Digital Cooperation Organization

DIGITAL ECONOMY TRENDS 2024

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Foreword
DCO Digital Economy Trends 2024

We live in an era characterized by unparalleled innovation, where the Digital Economy is exponentially growing due to rapid technological advancement and digital transformation. Understanding how the digital economy is performing now, plays a pivotal role in shaping how governments, businesses, and civil societies operate.

As the Digital Cooperation Organization embarks on a journey to explore the dynamic landscape of the digital world, it is with great excitement that we present the first edition of the "Digital Economy Trends in 2024" report, where we delve into the emerging trends that are shaping our future. We offer our distinctive viewpoint on the digital economy, formulating a 'how-to guide' for each of the trends, covering implications and recommendations for stakeholders across the global digital economy ecosystem, ensuring there's something valuable for everyone who aspires to contribute to the growth of an inclusive and sustainable digital economy.

As we strive to become a reliable information provider and advisor, it is our commitment to ensure that our findings are not only insightful but actionable, providing an outlook on digital economy trends for those who aspire to shape and be part of the growing global digital agenda. This aligns with the Digital Cooperation Organization's mission of 'achieving social prosperity and growth of the digital economy by unifying efforts to advance digital transformation and promote common interests'.

As we delve into these trends, we invite you to join us in reflecting and embracing the profound impact they have on governments, businesses, and civil society.

We extend our gratitude to the experts and industry leaders who contributed their breadth and depth of insights and expertise to this endeavor, bringing the best of our global ecosystem together to enable digital prosperity for all.

Deemah AlYahya
Secretary-General
The Digital Cooperation Organization

Deemah AlYahya

02.

Executive Summary

Executive Summary

In the inaugural edition of the DCO Digital Economy Trends report, we uncover a digital economy roadmap for 2024, that not only drives public and private sectors into a new era of digitization, but also redefines the future of our civil society. The shift of this technological paradigm is projected to unleash a series of opportunities across six themes that will exert significant influence over the digital economy in 2024:

Artificial Intelligence | Trust Economy | Digital Reality | Cybersecurity | Smart Ecosystems | Green Economy

Each of the themes identified comprises several trends that collectively shape the future of the digital economy.

Applying our state-of-the-art methodology, thought leadership, experience from international technical and visionary experts, coupled with insights from global think tanks, has allowed us to anticipate how each trend's disruptive influence can be hypothesized, envisioned, approached, and actioned in 2024.

Our analysis covers the fueling enablers for the trends identified, which serve as catalysts to drive the effective adoption and evolution across the six themes with the potential to shape the digital economy in 2024. The key enablers identified for 2024 are:

Digital Infrastructure | Digital Government | Emerging Technologies | Digital Transformation | Data | Digital Skills

Moreover, stemming from the DCO's role as an information provider and advisor, our report includes implications and recommended actions, ranging from guiding the implementation of digital technologies, targeting global priorities, applying appropriate governance for the adoption of trends, or even redefining business priorities, to contribute to the growth of the global digital economy.

These key takeaways are provided and tailored to the requirements of all relevant digital economy stakeholders, including public and private sectors, and inter-governmental organizations.

Before we delve into the detailed digital economy trends identified for 2024, a summary of the six core themes and associated trends is presented below:

Artificial Intelligence

In the past few years, AI, and particularly generative AI (GenAI) models have significantly expanded their reach and sophistication, facilitating applications across sectors ranging from creative media to healthcare. **GenAI is envisioned to play a pioneering role in cutting-edge software development, driving AI-powered digital government, and also contributing to accelerate environmental sustainability.** The transformative impact of GenAI on the digital ecosystem is projected to expand its market to USD207 Bn by 2030[5]. This holds significant implications and associated recommended actions for all stakeholders, as concerns related to ethics, misinformation, and bias are required to be managed.

Key Recommended Actions:

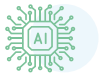
01 Public Sector

Create controlled testing environments with flexible AI regulatory frameworks to foster innovation while ensuring responsible practices.

Collaborate with the private sector to prioritize investments in AI digital skills and requisite infrastructure.

Establish transparency and accountability measures for secure, responsible, and sustainable applications of AI.

02 Private Sector



Engage with regulators to keep AI regulatory frameworks aligned with innovation and business needs.

Embrace a culture of AI "coopetition" through joint research consortia and shared service platforms.

Prioritize the implementation of AI cybersecurity, data privacy, and sustainability measures.

03 IGOs, IOs, and others

Foster global collaboration around AI governance.

Encourage academics, industry leaders, and NGOs to join international forums to build partnerships and converge on unified standards for AI technologies.

Trust Economy

Blockchain technology has evolved into a transformative force, transcending sectors to fuel a 'trust economy'. It has witnessed increased adoption in various sectors, including financial services, healthcare, supply chain, and logistics.

Blockchain promises to impact and redefine sustainability initiatives and next-generation governments' modus operandi, enabling trust, transparency, and accountability to boost the digital economy.

This progress hinges upon recommended actions, including the establishment of a robust and standardized regulatory framework, the enhancement of workforce skills, and collaborative efforts to promote digital preparedness for the required seamless interoperability.

Key Recommended Actions:

01 Public Sector

Develop national strategies for the adoption of blockchain, including sectoral ambitions and initiatives, in collaboration with the private sector.

Invest in the development of interoperable standards to enable seamless data exchange across different blockchain networks.

Invest in blockchain capacity building programs to foster a culture of innovation through education, boosting the trust economy.

02 Private Sector

Evaluate existing technology infrastructure through comprehensive impact assessments prior to integrating with blockchain solutions, to ensure interoperability and maximize benefits.

Identify and prioritize key areas where blockchain can improve efficiency within supply chains, to boost operational performance and build trust in sectors where information traceability is important.

03 IGOs, IOs, and others

Encourage collaboration in developing common standards, to foster a strong regulatory landscape for blockchain innovation.

Disseminate requisite information to promote early adoption of blockchain-powered operations by public and private sectors.

Digital Reality

Extended Reality technologies (XR) have become integral tools across industries through a broad spectrum of applications, including hyper-personalization in various sectors, like healthcare, education, retail, fashion, and gaming.

Substantial interest from major global technology players is propelling XR to the forefront, as **we increasingly witness XR revolutionize everything, from enhancing customer experiences to optimizing operations of an organization through product innovation, prototyping, virtual sales, and remote collaboration.**

Digital Reality recommended actions can be far-reaching, from ensuring responsible usage to promoting digital inclusion and mitigating environmental impact.

Key Recommended Actions:

01 Public Sector

Develop regulatory frameworks centered on data governance and XR risk management for XR applications and services.

Prioritize privacy-by-design principles in XR development, fostering a secure environment for immersive technologies to boost user trust.

02 Private Sector

Focus on affordability, cultural inclusivity, and continuous user feedback integration, to boost inclusivity.

Collaborate with relevant stakeholders, including regulatory bodies, to create sustainable policies that encourage responsible XR production and consumption.

Proactively address concerns around privacy, security, and interoperability, to create a more informed market and accelerate the integration of XR technology across various applications.

03 IGOs, IOs, and others

Cooperate with the public and private sectors to establish technical standards for digital infrastructure, devices, and applications, to facilitate seamless interactions between different XR platforms worldwide.

Cybersecurity

By 2026, 70% of company boards will include one member with cybersecurity experience[63], and this is attributed to the need for cultivating trust and confidence among consumers and businesses, to drive digital economy growth.

The present cybersecurity environment, governed by numerous policies and regulations, has spawned modern approaches such as Zero-Trust and DevSecOps, counter the increasing number of innovative attacks.

Looking ahead, AI-driven advancements in cybersecurity promise more sophisticated tools and mechanisms to better counter cyber threats. Advancements in cybersecurity will stimulate the growth of the digital economy by nurturing trust, fostering innovation, and encouraging skill development.

Key Recommended Actions:

01 Public Sector

Facilitate public access to e-learning resources and focus on initiatives to spread awareness in cybersecurity best practices, including the prudent use of digital assets and encryption significance.

Define and/or regularly update national future-proof cybersecurity strategies, policies, and action plans that address cybersecurity threats.

Issue national cybersecurity advisories on emerging threats and propose relevant cybersecurity readiness initiatives to safeguard critical national infrastructure.

02 Private Sector

Build technology system products based on security-by-design principles.

Foster an integrated cybersecurity culture within private sector organizations to avoid internal siloed practices while considering organizational priorities and the required cybersecurity related investments.

Comply with existing cybersecurity regulations, frameworks, and standards to implement advanced cybersecurity measures to safeguard systems, data, and customer information.

03 IGOs, IOs, and others

Foster cooperation at various national, regional, and global levels among relevant cybersecurity stakeholders, to address advanced cyber threats via regulatory, technical, and capacity-building efforts.

Smart Ecosystem

From remotely controllable household appliances to technology-enabled smart cities, the Internet of Things (IoT) has significantly transformed smart ecosystems over the years. Projections indicate a substantial rise in the number of IoT-connected devices globally, expected to reach USD29 Bn by 2030[98].

The proliferation of these smart ecosystems is poised to drive industry optimization, foster circular economy initiatives, and elevate customer experiences in interconnected digital cities.

This shift will be enabled by enhancements to the underlying digital infrastructure and data processing capabilities and making smart ecosystems cybersecure through relevant regulations.

Key Recommended Actions:

01 Public Sector

Set comprehensive guidelines for security regulatory standards for IoT devices, promoting a baseline level of security that devices shall meet.

Promote ongoing capacity-building programs for relevant stakeholders on best IoT security practices.

Establish Public-Private Partnerships (PPP) for the development of requisite large scale IoT infrastructure.

02 Private Sector

Prioritize investments in high-speed connectivity to ensure seamless integration and operation of IoT devices.

Engage in persisting R&D ensuring that IoT systems remain adaptable and scalable for future advancements.

03 IGOs, IOs, and others

Cooperate with governments to encourage interconnectivity and interoperability of IoT devices.

Green Economy

The growing awareness of climate change has driven substantial investments in the green economy, fueling initiatives on green innovation, circular economy practices and industry-driven sustainability efforts, that contribute to a more environmentally friendly world.

The environmental sustainability sector is growing and is projected to reach USD83 Bn by 2032[135] as it immerses in the digital economy, witnessing a surge in green technologies.

The future outlook indicates increased adoption of green technology solutions, sustainable agricultural technology, and a rise in stringent regulations to facilitate the green transition.

Key Recommended Actions:

01 Public Sector

Develop and continuously update relevant regulations to encourage pre-submission consultations while scaling up requisite infrastructure.

Accelerate progress to achieve National Determined Contributions (NDCs) and UN Sustainable Development Goals (SDGs) by establishing specialized structures that focus on the green economy.

Promote domestic and foreign investments through capital market pathways to effectively scale up climate finance.

02 Private Sector

Private sector organizations should strategically position themselves by implementing Environment, Social, and Governance (ESG) practices.

Actively engage in "on-the-job" learning initiatives and establish capacity building partnerships to ensure the availability of green skilled talent in the future.

03 IGOs, IOs, and others

Promote the international harmonization of green taxonomy and standards, and enhance transparency, for a more coordinated approach across sectors and regions.

Strategically address trade barriers for environmental technologies within the International Harmonized Tariff System (IHTS) using green taxonomies.

03. INTRODUCTION

Introduction

In over two decades, digital technologies have reached about half of the developing world's population[1], revolutionizing society and advancing faster than any other innovation in human history. The pervasive nature of digital technology allows it to bridge gaps and address pressing challenges across various sectors, including the economic sector.

With the benefit of creating new jobs and markets, expanding access to financing, and enhancing efficiency and transparency, digital technologies and platforms are becoming increasingly significant in tackling global concerns and responding to international events.

