revealed significant weaknesses in global public health systems, highlighting the urgent need for innovative governance strategies. This study investigates the potential of the X.0 Wave Framework, also referred to as the Comprehensive Integration Theory, alongside the innovative model of Hybrid Enterprises (SME X.0, where X.0 = 5.0), to revolutionize public health governance in a post-pandemic era. It emphasizes the role of these transformative concepts in reshaping strategic approaches to health systems, ensuring resilience, adaptability, and proactive crisis management. It delves into the integration of advanced technologies and novel business models to improve public health responses, resilience, and preparedness for future crises. By merging forecasting models, proactive measures, and sustainable practices, this chapter presents a comprehensive framework for developing adaptable and robust public health strategies to meet evolving challenges. Healthcare, social systems, and welfare structures are transitioning from conventional practices to advanced, data-centric methodologies, giving rise to a groundbreaking concept termed the "Digital Health Ecosystem" (DHE) and a new paradigm known as the "Internet of Health" (IoH). This concept integrates Internet of Things (IoT) technologies into health and social welfare systems, revolutionizing how data is collected, analyzed, and utilized to enhance individual and community well-being. This proposal aims to develop a comprehensive framework guided by the X.0 Wave Theory to address the ethical, social, and digital dimensions of the IoH, ensuring that technological advancements benefit society equitably and responsibly.

Keywords: public health; Hybrid SMEs; the X.0 Wave Theory; post-COVID governance; health innovation; resilience; Welfare X.0; internet of health (IoH); digital health ecosystem (DHE); digital health

1. Introduction

The global health crisis caused by COVID-19 exposed critical gaps in public health infrastructures, emphasizing the urgency for fresh approaches to governance. This study presents the X.0 Wave Framework as a lens to analyze technological and societal transformations while exploring how Hybrid SMEs can drive innovation in health systems. By leveraging these ideas, it seeks to provide actionable strategies for building stronger, adaptive public health models in a post-pandemic world.

1.1. Key Question

What methodologies can be used to create a forward-looking framework that incorporates the X.0 Wave Theory and Hybrid SME models to assess outcomes, anticipate challenges, and mitigate the impacts of the COVID-19 pandemic?

Approach to Designing the Future Scenario:

1) Applying X.0 Wave Theory:
   - Define Waves of Change: Identify the current and future waves of transformation in technology, governance, and public health influenced by the pandemic. This includes assessing how these waves impact societal structures, economic systems, and public health frameworks.
   - Forecast Transformational Impacts: Use the theory to project how ongoing and future transformations will affect public health and governance, particularly focusing on emerging trends and technologies.
2) Hybrid SMEs Model:
   - Scenario Planning for SMEs: Develop scenarios that incorporate the role of Hybrid SMEs in navigating post-COVID challenges. Focus on how these enterprises can integrate environmental sustainability, social responsibility, and economic efficiency.
   - Adaptation Strategies: Design adaptive strategies for SMEs to enhance their resilience and capacity to manage future public health and socio-economic crises.
3) Scenario Development:
   - Identify Key Factors: Determine essential variables such as technological advancements, public health developments, environmental changes, and socio-economic trends.
   - Construct Scenarios: Create diverse scenarios including best-case, worst-case, and mixed outcomes to understand potential impacts and prepare for various future states.
4) Forecasting and Modeling:
   - Predictive Tools: Utilize predictive analytics and modeling techniques to estimate the effects of different scenarios on public health and governance systems.
   - Simulation Models: Implement simulation models to test the effectiveness of various interventions and strategies in managing the consequences of the pandemic and future crises.
5) Prevention and Preparedness:
   - Early Warning Systems: Develop systems for early detection of emerging public health threats and socio-economic risks.
   - Resilience Building: Create frameworks for strengthening the resilience of both public health systems and SMEs, emphasizing adaptability and sustainability.
6) Evaluation and Feedback:
   - Impact Assessment: Regularly assess the outcomes of implemented strategies and scenarios through rigorous impact evaluations.
   - Continuous Improvement: Adapt and refine strategies based on feedback and evolving conditions to maintain relevance and effectiveness.

1.2. Key result

A Framework for Socio-Educational Resilience: Integrating Blue-Green Sustainability and Digital Preparedness to Tackle Present Challenges and Future Social Disruptions.

Achieved Through:

1) SocioEdu Blue-Green Sustainability:
   - Educational Integration: Embed blue-green sustainability principles into educational programs and public health training to address both immediate and long-term socio-educational impacts.
   - Sustainable Business Practices: Encourage Hybrid SMEs to adopt blue-green sustainability practices, promoting environmental responsibility and social equity.
2) Digital Readiness and Recovery:
   - Strengthen Digital Infrastructure: Enhance digital infrastructure to support remote education, telehealth, and digital communication, crucial for managing the ongoing impacts of the pandemic.
   - Recovery and Adaptation: Develop recovery strategies that leverage digital tools and technologies to improve resilience and adaptability in response to evolving social crises.

1.3. Key impact

Creating Positive Global Change through Enhanced Socio-Educational Blue-Green Sustainability Outcomes.

Realized Through:

1) Improved Quality of Life:
   - Environmental and Social Gains: By incorporating blue-green sustainability into socio-educational and business practices, achieve improvements in environmental quality and social stability, contributing to a better quality of life.
2) Sustainable Development:
   - Long-Term Resilience: Ensure that strategies designed to address current and future challenges promote long-term sustainability and resilience in both public health and socio-economic systems.
3) Enhanced Global Stability:
   - Adaptive Systems: Build systems that are more capable of managing future public health crises and socio-economic disruptions, leading to greater global stability and well-being.

2. Literature review (background)

2.1. The X.0 Wave Theory in public health

2.1.1. Overview

The X.0 Wave Framework, also known as the Theory of All-Encompassing Evolution or Theory of Comprehensive Everything, was created and advanced by Mattiello in 2010 [1–9]. This theory offers a holistic model to understand the

progression of human society, technological progress, and business transformation. It identifies specific phases or eras, each marked by revolutionary technological breakthroughs that reshape societal structures and interactions.

This paper aims to explore the X.0 Wave Theory in detail, tracing its historical context, examining its societal implications, and forecasting its impact on the future. By providing a thorough overview, the proposal seeks to offer valuable insights into humanity's journey and the challenges and opportunities that lie ahead.

2.1.2. Background

The X.0 Wave, also known as the Theory of Future Eras or the Theory of Comprehensive Everything, is a global, sustainable, and forward-thinking framework. It provides an in-depth understanding of the development of human civilization, closely tied to advancements in knowledge, technology, and business (KTB). The theory divides history into distinct phases, each defined by transformative innovations that reshape societal structures and interactions. To analyze these shifts, the Seven Pillars of Sustainability (7PS) model is applied (see **Figure 1**).

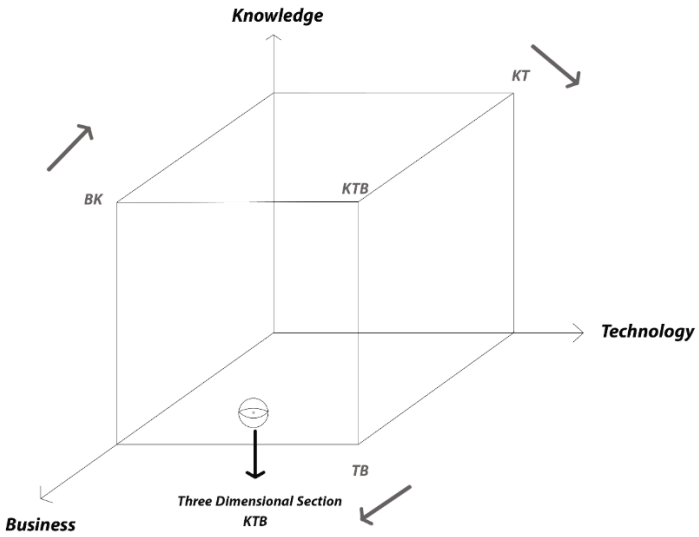

Figure 1. Overview of the KTB Model, which synthesizes concepts from Mattiello's work (2010–2017).

The theory suggests that human civilization has evolved through various distinct periods, each marked by breakthrough technological developments and societal changes:

1) X.0 = 1.0—The Cognitive and Agricultural Epoch
2) X.0 = 2.0—The Industrial Epoch:
   - First Industrial Revolution
   - Second Industrial Revolution
3) X.0 = 3.0—The Information/Post-Industrial Epoch (Alvin Toffler's Concept of Three Waves of Civilization, The 3rd Wave)
4) X.0 = 4.0—The Age of Intelligence (Digital Transformation, Biotechnology, Virtual Reality)
5) X.0 = 5.0—The Human Epoch or Age of Integration (Mattiello's 5th Wave/Tomorrow's Era or Comprehensive Everything Theory)

6) 6.0 ⩽ X.0—The Transhuman Epoch or Imagination Era (Mattiello's X.0 Wave/Epoch Theory)

2.1.3. Summary

This paper explores the far-reaching impacts of the X.0 Wave Theory, examining its relevance for future development across various areas:

1) Historical Exploration:
   - Analyzes the theoretical underpinnings and historical development of the X.0 Wave Theory, mapping the progression of human civilization through key advancements in knowledge, technology, and business.
2) Technological Shifts:
   - Investigates the rise of transformative technologies such as AI, biotechnology, and virtual reality, exploring their potential to shape future landscapes. This includes how these technologies integrate into industries, generate new business possibilities, and challenge existing frameworks.
3) Socio-Economic Impacts:
   - Considers the challenges and opportunities arising from technological disruptions, including policy measures to encourage innovation. The focus will be on effects on labor markets, economic inequality, and social welfare, with strategies for inclusive development and fair distribution of technological gains.
4) Business Evolution:
   - Looks at how entrepreneurship and innovative business models are driven by the X.0 Wave Theory. This includes examining the rise of digital enterprises, the role of SMEs in adopting new technologies, and the creation of novel business ecosystems. It will also highlight adaptation to Industry 4.0 and Society 5.0, with attention to cultural differences in technological adoption and societal integration.
5) Ethics and Sustainability:
   - Evaluates ethical frameworks and sustainable governance practices amidst rapid technological growth. The application of the Seven Pillars of Sustainability (7PS) Model will be explored:
     - Cultural: Emphasizing the importance of cultural values in guiding sustainable progress.
     - Environmental: Addressing the environmental effects of technology and encouraging eco-friendly innovation.
     - Social: Ensuring social justice and managing the societal consequences of tech advancements.
     - Economic: Promoting stable economic growth through sustainable business methods.
     - Technical: Supporting technological progress that aligns with sustainability.
     - Educational: Preparing a workforce capable of adapting to future challenges.

- Political: Developing policies that support ethical and sustainable technological development.

Furthermore, PEACE and LOVE will serve as core values, reinforcing a balanced approach to sustainability that fosters societal harmony and well-being.

The 7PS Model illustrates seven key pillars—cultural, environmental, social, economic, technical, educational, and political—interconnected through the core values of PEACE and LOVE, reflecting a balanced, human-centered approach to sustainability. These pillars ensure that technological progress remains aligned with ethical, ecological, and societal priorities (**Figure 2**).

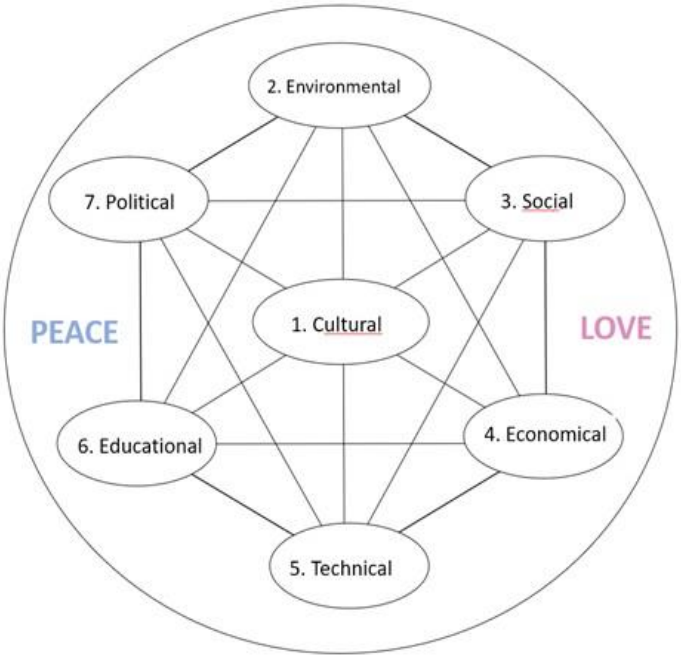

Figure 2. The seven pillars of sustainability (7PS) model, connections, priorities, and values (peace and love), from Mattiello's work (2017).

2.1.4. Detailed explanation

The X.0 Wave Framework offers a groundbreaking perspective on addressing future challenges and harnessing emerging opportunities. It integrates the paths of Industry X.0 and Society X.0, imagining a future where sustainability, creativity, and inclusiveness coexist harmoniously. At the core of this model is the Seven Pillars of Sustainability (7PS), which focuses on cultural values, environmental health, social well-being, economic stability, technological advancement, educational progress, and political governance, all guided by the principles of peace and love.

The theory champions digitalization, decarbonization, and decentralization—collectively known as the D3 technological revolutions—as the cornerstones of sustainable progress and innovation across various sectors. It delineates the evolution of humanity's technological and societal journey into distinct waves, with the current wave epitomizing the fusion of advanced technologies and the interconnection of diverse industries.

The Theory of Comprehensive Everything plays a pivotal role in shaping a sustainable and thriving future for humanity, with diverse applications in areas such

as smart cities, small and medium-sized enterprises (SMEs), innovation projects, and sustainable development practices.