Digital technologies can also significantly increase equality by improving financial inclusion, trade accessibility, connectivity, and public service delivery. The Digital Economy is a multifaceted and rapidly evolving concept encompassing a wide range of economic activities, transactions, and interactions in the digital realm. Its scope extends well beyond the confines of traditional industries, offering new avenues for innovation and societal transformation.

It is an expansive and transformative force encompassing technological innovation, economic activities, and societal change. Its scope continually expands as digital technologies evolve and new opportunities and challenges emerge. Understanding the Digital Economy is crucial for the public and private sectors, and civil society as they navigate this ever-changing landscape and harness its potential for economic growth and societal progress.

The question to ask all stakeholders across the Digital Economy is:

Are we equipped with the right information and tools to understand how to navigate the complexities of the Digital Economy?

In most cases, the public and private sectors and civil society find it challenging to identify the trends, the headwinds, and the opportunities they bring about and use this knowledge to their advantage.

A Digital Economy trend refers to the evolving economic landscape driven by the widespread use and integration of digital technologies, influencing how organizations operate, trade, and innovate. To ensure all stakeholders of the global digital economy are equipped with the correct information and tools to identify and act on the most critical trends of today, the DCO has developed the first edition of this annual report.

Through meticulous screening and analysis, we have identified six themes — Artificial Intelligence, Digital Reality, Trust Economy, Cybersecurity, Smart Ecosystems, and Green Economy — forming the core of our report. Our methodology for identifying and analyzing these themes and underlying trends involves a comprehensive blend of expert-led primary and secondary research. Each theme and trend undergoes an assessment utilizing the DCO's trend evaluation scoring matrix, complemented by quantitative and qualitative evaluations with subject matter experts.

The DCO's Digital Economy Trends 2024 report is a 'one-stop shop' for Digital Economy insights, providing guidance and a basis for collaboration for all constituents of the global digital economy, turning insights into action through the power of the DCO's core functions and strength of the DCO's ecosystem.

04. DIGITAL ECONOMY TRENDS

Introducing the DCO Digital Economy Trends Blueprint

In this first edition of the report, the DCO Digital Economy Trends Blueprint has been designed to provide a holistic representation of the Digital Economy trends that have been identified in our analysis.

The trends are categorized into six core themes for 2024, each with significant implications for all participants in the Digital Economy. The six themes – Artificial Intelligence, Trust Economy, Digital Reality, Cybersecurity, Smart Ecosystems, and Green Economy – each encompass up to three trends that are anticipated to impact the Digital Economy in 2024 significantly.

This blueprint also presents the criticality* of each of the trends identified in the global digital economy in 2024 and maps each of the identified themes to specifically identified enablers that can unlock the full potential of the trend.

The enablers, which include:

- Digital Infrastructure
- Digital Government
- Data
- Emerging Technology
- Digital Transformation
- Digital Skills

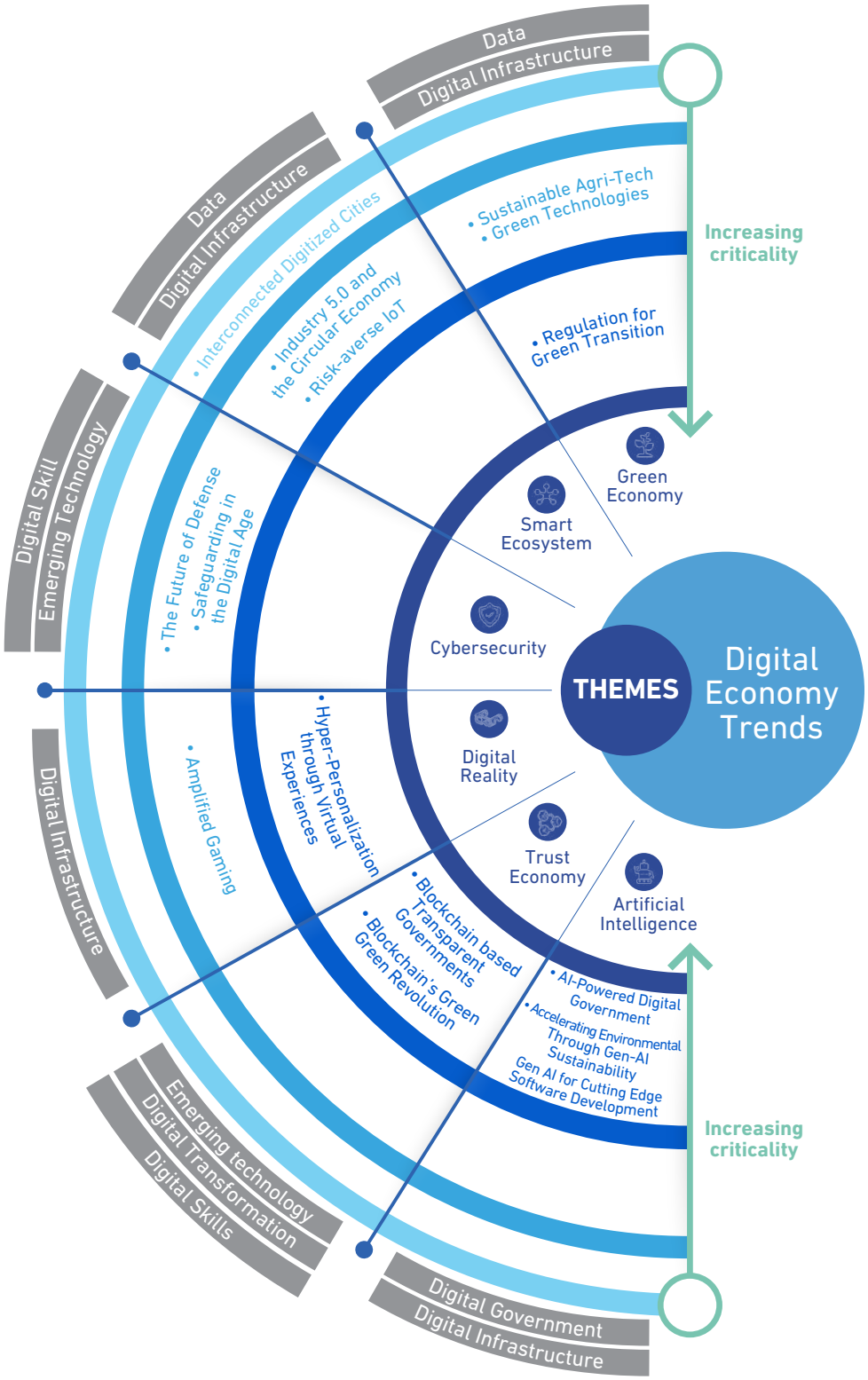
serve as catalysts that will propel the adoption of these digital economy trends.

The DCO's Digital Economy Trends Blueprint can serve as a tool to identify synergies between the themes and trends outlined in this report, reflecting the dynamic and symbiotic nature of the digital ecosystem. Each trend converges and collaborates, creating a network of influences that collectively shape the future of the Digital Economy.

For instance, trust emerges as a common thread, facilitated by blockchain in the Trust Economy, ensuring the reliability of sustainable practices in Green Economies and promoting confidence in digital innovations.

Sustainability is omnipresent, with Smart Ecosystems and Green Economies mutually reinforcing each other, while Digital Reality and IoT accelerate digital transformation.

As the blueprint evolves over the years, it will enable the DCO to perform a longitudinal analysis of themes and corresponding trends, tracking how digital economy themes, trends, and enablers emerge, evolve, and transform over time.



The DCO Digital Economy Trends Blueprint is comprised of elements which provide a holistic representation of the digital economy trends

Themes Enablers Criticality of the trends

Artificial Intelligence (AI)

Trends

01 **Gen AI** for Cutting Edge Software Development

02 **AI-Powered** Digital Government

03 Accelerating Environmental Sustainability Through **Gen-AI**

AI
How Will Gen AI Shape the Future Agendas of Private & Public Sectors?

The Evolution of Generative AI

Generative Artificial Intelligence (Gen AI) has a rich history, beginning with early AI research in the 1950s and 1960s. It evolved through natural language generation, neural networks, and deep learning. Key milestones include the development of GANs in 2014 and the introduction of Transformer models that revolutionized generative AI, such as GPT-4, introduced in March 2023.

These models are now widely used for various tasks and applications, but ethical and legal concerns, such as privacy, misinformation, lack of trust, and intellectual property rights (IPR), remain important issues in the field. Gen AI represents merely one aspect of AI. Predictive analytics and simulation using methods like machine learning (ML) are becoming increasingly popular commercially. Similarly, chatbots are being increasingly powered by natural language processing, or NLP.

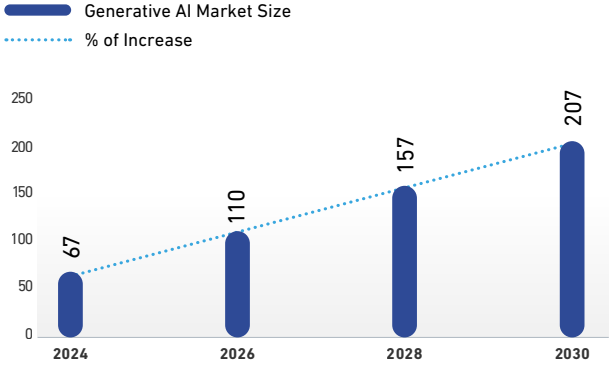
The generative AI models have found widespread applications across the public and the private sector, as well as civil society, with the potential to unlock the next wave of productivity, creating business value and contributing to the growth of the digital economy. They are now essential tools for everything from manufacturing and customer service to healthcare and banking, radically changing how society and government's function. However, as generative AI continues to grow in importance, concerns related to ethics and the potential for misinformation and bias have taken center stage.

Even while the results of AI are fascinating, significant human intervention is required to validate the findings, especially in regulated professions like the legal, medical, and financial services industries.

According to projections, the market for generative AI is expected to reach a valuation of USD88 Bn by 2025, accounting for 30% of the overall AI market[2]. Generative AI has experienced remarkable levels of adoption, as exemplified by the rapid growth of ChatGPT, which garnered one Mn users within a mere five days and reached an astounding 100 Mn users in just two months[3]. As of November 2023, the platform had a weekly user base of 100 Mn[4].

By 2030, the market is likely to reach a volume of USD207 Bn, growing at a compounded yearly growth rate (CAGR) for the period 2023-2030 of 24.4%[5].

Generative AI Market Size
(In USD Bn)



Source: *Statista*

Success to Date
Where Has Gen AI Been Implemented and What Impact is Being Generated?

The recent implementation of Generative AI within the Artificial Intelligence space is expected to have an even more significant impact on the job market.

Thanks to its technological advancements, Gen AI is making waves in various industries, reshaping how businesses operate and create value. Some key applications of Generative AI include:

> In 2020, the World Economic Forum forecasted that AI is expected to displace over 85 Mn jobs globally but generate 97 Mn new jobs by 2025[6].

Generative AI-based conversational assistants

can disseminate the potentially tacit knowledge of more able workers and help newer workers move down the experience curve[7]. These tools serve a dual function by improving the customer experience and diminishing the need for managerial involvement, thereby enhancing employee retention.

Select leading conversational AI tools available in the market include ChatGPT-4, IBM Watson Assistant, Kore.ai, Avaamo.ai, Amazon Lex, Oracle Digital Assistant, and Microsoft Bot Framework.

Use Case Spotlight

Embedded Generative AI tools would be integrated into existing word processing applications, spreadsheets, and email clients. Microsoft 365 Copilot is a generative AI assistant built into apps across the Microsoft 365 productivity suite.

In the software development lifecycle, AI is proving to be a big enabler in predicting faults in programs and help alter the code to avert problems. AI programs can do this automatically, thus saving programmers significant effort. However, Gen AI must be looked at as more than just a tool for code creation. Repetitive work can be automated through Gen AI. When it comes to pattern synthesis and matching, such as translating between languages, Gen AI excels.

The most evident application of this power in software delivery is for a novel form of code generation, where the AI converts one sort of code into another or transforms natural language into code. Locating the correct information from reliable sources is time-consuming and it impacts the efficiency of software engineers.

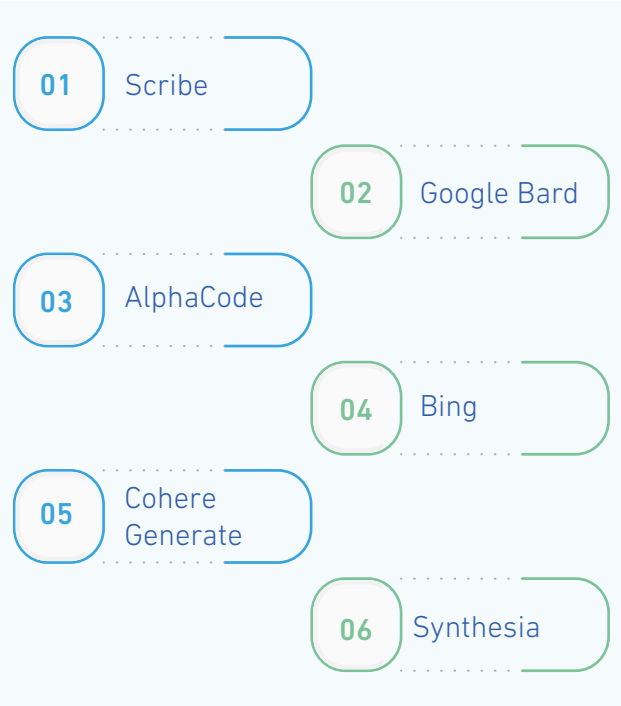
Finding the correct information is one of the biggest causes of inefficiency for software engineers. Finding the right place to look for information can be time-consuming, whether it is through internal documentation or internet searches.

Use Case Spotlight

Microsoft GitHub Copilot generates codes, helps predict and fix programming code errors before the applications are put into production.

It identifies reasons for program failures and predicts potential issues. Copilot CHAT, a Gen AI tool from GitHub, expands on the coding help features already available in Copilot to offer developers context-specific and natural language support.

Automation of artistic media and creative content such as visual arts, music, and literature, can be facilitated through Generative AI tools, such as:



This has the potential to increase efficiency and effectiveness in marketing and communication strategies.

However, careful consideration of human oversight and biases, creativity, authorship, aesthetics, legal aspects, and the future of creative work is still essential in deploying Generative AI.

Use Case Spotlight

Ferrero employed AI to create 7 Mn unique versions or labels for its Nutella hero pack. Different patterns and colors were blended autonomously for each design, assigning a unique ID code to ensure individuality across all labels[8].

Finally, although at a nascent stage, **AI's role in healthcare has been transformative,** offering a wide array of applications that enhance patient care, streamline processes, and aid medical professionals in their work.

It is used for medical image analysis, disease prediction, drug discovery, personalized medicine, and telemedicine.

The impact of AI on healthcare is driven by improved patient outcomes and cost reduction, but it also requires careful consideration of privacy and ethical concerns due to the sensitive nature of input data and output quality.

A case in point would be Apollo hospitals which has plans to use more advanced Med-Pathways Language Model (PaLM) 2, a LLM developed by Google that is trained in medical knowledge and can answer medical questions and generate genuine clinical text summaries[9].

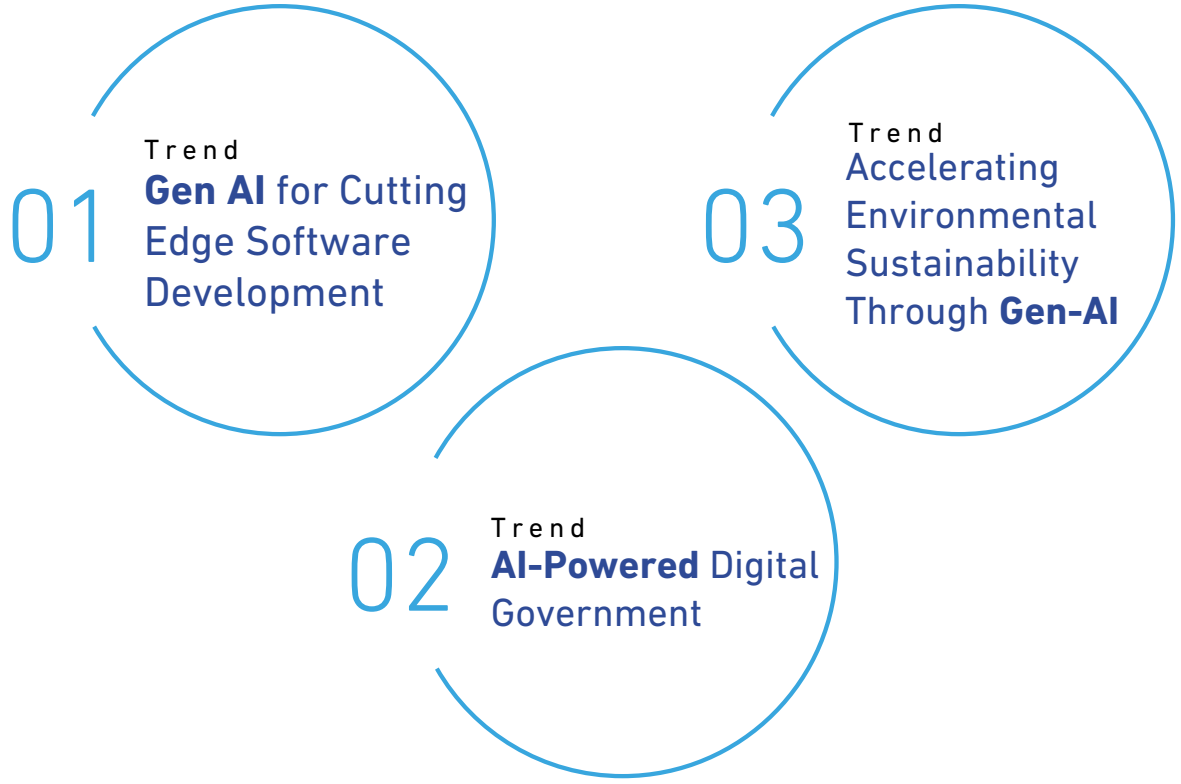
Envisioning 2024
Introducing the Gen AI global trends

In the dynamic intersection of Generative AI and digital economy, we uncover a possible roadmap that not only drives Government, business, and civil societies into a new era of digitization, but also redefines the future of our civil society.

While private entities are striving to optimize their internal operations and deliver more personalized experiences to their customers, governments around the world are facing pressing challenges to improve citizen services, modernize digital infrastructures, and deliver more effective policies on concerning matters such as climate change.

The urgent challenges that fill the global agenda of both private and public sectors are expected to be tackled promptly and with heavy investments in emerging technologies such as Gen AI.

As a result, the shift of this technological paradigm is projected to unleash an unprecedented impact and opportunities across three focus areas – "Product Design and development, Governance, Policy and Regulation Development and Environmental Sustainability", which are expected to emerge into the following three key trends, directly addressing some of the 2024 world agenda items:



Trend 1:

Gen AI for Cutting Edge Software Development

By streamlining and accelerating turnaround time through auto-generating personalized designs & prototypes, and software development automation, Gen AI offers invaluable tools to facilitate the rapid development of innovative products and services.

According to one subject matter expert, "With a capacity to think, act, and even learn like human beings, AI has begun catalyzing deep structural changes in the nature and application of tool-mediated design.

As 'thinking machines', generative AI can now test, debug, and deploy software without the need for human intervention. AI is a force multiplier with the capacity to reshape the nature of human engineering and design.

Amongst the many sectors that have been embracing this technology to reach a competitive edge, the ICT sector has uncovered great potential in the AI-powered 'low-code-no-code' (LCNC) capabilities.

ICT is leveraging next generation technologies to **reshape the process of software development and fuel the growth of low-code-no-code (LCNC).**

This intrinsic value of LCNC lies on the drastic reduction in turnaround time (TAT) for coding, with a significant shift away from tech-savvy dependency logic currently in place.

This shift could enable business professionals to design and develop end-to-end software applications by themselves.

Big tech companies (e.g., Google AppSheet) have started to invest heavily in such platforms to support users with the development of apps through automated processes without writing code.

For businesses, adding generative AI to low-code and no-code platforms presents a significant opportunity since it can accelerate development cycles by reducing adoption barriers and empowering business users with more ability to design apps.

By 2026, it is projected that at least 80% of low-code development tool users will come from outside of established IT departments. This is driven by the aim to achieve the level of digital proficiency and delivery speed required for the contemporary agile environment[10].

Use Case Spotlight

Google Cloud's foundation models allow developers to build next-generation applications with access to multimodal models from Google, including code generation and code completion models with Codey[11].

Trend 2:

AI-Powered Digital Government

Governments are adopting generative AI in many aspects of their governance and processes. Generative AI-powered automation is essential in helping public sector organizations streamline their operations by automating repetitive and routine tasks.

In summary, generative AI can automatically produce comprehensive reports, reducing the administrative workload for public administration and making data analysis and report compilation more efficient, thereby facilitating quicker decision-making.

Another area where Gen AI proves helpful is in accessing Legal documentation, simplifying the creation of legal documents for the public to comprehend.

This not only lowers the complexity of the law, but also increases accessibility, lessening the necessity for legal counsel.

Moreover, by analyzing historical spending patterns, conducting trend-based forecasting of future needs, and enabling well-informed decision-making regarding resource allocation, Generative AI in government has the potential to completely transform budgeting procedures, making them efficient and fast -tracking them.

Using a Generative AI service desk, government agencies can automate the examination of a significant volume of financial and other relevant data, allowing AI to find patterns and trends in this data to detect possible tax evasion or fraud with greater accuracy.

Gen AI plays a pivotal role in optimizing policy-making processes by conducting thorough assessments of complex datasets contributing to the formulation of factual, evidence-based policies to facilitate informed decision-making making processes for public administrations.

By expediting the evaluation of potential impacts, Generative AI empowers governments to respond quickly and efficiently to pressing challenges, including but not limited to public health crises and environmental concerns.

Gen AI is playing a significant role in simplifying e-Government Services. The reduction of rusty, long, and static bureaucratic procedures has long been debated among public institutions around the world.

Whether it is chatbots addressing and solving citizens' requests, automated document verification and validation, smart resource allocation through advanced predictive analytics, or preventive fraud detection applications, Gen AI has the power to revolutionize e-services and enhance core operational activities, resulting in less significant administrative burdens, and improved citizen satisfaction.

> “Gen AI has the power to revolutionize e-services and enhance core operational activities, resulting in less significant administrative burdens, and improved citizen satisfaction.”

Trend 3:

Accelerating Environmental Sustainability Through Gen-AI

Despite the development and deployment of AI models, including Gen AI, such systems can require significant computational power.

This may demand increased energy consumption, enormous quantities of water for cooling and potentially electronic waste through the shorter lifecycles of hardware components, its meticulous processing and interpretation of environmental data.

These place Generative AI at the forefront of the innovations that can directly endorse and elevate the efforts made within the sustainability cause.