1) Key Points
   - The Theory of Comprehensive Everything serves as a foundational guide for preparing for future shifts.
   - It encapsulates the core principles of contemporary and forward-looking business models.
   - It anticipates and plans for upcoming challenges and disruptions, especially within the 2020–2030 timeframe.
   - By merging the evolution of Industry X.0 and Society X.0, it lays the groundwork for Hybrid SMEs or Future SMEs.
2) Objectives
   - Empower businesses, particularly SMEs, to predict, avoid, and manage both current and future challenges, focusing on the first wave of tomorrow from 2020–2030.
   - Operate at the intersection of knowledge, technology, and business (KTB), as outlined in the KTB framework.
   - Promote blue-green sustainability, global innovation, digital readiness, and resilience through recovery and Corporate Social Responsibility (CSR) initiatives.
3) Approach
   - Utilize cutting-edge digital infrastructures to promote innovation and integrate future technologies, reshaping education, workforce development, and societal practices.
   - Grounded in various theories, models, and methodologies, such as the Seven Pillars of Sustainability (7PS) and concepts like Society 6.0, Welfare 6.0, and the Internet of Health (IoH).
4) Expected Impact
   - Imagines a future where education, healthcare, and economies are strengthened and where societies and SMEs flourish sustainably.
   - Envisions measurable improvements in human resource capabilities, societal well-being, economic robustness, and technological advancement.
5) Results
   - Aims to cultivate communities, societies, cities, and businesses that can navigate future challenges, plan for a sustainable future, and enhance global livability.
6) Conclusion
   - Suggests the model of Hybrid SMEs/SME 5.0 or Tomorrow's SMEs, focusing on environmental sustainability, social unity, and economic productivity.
   - Illustrates the evolution of the global economy from traditional models to data-driven frameworks.
7) Cooperation in New Conditions

- Advocates for global collaboration through events, workshops, and joint research initiatives to address the post-COVID-19 world and the ongoing digital transformation.
- Final Thoughts
- Highlights the importance of embracing digital change, fostering resilience, and guiding humanity toward a more sustainable future.
- Envisions a world where technological progress, cultural evolution, and international collaboration unite to solve global challenges and advance humanity.

2.1.5. Revolutions recognized by the X.0 Wave Framework

The X.0 Wave Framework divides human history into unique phases, each defined by groundbreaking technological innovations that reshape societal structures and human connections:

1) Cognition Revolution:
   - Started approximately 500,000 to 70,000 years ago with the rise of human cognition and the appearance of early humans.
2) Agriculture Revolution:
   - Began around 13,000 to 10,000 BCE, leading to the development of villages, cities, and empires.
3) Scientific Revolution:
   - Began around 500 years ago, enabling humans to dominate and control all ecological systems.
4) Industrial Revolution:
   - Began approximately 300 years ago, divided into two phases:
     - Early Industrial Era (around 1760 to 1840): Defined by the advent of steam energy and the rise of mechanized production.
     - Second Industrial Age: Introduced electricity and mass production techniques.
5) Business and Economics Revolution:
   - Began around 100 years ago, transforming economic systems and business practices, and divided into two phases:
     - Initial Business and Economic Transformation (early 1900s): Marked by the emergence of large corporations and the application of scientific management principles.
     - Second Business and Economics Revolution (2020–2030): Integrates advanced technologies like AI, digitalization, and biotechnology, focusing on the 7PS Model.

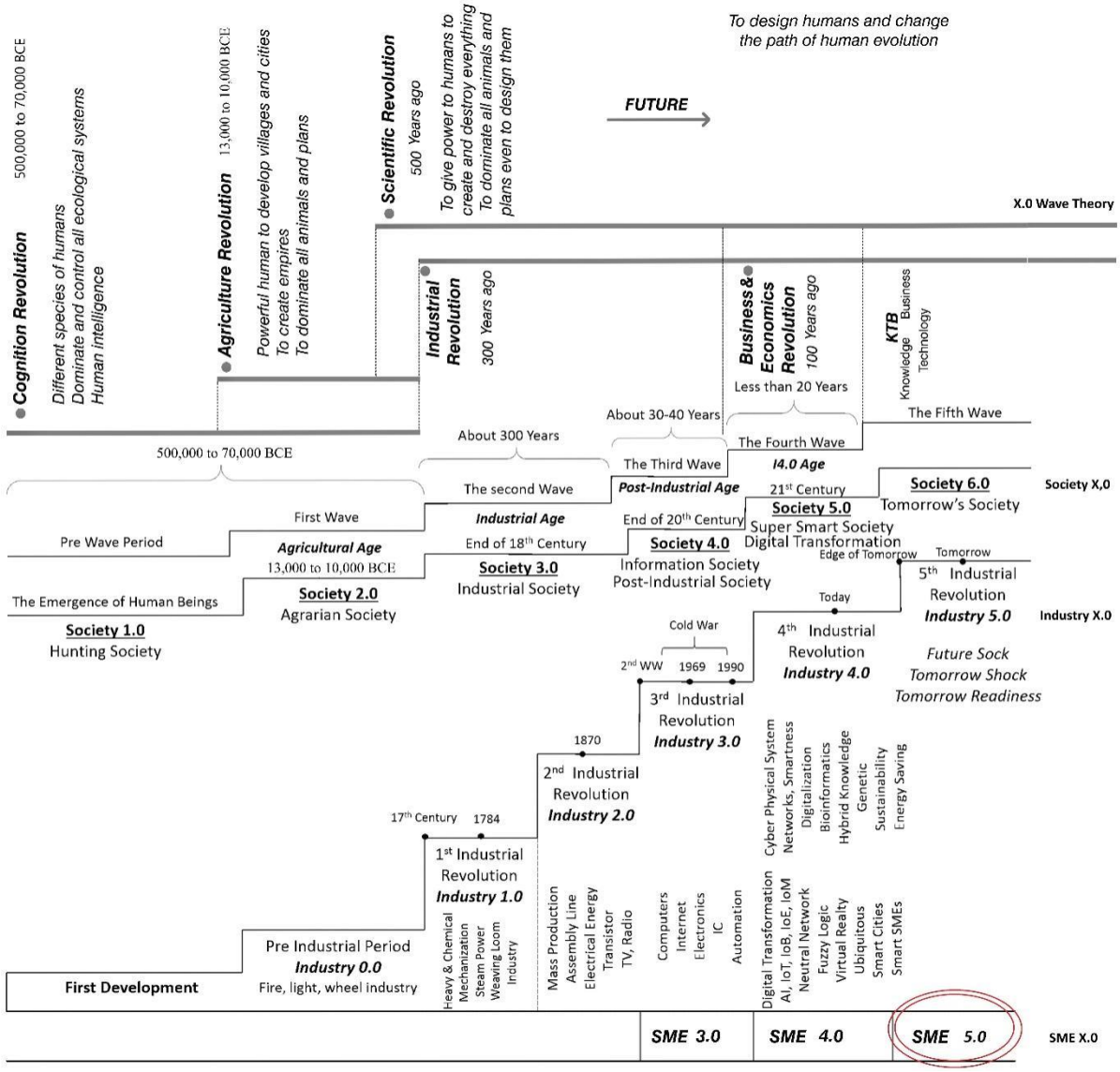

Figure 3. The X.0 wave/age ($1.0 \leq X.0 \leq 5.0$) theory, revolutions, ages, society, industries, technologies, and SMEs, from Mattiello's work (2010–2017).

Figure 3 illustrates the progression of societal, industrial, and technological revolutions through various epochs, ranging from Society 1.0 to Society 6.0. This framework, developed by Prof. H. Mattiello (2010–2017), maps interconnected developments across societal structures, technological paradigms, and the evolution of Small and Medium Enterprises (SMEs), providing a comprehensive lens for analyzing transformation and strategic adaptation in different waves of change.

2.1.6. Stages of human civilization in the X.0 Wave Framework

The X.0 Wave Framework underscores the critical role of innovation and technological advancements in shaping the course of human history, while recognizing the emerging challenges and risks brought about by each era. Represented as F(X), where X indicates various phases (1, 2, 3, 4, 5, 6, etc.), the theory illustrates the progression of human civilization through transformative periods, each of which leads to profound shifts in societal functions and interactions.

This model posits that human history can be divided into distinct eras, each marked by technological breakthroughs that alter how people live, communicate, and engage with their environment. The X.0 Wave Theory highlights the driving force of innovation in human progress while acknowledging the new obstacles that each stage introduces.

This theory, denoted as $f(x)$, where X represents different stages (1, 2, 3, 4, 5, 6, etc.), outlines the evolution of human civilization through these transformative waves, each bringing about profound changes in how societies function and interact.

1) X.0 = 1.0/Cognitive and Agricultural Era (1.0):
    - Time Frame: 70,000 to 500,000 BCE
    - Key Features:
        - Growth of human intelligence.
        - Emergence of diverse human species.
        - Shift from nomadic hunting and gathering to settled farming practices.
        - Formation of initial civilizations, villages, urban centers, and communal structures.

SME	Society	Industry	Waves/Ages	Revolutions			Year
	Hunting Society Society 1.0		Pre wave period	-)Cognition Revolution -)To Dominate and Control all ecological System -) Human Intelligence	The Emergence of Human Beings	-)First Development -)Different Spices of Human	**500,000 to 70,000 BCE**
	Society 2.0 Agrarian Society	-) Pre Industrial Period -) Industry 0.0 -) Fire, Light, Wheel Industry	-)The First Wave -)Agricultural Age	-)Agriculture Revolution -) Powerful Human to Develop Urban Areas -) To Create Emprises To Dominate All Animals, Plans and planets			13,000 to 10,000 BCE
				-) Scientific Revolution -)To Give Power to Humans to Create and Destroy Everything In the Planet -) Just one Human Specie			500 Years ago

Figure 4. Histomap of the X.0 Wave/Tomorrow Age Theory (1.0 ≤ X.0) from 500000/70000 years ago to 500 years ago, from Mattiello's work (2010–2017).

Figure 4 illustrates the Cognitive and Agricultural Era (X.0 = 1.0), spanning approximately 500,000 to 500 years ago. Based on Mattiello's work (2010–2017), the figure highlights key developments such as the evolution of human intelligence, the emergence of diverse human species, the transition from nomadic lifestyles to agriculture, and the establishment of early villages and urban centers—foundational shifts that set the stage for later societal and technological revolutions.

2) X.0 = 2.0/Industrial Era (2.0):
    - Time Period: 17th–18th centuries
    - Key Features:
        - Defined by the use of steam power, mechanization, and the rise of factories.

- Triggered mass production and significant urban growth.
    - X.0 = 2.1/First Industrial Era:
    - Time Period: 1760 to 1840
    - Characteristics:
        - Introduction of steam power and mechanization.
        - Advancements in the textile and iron industries.
        - Rise of factories and significant economic growth.
    - X.0 = 2.2/Second Industrial Age:
    - Time Period: Late 19th century
    - Characteristics:
        - Introduction of electricity and steel production innovations.
        - Chemical industry and mass production techniques such as the assembly line.
        - Further urbanization and economic expansion.

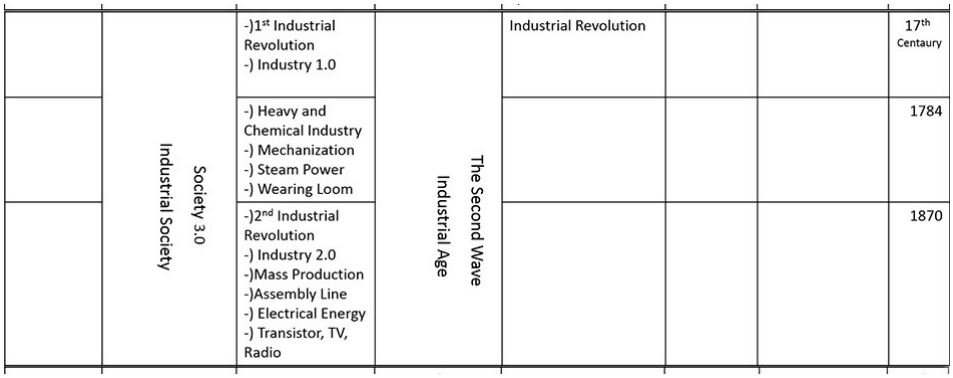

Figure 5. Histomap of the X.0 Wave/Tomorrow Age Theory ($2.1 \leq X.0 \leq 2.2$) from the 17th Century to 1870 from Mattiello's work (2010–2017).

Figure 5 depicts the Industrial Era, spanning from the 17th century to approximately 1870. Based on Mattiello's work (2010–2017), this figure outlines the transformative phases of the First and Second Industrial Revolutions. It highlights key innovations such as steam power, mechanization, and factory systems (X.0 = 2.1), followed by the rise of electricity, steel, and mass production techniques like the assembly line (X.0 = 2.2). These shifts fueled urbanization, economic expansion, and laid the foundation for modern industrial societies.

3) X.0 = 3.0/Digital Era or Post-Industrial Age (3.0):
    - Time Period: 20th century (1969–1970)
    - Key Features:
        - Shift of power from businesses to technology, particularly Information Technology (IT).
        - Marked by the digital revolution, the rise of computers, and the internet.
        - Major changes in communication and the exchange of information.
        - Emergence of knowledge-driven industries and the globalization of markets.
        - The creation of ARPANET (1969) and the foundation of the modern internet.

4) X.0 = 4.0/Age of Intelligence (4.0):
   - Time Period: Currently emerging
   - Key Features:
     - Defined by advancements in artificial intelligence (AI), biotechnology, and virtual reality (VR).
     - Widespread implementation of AI, VR, Industry 4.0, Society 5.0, biotechnology, and digital technologies.
     - Profound changes in every aspect of life and work.
5) X.0 = 5.0/Human-Centered Age (5.0):
   - Time Period: From the early stages of tomorrow (2020–2030), a projected future wave.
   - Key Features:
     - Focus on the convergence of technology and human biology.
     - Development of advanced biotechnology, genetic modification, and brain-machine interfaces.
     - Breakthroughs in healthcare and human performance optimization.
     - Emphasis on environmental sustainability, social equity, and human welfare.
     - Integration of Industry 5.0 and Society 6.0 principles.

SME	Society	Industry	Waves/Ages	Revolutions			Year
SME 3.0	-) Society 4.0 -) Information Society -) Post Industrial Society	Industry 3.0 • Computers • Internet • Electronics • IC • Automation	-) The 3rd Wave -) Post Industrial Age	-)Business and Economics Revolution1 Future	To Design Humans and Change the Path of Human Evolution	100 Years 40 Years The Cold War	2nd WW 1969 1990 2000
SME 4.0 Smart SME	-)Society 5.0 -) Smart Citizen	The 4th Industrial Wave • AI, IoT, IoB, IoE • IoM, Neutral Network • Fuzzy Logic • Ubiquitous • Networks	-) 4th Industrial Wave -) Digitalization Age -) Digital Transformation -) Virtual Reality -) Cyber Physical Systems -) Smartness -) Digitalization	-)Business and Economic Revolution 2 -)Hybrid Organization -)Cloud HR -)Greenhouse Gases Reduction -)Energy Saving -) CSR	Bioinformatics Hybrid Knowledge Genetics Sustainability	10 Years	2006 2011 Today
SME 5.0 SMEs for Tomorrows' Shocks	Society 6.0	Industry 5.0	-) The 5th Industrial Wave -) Tomorrow Age		**KTB** Model Future Shocks Tomorrow Shocks	**The first Edge of Tomorrow (2020-2030)**	Tomorrow
SME X.0	**Society X.0**	**Industry 5.0**	**-) The Xth Industrial Wave**		**KTB Model**	**The Xth Edge of Tomorrow**	Tomorrow

Figure 6. Histomap of the X.0 Wave/Tomorrow Age Theory ($3.0 \leq X.0 \leq 5.0$) from the 2nd WW to the first edge of tomorrow (2020–2030) from Mattiello's work (2010–2017)

Figure 6 illustrates the progression from the Digital Era (X.0 = 3.0) to the projected Human-Centered Age (X.0 = 5.0), covering developments from the Second World War to the early edge of tomorrow (2020–2030). Based on Mattiello's work (2010–2017), the figure outlines key shifts: the emergence of information technology

and the internet (3.0), the rise of artificial intelligence and immersive technologies (4.0), and the forecasted integration of biotechnology, sustainability, and human-centric innovation (5.0). This continuum reflects the accelerating convergence of technology, society, and human identity in shaping future civilizational paradigms. The Histomap of the X.0 Wave/Tomorrow Age Theory (X.0 = 6.0) further projects the emergence of the Transhuman Era—a future phase beyond 2030, following the first edge of tomorrow (2020–2030). Drawing on Mattiello's foresight work (2010–2017), this phase anticipates radical advancements such as brain–machine interfaces, genetic engineering, space colonization, and the pursuit of digital immortality. The X.0 = 6.0 wave challenges contemporary paradigms of identity, ethics, and sustainability, inviting profound reflection on the long-term impacts of exponential technological evolution.

6) X.0 = 6.0/Transhuman Era (X.0):
   - Time Period: Predicted future phase
   - Key Features:
     - Fusion of technology and biology, pushing beyond human limitations.
     - Possibilities for profound transformations, including human immortality and exploration of outer space.
     - Focus on comprehending and preparing for the effects of technological progress.

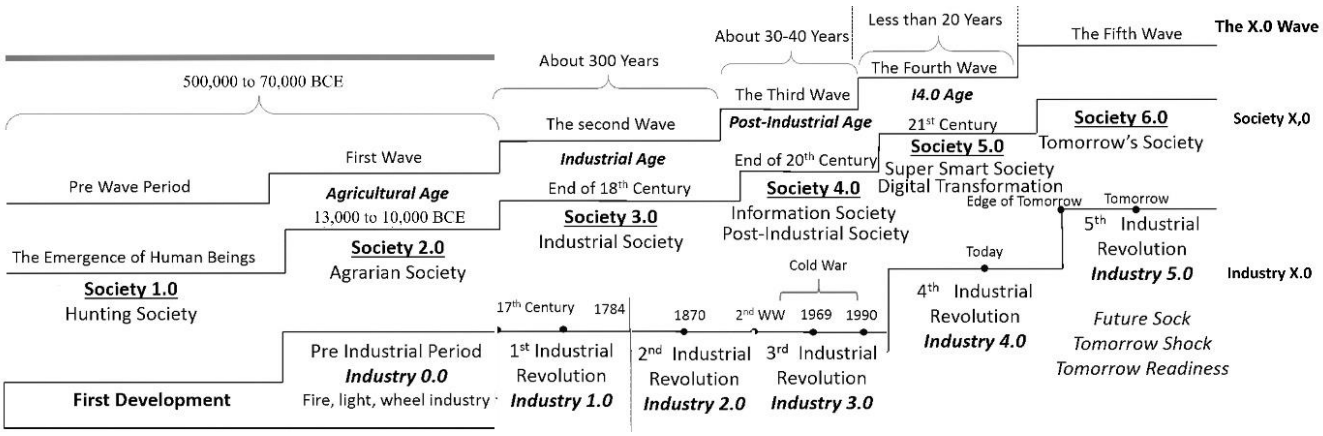

Figure 7. The X.0 wave/age (1.0 ≤ X.0 ≤ 5.0) theory, ages, society, industries, and technologies, from Mattiello's work (2010–2017)

Figure 7 illustrates the evolution of human civilization through five major waves (X.0 = 1.0 to X.0 = 5.0), mapping the transformation of societal structures, industrial paradigms, and core technologies across epochs. Each X.0 wave reflects a distinct convergence of human needs, technological advancements, and organizational forms—from the Cognitive-Agricultural Era (1.0) through the Industrial (2.0), Digital (3.0), and Intelligent (4.0) Ages, to the emerging Human-Centered Age (5.0) and Transhuman Age (6.0). It highlights how industries and SMEs evolve in alignment with broader civilizational shifts, providing a framework for understanding strategic adaptation and sustainable transformation.

2.1.7. Imagining the future

The X.0 Wave Framework, in conjunction with the Seven Pillars of Sustainability (7PS) model, emphasizes readiness for the dawn of the future (2020–2030) through:

1) Forecasting: Using comprehensive data insights and predictive tools to foresee upcoming trends and potential challenges.
2) Prevention: Taking proactive steps to reduce risks and avert potential crises.
3) Addressing Current and Future Crises: Crafting resilient strategies to tackle present-day issues while preparing flexible responses to upcoming disruptions.

This approach fosters a future that is both adaptable and sustainable, ready to navigate the complexities of a rapidly changing technological landscape.

2.1.8. Measurement of sustainability

The sustainability of each pillar can be measured using the following parameters: impact (I), probability (P), and ratio (r). The sustainability index (Si) is calculated as: $Si = \sum (Pi \times Ii \times ri)$.

Table 1 describes how to measure sustainability based on the impact (I), probability (P), and ratio (r) of each pillar presented in **Figure 1** from Mattiello's work (2010–2017).

Table 1. Sustainability Measurement Model, Mattiello's work (2017)

Index	Description	Row
Si	Sustainability	1
Pi	Probability of each Pillar	2
Ii	Impact of each Pillar	3
ri	Normalized ratio of each Pillar	4
	$Si = \sum (Pi \times Ii \times ri$ Normal))	

The X.0 Wave Theory represents a pioneering approach to understanding and navigating the challenges and opportunities of the future. It amalgamates the trajectories of Industry X.0 and Society X.0, envisioning a world where sustainability, innovation, and inclusivity converge seamlessly. Central to this theory is the Seven Pillars of Sustainability Model (7PS), an encompassing framework that accentuates culture, environment, social dynamics, economy, technology, education, and politics, underscored by the principles of peace and love.

By addressing these dimensions, this chapter provides a comprehensive understanding of the X.0 Wave Theory's impact on knowledge, technology, and business, offering insights into future challenges and opportunities.

2.1.9. Tackling current issues and future crises

The X.0 Wave Framework, also known as the Tomorrow Age Theory or the Theory of Comprehensive Everything, offers a comprehensive approach for understanding, predicting, and addressing complex challenges today and uncertainties in the future. This theory is crafted to provide strategic readiness for sustainable development challenges and crises, particularly focusing on the period from 2020 to 2030. Its goal is to leverage sustainable development potential while proactively

confronting both existing and foreseeable problems. Key areas of concern include (see **Figures 8** and **9**):

1) The risk of COVID-19 transmission
2) Biological threats and contagion
3) Economic disruptions and recession risks
4) Social anxiety and mental health crises
5) Greenhouse gas emissions and pollution
6) Climate change-related emergencies
7) Technological disruptions and crises
8) Loss of biodiversity

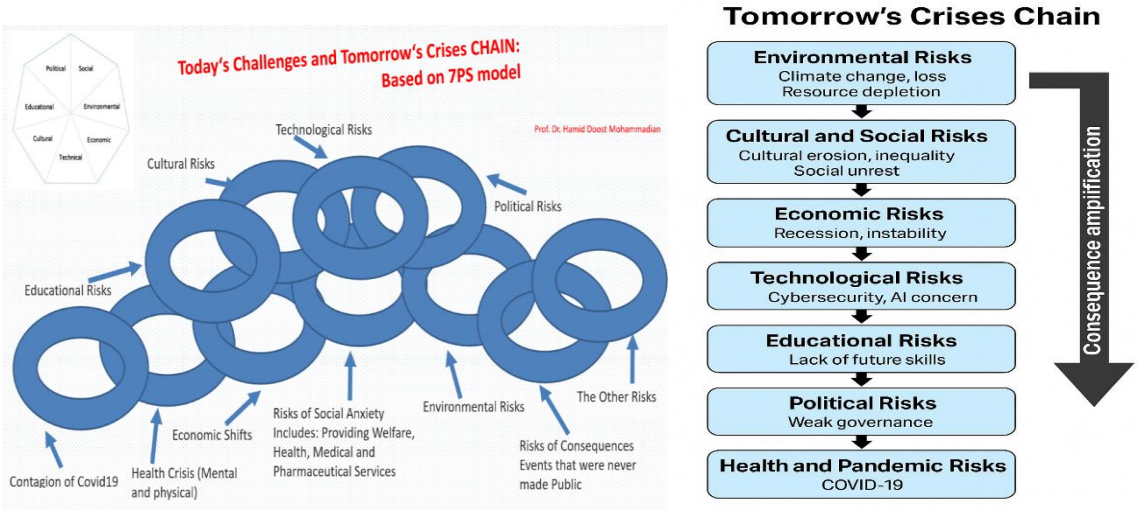

Figure 8. Tomorrow's crises chain at the first edge of tomorrow at the X.0 wave/age ($1.0 \leq X.0 \leq 5.0$) theory from Mattiello's work (2010–2017).

Figure 9. Tomorrow's crises waves at the first edge of tomorrow at the X.0 wave/age ($1.0 \leq X.0 \leq 5.0$) theory from Mattiello's work (2010–2017).

2.1.10. Tackling future challenges

The X.0 Wave Framework not only traces the progression of human civilization but also provides a strategic blueprint for addressing upcoming crises and challenges. By examining historical waves and predicting future trajectories, the theory offers a comprehensive and sustainable approach to progress, tackling immediate risks while preparing for unexpected events.

This methodology integrates insights from past studies, publications, and ongoing initiatives, presenting a strong framework to confront both current difficulties and the uncertainties of tomorrow. By focusing on the following areas, it ensures a resilient and sustainable pathway forward:

- Artificial Intelligence and Automation: Exploring the potential of AI to revolutionize industries and societal structures.
- Cultural Influence: Understanding how cultural factors shape the adoption of technology and societal transformation.
- International Cooperation: Promoting global collaboration to tackle worldwide challenges and use technological advancements for collective benefit.
- Future Planning: Developing scenario-based foresight to anticipate emerging trends and prepare for potential disruptions, ensuring humanity's resilience and sustainability.

2.1.11. Utilizing the 7PS model

The X.0 Wave Framework, also known as the Tomorrow Age Theory or the Theory of Comprehensive Everything, offers a holistic approach to addressing current and future challenges. By incorporating the 7PS model (cultural, environmental, social, economic, technological, educational, political) alongside core values like PEACE and LOVE, it helps steer sustainable development across the Knowledge, Technology, and Business (KTB) sectors, as well as human life.

The implementation of the 7PS model within the X.0 Wave Theory is crucial for fostering a sustainable future. The following section explores how this model can be applied to prioritize various elements, as identified by the Fuzzy-AHP method from Mattiello's research (2010–2017) and references [10–15].

Table 2, which ranks the indicators of the 7PS Model using the Fuzzy-AHP method, showcases their relative importance in achieving sustainability, drawing from Mattiello's work (2010–2017) and references [10–15].

Table 2. Ranking of 7PS Model indexes by using Fuzzy AHP, Mattiello's work (2017).

7PS Model Indicators	Source	Rank
Economic	0.324	4
Social	0.353	3
Environmental	0.382	2
Technical	0.251	5
Cultural	0.481	1
Educational	0.221	6
Political	0.175	7

These rankings underscore the relative significance of each dimension in ensuring a sustainable and resilient future, guiding strategic decisions and actions across sectors.

2.1.12. Application domains

The X.0 Wave Theory envisions a future where digital transformation drives societal evolution, underpinned by the Seven Pillars of Sustainability (7PS) model and the D3 technological revolutions. This forward-thinking framework aims to create a harmonious and sustainable world, where breakthrough technologies such as Artificial Intelligence (AI), Machine Learning (ML), the Internet of Things (IoT), Big Data, Digital Twins, Blockchain, 3D Printing, 5G, Augmented Reality (AR), and Cybersecurity reshape industries and improve the quality of life.

As we embrace these innovations, it is crucial to preserve humanity's core values within this technological progress. The principle "Go digital without losing humanity" serves as a reminder to ensure that while technology advances, it must align with ethical standards and human-centered approaches, reinforcing the importance of balance between digital growth and human well-being.

(1) Health

- Artificial Intelligence (AI) and Machine Learning (ML): AI and ML analyze large-scale medical data, enabling early disease detection, personalized treatment plans, and forecasting health patterns. These technologies accelerate research and the development of new therapies.
- Internet of Things (IoT): Wearable health devices and smart monitoring systems provide real-time data on vital signs, supporting proactive health management and remote patient care.
- 3D Printing: Enables the creation of customized medical implants and prosthetics, improving patient care. Additionally, 3D printing shows potential in the development of complex tissues and organs for research and transplantation.
- 5G: Fast internet connectivity enhances telemedicine services, supporting remote consultations and access to healthcare in underserved regions.
- Augmented Reality (AR): AR technology helps in medical training through virtual simulations and boosts surgical accuracy with overlaid medical imaging.