By providing invaluable insights into key trends, patterns, and potential environmental risks across concerning parameters such as air and water quality, Gen AI represents a tangible opportunity to address some of the world's key environmental concerns.

Use Case Spotlight

To provide a thorough energy study, generative AI may examine the layout, materials used in construction, and surrounding circumstances of the structure. This analysis can help the facility comply with the most recent sustainability standards by pointing out possible energy savings and making recommendations for upgrades.

Generative AI can help uncover opportunities for energy savings and sustainability improvements that might not have otherwise been thought of, as well as save time and money. It can also increase the accuracy and dependability of energy audits.

The energy performance rating of a building—a gauge of energy efficiency used in certification schemes like the LEED (Leadership in Energy and Environmental Design) program—can be automatically calculated by generative AI.

AI capabilities extend to pollution sources monitoring, endorsing environmental standards enforcement and addressing key global concerns related to industrial emissions and illicit waste disposal. By scrutinizing data from diverse sources such as satellite imagery and sensor networks, Generative AI contributes to inform regulatory policies aimed at tackling environmental standard enforcement.

AI is also being used to enhance climate change monitoring & interventions. AI-enabled forecasting modeling, can also support climate change researchers and organizations thoroughly examine historical data and produce ad-hoc simulations on a multitude of future scenarios, enabling policy-makers to formulate more informed and precise mitigation plans, addressing not only human awareness of climate change matters, but also allowing relevant entities to predict and mitigate possible natural disasters through adequate responses such as early warnings and effective disaster response planning.

With the world's population increasing at a fast pace, global food production has been a key area of debate amongst local governments and international institutions and consortiums.

In agriculture, Gen AI is believed to have the potential to become a primary contributor in the optimization of current operations aimed at ensuring large-scale improvements on resource allocation and utilization. Through its core technological capabilities, Generative AI offers critical data elaboration on key agricultural components such as water usage, energy consumption, soil conditions and crop health, enabling farmers to enhance productivity while mitigating environmental impact.

Approaching 2024
An Overview of Key Enabling Forces for AI including Gen AI

The potential for Generative AI to shape economies is evident, as demonstrated by the earlier highlighted applications.

While the degree of these impacts may vary across different digital economy components, this section will delve into three macro enablers that are pivotal to expedite the adoption and growth of Gen AI within next generation economies.

Upskilling Talents & Promote Human – Machine Cooperation

As observed in previous technological shifts, Gen AI is expected to pose risks for certain existing jobs while simultaneously creating opportunities for new ones.

The pace at which the transition toward acquiring new skill sets appears to be accelerating with the introduction of advanced technologies. Following the 'fast fish eat the slow fish' analogy, visionary and better equipped organizations have the opportunity to gain a competitive edge by establishing a proactive transition strategy to introduce cultural acceptance, functional frameworks and governance policies around human and machine collaboration, in addition to facilitate learning and development activities aimed at upskilling current employees on the impact and implications of innovative and disruptive technologies such as Gen AI.

Laying Solid Digital Foundations

In a time marked by rapid technological evolution, the integration of Generative AI stands as a transformative force, promising innovation, efficiency, and opportunities for nations, organizations, and individuals alike.

However, with Gen AI integration requiring a great degree of digital readiness and infrastructural modernization, organizations around the world are called to review their digital maturity to ensure adequate infrastructures that can integrate, absorb, and scale the value of Gen AI.

The first step to accommodate the power of Gen AI across public and private entities begins with ensuring solid data governance and quality assurance frameworks and processes to enable access to robust and quality datasets.

This, along with scalable infrastructures such as cloud-based solutions, which enable seamless system integration, and a sound cybersecurity system, can help organizations unlock the real value of Gen AI applications and pave the way toward a future made of innovation, enhanced efficiency, and boundless opportunities.

AI-focused regulatory frameworks

We have observed significant emerging efforts from governments and regulatory authorities in the attempt to tackle some of the pressing topics related to the Artificial Intelligence ecosystem.

For instance, the EU's AI Act is the world's first comprehensive AI law designed with the objective of establishing clear obligations for AI providers and users based on the degree of risk associated with their use of AI functionalities, including Gen AI, ensuring a safer, more transparent, non-discriminatory, and environmentally friendly adoption of this technology.

The AI Act establishes a clear regulatory framework for AI development and will provide businesses with the certainty they need to invest in AI and bring innovative products and services to the market. It takes a risk-based approach to regulation and the applicability of regulation will depend on the level of risk posed by an AI system. This approach avoids stifling innovation while still protecting public safety and fundamental rights.

The Act includes a number of provisions including support for AI sandboxes, real-world testing, and the development of European AI standards to support AI innovation.

The AI Act also includes a number of restrictions on the use of AI, designed to protect public safety, fundamental rights, and democracy. Key provisions mentioned in the act that are most relevant to businesses include a ban on certain AI applications, stringent requirements on high-risk AI systems, transparency and explainability and data governance[12,13], for instance, the EU's provisional deal pertaining to the use of AI by the government in biometric surveillance.

To conclude, the integration of Gen AI is more than just a technological advancement, but rather a strategic move for businesses and governmental entities that aspire to prosper in the digital era. With governments and regulators increasingly focusing on the vast artificial intelligence landscape, how and where are public sector entities prioritizing efforts to derive value from it in 2024?

Key Takeaways
Tackling Gen AI in 2024

As we conclude our analysis of the applications, future scenarios, and implications of Gen AI, it becomes self-evident that the transformative power this technology holds demands a comprehensive and collaborative response from multiple stakeholders, namely private businesses, public institutions, as well as citizens.

Implications and Recommended Actions the Public Sector

Regulatory Landscape

Implications

Public sector organizations are facing the challenge of implementing new regulatory frameworks that support technological advancements (such as AI) and ensure adequate balance between innovation, ethical, and socio-economic concerns.

Recommended Actions

The public sector should partner with relevant private sector stakeholders, and others, to create regulatory sandboxes for responsible, yet innovative development of AI. These temporary, adaptable frameworks would allow for rapid experimentation with clear accountability and liability measures, fostering innovation within a controlled environment. Additionally, the public sector should invest in training programs to equip government personnel with the knowledge needed to effectively regulate this evolving technology.

Citizens Inclusivity & Empowering Governance

Implications

Promote digital education, bridging the digital gaps with tailored interventions to enhance AI potential for as many citizens and businesses as possible.

Recommended Actions

Public entities should make significant investments in digital infrastructure, coupled with the development of supportive policies within institutions and targeted public awareness campaigns, to empower individuals with digital literacy and facilitate equitable access to the digital ecosystem.

Transparency and Accountability

Implications

Governments must protect the credibility and organic evolution of AI by ensuring that private & public sectors are held accountable for any misuse of such technologies.

Recommended Actions

Private sector organizations should ensure responsible and trustworthy use of AI in public services by implementing robust transparency and accountability measures. This includes establishing well-defined compliance frameworks, conducting regular audits of AI systems, and providing accessible channels for citizens to report concerns and seek redressal.

Implications and Recommended Actions for the Private Sector

Business & Ethical Impact

Implications

Acknowledge the inevitable economic transformation due to AI-driven automation and the challenges associated with its development, such as Intellectual Property Rights (IPR), induced bias and potential job displacement.

Recommended Actions

Private sector organizations must prioritize employee development through robust upskilling initiatives. This requires cultivating a culture of adaptability and open-mindedness to embrace innovation. Additionally, companies should establish ethical frameworks that guide responsible AI deployment and ensure its positive impact. Collaborative efforts with educational institutions are vital to ensure curricula remain relevant and responsive to the evolving needs of the job market.

Compliance, Governance & Regulations

Implications

Companies should diligently adapt to evolving regulatory requirements and compliance frameworks as per regional and global best practices on AI technologies.

Recommended Actions

The Private sector should actively collaborate with regulatory bodies and contribute to shaping AI policy, leveraging industry expertise to foster regulations that strike a balance between fostering innovation and safeguarding economic and social well-being. Additionally, ensure adherence to evolving regulatory requirements, fostering a culture of compliance and transparency across all aspects of operation, particularly within algorithm development.

Collaboration & Alliances

Implications

Establish strategic cross-sector and cross-country collaborations to stay updated on the latest developments in the field of AI.

Recommended Actions

The private sector, and other stakeholders shall foster a competitive edge and facilitate mutually beneficial collaborations, to promote a culture of "coopetition." This involves nurturing an ecosystem where businesses can thrive together and establish liaison roles to bridge communication gaps locally and internationally. Concrete steps toward achieving this goal include creating joint research consortia and shared service platforms.

Sustainable Innovation

Implications

Achieve balanced innovation that grows with responsible and sustainable practices at heart. This emphasis the significance of AI solutions that propel advancement while upholding ethical standards and being environmentally friendly.

Recommended Actions

Private sector organizations should embed sustainability and responsible innovation as fundamental principles within their ecosystem, proactively assessing and addressing the long-term societal implications of artificial intelligence applications, taking specific measures to mitigate any potential adverse effects.

Data Privacy and Security

Implications

The effectiveness of AI applications is rooted in the quality and relevance of the datasets used. Hence, Public and Private sectors institute and uphold rigorous data privacy and security standards while managing datasets.

Recommended Actions

To foster trust and mitigate security concerns among users and stakeholders, private sector organizations should prioritize the implementation of robust data protection measures. This includes employing encryption technologies, conducting regular audits of data handling practices, and ensuring strict adherence to all relevant regulatory requirements.

Implications and Recommended Actions for Inter-Governmental Organizations (IGOs), International Organizations (IOs), and others

Global Collaboration

Implications

There is a need for global cooperation among IGOs, IOs, NGOs, and relevant private sector organizations to ensure a cohesive approach regarding AI governance.

Recommended Actions

IGOs, IOs should encourage active involvement in international forums dedicated to AI, cultivating, and promoting partnerships and collaborations between international entities, academia, industry experts, and diverse organizations to achieve convergence on global governance standards for AI technologies.

Trust Economy

Trends

01 **Blockchain's** Green **Revolution**

02 Blockchain-based **Transparent Governments**

Trust Economy

Unlocking the digital asset opportunity, verifying the green revolution, and enabling next gen digital services

Blockchain Fundamentals

The blockchain, a distributed ledger technology (DLT) initially conceived as the tech-enabler for the cryptocurrency Bitcoin, has evolved into a revolutionary force impacting various industries. At its core, DLT can be set up to allow businesses or civil societies to directly record information of any kind in a structured, chronological, and incorruptible manner. The decentralized nature enables enhanced security and transparency.

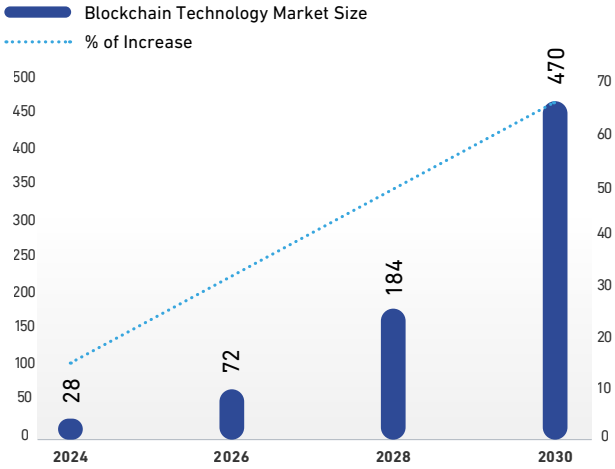
Blockchain can be used to track the ownership of assets like money or property, to record agreements between parties, or simply to log events or activities happening in a business environment like a supply chain network. As we delve deeper into this theme, the sections will explore the technology's recent application, use cases, future opportunities, and implications offered by blockchain in the context of the digital economy.