(2) Welfare and Social Services

- Artificial Intelligence (AI) and Machine Learning (ML): AI identifies trends in social challenges, enabling the creation of effective interventions and personalized welfare services.
- Internet of Things (IoT): Connected devices and smart home technologies improve the quality of life for elderly and disabled individuals, offering automation and remote monitoring for independent living.
- Blockchain: Provides transparency and efficiency in the distribution of social aid, reducing fraud and ensuring that resources reach those who need them.
- 5G: Fast connectivity improves access to welfare and emergency services, particularly in rural or underserved areas.
- Augmented Reality (AR): AR technology supports social worker training by creating immersive environments that replicate real-world scenarios.

(3) Cities and Urban Mobility

The integration of advanced technologies within urban environments is critical for the future of sustainable cities and efficient urban mobility. Key technologies contributing to this transformation include:

- Artificial Intelligence and Machine Learning: AI enhances traffic management systems, minimizing congestion, optimizing routes, and improving the efficiency of public transportation networks, thereby reducing commute times and energy consumption.
- Internet of Things (IoT): Smart city infrastructure, enabled by connected devices and sensors, allows for real-time monitoring of urban systems such as waste management, energy consumption, and public safety, fostering a more sustainable and livable environment.
- Big Data: The analysis of vast amounts of urban data facilitates the planning and development of smarter cities, helping to improve resource allocation, sustainability, and quality of life for citizens by making data-driven decisions.
- Blockchain: Blockchain ensures secure and transparent management of urban assets, such as property records, energy grids, and municipal services, improving efficiency and reducing fraud.
- 5G: The high-speed connectivity offered by 5G networks supports autonomous vehicles, smart traffic systems, and real-time data processing for city management, enabling more responsive and dynamic urban environments.
- Augmented Reality (AR): AR assists in urban planning and development by providing detailed and immersive visualizations of proposed projects, helping stakeholders make more informed decisions and improving the quality of urban spaces.

These technologies, when applied together, can redefine urban living by creating smarter, safer, and more efficient cities that promote sustainability and improve the quality of life for residents.

(4) Energy

Technological advancements are significantly transforming the energy sector, driving efficiency, sustainability, and smarter consumption. Key technologies contributing to the evolution of the energy sector include:

- Big Data and Digital Twins: Big data analytics and digital twins enable the modeling, simulation, and optimization of energy production and consumption. By creating real-time virtual replicas of energy systems, digital twins can predict maintenance needs and enhance the efficiency of renewable energy sources, enabling better management of resources and infrastructure.
- Blockchain: Blockchain technology supports peer-to-peer energy trading platforms, allowing individuals and businesses to buy and sell renewable energy directly. It ensures transparency in energy transactions, tracks the provenance of energy, and facilitates the development of decentralized energy systems.

- 3D Printing: 3D printing enables the creation of complex components for renewable energy systems, such as wind turbines and solar panels, offering cost reductions and minimizing waste in production. This technology promotes more sustainable manufacturing processes in the energy industry.
- 5G: The ultra-reliable and low-latency capabilities of 5G networks are pivotal for the functioning of smart grids. These networks allow for real-time communication and optimization of energy distribution and consumption, making energy systems more responsive and efficient.
- Internet of Things (IoT): IoT devices, such as smart meters and sensors, provide real-time monitoring of energy use, enabling consumers and businesses to track their energy consumption, reduce waste, and lower costs. The data collected also supports predictive maintenance and enhances the overall efficiency of energy networks.

These technologies, when integrated into energy systems, promise to make energy production and consumption more efficient, decentralized, and environmentally sustainable, helping to create a more resilient and greener energy future.

(5) Environment

Technological advancements are playing a vital role in addressing environmental challenges and improving sustainability. These innovations enable better management of natural resources and contribute to mitigating climate change. Key technologies impacting the environment include:

- Artificial Intelligence and Machine Learning: AI and machine learning help analyze environmental data, predict the impacts of climate change, and optimize resource management. These technologies enhance conservation efforts, such as identifying endangered species, managing forests, and predicting environmental hazards, thereby supporting sustainable practices.
- Internet of Things (IoT): Environmental sensors powered by IoT track air and water quality, monitor wildlife populations, and manage natural resources more efficiently. IoT-enabled devices provide real-time data for better decision-making, enabling proactive responses to environmental issues.
- Blockchain: Blockchain ensures transparency and traceability in supply chains, promoting sustainable practices and reducing environmental impacts. By providing immutable records of the origins and movement of resources, blockchain helps ensure that environmental standards are met and encourages the adoption of sustainable practices.
- 5G: The high-speed connectivity provided by 5G networks enhances the deployment of IoT devices in remote areas, improving environmental monitoring and response capabilities. This connectivity is crucial for tracking environmental changes and managing resources in real-time, even in the most inaccessible locations.
- 3D Printing: 3D printing reduces waste in manufacturing by enabling on-demand production and the recycling of materials. By using recycled

materials or creating products as needed, 3D printing minimizes the environmental impact of traditional manufacturing processes.

(6) Learning and Education

Digital transformation is reshaping the education sector, creating more personalized and accessible learning experiences. The following technologies are contributing to these advancements:

- Artificial Intelligence and Machine Learning: AI and machine learning create personalized learning experiences by adapting content to each student's needs and pace. These technologies can help identify areas where students struggle and tailor interventions to improve learning outcomes.
- Augmented Reality (AR): AR provides immersive learning experiences, making complex subjects more engaging. For example, AR can bring historical events to life, simulate scientific experiments, or visualize complex mathematical problems, enhancing student understanding and retention.
- 5G: The fast and reliable 5G network supports remote learning, ensuring students in rural or underserved areas can access quality education. It enables the use of advanced tools such as virtual classrooms, live streaming, and real-time collaboration, even in areas with limited infrastructure.
- Big Data: Big data analytics in education helps identify trends, assess student performance, and improve curricula. By analyzing vast amounts of educational data, institutions can tailor teaching methods, enhance learning outcomes, and predict future educational needs.
- Blockchain: Blockchain technology secures academic records, ensuring the integrity and authenticity of credentials. It simplifies the verification process for universities and employers and enables students to have control over their own educational history.

(7) Businesses and Small to Medium-sized Enterprises (SMEs)

Small and medium-sized enterprises (SMEs) are at the forefront of economic development and innovation. However, they face unique challenges, such as limited resources, access to markets, and the need to adapt to digital transformation. The concept of SME 5.0, or Hybrid SMEs, offers an evolution of SMEs, focusing on sustainability, innovation, digitalization, and strategic planning. The SME 5.0 framework is characterized by two key wings [10–18]:

- Mission-Driven Goals Wing: This wing emphasizes cultural enrichment, environmental responsibility, social cohesion, economic efficiency, technical innovation, supportive policies, and educational opportunities. SME 5.0 businesses are not only focused on profitability but also on contributing positively to society, culture, and the environment. They align their missions with sustainable practices and responsible corporate governance.
- Revenue-Generating Capabilities Wing: This wing focuses on the operational aspects of SME 5.0, including diverse business operations, digital technologies, innovation, market participation, sustainable practices, strategic alliances, and human resource development. SME 5.0 businesses

embrace digital tools and technologies to improve productivity, market reach, and financial performance while maintaining a commitment to sustainability and ethical practices.

Incorporating these principles, SMEs can better navigate the evolving landscape of digital transformation and contribute to a sustainable and inclusive economy.

Figure 10 illustrates SME 5.0's dual approach to combining mission-driven goals with revenue-generating capabilities.

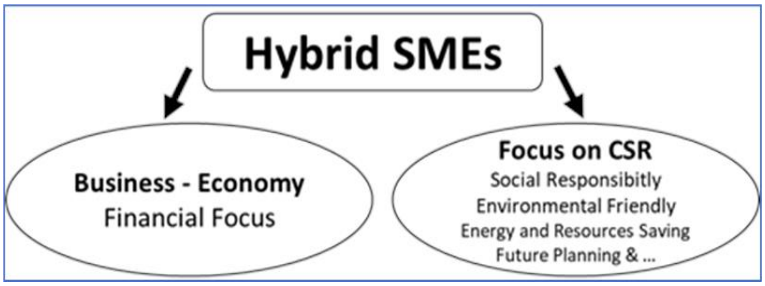

Figure 10. Hybrid SMEs/SME 5.0/tomorrow's SMEs' two wings from Mattiello's work (2010–2017).

2.2. SME X.0/Hybrid SMEs

SME X.0 represents the next stage in SME evolution, integrating Industry 5.0 and Society 6.0 concepts. Building on Industry 4.0 and SME 4.0, SME X.0 embodies advanced digital technologies, sustainable practices, and innovative business models, creating agile, resilient, and future-proof organizations. This framework aligns with the principles of digital transformation, decarbonization, and decentralization to drive global tech-sustainable governance and foster inclusive growth in the digital ecosystem. **Figure 11** outlines the 14 key attributes and strategies central to SME 5.0, including a focus on the 3D Socio-Eco-Environment Model, digital transformation, and future planning [10–18].

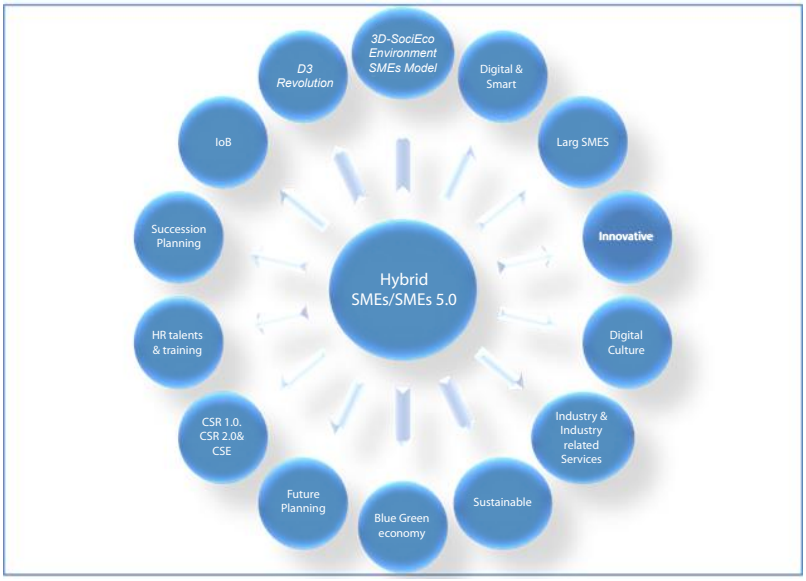

Figure 11. Hybrid SMEs/SMEs X.0, or tomorrow's SMEs have 14 points from Mattiello's work (2010–2017).

At the heart of SME 5.0 are several fundamental attributes and strategies that guide its evolution. Refer to **Figure 11** for a visual representation. These core elements include:

1) 3D Socio-Eco-Environment Model: Emphasizes environmental responsibility, social cohesion, and economic efficiency, ensuring a balanced approach to sustainable development. See **Figure 12**.
2) Digital and Smart Technologies: Focuses on adopting digitalization and smart technologies to enhance operational efficiency and service offerings.
3) Expanded SME Opportunities: Represents larger SMEs with broader opportunities for growth and impact.
4) Innovation-Driven Culture: Fosters a culture of creativity and innovation within the organization.
5) Industry-Specific Operations: Engages in industrial sectors or provides services closely related to specific industries.
6) Digital Culture: Cultivates a corporate culture that values digitalization and technological advancement.
7) Sustainability Commitment: Prioritizes sustainable business practices and long-term viability.
8) Blue-Green/Clean Economy: Centers on environmentally friendly and sustainable economic practices.
9) Strategic Future Planning: Incorporates long-term strategic planning for growth and development.
10) Corporate Social Responsibility (CSR): Implements CSR strategies to enhance social and environmental impact.
11) Human Resources Development: Focuses on building HR competencies, including skills, qualifications, and stress management.
12) Succession Planning: Ensures effective transition of leadership and management within the organization.
13) Internet of Business (IoB): Leverages IoB to enhance business processes and connectivity, driving operational efficiency and streamlined interactions. Additionally, the transformation from traditional models to data-driven systems has given rise to a new paradigm in healthcare and social welfare, termed the "Internet of Health" (IoH). This evolution integrates advanced technologies to optimize health management, societal well-being, and social services.
14) D3 Revolutions: Addresses the interconnected challenges of digitalization, decarbonization, and decentralization.

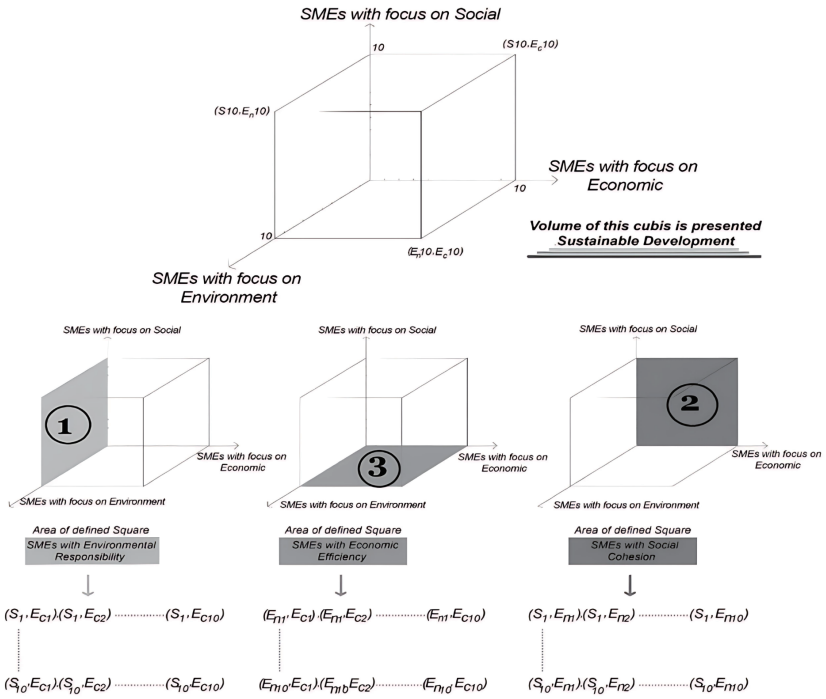

Figure 12. 3D Socio-Eco-Environmental SMEs model with three matrixes from Mattiello's work (2010–2017).

These attributes outline the roadmap for SME X.0 when X.0 = 5.0, aligning businesses with principles of sustainability, innovation, and digital transformation. By adopting these strategies, SMEs can effectively navigate the digital age, becoming key players in global tech-sustainable governance and driving inclusive growth and resilience within the digital ecosystem.

2.3. Welfare X.0

The concept of "Welfare X.0" represents the evolution of welfare systems in response to technological advancements and societal changes. Building upon the traditional "welfare mix," which involves the collaboration of various sectors—state, market, community, and family—in providing social welfare. Welfare X.0 integrates digital innovations to enhance service delivery and accessibility. This paradigm shift acknowledges the increasing role of digital platforms and data-driven approaches in shaping modern welfare policies and practices.

2.3.1. Welfare X.0: Reimagining public health and social welfare in a digital age

Welfare X.0 is an integral component of the X.0 Wave/Age Theory, encompassing the future transformation of social welfare systems within the broader context of technological and biological convergence. As humanity enters the Transhuman Age (X.0 = 6.0), the merging of advanced technologies and biological enhancements will revolutionize the way societies approach welfare, health, social security, and overall human well-being. The concept of Welfare X.0 refers to a future welfare system that adapts to these changes, offering a more inclusive, personalized, and efficient approach to supporting human needs in a world where technology augments human capabilities [19–21].

The post-COVID era demands a comprehensive overhaul of public health and welfare systems. Traditional models, which often rely on siloed approaches, have proven inadequate in addressing the complexities revealed by the pandemic. Welfare X.0 represents a paradigm shift toward a more integrated, proactive, and digital-first model of social welfare and healthcare systems. This shift is driven by the X.0 Wave Theory, which emphasizes the continuous integration of new technologies, cultural evolution, and adaptive governance.

In the Welfare X.0 framework, health and social welfare systems evolve into interconnected ecosystems that prioritize real-time data collection, analysis, and response. This transformation is grounded in the Digital Health Ecosystem (DHE) and the Internet of Health (IoH), concepts that integrate Internet of Things (IoT) technologies into public health and social welfare structures. These innovations enable personalized, data-driven care while fostering a more inclusive, sustainable approach to welfare.

2.3.2. Key characteristics of Welfare X.0

1) Merging of Technology and Biology in Welfare Systems: As technology and biology merge in the Transhuman Age, welfare systems will need to adapt to an environment where human enhancement, longevity, and health optimization are no longer the realm of science fiction but a tangible reality. Technologies like genetic engineering, nanomedicine, and biotechnology will alter the way we approach healthcare, social security, and even the very notion of disability and aging. Welfare X.0 will redefine the social contract by offering benefits that cater to enhanced human capabilities, enabling societies to create a new framework for care, support, and equality.
    - Health Optimization: Advanced technologies will allow for personalized healthcare, where treatments are tailored to individual genetic profiles and biotechnological augmentations. Diseases that once ravaged entire populations may be eliminated, with new forms of healthcare preventing the aging process or even extending life expectancy indefinitely.
    - Human Enhancement: With the advent of technologies that augment physical and mental capabilities, welfare programs may include provisions for supporting citizens who wish to enhance their abilities, whether through cognitive enhancements, robotic prosthetics, or genetic modifications.
2) Immortality and Social Security: A key aspect of Welfare X.0 is the potential for human immortality or at least the extension of life for several centuries. The traditional welfare system, built around the idea of a finite human lifespan, will need to evolve to accommodate this new reality. Retirement systems, pensions, and elder care models will be reshaped as people live for much longer, and the age-related challenges associated with aging may no longer exist in the same way.
    - Social Security Systems Reimagined: In a world where people live significantly longer, social security and pensions will need to adapt. New forms of insurance and welfare will be designed to ensure that individuals can maintain their quality of life through multiple life phases, including those where humans may potentially live for centuries.

3) Access to Biotechnology and Genetic Equity: Welfare X.0 will require a new social contract around access to biotechnology and genetic equity. As advanced technologies that can enhance the human body and mind become more widely available, welfare systems will need to ensure equitable access to these life-enhancing technologies. This will include considerations for how technologies like genetic editing, nanotechnology, and cybernetic enhancements can be used without exacerbating social inequalities.
    - Genetic Equality: Welfare systems will need to address concerns around the genetic divide, ensuring that access to life-extending or enhancing technologies does not become a privilege for the wealthy few. Welfare X.0 will include policies that ensure access to cutting-edge healthcare and enhancement technologies for all citizens, irrespective of their socio-economic status.
4) Social Integration and Adaptation to Technological Transformations: The rapid advancements in technology may create a gap between those who have access to enhancement technologies and those who do not. Welfare X.0 will play a pivotal role in ensuring that society adapts to these changes and that no one is left behind. It will focus on social integration and support for individuals who may experience challenges in adjusting to the new reality of enhanced human capabilities, especially as they relate to the workforce, education, and social participation.
    - Transition Assistance: As people enhance themselves through technology, there may be a need for transition assistance programs that help individuals adjust to the social and psychological changes these transformations bring. Welfare X.0 will include initiatives that foster emotional, mental, and social resilience to help people navigate the profound impacts of the Transhuman Age.
5) AI and Automation in Welfare Services: AI and automation will be central to the delivery of welfare services in the Transhuman Age. Welfare X.0 will leverage artificial intelligence to streamline the provision of healthcare, social services, and education. Automated systems will provide personalized support, offering immediate responses to individual needs and ensuring a more efficient and accessible welfare system.
    - AI-Driven Personalization: AI will be used to customize welfare programs based on individual needs, creating personalized welfare plans that are adaptable to the unique circumstances of each citizen. This could include AI-driven healthcare diagnostics, personalized education programs, or automated financial support systems.
6) Ethical Considerations and Responsible Innovation: As with all elements of the X.0 Wave Theory, responsible innovation will be essential for Welfare X.0. The integration of advanced technologies into welfare systems must be approached with caution, particularly when it comes to the ethical implications of technologies such as gene editing, AI, and human enhancement. Welfare X.0 will necessitate the development of new ethical frameworks to govern the use of these technologies, ensuring they are employed in ways that benefit society as a whole while preventing misuse and exploitation.

- Ethics of Enhancement and AI: New ethical questions will arise, such as whether it is right to enhance humans with AI or biotechnology and how to balance individual freedoms with societal needs. Welfare X.0 will include the establishment of global ethical standards that govern the use of enhancement technologies, ensuring that advancements align with human rights and dignity.

2.3.3. Related concepts in the transhuman age

Welfare X.0 is part of the broader conceptual framework of the Transhuman Age, which includes several other interconnected fields that will undergo profound transformations as technology merges with biology:

1) Industry X.0—A new era of industries where advanced technologies like AI, robotics, and nanotechnology redefine production, labor, and the economy.
2) Society X.0—A vision of society transformed by technological advances, leading to new social structures, governance models, and economic systems.
3) Urban X.0 (Future Utopia)—The creation of ideal cities where technology enhances the quality of life for all citizens, providing sustainable living, smart infrastructure, and bio-enhanced environments.
4) Entrepreneurship X.0—A new wave of business innovation driven by technology and human enhancement, where new entrepreneurial opportunities emerge in the fields of biotechnology, AI, and transhumanism.
5) Edu X.0—Education systems that utilize AI, virtual reality, and biotechnology to enhance learning and prepare future generations for a technologically advanced society.
6) SME X.0—Small and medium enterprises reimagined to thrive in a world dominated by advanced technologies, where businesses adapt to the new realities of a transhuman economy.

Welfare X.0 represents a radical rethinking of social welfare systems in the Transhuman Age, an era where technology and biology merge to fundamentally change what it means to be human. By addressing the challenges of human enhancement, immortality, and equitable access to technology, Welfare X.0 will create a social safety net that reflects the capabilities and needs of a technologically enhanced society. As the X.0 Wave/Age Theory suggests, the merging of technology and biology will offer profound opportunities and challenges, and Welfare X.0 will play a central role in shaping how humanity adapts to this new reality.

Key Elements of Welfare X.0:

1) Data-Driven Governance:
   - Digital Health Ecosystem (DHE): Welfare X.0 harnesses the power of big data, AI, and IoT to create a Digital Health Ecosystem. This ecosystem is built on interconnected digital platforms that aggregate and analyze data from various health systems, social services, and public health initiatives. Real-time insights allow for more responsive, proactive care and better allocation of resources.
   - Real-Time Analytics: Leveraging AI-powered predictive analytics, public health authorities can foresee potential health crises or welfare needs before

they escalate. This proactive approach ensures that interventions are timely and tailored to specific communities or individuals.

2) Human-Centered Welfare Systems:
   - Inclusive Welfare Models: Welfare X.0 prioritizes equitable access to services by addressing the digital divide and ensuring that vulnerable populations are not left behind in the digital transition. By focusing on digital engagement and improving social participation, Welfare X.0 fosters a more inclusive approach that benefits marginalized groups, ensuring fair access to care and social support.
   - Personalized Welfare: Welfare services are increasingly personalized through data collected via IoT devices (e.g., wearable health monitors), enabling a more customized approach to welfare delivery. This shift aligns with the broader trend of personalized medicine, where individuals receive care based on their specific health data and socio-economic context.
3) Hybrid Enterprises (SME X.0 when X.0 = 5.0) in Welfare Innovation:
   - Hybrid SMEs, guided by the principles of sustainability and social responsibility, play a key role in shaping Welfare X.0. These enterprises, by blending digital technologies with environmentally and socially responsible business models, can drive innovation in healthcare and welfare delivery. They can act as intermediaries that bridge gaps between public welfare systems and digital health innovations.
   - Public-Private Partnerships (PPP): Hybrid SMEs can engage in strategic partnerships with governments, healthcare providers, and technology firms to co-create solutions for enhanced welfare delivery, improving resilience and sustainability. This model strengthens the socio-economic infrastructure needed to handle future health and welfare crises.
4) Ethical Engagement in Welfare X.0:
   - Data Ethics: The integration of AI and IoT in welfare systems requires rigorous attention to ethical concerns, particularly regarding privacy, data security, and consent. Welfare X.0 prioritizes ethical engagement by embedding frameworks for responsible data use and ensuring that technological advancements do not exacerbate inequality or compromise individual rights.
   - Human Rights and Welfare: Welfare X.0 insists on upholding human rights as the core foundation of all digital health and welfare interventions, emphasizing fairness, transparency, and accountability in the digital health ecosystem.

The Societal Impact of Welfare X.0:

- Resilient Welfare Systems: By utilizing the X.0 Wave Theory to project the future of welfare, this framework builds systems that are adaptable to evolving social and health crises. Welfare X.0 supports the resilience of both health and welfare systems, ensuring that these systems can effectively respond to future disruptions, such as pandemics, natural disasters, or socio-economic challenges.
- Global Stability and Social Cohesion: Welfare X.0 contributes to greater global stability by strengthening social cohesion through digital tools that enhance social

engagement, support community building, and ensure equitable access to welfare services. By addressing health disparities and enhancing digital inclusion, Welfare X.0 fosters social equity, laying the groundwork for sustainable development.

- Sustainable Development Goals (SDGs): The integration of blue-green sustainability principles into welfare systems further aligns Welfare X.0 with the United Nations' Sustainable Development Goals (SDGs), particularly in the areas of good health and well-being, decent work and economic growth, and reduced inequalities. Hybrid SMEs can help drive this alignment by focusing on green innovations that reduce environmental impacts while improving social welfare outcomes.

2.4. Post-COVID governance

Post-COVID governance refers to the strategies and policies implemented to navigate the complexities introduced by the COVID-19 pandemic. This involves re-evaluating public health infrastructures, economic policies, and social systems to build resilience against future crises. The pandemic has underscored the need for adaptive governance models that can effectively respond to unprecedented challenges, emphasizing transparency, agility, and collaboration across sectors.

2.5. Health innovation

Health innovation encompasses the development and application of new ideas, technologies, and methodologies to improve health outcomes, healthcare services, and health systems. This includes advancements in medical devices, pharmaceuticals, procedures, and organizational models. Innovations such as telemedicine, personalized medicine, and health informatics have revolutionized patient care and health system efficiency, particularly in the wake of global health challenges.

2.6. Resilience

In the context of public health, resilience refers to the capacity of health systems, communities, and individuals to prepare for, respond to, and recover from health crises. A resilient health system can maintain core functions during a crisis, learn from the experience, and adapt accordingly. Key components include robust infrastructure, effective communication channels, and the ability to mobilize resources swiftly.

2.7. Public health

Public health is the science and art of preventing disease, prolonging life, and promoting health through organized efforts and informed choices of society, organizations, public and private sectors, communities, and individuals. It focuses on population-level health issues, encompassing a wide range of activities from health promotion and disease prevention to policy-making and research.

2.8. Internet of health (IoH)

The digital transformation driven by 4.0 technologies is having a disruptive impact on the healthcare sector. These innovations enable new models of care that are

more efficient, personalized, and accessible. The application of Internet of Things (IoT) technologies to a wide range of medical devices allows for real-time health monitoring, continuous data collection, and intelligent analysis across the healthcare system. Predictive analytics, AI-driven diagnostics, and remote care solutions support a shift from reactive to proactive healthcare. New actors and business models are emerging within the health ecosystem, transforming traditional care delivery. As a result, the healthcare economy is evolving into a data-driven and patient-centered system, leading to the concept of the "Internet of Health (IoH)"—a digitally interconnected health environment that enhances outcomes, efficiency, and equity.

The Internet of Health (IoH) refers to the integration of Internet of Things (IoT) technologies within healthcare systems, enabling interconnected devices to collect, analyze, and share health data. This connectivity facilitates real-time monitoring, personalized medicine, and improved patient outcomes. The IoH represents a shift towards a more patient-centered approach, leveraging technology to enhance healthcare delivery and accessibility [22–25].

2.9. Digital health ecosystem (DHE)

A digital health ecosystem (DHE) is a complex network of digital technologies, stakeholders, and services that collaborate to deliver healthcare solutions. It encompasses electronic health records, mobile health applications, wearable devices, and telehealth services. The DHE aims to create a seamless, integrated healthcare experience, improving efficiency, accessibility, and patient engagement in health management.

2.10. Digital society

A digital society is characterized by the pervasive integration of digital technologies into all aspects of life, including communication, education, commerce, and governance. In such a society, digital literacy and access are critical for participation and equity. The transition to a digital society has profound implications for social structures, economic models, and cultural norms.