The Rise of Blockchain

While initially associated with cryptocurrencies, the potential applications of blockchain extend far beyond the crypto space. In 2015, Ethereum was launched, further broadening the scope of blockchain technology to include the automation of more complex activity using "smart contracts". Smart contracts can be used to maintain registers of asset ownership, or to automate complex business workflows that involve information and value exchange among multiple parties.

The global blockchain technology market size was valued at over USD11 Bn in 2022 and is expected to grow at a CAGR of nearly 60%, with a projected global value of USD470 Bn by 2030[14], while financial applications account for roughly a third of this activity, adoption across many sectors is expected.

Blockchain Linked Services Market Size (In USD Bn)



Source: *fortune business insights*

The projected growth in service demand is coupled with projected growth of both consumer and corporate adoption of blockchain and digital asset technologies. In 2023, crypto transactions by volume grew more in Saudi Arabia than any other country (12%) signaling a sharp increase in consumer demand[15].

Success to Date
How Blockchain is Changing the Game

As we dive into the logic of this technology, we will introduce several applications and use cases to illustrate how its transformative impact is spreading across different domains such as financial services, Information Management, identity management, healthcare, and supply chain & logistics.

Applications in Financial Services

The value of DLT as a transformative force is perhaps most obvious in the financial sector, trends here range from the volatile web3 and crypto sector, to the digitization of regulated securities and capital markets infrastructure, and the creation of new forms of regulated digital money among central banks and supporting financial institutions.

Use Case Spotlight

The Canton Network is a privacy-enabled platform that facilitates interoperability and synchronization among isolated financial systems. It operates as a decentralized infrastructure, connecting independent applications using Digital Asset's smart-contract language, Daml. This "network of networks" enables financial systems in highly regulated industries to interoperate with proper governance, privacy, permissions, and controls.

The solution provides institutions with a secure and reconciliation-free environment, allowing assets, data, and cash to synchronize seamlessly across applications. This promotes innovation, efficiency, and improved risk management for financial institutions, enabling them to offer new and innovative products to their clients[16].

Domestic and Cross-border Digital Payments: By removing intermediaries from the equation, blockchain empowers financial institutions to conduct real-time domestic and international remittances, diminishing settlement times and minimizing transaction expenses.

Digital Securities: The global market for issuance, management and trading of securities represents a vast opportunity space for blockchain technologies, and a dazzling array of new platforms are emerging to enable a new value chain for 'tokenized' securities among regulated financial institutions, across asset classes like funds, bonds, equities, and derivatives.

Atomic Settlement: In contrast to legacy securities trading processes (which can take days to complete), blockchains are able to offer instant atomic settlement, meaning both the buyer's asset (e.g., digital money) and the seller's asset (e.g., units of a digital bond) can be exchanged instantly and at the same time. In addition to the operational benefits of faster settlement, atomic settlement also means counterparty risk among traders is reduced.

Know Your Customer (KYC): In an increasingly digitized world, digital identity verification becomes pivotal for safe, secure, healthy, and sustainable socio-economic infrastructure. Blockchain improves the process of verifying

identities through KYC procedures, leveraging securely generated tamper-proof records of customer data. It reduces the probability of identity theft while ensuring compliance with regulatory requirements.

Use Case Spotlight

Blockpass offers a blockchain-based digital identity solution that helps organizations operating in highly regulated industries such as financial services.

This innovative company offers a one-stop shop for digital identity verification using a dashboard through which end-users can easily create a verified portable digital identity that can be used for any KYC process validation instantly[17].

Applications in Healthcare

In the healthcare sector, where data, integrity, and security are cardinal pillars, blockchain has emerged as a transformative solution that provides seamless operationalization amongst activities such as pharmaceutical traceability and clinical trials where the technology provides credibility and authenticity of the records and trial results, thereby enhancing overall trust and reliability in healthcare processes.

Pharmaceutical Traceability: Blockchain applications can help establish an adequate and incorruptible pharmaceutical traceability process by creating unalterable records of its supply chain. This ensures the authenticity of medications, mitigating the risk of counterfeits entering the market.

Research and Clinical Trials: Blockchain not only improves the credibility and reliability of clinical trials by facilitating secure and accurate data-sharing but also has the potential to reduce the time and effort required for tracing medicines linked to adverse events. By implementing a distributed ledger infrastructure, parties across the supply chain can contribute information to a shared database, addressing regulatory and data security concerns and enabling efficient tracking of adverse events associated with medicines[18].

Use Case Spotlight

Patientory is a collaborative blockchain platform designed to facilitate a more secure exchange of information. Patientory has the capability to autonomously validate the presence of insurance coverage for a patient, overcoming the direct dependency on insurance details and response time.

It fully decentralizes access rights, gives patients control over the distribution of their medical records, and enables medical professionals to quickly and safely diagnose patients based on a clearer medical history. Moreover, pharmaceuticals and clinical trials can effortlessly identify top candidates for different trials[19].

Applications in Supply Chain & Logistics

As the supply chain industry faces multiple challenges, including inefficiencies, lack of transparency and a dated exposure to fraudulent operations, DLT can significantly improve the operational efficiency and the auditability of the entire value chain.

A number of use cases from around the world highlight a multitude of benefits derived from the operationalization of DLT in this context. Additionally, the integration of digital supply chain platforms with ports, border control,

customs, and tax authorities can facilitate further process streamlining, enhancing coordination and communication across various entities involved in the supply chain. Blockchain brings unparalleled visibility to the complex passage of goods across the supply chain, serving as a guarantor for consumers, organizations, and public entities.

Real-Time Tracking: Delivering real-time insights into the end-to-end supply chain of a product by recording, authenticating, and validating transactions and progress data - everything from shipment locations to temperature information at every stage. This empowers stakeholders to monitor the movement of goods, validate their authenticity and identify potential bottlenecks in a timely manner.

Anti-Counterfeiting Measures: With the proliferation of pirated and counterfeit goods estimated at nearly USD500 Bn[20], organizations and public authorities could tackle this through QR codes or radio-frequency identification tags (RFID) added to a blockchain.

By doing so, civil societies, businesses and governments could easily verify the authenticity of products, in particular when processing cross-border goods movements.

Use Case Spotlight

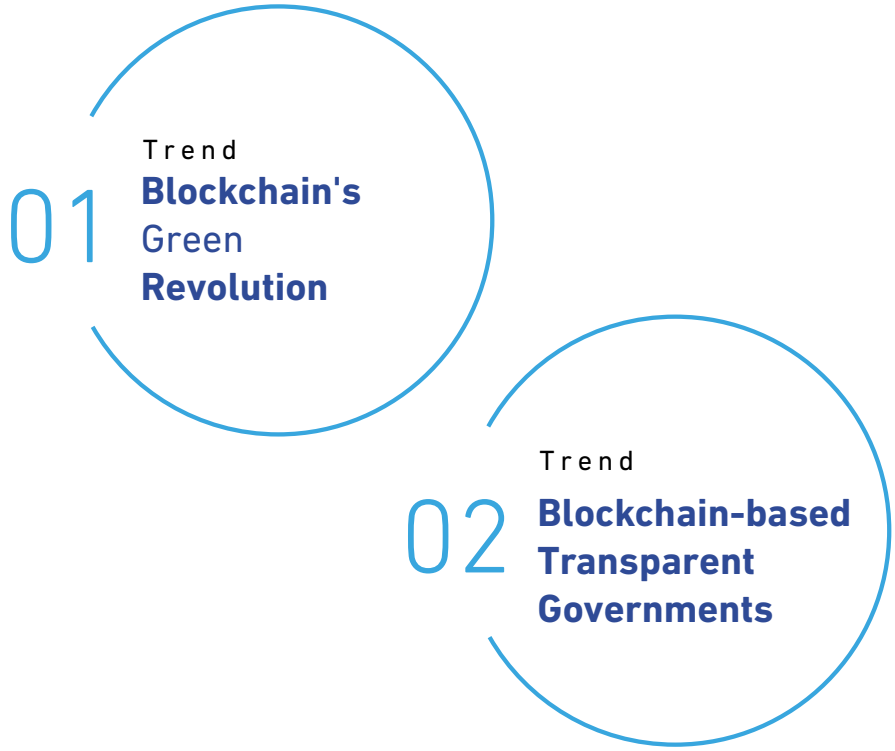
Oracle developed 'Intelligent Track and Trace', a blockchain-based solution designed to optimize and enhance supply chain and logistics operations.

Converging technologies, including blockchain, these innovative solutions provide end-to-end visibility into the movement of goods throughout the supply chain, including tracking the origin, transportation and delivery of products and enabling businesses to make informed decisions based on real-time data. The system helps reduce errors, minimize delays, streamline logistics processes, and enhance the overall supply chain efficiency[21].

Envisioning 2024
Roadmap for a Sustainable Future on the Blockchain

In the dynamic landscape of technological evolution, blockchain can play a pivotal role in helping organizations advance toward a more interconnected and sustainable world. Globally, governments and businesses are showing increased interest towards sustainability, which is evident through the increased participation witnessed in sustainable summits, including UN Climate Change conferences (or COPs).

As we delve into the **focus areas for 2024**– "Environmental Sustainability and Regulations, Policy, Governance and e-Governments", we attempt to anticipate how the disruptive influence of blockchain is set to impact, and perhaps redefine, sustainability initiatives and next-generation governments' modus operandi through the **below trends:**



Trend 1:

Blockchain's Green Revolution

Global initiatives such as the Voluntary Carbon Market (VCM)[22] and carbon credits monitoring, aim to mitigate or eliminate the adverse impacts of climate change.

With the introduction of the VCM, the global community can make encouraging environmental progress by introducing voluntary net-zero carbon emission targets for businesses and, similarly, by incentivizing cross-nation collaborations to attain ambitious Nationally Determined Contributions (NDCs).

Yet, there are multiple challenges faced, like double accounting and inaccurate reporting, due to lack of transparency and standardization[23].

These challenges emerge from a lack of clarity in both private and public sectors regarding climate goals, carbon accountability mechanisms, interoperability issues, and transparency in tracking systems.

The United Nations Development Programme (UNDP), responsible for supporting over 120 countries in enhancing NDCs, has concluded that a lack of integrated data systems and inconsistent measuring methods are critical challenges that must be addressed to ensure global coordination in achieving climate targets[24].

The potential role of blockchain technology in the context of climate targets is twofold. Firstly, DLT-based systems can enable transparent data collection, effective measurement, reporting and verification (MRV), and facilitate scalable and verifiable climate action by providing trustworthy accounting systems that align incentives among governments and private sectors, fostering trust within the ecosystem.

Secondly, blockchain may offer an attractive technology for the development of accessible, efficient and verifiable markets for carbon trading among organizations seeking to ensure emissions are fully offset.

In summary, Blockchain technology has the potential to supercharge progress toward environmental sustainability by addressing challenges like misreporting.

The year 2024 may witness organizations incorporating and encouraging the use of blockchain technologies as a strategic measure to enable transparent MRV and undergo a transformative shift toward accountability and collaboration in achieving climate targets.

According to CJ Hetherington, Co-Founder of Atlantis World,

> “Blockchain technology has the potential to incentivize changed behavior for the better of the planet, empowering communities to monetize stewardship of their natural capital and ecological assets[25]”

Use Case Spotlight

As a pioneer of regenerative finance (ReFi), Thallo provides a 'Carbon-as-a-Service' (CaaS) solution that enables businesses to save money, drive customer engagement while making an impact on the planet, by connecting them with the carbon market, streamline their environmental actions and offer carbon offsetting options to their customers.