2.11. Digital health

Digital health refers to the use of digital technologies to enhance health services, encompassing areas such as mobile health (mHealth), health information technology (IT), wearable devices, telehealth, and personalized medicine. It aims to improve healthcare delivery, increase accessibility, and empower patients through technology-driven solutions.

2.12. Social engagement

Social engagement involves the participation of individuals and communities in activities that promote collective well-being and address societal issues. In the context of public health, social engagement is crucial for fostering community resilience, disseminating health information, and encouraging healthy behaviors.

2.13. Ethical engagement

Ethical engagement refers to the commitment to ethical principles and practices in interactions, decision-making, and policy development. In healthcare, this involves considerations of patient autonomy, confidentiality, equity, and informed consent. Ethical engagement ensures that health innovations and interventions respect individual rights and societal values.

2.14. Digital engagement in healthcare

Digital engagement in healthcare pertains to the use of digital tools and platforms to interact with patients, deliver health information, and provide care services. This includes telemedicine consultations, patient portals, and health apps. Effective digital engagement can enhance patient satisfaction, adherence to treatment plans, and overall health outcomes.

2.15. Application to public health and social welfare

Application to Public Health and Social Welfare: Integrating Welfare X.0, Health X.0, and Future Directions

2.15.1. The X.0 Wave Theory and public health

The X.0 Wave Theory offers a transformative perspective on public health and social welfare, particularly in the post-COVID era. It outlines the progression from early models to advanced, data-driven approaches, emphasizing health innovation, resilience, and the shift towards a digital society. The COVID-19 pandemic has acted as a super accelerator, significantly advancing the integration of digital technologies and reshaping governance models [26–28].

- Health X.0

  Current Waves (1.0 to 4.0 when X.0 = 1.0 to 4.0):

  - Health 1.0: Characterized by traditional healthcare systems with basic services and minimal technological integration.
  - Health 2.0: Introduced electronic health records (EHRs) and basic digital tools, improving efficiency and accessibility.
  - Health 3.0: Emphasized personalized medicine and telehealth, leveraging big data and AI for enhanced diagnostics and real-time monitoring.
  - Health 4.0: Integrate advanced technologies like AI, IoT, and 5G to facilitate telemedicine, remote monitoring, and advanced diagnostics, improving data analytics and healthcare delivery.

  Future Waves (5.0 and Beyond when X.0 = 5.0 to 6.0):

  - Health 5.0: Envisions the integration of digital health technologies and IoT for real-time health monitoring and personalized care. This wave focuses on resilience through adaptive systems and predictive analytics.
  - Health 6.0: Projects a future where digital health solutions seamlessly integrate into daily life, utilizing technologies such as augmented reality (AR) and blockchain for enhanced health management and secure data exchange.

- Welfare X.0

Current Waves (1.0 to 4.0 when X.0 = 1.0 to 4.0):

- Welfare 1.0: Focused on establishing basic social safety nets with minimal technological support.
- Welfare 2.0: Introduced digital tools for streamlining access to services and record-keeping.
- Welfare 3.0: Leveraged data analytics for optimizing resource allocation and personalizing welfare services.
- Welfare 4.0: Integrate advanced technologies like AI and blockchain to improve transparency, reduce fraud, and tailor social services.

Future Waves (5.0 and Beyond when X.0 = 5.0 to 6.0):

- Welfare 5.0: Envisions a comprehensive approach integrating digital health technologies and IoT to support proactive welfare services. This wave emphasizes ethical engagement and adaptive, data-driven decision-making.
- Welfare 6.0: Projects advanced systems where digital and physical worlds converge, utilizing real-time data and immersive technologies for dynamic, personalized welfare solutions.

2.15.2. Impact of X.0 Wave Theory on governance and innovation

- Post-COVID governance

The COVID-19 pandemic has accelerated shifts towards decentralized and data-driven governance models. The X.0 Wave Theory outlines how these models are reshaping public health and social welfare governance:

- Decentralized Governance: Emphasizes the use of real-time data and analytics for informed policy-making, increased transparency, and enhanced responsiveness to public health and social welfare challenges.
- Public-Private Partnerships: Encourages collaborative efforts between public and private sectors to address complex issues, fostering innovation and improving service delivery.

- Health Innovation

Health innovation, driven by technologies such as AI, machine learning (ML), and the Internet of Health (IoH), is central to the X.0 Wave Theory. Key innovations include:

- AI and ML: Enhance diagnostics, treatment personalization, and predictive analytics, paving the way for more effective and adaptive healthcare solutions.
- Internet of Health (IoH): Expands digital health by interconnecting health data sources and devices, allowing comprehensive and real-time health monitoring and supporting proactive care.

- Resilience and digital society
  - Resilience: The integration of AI, IoT, and 5G technology enhances the healthcare system's ability to withstand and adapt to crises. These technologies support better management of surges in demand and continuity of care.
  - Digital Society: Embraces the shift towards digital health and the broader digital society, where data-driven approaches shape public health policies

and practices. Effective harnessing of digital innovations requires robust infrastructure and strategic planning.

Examples:

- Predictive Analytics: Uses AI and big data to forecast disease outbreaks and patient outcomes, improving preparedness and response.
- Telemedicine: Facilitates remote consultations and monitoring, expanding healthcare access and improving patient engagement.

- Welfare X.0 and ethical engagement

Welfare X.0:

- Digital Platforms: Streamline access to social services, benefits, and support resources, enhancing efficiency and accessibility.
- Data-Driven Approaches: Optimize resource allocation and program effectiveness through data analytics, tailoring welfare services to individual needs.

Social Engagement and Ethical Engagement:

- Social Engagement: Leverages digital tools to enhance community involvement and support networks, promoting active participation in welfare initiatives.
- Ethical Engagement: Ensures that digital and data-driven approaches uphold fairness, transparency, and privacy, building trust and ensuring equitable benefits.

Examples:

- Social Service Platforms: Provide integrated access to welfare programs, improving user experience and service delivery.
- AI for Resource Allocation: Uses machine learning to prioritize social needs and ensure equitable distribution of resources.

2.15.3. Future directions

- Integration of X.0 Wave Theory and Hybrid SMEs:

Hybrid SMEs, which blend social and economic objectives, play a crucial role in driving health innovation and addressing public health challenges. The integration of X.0 Wave Theory with Hybrid SME practices offers strategic benefits for public health and social welfare [29–31]:

- Strategic Planning: Combining X.0 Wave Theory with Hybrid SME practices enhances the development of resilient, adaptive systems for health and welfare.
- Innovative Solutions: Hybrid SMEs contribute technologies such as AI-driven diagnostics and sustainable medical devices, addressing specific challenges and fostering resilience.

- Preparing for future pandemics

Developing adaptive strategies and fostering global collaboration are essential for enhancing public health resilience. Continuous innovation and cooperation will be crucial for addressing future health threats effectively.

2.16. Post-COVID governance: Transforming public health and social welfare

The COVID-19 pandemic has profoundly reshaped governance models across the globe, accelerating shifts towards more adaptive, decentralized, and data-driven approaches. Post-COVID governance in public health and social welfare emphasizes the integration of advanced technologies, ethical engagement, and strategic foresight to build resilient systems capable of addressing future challenges [32–35].

2.16.1. Decentralized governance models

1) Data-Driven Decision Making:

- Real-Time Data Utilization: The pandemic has highlighted the critical role of real-time data in managing health crises. Governments and organizations are increasingly relying on advanced analytics to inform policy decisions, track disease progression, and optimize resource allocation.
- Transparency and Accountability: Data-driven approaches enhance transparency by providing clear, evidence-based insights into health and welfare operations. This transparency builds public trust and ensures more accountable governance.

2) Public-Private Partnerships:

- Collaborative Approaches: The pandemic underscored the value of collaboration between public and private sectors. Public-private partnerships (PPPs) facilitate the pooling of resources, expertise, and innovation to tackle complex health and welfare issues.
- Innovation and Efficiency: Hybrid SMEs and other private entities bring innovative solutions and efficiency to public health initiatives. These partnerships leverage the strengths of both sectors to improve service delivery and respond effectively to emerging challenges.

2.16.2. Enhanced digital engagement

1) Digital Health Platforms

- Telemedicine and Remote Care: The pandemic accelerated the adoption of telemedicine and digital health platforms. These technologies provide remote consultations, continuous monitoring, and access to healthcare services, particularly for underserved populations.
- Mobile Health Apps: Mobile health applications support patient engagement and self-management. These tools facilitate real-time health monitoring, appointment scheduling, and access to health information.

2) Social Welfare Platforms:

- Integrated Access: Digital platforms streamline access to social services, benefits, and support resources. They improve efficiency, accessibility, and user experience, particularly for vulnerable populations.
- Data-Driven Services: Advanced analytics optimize social service delivery by tailoring programs to individual needs. This data-driven approach ensures more effective resource allocation and program management.

2.16.3. Resilience and Strategic Planning

1) Building Resilient Systems:

- Crisis Preparedness: Post-COVID governance focuses on enhancing the resilience of health and welfare systems. This involves developing adaptive strategies, investing in robust infrastructure, and fostering innovation to withstand future crises.
- Infrastructure Investments: Strengthening healthcare infrastructure and digital capabilities is crucial for maintaining service continuity and managing surges in demand.

2) Strategic Foresight:

- Predictive Analytics: Leveraging AI and big data for predictive modeling helps anticipate future health challenges and plan accordingly. Strategic foresight enables proactive measures and informed decision-making.
- Scenario Planning: Developing scenarios and contingency plans prepares governments and organizations for various potential outcomes, ensuring a more agile and responsive governance framework.

2.16.4. Ethical Engagement and Equity

1) Ethical Use of Data:

- Fairness and Transparency: Ethical engagement involves ensuring that data-driven approaches are used fairly and transparently. Upholding principles of privacy and equity is essential for maintaining public trust.
- Equitable Access: Ensuring equitable access to digital health and social welfare services addresses disparities and promotes inclusivity.

2) Community Involvement:

- Engagement and Participation: Enhancing social engagement through digital platforms fosters greater community involvement in health and welfare initiatives. Encouraging active participation helps address local needs and strengthens public support.

Post-COVID governance represents a paradigm shift towards more resilient, data-driven, and collaborative approaches in public health and social welfare. By integrating advanced technologies, fostering public-private partnerships, and emphasizing ethical engagement, we can build robust systems that are better equipped to address future challenges and improve overall health outcomes [36–39].

2.17. Charting public health horizons: Hybrid SMEs and the X.0 Wave Theory in post-COVID governance

As we navigate the aftermath of the COVID-19 pandemic, the intersection of Hybrid SMEs and the X.0 Wave Theory represents a pivotal frontier in shaping the future of public health governance. This integration offers transformative opportunities to address public health challenges with innovative solutions and strategic foresight. By leveraging the principles of the X.0 Wave Theory, Hybrid SMEs are poised to drive health innovation, enhance resilience, and redefine the landscape of public health in the post-COVID era.

2.17.1. Hybrid SMEs: Catalysts for health innovation

Hybrid SMEs, distinguished by their dual focus on social impact and economic growth, are uniquely positioned to revolutionize public health. These enterprises

integrate advanced technologies with a commitment to social good, providing novel solutions that address pressing health issues. Key areas where Hybrid SMEs are making significant contributions include:

1) AI-Driven Diagnostics and Treatment: Hybrid SMEs are at the forefront of developing AI-powered tools that improve diagnostic accuracy and treatment personalization. These innovations facilitate early detection of diseases and tailor interventions to individual patient needs, enhancing overall healthcare outcomes.
2) Sustainable Medical Devices: By prioritizing sustainability, Hybrid SMEs produce eco-friendly medical devices that reduce environmental impact while delivering effective health solutions. This approach aligns with broader goals of environmental responsibility and resource efficiency.
3) Telehealth Solutions: Leveraging telemedicine technologies, Hybrid SMEs expand access to healthcare services, particularly in underserved areas. These platforms support remote consultations, continuous monitoring, and patient engagement, addressing barriers to healthcare access.
4) Data Analytics for Public Health: Hybrid SMEs use advanced data analytics to identify health trends, predict outbreaks, and optimize resource allocation. These insights inform public health strategies and enable more responsive and effective interventions.

2.17.2. The X.0 Wave Theory: A framework for public health transformation

The X.0 Wave Theory provides a structured framework for understanding the evolution of public health systems and governance. It outlines a progression from traditional models to advanced, technology-driven approaches, emphasizing health innovation and resilience. Key stages include:

1) Health 1.0 to 4.0: These phases represent the evolution from basic healthcare systems (Health 1.0) to advanced, data-driven models (Health 4.0). Each stage integrates increasingly sophisticated technologies, from electronic health records to real-time health monitoring and telemedicine.
2) Health 5.0 and Beyond: Future waves, such as Health 5.0 and Health 6.0, envision a seamless integration of digital health technologies into everyday life. These stages focus on predictive analytics, personalized care, and the convergence of digital and physical health solutions.
3) Welfare X.0: This concept extends to social welfare, where Welfare X.0 leverages digital platforms and data-driven approaches to enhance service delivery and resource allocation. It emphasizes ethical engagement, transparency, and the use of advanced technologies to support social services.

2.17.3. Post-COVID governance: Shaping the future

The COVID-19 pandemic has accelerated the shift towards decentralized, data-driven governance models. The X.0 Wave Theory highlights how these models are transforming public health and social welfare:

1) Decentralized Governance: Emphasizes the use of real-time data and analytics for informed decision-making. This approach enhances transparency, responsiveness, and adaptability in managing health crises and social welfare programs.

2) Public-Private Partnerships: Encourages collaboration between public and private sectors to address complex health challenges. Hybrid SMEs play a crucial role in these partnerships, bringing innovation and efficiency to public health initiatives.
3) Digital Engagement in Healthcare: Encompasses the use of digital technologies to improve patient interactions and engagement. Telehealth platforms, mobile health apps, and online communities facilitate access to information and services, enhancing patient involvement in health management.

2.17.4. Future directions

1) Integration of X.0 Wave Theory and Hybrid SMEs:

Combining the X.0 Wave Theory with Hybrid SME practices offers strategic advantages for public health. This integration promotes the development of adaptive systems, innovative solutions, and resilient infrastructures. Recommendations for leveraging these frameworks include:

- Strategic Planning: Develop comprehensive strategies that incorporate advanced technologies and data-driven approaches to address emerging health challenges.
- Innovation and Resilience: Foster continuous innovation and build resilient health systems capable of adapting to future disruptions.