Thallo promotes voluntary carbon market and turns every transaction into a powerful climate action[26].

Use Case Spotlight

Algorand is driving the convergence of conventional and decentralized models into a unified system that is seamless, inclusive, and secure.

Used by over 500 organizations, Algorand is designed to facilitate the development of next-generation financial products and the exchange of value, helping companies to effortlessly transition into the future of finance (FutureFi)[27].

In the context of **climate action, Blockchain** has the potential to serve as an effective tool for monitoring and tracing initiatives aimed at mitigating and preventing climate change.

With its transparent and decentralized structure, and powered by its immutable ledger of transactions, Blockchain enables better tracking and reporting of reductions in carbon emissions throughout the value chain.

However, it is essential to note that the energy consumption of certain blockchain networks, particularly those utilizing proof-of-work consensus, still pose environmental concerns. In 2020, the data centers and transmission networks supporting digitalization contributed to 0.6% of the total greenhouse gas emissions[28].

Despite this, the technology encourages more participation, transforming climate action into a networked effect.

Through smart contracts, Blockchain provides the capability to automatically execute agreements for climate-action incentivization based on predetermined conditions.

In the transition to a circular economy, blockchain could assume a vital position. A circular economy incentivizes "e-waste management" to reuse products instead of discarding them, aiming to reintegrate waste into the economy, promoting environmental protection, resource efficiency and optimal use of natural resources, helping in combating critical issues like climate change and pollution.

Global electrical and electronic waste (e-waste) is set to grow to 75 Mn metric tons by 2030, according to the United Nations Global E-waste Monitor[29].

Blockchain facilitates tracking and management of materials and components across supply chains, enabling increased levels of material reuse, remanufacturing, recycling, or composting.

The technology enables transparent digital supply chains, providing an unchangeable transaction record that validates product origins. By storing these details, Blockchain enables end consumers to see the entire chain of materials and production steps associated with a product access to end consumers through QR codes.

Further, it promotes awareness of the product's origin and enables consumers to make informed decisions about product maintenance or disposal. Enhanced transparency in material flow not only reassures consumers but also encourages more sustainable consumption behaviors.

Use Case Spotlight

Coca-Cola in South Africa, has partnered with BanQu with the goal of ensuring that 100% of its packaging becomes recyclable by 2025, aiming to drive a circular economy, and financially empower recycling collectors in the process.

BanQu utilizes blockchain-powered online supply chain tracking and payment connections to trace recycled materials throughout the value chain.

This system generates a permanent transaction history, enabling recycling collectors and waste pickers to demonstrate their income, thereby enhancing their bankability. Additionally, it allows Coca-Cola to effectively monitor and trace recycled materials across the value chain[30].

Another aspect of blockchain's green revolution is food waste management.

Food and Agriculture Organization (FAO) estimates that each year, approximately one-third of all food produced for human consumption in the world is lost or wasted[31].

Blockchain technology is introducing a new phase of food waste mitigation by enhancing traceability to tackle food safety concerns and promote sustainability by eliminating inefficiencies in the food supply chains.

Blockchain can potentially increase visibility enabling food producers, distributors, and retailers to identify chances for reducing wastage across the entire supply chain.

Use Case Spotlight

IBM Food Trust is a blockchain solution that uses trust to build transparency across the expanding food supply chain.

It connects participants through a permissioned, immutable, and shared record, and provides authorized users with immediate access to the food supply chain data including history, current location, test data and certifications, among others[32].

Trend 2:

Blockchain-based Transparent Governments

Skepticism toward government services is mainly attributed to insecure handling of citizen data and less efficient operational processes with high turnaround time.

To tackle such issues, governmental entities are exploring new, innovative ways to bring transparency and efficiency into both their internal processes, and the services offered to the public.

In 2024, public entities could prioritize blockchain applications as a direct means to enhance citizens trust, confidence and improve engagement in government e-services, as well as in the development of data-driven policies.

According to a subject matter expert, "the rationale for closed systems of decision-making in which citizen participation is confined to voting or interest group activism belongs to a different era.

In an era of networks, we now need tools that bridge algorithms with new forms of collaborative decision-making."

Governments around the world are expected to redefine community decision-making conceptually and practically, by introducing governance platforms.

These platforms aim to enhance citizens' participation and inclusion, overcoming the opacity of current systems through auditable voting mechanisms.

A similar principle applies to the use of **smart contracts to automate transactions and simplify bureaucracy.** This facilitates efficient transfer of ownership, making it easier for civil societies and businesses to buy and sell properties, as well as to request, issue and store legal documentation, and public service transactions.

Use Case Spotlight

Estonia has implemented blockchain-based solutions to ensure data integrity and mitigate threats to national data.

The Estonian blockchain infrastructure covers e-services that span across sectoral base registries like health, law and court systems, police data, banking, business, and land ownership registration[33].

Approaching 2024
How Can Blockchain Act as a Catalyst for the Digitization of Global Economies?

The unique strength of blockchain lies in its decentralized architecture. This fortifies the system's security and minimizes susceptibility to fraudulent activities. When looking at the swift transactions of digital economies, security holds paramount importance, and blockchain effectively meets this requirement.

In this section, we will explore key driving factors that can create foundational ground for blockchain's adoption across different areas such as sustainability and e-governance.

Encouraging the exploration and testing of new technologies

Though the benefits of universally accessible platforms part of the appeal of blockchain technologies, the diverse array of blockchain platforms currently in use have created a new generation of interoperability challenges that will need to be addressed before the vision of blockchain is fully realized.

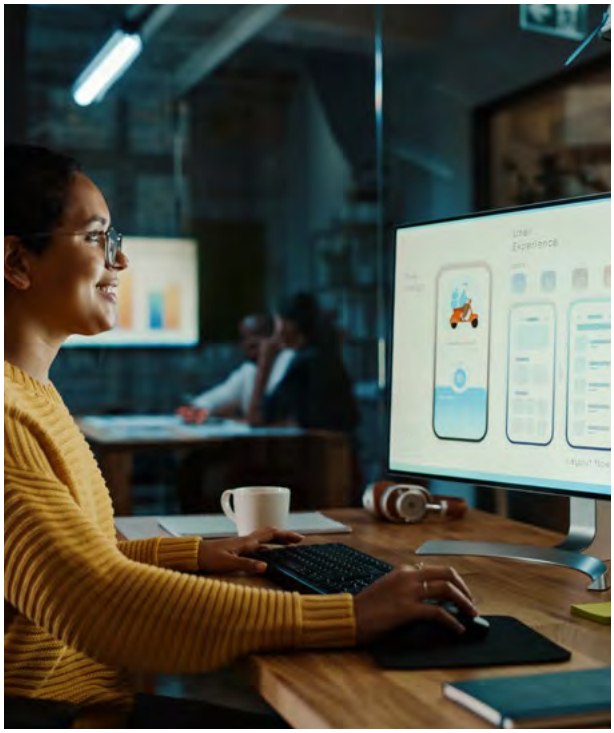
Encouraging cross-collaboration to create proof of concept can accelerate the deployment of blockchain integration and its adoption across key areas of focus for organizations and civil society.

Proof of concepts should address regulatory compatibility, security, energy consumption, scalability, interoperability, and data governance concerns.

This is expected to provide an adequate level of reassurance amongst key stakeholders on the operational feasibility, viability, and sustainability of this technology.

Improved Accessibility & Intuitive UX&UI

Developing user-sensitive interfaces for blockchain applications can be a vehicle to drive awareness and demand, simplifying the user experience to encourage broader adoption and making blockchain easily accessible to people and organization without requiring technical knowledge.



Regulatory Clarity & Certainty

As with any other innovation, regulatory bodies should pave the way for blockchain applications by creating a favorable regulatory ecosystem that can minimize uncertainty in terms of security and privacy, interoperability standards, scalability, and compliance for businesses, investors, and civil societies, hence encouraging adoption.

Moreover, platforms operating across multiple jurisdictions may encounter the challenge of meeting differing, or even conflicting regulatory requirements, thereby complicating the landscape for new market entrants.

In this context, regulators can play an important role in fostering growth by actively engaging with innovators and supporting the testing of new technologies.

Many governments have taken proactive measures, such as launching regulatory sandboxes to facilitate the early-stage testing of new technologies and services. For example, UK's Digital Securities Sandbox, allow financial market participants to conduct various activities related to digital securities under a temporarily modified legislative and regulatory framework[34].

A Skilled Workforce

With the integration of blockchain solutions into global markets, the world will be facing a significant increase in demand for professionals who can design, implement, and manage blockchain solutions.

Currently, blockchain penetration in the job market indicates low levels of maturity across most geographies globally, reaching its peaks primarily in the USA and the UK, followed by Germany and France[35].

This highlights a critical gap that needs to be addressed through the creation of new talent and upskilling of the existing workforce to facilitate a smooth and productive transition into a blockchain-powered world.

Key Takeaways

How Can Stakeholders Address Blockchain Challenges and Capture its Opportunities in 2024?

Having analyzed the key trends within the trust economy and their enablers, we summarize key takeaways to help stakeholders explore what next steps are recommended to derive maximum value from it.

As thoroughly discussed, blockchain has the potential to contribute significantly to the global economy. Public and private sector organizations must formulate appropriate strategies for this opportunity space, taking into consideration their objectives, ambition, and risk-reward appetite.

Implications and Recommended Actions for the Public Sector

Regulatory Landscape

Implications

Lack of standardized blockchain regulations creates regulatory uncertainty as well as data privacy concerns which may affect blockchain adoption for public and private sectors. Moreover, siloed blockchain networks can cause inefficiencies and limited collaboration.

Recommended Actions

The public sector shall develop a national blockchain and digital asset strategy, outlining government goals across all sectors and fostering public-private cooperation. In addition, the public sector should encourage interoperable standards for seamless data exchange between blockchain networks, and launch regular awareness campaigns to inform and educate citizens on the applications of blockchain in digital public services.

Personnel Skillsets

Implications

Lack of staff with blockchain related expertise amongst public institutions may present a risk and hinder the adoption and expansion of blockchain in e-governance applications.

Recommended Actions

Public entities should invest in dedicated blockchain capacity-building programs to build expertise amongst public sector employees and help them understand blockchain applications in public administration, creating a culture of innovation through education.

Implications and Recommended Actions for the Private Sector

Digital Readiness for Systems Integration and interoperability

Implications

The integration of private sectors with traditional government services like procurement for "blockchain-based e-governance" requires a thorough system overhaul. This includes upgrading legacy architectures, ensuring interoperability, and implementing robust cybersecurity measures.

Recommended Actions

Private sector organizations shall conduct thorough evaluations of their technological infrastructure, encompassing comprehensive impact assessments, prior to the integration of interoperable blockchain-based solutions. Such a detailed assessment is crucial for identifying potential challenges, ensuring seamless integration of various interoperable blockchain platforms, and maximizing the benefits derived from incorporating blockchain solutions into the existing technological framework.

Supply Chain Management

Implications

Blockchain has a transformative impact on e-governance and supply chain systems by tackling common inefficiencies and quality assurance concerns faced in current supply chain management processes, like poor accounting oversight and higher turnaround time for availing public services.

Recommended Actions

Private sector organizations should aim at achieving end-to-end supply chain visibility, starting with the identification of key areas where blockchain can immediately enhance operational efficiency. This approach can also be used to gain a competitive edge and establish higher credibility in the market, especially in sensitive areas involving government services where document/information traceability is crucial (e.g., citizen and corporate records including land registry, certificates, and tax filings).