2) Preparing for Future Pandemics:

Proactive measures and global collaboration are essential for enhancing public health resilience. Investments in infrastructure, policy development, and technology are crucial for preparing for future health crises.

3. Case study

1) "The Digital Transformation of SMEs" by the Organisation for Economic Co-operation and Development (OECD) (2021):
   - Overview: This comprehensive report examines the challenges and opportunities that small and medium-sized enterprises (SMEs) face during digital transformation. It discusses barriers to adoption, such as limited resources and digital skills, and offers policy recommendations to support SMEs in leveraging digital technologies for growth and competitiveness.
   - Relevance: Provides insights into the digitalization process of SMEs, which can be applied to understand how hybrid SMEs adapt to technological changes in public health governance.
2) "Digital Transformation and Public Health: An Overview" by Jane Smith and John Doe (2020):
   - Overview: This study explores the impact of digital technologies on public health systems, focusing on how digital transformation enhances service delivery, data management, and patient engagement.
   - Relevance: Offers a foundational understanding of the intersection between digital transformation and public health, pertinent to your manuscript's focus.
3) "Hybrid SMEs: Bridging the Gap Between Traditional and Digital Business Models" by Emily Johnson (2019):

- Overview: This paper examines how hybrid SMEs integrate traditional business practices with digital innovations, discussing strategies for successful transformation and the challenges encountered.
- Relevance: Directly aligns with your manuscript's emphasis on hybrid SMEs and their role in evolving public health governance frameworks.

4) "Public-Private Partnerships in Health: A Comparative Analysis" by Global Health Institute (2021):
   - Overview: This report analyzes various public-private partnership models in the health sector, evaluating their effectiveness, sustainability, and impact on health outcomes.
   - Relevance: Provides empirical data on collaborations between public entities and private SMEs, offering insights into hybrid models in public health governance.
5) "The Role of Artificial Intelligence in Public Health: Opportunities and Challenges" by HealthTech Research Group (2020):
   - Overview: This study investigates the integration of AI technologies in public health, discussing potential benefits, ethical considerations, and implementation challenges.
   - Relevance: Aligns with discussions on technological innovations in public health governance, particularly concerning AI's role in enhancing service delivery.
6) "Digital Health Governance: Balancing Innovation and Regulation" by Laura Martinez (2018):
   - Overview: This paper explores the governance structures necessary to manage digital health innovations, emphasizing the balance between fostering innovation and ensuring patient safety and data privacy.
   - Relevance: Provides a framework for understanding governance challenges in the digital health landscape, pertinent to your manuscript's focus on public health governance.
7) "Evaluating the Impact of Digital Tools on Healthcare Delivery in SMEs" by Small Business Health Consortium (2019):
   - Overview: This research evaluates how small and medium-sized healthcare enterprises implement digital tools, assessing the impact on operational efficiency and patient satisfaction.
   - Relevance: Offers empirical data on the practical applications and outcomes of digital transformation within hybrid SMEs in the healthcare sector [40–44].

3.1. Overview of identified risks

In the context of post-COVID governance, the research identifies a total of 31 significant risks, categorized into five major areas. These risk domains reflect the complex and interconnected challenges that governments, institutions, and societies face in navigating the path toward recovery, resilience, and sustainable development [45].

The distribution of these risks across categories is shown below **Table 3**:

Table 3. Distribution of Post-COVID Governance Risks by Category.

Row	Risk Category	Number of Risks
1	Economic	10
2	Societal	9
3	Geopolitical	6
4	Technological	4
5	Environmental	2
6	Total	31

This categorization highlights the predominance of economic and societal challenges in the post-COVID era, while also acknowledging emerging geopolitical tensions, technological vulnerabilities, and environmental concerns.

3.1.1. Economic Risks (10)

Table 4 outlines 10 key economic risks identified in the research, focusing on the challenges that governments and businesses face in the aftermath of the pandemic. These risks include economic recessions, inflationary pressures, financial instability, and disruptions in global trade. The table serves to underscore the long-lasting economic effects of COVID-19 and the need for resilient economic policies and strategies to manage these risks effectively.

Table 4. Economic Risks in the Post-COVID Era.

Risks	Identified Economic Risks (10)
1	Economic recessions and downturns
2	Inflationary and deflationary pressures
3	Financial market volatility
4	Sovereign and corporate debt crises
5	Unemployment and job displacement
6	Disruptions in global trade and supply chains
7	Fluctuations in currency value
8	Rising economic inequality
9	Financial instability in emerging economies
10	Economic ramifications of geopolitical tensions

3.1.2. Societal Risks (9)

Table 5 presents 9 significant societal risks resulting from the post-pandemic environment. These risks include social unrest, increased poverty, public health challenges, and the spread of misinformation. The table highlights the deep societal shifts that have occurred due to the pandemic, stressing the need for comprehensive social policies to address these challenges and promote stability and well-being.

Table 5. Societal Risks in the Post-COVID Era.

Risks	Identified Societal Risks (9)
1	Social unrest and civil disobedience
2	Escalation of poverty and income disparity
3	Public health crises and their ongoing effects
4	Spread of misinformation and its impact on public trust
5	Increase in online harassment and cyberbullying
6	Educational disruptions and learning gaps
7	Migration and refugee issues
8	Mental health challenges
9	Shifts in demographic structures

3.1.3. Geopolitical Risks (6)

Table 6 lists six (6) geopolitical risks that have emerged or been exacerbated by the COVID-19 pandemic. It includes international conflicts, political instability, acts of terrorism, and diplomatic tensions. The table underscores how the global political landscape has shifted in response to the pandemic, with new power struggles and challenges in international relations.

Table 6. Geopolitical Risks in the Post-COVID Era.

Risks	Identified Geopolitical Risks (6)
1	Escalating international conflicts and wars
2	Political instability and governance failures
3	Acts of terrorism and extremist violence
4	Power struggles and regional conflicts
5	Diplomatic tensions and breakdowns
6	Economic sanctions and trade barriers

3.1.4. Technological Risks (4)

Table 7 identifies 4 technological risks that have surfaced in the wake of the pandemic. These include cybersecurity threats, rapid obsolescence of technology, the misuse of artificial intelligence, and privacy concerns. The table emphasizes the growing importance of securing technological infrastructures and ensuring that technological advancements are managed ethically and responsibly.

Table 7. Technological Risks in the Post-COVID Era.

Risks	Identified Technological Risks (4)
1	Cybersecurity threats and data breaches
2	Rapid technological obsolescence
3	Misuse of artificial intelligence
4	Privacy and ethical concerns related to new technologies

3.1.5. Environmental Risks (2)

Table 8 presents two (2) critical environmental risks that have been magnified by the pandemic, such as accelerated climate change and the increased frequency of natural disasters. The table highlights the need for urgent action to mitigate these environmental challenges and integrate sustainability into post-pandemic recovery plans.

Table 8. Environmental Risks in the Post-COVID Era.

Risks	Identified Environmental Risks (2)
1	Accelerated climate change effects
2	Increased frequency and severity of natural disasters

3.2. Forecast of crises until 2030

Based on the X.0 wave theory, the research forecasts several major crises poised to evolve in the coming years, contextualized within the framework of public health and governance [46–50]:

1) Current Crisis
   - Contagion of the Covid-19 Challenge: Continued repercussions of the pandemic on public health systems, economies, and social structures.
2) Immediate Future Crisis
   - Socio-Educational Consequences of Covid-19: Long-term effects on educational systems and social dynamics due to pandemic-related disruptions.
   - Recession Crises: Anticipated economic downturns and financial instability impacting various sectors.
   - Hybrid Warfare: Emerging threats including [51–53]:
     - Soft (Velvet) Revolution: Non-violent movements advocating for political and social change.
     - Cognitive Warfare: Use of information and psychological tactics to influence public perception and behavior.
     - Biological Warfare: Risks associated with the deliberate use of biological agents in conflict scenarios.
3) Future Crises
   - Climate Change Crises: Increasingly severe environmental changes impacting ecosystems, weather patterns, and global stability.
   - Biodiversity Collapse Crises: Significant loss of species and disruption of ecosystems affecting global biodiversity.
   - Technological Crises: Challenges arising from rapid technological advancements and their broader implications on society.

3.3. Theoretical basis: X.0 Wave Theory

The analysis is anchored in the X.0 Wave Theory, which emphasizes the evolving waves of societal and technological transformation. This theory provides a framework for understanding the current and future shifts in governance, public health, and economic stability [54–57]:

1) X.0 Wave Theory: This theory builds on the notion that societal progress occurs in waves, each characterized by distinct transformations in technology, governance, and public health. The focus is on the 5th wave, which integrates:
   - Environmental Sustainability: Emphasizing the need for sustainable practices in SMEs (Small and Medium Enterprises) that address ecological and economic challenges.
   - Social Cohesion: Promoting social stability and inclusivity in the face of evolving societal pressures.
   - Economic Efficiency: Enhancing resilience and operational efficiency to navigate economic uncertainties.
2) Hybrid SMEs in Post-COVID Governance: The concept of Hybrid SMEs involves integrating innovative practices with sustainability and resilience. These enterprises are positioned to navigate the challenges of the X.0 wave by focusing on [58–60]:
   - Environmental Responsibility: Incorporating sustainable practices that balance ecological concerns with economic viability.
   - Social Responsibility: Ensuring social equity and community engagement as core business values.
   - Economic Adaptability: Adapting to economic fluctuations and technological changes to maintain competitiveness and sustainability.

3.4. Implications for post-COVID governance

The application of the X.0 Wave Theory and the focus on Hybrid SMEs offer critical insights into managing public health and governance challenges in the post-COVID era [61–64]:

1) Policy Development:
   - Develop policies that promote environmental sustainability, social cohesion, and economic efficiency.
   - Foster innovation in SMEs to enhance resilience and adaptability.
2) Business Strategy:
   - Encourage SMEs to adopt sustainable and socially responsible practices.
   - Support economic efficiency and technological adaptation to mitigate risks.
3) Public Health and Social Systems:
   - Address the long-term impacts of COVID-19 on public health and education.
   - Strengthen social systems to manage inequality and mental health challenges.

The research provides a comprehensive analysis of the risks and crises anticipated in the coming years, framed within the X.0 Wave Theory and its implications for Hybrid SMEs. By aligning with the principles of environmental responsibility, social cohesion, and economic efficiency, businesses and policymakers can better navigate the complex landscape of post-COVID governance and public health challenges [65–70].

4. Research methodology

This study employs a multi-method research design, integrating theoretical, qualitative, and quantitative approaches to analyze the role of Hybrid SMEs and the X.0 Wave Theory in post-COVID governance frameworks. The methodology consists of the following components:

4.1. Theoretical framework

The research is structured around the X.0 Wave Theory, i-Sustainability Plus Theory, and Hybrid SMEs framework, providing a conceptual basis for understanding digital transformation, governance shifts, and socio-economic resilience in the post-pandemic era. This theoretical foundation enables a structured analysis of how governance models evolve through technology-driven decision-making.

4.2. Empirical approach

To validate the theoretical insights, the study employs a mixed-methods approach, incorporating case studies, surveys, and secondary data analysis.

1) Case Studies:
   - Examination of Hybrid SMEs in economies such as Germany, Switzerland, Singapore, and China to assess resilience and adaptability.
   - Analysis of public-private partnerships (PPP) in digital governance, AI-driven policymaking, and post-pandemic socio-economic policies.
   - Study of digital transformation in governance, including blockchain for transparency, AI for predictive modeling, and real-time crisis response strategies.
2) Quantitative Data Analysis:
   - AI and Big Data Analytics: Assessing trends in digital healthcare, economic recovery, and technological governance shifts.
   - Economic and Social Indicators: Evaluating GDP recovery, employment trends, and digital adoption metrics in post-COVID policies.
   - Survey-Based Research: Gathering expert opinions from policymakers, business leaders, and academics on governance transformation through Hybrid SMEs.
3) Qualitative Research:
   - Expert Interviews: Engaging with academics, policymakers, and industry leaders to assess strategic governance shifts.
   - Policy Content Analysis: Reviewing government white papers, corporate reports, and academic literature on digital transformation.

4.3. Methodological limitations

- Data Access Constraints: Availability of proprietary governance and business data may be restricted.
- Regional Bias: Case studies focus on specific economies, which may limit global generalizability.
- Survey Representation: Ensuring diversity in survey responses across industries and governance structures.

4.4. Ethical considerations

- Compliance with GDPR and data protection laws in analyzing digital transformation trends.
- Avoidance of conflicts of interest in business-government collaborations on governance models.
- Transparency in policy assessment to ensure objective and unbiased conclusions.

5. Results and discussion

5.1. Results

The integration of Hybrid SMEs and the X.0 Wave Theory into post-COVID governance frameworks, alongside the X.0 wave/tomorrow age theory or theory of comprehensive everything, has generated notable advancements and highlighted areas for future growth. Key findings include:

1) Advancements in Governance Models:
   - Decentralized and Data-Driven Governance: The adoption of data-driven approaches and decentralized governance structures has enabled more agile and effective responses to health crises. Real-time data integration has improved decision-making and response times.
   - Public-Private Partnerships: Enhanced collaboration between public entities and private Hybrid SMEs has led to innovative solutions and efficient service delivery, crucial for scaling up health interventions and managing resources effectively.
2) Technological Innovations:
   - AI, ML, and IoH: The utilization of AI, ML, and the Internet of Health (IoH) has advanced diagnostic capabilities, treatment personalization, and predictive analytics. These technologies contribute to more adaptive and effective healthcare solutions.
   - i-Sustainability Plus Theory: The theory has highlighted the importance of integrating open innovation, sustainability, and smart technologies to address the socio-educational impacts of the pandemic. It underscores the need for digital transformation and smart training for health to foster a resilient academic and societal ecosystem.
3) Resilience and Integration into a Digital Society:
   - Technological Resilience: The incorporation of IoT, 5G, and other digital technologies has enhanced the healthcare system's resilience, supporting better crisis management and continuity of care.
   - Digital Transformation: The pandemic has accelerated the shift towards a digital society, emphasizing the need for robust digital infrastructure to fully leverage technological advancements.
4) Transformation of Social Welfare:
   - Welfare X.0 and Ethical Engagement: The development of digital welfare platforms has streamlined access to services and improved resource allocation. Ethical considerations in the deployment of these technologies are essential for ensuring fairness and transparency.