Implications and Recommended Actions for Inter-Governmental Organizations (IGOs), International Organizations (IOs), and others

Incentive Mechanisms & Lead by Example

Implications

Facilitating blockchain development and adoption across suggested trends requires a collaborative effort from various agencies and organizations to create a supportive regulatory landscape, promote standards, encourage innovation, and reduce uncertainty for business.

Recommended Actions

IGOs and IOs shall encourage collaboration in developing common standards, to foster a strong regulatory landscape for blockchain innovation. They should also support educational initiatives, allocate resources for research, and create innovation hubs. Moreover, such collaborations can extend to promote the provision of incentives by governments, such as tax credits to boost blockchain adoption across sustainability applications. This, combined with the early adoption of blockchain-powered operations by public and private sectors, provides the right degree of confidence and reassurance in the technology's reliability.

Digital Reality

Trends

01 **Hyper-Personalization** through **Virtual Experiences**

02 **Amplified Gaming**

Digital Reality

A revolution toward redefining human experience, amplifying connections, and transforming industries

The Evolution of Extended Reality

In the current digital ecosystem, Digital Reality and Extended Reality (XR) represent same concepts and, referring to the spectrum of technologies that combine real and virtual environments to create immersive and interactive experiences, hyper-spatiotemporal and self-sustaining virtual shared space; and includes Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR).

However, the scope of what encompasses Digital Reality will continue to grow, as XR continues to evolve and transform with technological advancements and innovation.

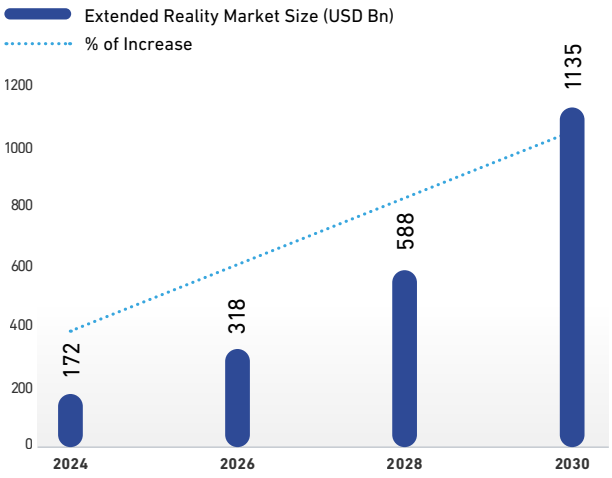
The evolution of XR has been marked by advancements in hardware, software, and applications. XR applications, catalysts for significant growth and development of the digital economy, create a dynamic ecosystem where technological innovation and economic growth are intertwined.

The evolution of XR is ongoing, with continuous innovations shaping the future of immersive technologies. As technology advances, XR will become more integrated into our daily lives.

The recent surge in AR/VR development, and the usage of 3D displays driven by major players like Apple, Google, Microsoft, Nvidia, and Sony, is poised to make XR an important topic in 2024.

The metaverse, brought into focus by Meta's rebranding in 2021, is seen as the future of the internet, promising a 3D and immersive experience. The global Extended Reality market size was valued at USD92.88 Bn in 2022 and is projected to reach USD1,134.79 Bn by 2030, exhibiting a CAGR of 36.0% during the forecast period [36].

Extended Reality Market Size (In USD Bn)



Source: *fortune business insights*

Success to Date
Charting the Course of Digital Reality

XR is poised to find widespread applications across the public and private sectors, as well as civil society. They've already become important tools in the fields of healthcare, manufacturing, and entertainment, e-learning, simulation, and visualization experiences.

XR technologies have also contributed to advancements in remote collaboration, facilitating seamless teamwork for groups despite geographical distances.

The applications of XR can align with the goals of different stakeholders, including public and private sector organizations, contributing to economic development, social progress, and sustainable practices, extending to fostering inclusion, innovation and collaboration and ensuring business continuity.

Apple has announced the release of "Apple Vision Pro" in Q1, 2024 . The mixed reality headset has the potential to display VR/AR content and seamlessly blend digital content with the physical world while allowing users to stay present and connected with others[37].

XR is transforming how we engage with digital content, revolutionizing the gaming industry and introducing a new era of immersive gaming experiences.

XR encompasses both virtual and augmented reality, which together create a highly interactive and engaging gaming environment. Major players like Sony and Microsoft are making substantial investments in XR technology to capture this highly growing market.

Use Case Spotlight

Microsoft has completed its USD69 Bn acquisition of the video game company Activision Blizzard, marking one of the largest consumer tech acquisitions. The acquisition will allow Microsoft to tap into the development of virtual worlds for gamers[38].

Use Case Spotlight

In a significant move, Sony Group has increased its research and development (R&D) spending in the gaming sector, primarily focusing on enhancing technology in live service games and the extended reality. The company is allocating 300 Bn Yen (approximately USD 2.13 Bn) for research and development in its game segment for the fiscal year ending in March 2024[39].

XR supports the visualization of Digital twins to foster product and process innovation by enabling quicker time-to-market through rapid iterations and optimizations of product designs across industries.

The improved process facilitates the upgrade of product quality through identification of flaws in the design much quicker.

Product digital twins also reduce waste by reducing the need for physical prototypes, which helps determine real-world fit before installation.

Use Case Spotlight

Ford creates virtual replicas of its products to explore multiple scenarios, aiming to enhance product quality and refine the production process.

This approach supports the designing and manufacturing of the cars and the related components, resulting in faster turnaround time, reduced process inefficiency and improved customer experience[40].

Citizens face challenges accessing public services due to complexity, bureaucracy, digital divide, and ineffective engagement.

XR can enhance such services by improving citizen engagement through virtual events, XR-based assistance for public infrastructure, industrial design and urban planning through digital twins, simulations for disaster management, and the virtual creation of government IDs.

Specifically, the implementation of digital IDs has the potential to modernize public services and extending full digital ID coverage could unlock economic value equivalent to 3 to 13 percent of GDP in 2030[41].

Use Case Spotlight

Shanghai is an example of a digital twin city. The digital version of the city models more than 100,000 elements, including road traffic and the location of apartment buildings. The model is used to plan public services, simulate the effects of natural disasters, and aid response planning[42].

Envisioning 2024

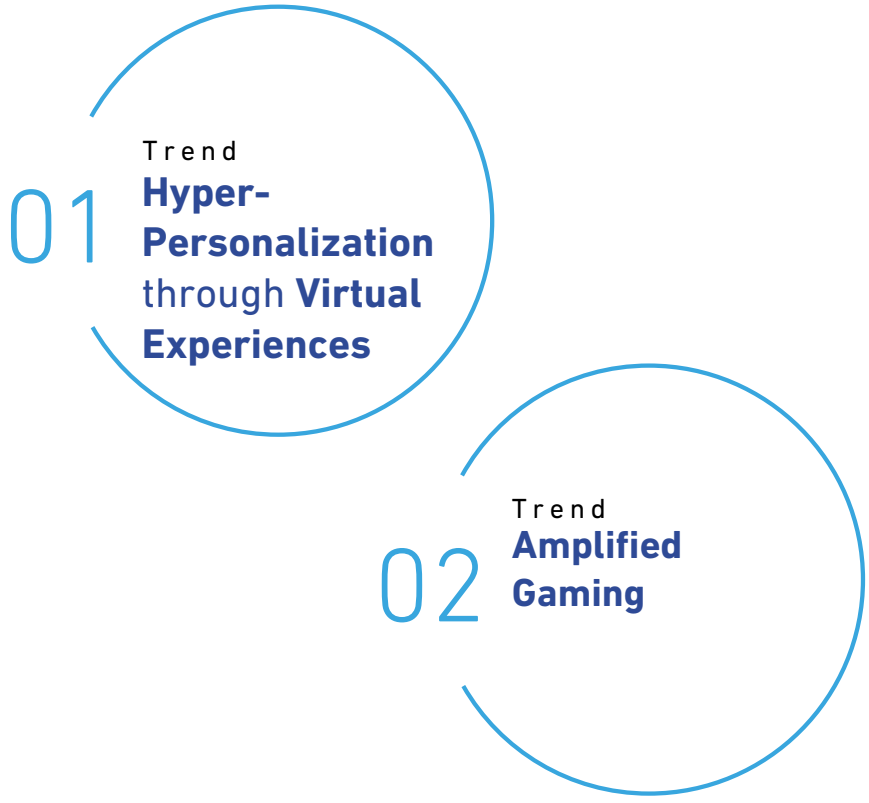
How can the development and application of XR impact the global agenda?

The increasing use cases of digital reality present significant potential for value creation in both the public and private sectors.

XR is poised to revolutionize various aspects, from enhancing customer experiences to optimizing organizational operations, including product innovation, prototyping, virtual sales and remote collaboration. This transformative impact extends across various domains such as education, healthcare and entertainment, marking a shift in the way we interact with technology, businesses, and communities.

XR is anticipated to create opportunities across two key **focus areas** – "Product Design and Development and Customer Experience."

Further, these areas will emerge into the following two key trends that directly address some of the 2024 world agenda items:



Trend 1:

Hyper-Personalization through Virtual Experiences

Extended reality has the potential to redefine how users interact with content and services across various online channels, providing them with an omnichannel experience-customer-centric approach in which all channels are integrated and providing streamlined interactions across multiple channels in a unified way [43].

By combining immersive technologies with real-time adaptation and user behavior analysis, XR delivers hyper-personalization across domains, creating more engaging, relevant, and tailored products/experiences for individuals more specific to their needs and requirements. XR facilitates immersive visualization and fosters real-time collaboration, helping organizations retain their customers.

As we look into the future, hyper-personalization, driven by digital reality and other emerging technologies is offering seamless user experience across sectors such as education, healthcare, entertainment, fashion, and beauty. These technologies enable public and private sector organizations to create deeply contextualized user communications across touchpoints; and transforming the landscape, and offering an unprecedented level of personalization, from tailored product recommendations to virtual after-sales supports.

Use Case Spotlight

Metaverse Fashion Week is an annual event where fashion brands build virtual spaces to showcase fashion and digital architecture. It features runway shows, after-parties, immersive experiences, and shopping[44].

XR is revolutionizing the education sector, offering personalized and interactive experiences. XR technology enables the development of products that provide immersive learning experiences, bridging the digital divide and democratizing access to education.

Virtual education becomes a preferable alternative in scenarios where real-world training is expensive or hazardous. Moreover, intelligence models learn from interactions, enhancing their understanding of learners and enabling tailored learning experiences to improve knowledge-based practices.

When integrated with the XR, the technology allows students to practice and hone their skills in a hyper-personalized learning environment. The retention rate for traditional training methods is 5-10%, whereas immersive learning has been shown to improve retention rates up to 75%[45].

Use Case Spotlight

EngageVR serves as an education and training platform within the virtual reality domain. It enables educators and businesses to coordinate meetings, conduct presentations, offer courses, and organize events.

The EngageVR platform facilitates the swift creation of training programs and virtual reality experiences, allowing users to develop them in a matter of minutes[46].

Through virtual and augmented shopping experiences businesses are able to present and maintain a consistent brand experience across channels.

XR based shopping enables customers to engage with brands and products via digital experiences that allow them to try on, try out, or personalize their products virtually [47].

This transformation in consumer journeys enhances engagement, brand building, loyalty, and marketing potential. XR enables virtual product testing, reduces the need for physical store visits, and ensures more reliable product availability.

Use Case Spotlight

L'Oréal uses AR and machine learning-powered technology ModiFace to make shopping for cosmetics online easier by offering customers the ability to virtually try-on before they buy[48].

XR's integration into healthcare signifies an innovative shift, enhancing remote and personalized care through immersive telemedicine experiences, VR-based diagnosis and providing realistic educational environments for medical professionals.