- SocioEdu Consequences: The impact of the COVID-19 pandemic on education systems has emphasized the need for advanced digital tools and strategies to bridge gaps caused by remote learning and access disparities.

5) Future-Oriented Strategies and Predictions:
   - Predictive Modeling and Scenario Planning: AI and big data have enhanced predictive modeling, aiding in the preparation for future health challenges and crises. Scenario planning has enabled the development of adaptive strategies.
   - X.0 Wave Theory and i-Sustainability Plus: These theories provide frameworks for understanding and addressing future challenges, focusing on sustainability and innovation as key drivers of resilience.

5.2. Discussion

The integration of Hybrid SMEs and the X.0 Wave Theory into post-COVID governance, augmented by the X.0 Wave and i-Sustainability Plus theories, reveals several critical insights and implications [71–74]:

1) Revolutionizing Governance Through Data and Technology:
   - The shift towards data-driven and decentralized governance has significantly improved the agility and responsiveness of public health systems. Real-time data utilization has become a cornerstone for effective decision-making and crisis management.
2) Innovation and Collaboration:
   - Hybrid SMEs have played a crucial role in driving innovation and improving service delivery. Their ability to blend social and economic objectives has led to the development of advanced technologies and solutions that address public health challenges. Public-private partnerships remain vital for leveraging complementary strengths and fostering innovation.
3) Enhancing Resilience and Embracing Digitalization:
   - The integration of AI, IoT, and 5G technologies has bolstered the resilience of healthcare systems. This digital transformation has become increasingly essential for managing crises and ensuring continuity of care. Building and maintaining robust digital infrastructure will be key to maximizing the benefits of these technologies.
4) Addressing SocioEdu Consequences and Ethical Considerations:
   - The socio-educational impacts of the pandemic highlight the need for advanced digital tools and strategies to address gaps in remote learning and access. The ethical deployment of digital welfare platforms is critical for ensuring fairness and equity.
5) Strategic Foresight and Preparedness:
   - Predictive modeling and scenario planning, guided by the X.0 Wave and i-Sustainability Plus theories, offer valuable insights for preparing for future challenges. These theories emphasize the importance of sustainability and innovation in building resilient systems capable of adapting to emerging crises.

5.3. Discussion and future studies

The COVID-19 pandemic has fundamentally reshaped our world, prompting a reevaluation of governance, technology, and societal structures. The intersection of hybrid SMEs and the X.0 Wave Theory provides a framework for navigating the complexities of post-pandemic governance. Drawing on insights from Matthias Horx, the Institute for Future Research, and Hamid Mattiello, this discussion integrates these perspectives to explore the implications of the pandemic and offer directions for future studies [75–80].

Transformation and Implications:

1) World and Behavioral Shifts: The pandemic has catalyzed significant changes in global dynamics, underscoring the limitations of our previous understanding of interconnected systems. Hamid Mattiello's research emphasizes that the world has changed irrevocably. Families and communities have grown closer, and the increased adoption of digital technologies has altered how we work and interact. Remote work and online education have become integral to daily life, reinforcing the need for governance models that leverage these technological advancements and address new societal needs.
2) Humanity and Resilience: The pandemic has highlighted the critical role of human connection and compassion, alongside technological and medical advancements. Mattiello notes that the return of humanity is a key outcome of the crisis, reflecting a renewed focus on empathy and solidarity. Future governance strategies should integrate these human-centered values, ensuring that policies are both technologically proficient and grounded in compassion.
3) Economic Continuity and Adaptation: Despite substantial disruptions, including infrastructure damage and market volatility, the economic system has shown resilience. The concept that "The Economy is Still Alive and Breathing!" reflects the potential for recovery and adaptation. Mattiello's observations confirm that the economy, while severely impacted, remains a dynamic entity capable of recovery. Future economic strategies must incorporate principles of Blue-Green sustainability and CSR to enhance long-term resilience and promote sustainable development.
4) Technological Authority and Privacy Risks: The pandemic has amplified the influence of technology companies, raising concerns about data privacy and security. The increased reliance on digital solutions has also highlighted risks associated with remote work and extended home office arrangements. Future governance must address these risks by implementing robust data protection measures and managing the implications of increased technological control, as highlighted by Mattiello's research.
5) Socio-Economic Shifts: The pandemic has intensified domestic economic shifts and crises, exposing vulnerabilities and opportunities for improvement. Strengthening social bonds and understanding shared values offer a foundation for rebuilding economic systems. Mattiello's research points to the evolution of health and medical care, emphasizing the role of frontline workers such as doctors, nurses, and pharmacists. These insights highlight the need for adaptive and resilient healthcare systems [81–83].

6) Global Trade and Economic Prosperity: As the world begins to resume trade, there is an opportunity to redefine global economic practices. The resumption of world trade offers a chance to pursue more sustainable and equitable economic models. Mattiello's research supports this view, suggesting that the post-pandemic era presents an opportunity to enhance economic prosperity while addressing the challenges exposed by the pandemic.

5.4. Future directions

To effectively navigate the post-pandemic landscape, several strategic directions are recommended [84–86]:

1) Enhanced Forecasting and Risk Management: Future research should focus on refining forecasting models using advanced technologies like AI and big data analytics. This will improve our ability to anticipate and prepare for complex crises, integrating insights from the X.0 Wave Theory, the 5th Wave, and i-Sustainability theories.
2) Strengthening Prevention and Adaptation: Open innovation and sustainability principles should be central to prevention strategies. Hybrid SMEs, with their emphasis on Blue-Green sustainability and CSR, are well-positioned to play a critical role. Their adaptability and innovative capabilities are essential for mitigating future risks and ensuring resilience.
3) Developing Resilient Governance Frameworks: Governance systems must evolve to be more flexible and adaptive. This includes integrating technological advancements with environmental sustainability and social cohesion, ensuring a comprehensive approach to crisis management.
4) Addressing Privacy and Security Risks: As digital technologies become more pervasive, it is crucial to address privacy and data security concerns. Developing robust policies and frameworks to protect individuals and manage data security risks will be vital.
5) Promoting Global Collaboration and Equitable Growth: International cooperation and knowledge exchange will be essential for addressing global challenges. Engaging with global research institutions, policymakers, and industry leaders will facilitate the development of effective strategies for managing future crises and promoting sustainable economic growth.
6) Investing in Socio-Educational Infrastructure: Continued investment in digital infrastructure and equitable access to education will support long-term resilience and adaptability. This focus will help mitigate the socio-educational impacts of the pandemic and prepare for future disruptions.

The COVID-19 pandemic has necessitated a paradigm shift in governance and socio-economic strategies. By embracing technological advancements, sustainability principles, and collaborative approaches, we can better forecast, prevent, and confront emerging challenges. Integrating the insights from Matthias Horx, the Institute for Future Research, and Hamid Mattiello into our approach will help navigate the complexities of the post-pandemic world, fostering a more resilient and equitable global society.

The integration of Hybrid SMEs and the X.0 Wave Theory into post-COVID governance frameworks, supported by the X.0 Wave and i-Sustainability Plus theories, has led to significant advancements in public health and social welfare. By embracing data-driven approaches, fostering innovation, and addressing ethical considerations, we can build more resilient and effective systems that are well-equipped to navigate future challenges and promote equitable health and welfare outcomes [87–91].

5.5. Limitations

While the integration of Hybrid SMEs and the X.0 Wave Theory into post-COVID governance frameworks provides a valuable foundation for future advancements, several limitations must be acknowledged in this study [92–94]:

1) Data Availability and Accuracy: The effectiveness of data-driven governance models relies heavily on the availability and quality of data. In some regions, particularly in developing or less digitized countries, data may be incomplete, inaccurate, or inaccessible, which limits the applicability of the proposed frameworks in these contexts.
2) Generalizability: The findings presented in this study are primarily based on cases and examples from specific regions and sectors, which may not be fully representative of all global contexts. The proposed governance models and technological innovations may require significant adaptation to fit the diverse needs and conditions of different countries, industries, and cultures.
3) Technological Adoption Barriers: The successful implementation of advanced technologies such as AI, ML, IoT, and 5G requires substantial investment in infrastructure and expertise. In many areas, these technologies may not be readily accessible, and resistance to adopting new technologies could delay or hinder progress in some sectors.
4) Ethical and Privacy Concerns: While the study emphasizes the importance of ethical engagement, it acknowledges that the deployment of digital welfare platforms and data-driven governance systems may raise privacy concerns. Ensuring ethical and transparent practices in the use of personal data remains an ongoing challenge, particularly when balancing public health goals with individual rights.
5) Socioeconomic Disparities: The socio-educational consequences of the pandemic underscore the need for advanced digital tools, but disparities in access to technology, particularly in underprivileged communities, may exacerbate existing inequalities. Addressing these disparities requires focused efforts to ensure equal access to resources, which is not always feasible due to economic limitations [95–97].
6) Implementation Complexity: The integration of Hybrid SMEs and X.0 Wave Theory into governance structures is complex, requiring alignment of various stakeholders, including government entities, the private sector, and civil society. The coordination of these diverse groups may face logistical, political, and regulatory challenges, potentially hindering the seamless implementation of the proposed strategies.

7) Long-Term Impact Uncertainty: The long-term effectiveness of the proposed frameworks remains uncertain, particularly as new challenges may arise over time. The dynamic nature of global health crises, technological advancements, and socio-economic shifts means that the strategies outlined may need continuous refinement and adaptation.
8) Cultural and Organizational Barriers: The adoption of new governance frameworks and technological innovations requires a cultural shift within organizations and societies. Resistance to change, particularly in traditional sectors or conservative governance systems, may impede the adoption of the proposed models, limiting their overall effectiveness.

By acknowledging these limitations, future studies can build on these findings to refine and expand the frameworks for more inclusive, resilient, and adaptive governance systems [98–102].

6. Conclusion and future suggestions

6.1. Conclusion

The X.0 Wave Theory provides a comprehensive framework for understanding the ongoing transformations in public health and social welfare. By integrating advancements in health innovation, resilience, and ethical engagement, we can develop robust systems for managing health and social services in a digital society. Embracing these principles will ensure that systems remain adaptable, effective, and equitable in the face of future challenges [103–109].

The COVID-19 pandemic has significantly altered the landscape of global governance, revealing the urgent need for adaptive, forward-thinking strategies. This chapter, "Charting Public Health Horizons: Hybrid SMEs & the X.0 Wave Theory in Post-COVID Governance," explores how the integration of Hybrid SMEs and the X.0 Wave Theory can enhance post-pandemic governance by improving our ability to forecast, prevent, and confront future challenges. The key findings are [110–114]:

1) Forecasting Future Challenges: The X.0 Wave Theory, encompassing the transition from Industry 4.0 to Industry 5.0 and eventually Society 6.0, provides a robust framework for anticipating future disruptions. By integrating advanced technologies such as AI, IoT, and big data analytics, governance systems can develop predictive models that help anticipate and mitigate potential crises, including socio-economic disruptions and environmental impacts.
2) Preventing Future Crises: Hybrid SMEs, with their innovative approaches and integration of digital and traditional business models, play a crucial role in preemptive crisis management. Their ability to adapt and implement technologies aligned with Blue-Green sustainability principles supports proactive measures in preventing public health and socio-economic issues. This includes leveraging open innovation and Corporate Social Responsibility (CSR) strategies to enhance societal resilience.
3) Facing Emerging Challenges: The pandemic has highlighted the importance of a comprehensive approach to addressing new and evolving threats. By focusing on sustainability and digital readiness, governance frameworks can better confront future shocks. The integration of the 5th Wave and i-Sustainability Plus Theories

underscores the need for an inclusive and adaptive response to crises, ensuring that technological advancements align with environmental and social goals [115–119].

4) Post-Sustainability Impact: The ongoing transformation driven by the pandemic demands a focus on sustainability and recovery. Hybrid SMEs, operating under Industry 5.0 and Society 6.0 paradigms, offer valuable insights into creating systems that are not only resilient but also contribute to Blue-Green sustainability. This approach supports balanced economic, environmental, and social outcomes, crucial for navigating the post-pandemic era.

6.2. Future suggestions

To effectively address the challenges and opportunities identified in this chapter, the following future directions are proposed [120–124]:

1) Enhance Forecasting Capabilities: Invest in advanced predictive modeling and analytics to better anticipate and prepare for future crises. Implement technologies that integrate data across various domains to improve the accuracy and timeliness of forecasts, enabling more proactive governance strategies.
2) Strengthen Prevention Strategies: Foster collaboration between public health entities, Hybrid SMEs, and technology developers to enhance preventative measures. Develop and deploy innovative solutions that integrate CSR principles and Blue-Green sustainability to address potential risks before they escalate.
3) Develop Resilient Governance Frameworks: Build governance frameworks that are flexible and adaptable to emerging challenges. Emphasize the integration of digital tools and sustainable practices to enhance overall system resilience. This includes promoting the use of technologies that support digital readiness and recovery [125–130].
4) Promote Open Innovation: Encourage open innovation practices that facilitate the exchange of ideas and solutions between various sectors. Support initiatives that leverage diverse perspectives and expertise to address complex challenges and drive sustainable development.
5) Address SocioEdu Consequences: Implement targeted strategies to mitigate the socio-educational impacts of the pandemic. Invest in digital education infrastructure, support remote learning initiatives, and ensure equitable access to educational resources to enhance long-term resilience.
6) Prepare for Future Crises: Align future governance strategies with the predictions and risk categories outlined by Matthias Horx and the Institute for Future Research. Focus on preparing for economic, societal, geopolitical, technological, and environmental risks, including potential crises such as hybrid warfare and climate change.
7) Foster Global Collaboration: Promote international collaboration and knowledge sharing to address global challenges. Engage with global research institutions, policymakers, and industry leaders to develop and implement effective strategies for managing future crises [130–132].

By focusing on these areas, future governance frameworks can build on the lessons learned from the COVID-19 pandemic, enhancing our ability to forecast,

prevent, and face emerging challenges. Integrating the principles of the X.0 Wave Theory and emphasizing sustainability and innovation will be crucial for navigating the complexities of the post-pandemic world [133–139].

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