The patient's healthcare journey is elevated with interactive 3D visualizations, providing personalized and custom-made recommendations for a more engaging and informative healthcare experience. Furthermore, Medical professionals benefit from realistic training environments, enhancing their skills through XR simulations.

Global collaboration among experts fosters knowledge exchange and patient education, benefiting from interactive 3D visualizations, while ensuring ethical and responsible use of XR in healthcare.

The global healthcare XR market size is expected to reach USD20.1 Bn by 2028, exhibiting a CAGR of 28.64% during 2023-2028[49].

Use Case Spotlight

FundamentalVR offers a virtual reality platform tailored for surgical training. This platform goes beyond conventional simulations by incorporating haptic feedback and performance analytics, allowing medical professionals to practice surgeries in a realistic, risk-free virtual environment [50].

Trend 2:

Amplified Gaming

XR, leveraging virtual reality, is increasingly employed to enhance and transform experiential services across entertainment industries.

Virtual environments make it possible for individuals from different geographies to attend events without the need for physical travel, making them more accessible to a global audience and people with differentiated abilities. In addition, businesses can generate additional revenue through virtual ticket sales, merchandise, and virtual advertising opportunities.

E-sports is reshaping the landscape of live entertainment for the future. E-sports, a category within gaming, involves competitive video gaming where individuals and teams compete against each other for both prize money and worldwide recognition. In the E-sports ecosystem, XR enables the production of arena-size live events and service tournaments.

Gamers represent just the tip of the iceberg for the e-sports ecosystem, which comprises publishers, licensing partners, event organizers, distributors, E-sports clubs, sponsors, and the audience. Increasing digitization, coupled with growing access to gaming devices, is expected to further boost this upward trajectory.

The E-sports market worldwide is projected to reach a revenue of USD5.7 Bn by 2028 from its current level of USD3.8 Bn in 2023[51].

Use Case Spotlight

The 'League of Legends' is an E-sports example, an XR multiplayer online battle arena video game developed and published by Riot Games.

It remains one of the most played and widely recognized online games. The E-sports market is expected to have a total of 924.5 Mn users by 2028[53].

Use Case Spotlight

The Middle East has positioned itself as a leader in the E-sports segment through various initiatives.

For instance, Saudi Arabia in 2023 hosted Gamers8, one of the largest independent E-sports events, featuring 13,000 events with participants from 70+ nations across the globe.

Furthermore, the country is set to host an annual E-sports World Cup in Riyadh, featuring the most popular global games with the largest prize pool in e-sports history. The Savvy Games Group in Saudi Arabia, under the ownership of the sovereign wealth fund PIF, announced a significant investment of 142 Bn Riyals (USD37.8 Bn) in 2022 to drive initiatives aimed at establishing Saudi Arabia as a worldwide gaming hub[52].

Compared to traditional sports, e-sports are often regarded as relatively sustainable and environmentally friendly. For instance, Formula 1 estimates an annual release of 256,000 tons of CO2 emissions, while analysts predict the FIFA 2022 Qatar World Cup has generated 10 Mn tons of equivalent carbon waste[54].

However, it is worth noting that e-sports, while presenting a greener alternative, is not without its environmental impact. According to Allianz, the ICT sector would be responsible for 830 MT of CO2 emissions by 2030[55].

With its recent advancements, E-sports has gained attention among larger stakeholders including corporations and multilateral bodies. Brands use e-sports as a channel for e-promotions and have formulated inventive marketing approaches to establish a shared connection between their brand and the e-sports industry.

In addition, multinational bodies have started to recognize and incorporate E-sports games as part of their flagship events. For example, the Olympic Council of Asia included eight medal E-sports events during its 2022 Asian games[56].

Approaching 2024
An Overview of Key Enabling Forces for XR

Millions of people interact in XR metaverses daily for activities such as gaming, collaboration, AR, travel, telemedicine, and events. However, despite this widespread interaction, there is skepticism about its adoption due to the complexity of XR devices, the disconnected nature of metaverses, and the expensive and time-consuming process of creating high-quality, 3D immersive experiences.

Adopting a balanced and responsible approach becomes essential as XR progresses along the maturity curve. This approach is crucial for unlocking the transformative potential of XR - Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR).

This section will delve into the key macro enablers that are pivotal to expediting the adoption and growth of XR within next generation digital economies.

1. Develop supporting infrastructure.
2. Laying foundational regulations and governance.

Develop supporting digital infrastructure

Infrastructure development requires significant investment in creating high-quality virtual experiences, including connected edge cloud architecture, realistic simulations, virtual environments, and interactive content aligned with diverse user needs. Infrastructure development should prioritize cross-platform compatibility, allowing XR applications to be interoperable and function seamlessly across various devices and platforms.

Partnerships between XR platforms, social networks, and other digital technologies are required to facilitate cross-industry and cross-tech collaboration to create an ecosystem where different metaverses can interconnect and share resources.

Improvements in technical capabilities, including enhanced network speed, increased bandwidth, and advanced device capabilities, are crucial for supporting the data-intensive nature of XR applications. These enhancements aid in bolstering the infrastructure, facilitating seamless adoption of XR technologies.

To facilitate ownership, transactions, and commerce in the metaverse, several elements will need to be determined and scaled. This includes Web 3.0 and Web 2.0 integrations with legacy and modern payment modes respectively, cross-border and cross-metaverse foreign exchange solutions[57].

Developing infrastructure for XR encounters significant supply-side constraints, particularly in the hardware domain. Any global shortage of components such as microchips emerges as a primary challenge, hindering the timely production and distribution of crucial XR components and impeding economies of scale. Additionally, the scarcity of skilled professionals proficient in XR poses a dual barrier, slowing innovation and obstructing the seamless integration of extended reality across diverse sectors. Addressing these challenges requires a coordinated effort between governments and industries involving thoughtful policy formulation, adaptive trade regulations, and strategic long-term planning.

Laying foundational regulations and governance

Robust regulations are needed to address data privacy, security, Intellectual Property Rights and ethical concerns associated with XR. Clear guidelines on user consent, content moderation and data collection to data archival, are essential for building trust and ensuring fair and responsible use of XR.

In 2022, the Metaverse Standards Forum was created to discuss technical principles and global standards for these immersive technologies. The entity seeks to create a meeting place for technology companies and regulatory organizations experienced in developing these norms.

The government is expected to play a pivotal role in establishing protocols and ethical standards for digital reality. This requires collaboration with industry experts, academia, and civil society to formulate XR governance frameworks that align with international standards to accelerate innovation.

Entities offering VR solutions, including developers, share the responsibility of upholding content policies and age restrictions. A well-balanced approach to VR policy encourages companies to adopt a culture of responsible XR utilization, emphasizing clear accountability.

Key Takeaways

Harnessing Power of XR in 2024

Extended Reality (XR) carries significant positive implications for society, institutions, and governmental bodies. Promoting digital literacy and inclusivity is crucial for society, ensuring equitable access to XR technologies. Public and private sector organizations should strategize for adaptation, exploring innovative opportunities and prioritizing robust cybersecurity measures. Government regulators must develop agile frameworks, collaborating with stakeholders to establish necessary regulatory guidelines. Collaborative efforts between all stakeholders are essential for navigating the technology landscape safely and securely, ensuring effective and responsible outcomes.

Implications and Recommended Actions for the Public Sector

Responsible usage

Implications

Excessive engagement with immersive technologies such as XR exposes users to risks like privacy breaches, addiction, and various psychological and physical hazards. According to a survey from Kaspersky, 42% of professional gamers worry about their mental health condition[58]. Hence, industry bodies and regulators shall collaborate and develop appropriate policies and regulatory guidelines to ensure safe and secure usage of XR technologies.

Recommended Actions

The public sector, including regulatory bodies, should develop data governance and risk management frameworks that prioritize user privacy, safety, and well-being. They should take an adaptive approach, enforcing guidelines that promote responsible consumption and prioritize privacy-by-design principles in XR development, to foster a balanced and secure environment for immersive technologies to boost user trust.

Implications and Recommended Actions for the Private Sector

Digital Inclusion

Implications

XR holds promise for digital inclusion by providing immersive educational experiences, enhancing accessibility, and fostering virtual social interactions. The affordability of XR devices and the need for inclusive design must be addressed to ensure equitable access.

Recommended Actions

The private sector should prioritize the development of accessible and inclusive designs catering to diverse user groups. This can be achieved through developing cost-effective solutions and supporting initiatives that promote community access, embracing cultural diversity by integrating varied content and ensuring multilingual accessibility, and establishing internal frameworks and mechanisms that prioritize inclusivity and foster continuous design improvement through iterative user feedback integration.

Adoption and demand

Implications

To foster interest and demand for Extended Reality (XR), it is imperative to launch initiatives that focus on educating the market about XR's capabilities, potential applications, and successful use cases. These initiatives should aim to provide comprehensive information, highlighting the technical aspects of XR and emphasizing its practical benefits across various industries.

Recommended Actions

The private sector should focus on educating the market showcasing real-world examples of successful XR implementations, illustrating its transformative impact on businesses and everyday experiences. Moreover, the private sector should take appropriate measures to address any misconceptions or barriers associated with XR, like privacy, security, property rights and interoperability, ensuring that potential users and stakeholders are well-informed about its positive contributions. Proactively disseminating knowledge and building awareness creates a foundation for a more informed and receptive market, driving the adoption and integration of XR technologies across diverse applications

Success metrics

Implications

Increasing integration of XR into everyday lives necessitates a realignment of success metrics for businesses. Organizations with growing exposure to XR technologies shall need to measure success, which now extends beyond the conventional metrics.

Recommended Actions

The private sector should consider incorporating user well-being into the design of their products, adopting a multifaceted approach to measure success. In addition to traditional user engagement metrics, Net promoter Score (NPS) is being used for software user satisfaction surveys and quality of life impact assessments. It is imperative for these approaches to incorporate metrics that gauge time well spent on meaningful tasks within the application and adherence to regulatory and ethical standards.

Environmental Impact

Implications

To support the growing data requirements of XR, a robust network infrastructure is essential. Therefore, public and private sectors are required to invest heavily in establishing advanced connectivity infrastructure. However, such efforts have adverse environmental consequences.

Recommended Actions

The private sector is required to collaborate with relevant stakeholders, including governments to implement robust eco-friendly policies that incentivize responsible production and consumption of XR devices. By adhering to rigorous environmental standards, the XR industry can demonstrably contribute to the global fight against climate change.

Implications and Recommended Actions Inter-Governmental Organizations (IGOs), International Organizations (IOs), and others

Building common standards

Implications

Common XR standards are essential to ensure global interoperability, address technical, privacy, and ethical concerns, fostering collaboration, trust, and a cohesive, accessible XR ecosystem.

Recommended Actions

IGOs and IOs should collaborate with the public and private sector to establish technical standards for digital infrastructure, devices, and applications, to facilitate seamless interactions between different XR platforms worldwide. These standards should inspire trust and confidence among users and policymakers by ensuring transparency and compatibility. This will allow users to engage with XR content without worrying about system limitations for the growth of the XR ecosystem[59].

Cybersecurity
Trends

01 **Safeguarding** in the **Digital Age**

02 **The Future** of **Defense**

Cybersecurity

Unlocking the digital asset opportunity, verifying the green revolution, and enabling next gen digital services

The Evolution of Cybersecurity

The roots of cybersecurity can be traced back to the 1970s, marked by the creation of a code serving as an antivirus program aimed at countering the experimental computer malware, the Creeper.

As digitization surged through the decades, the cyber threat landscape underwent a parallel evolution, marked by a surge in data breaches and the prevalence of ransomware, which pose a critical threat to the Digital Economy.

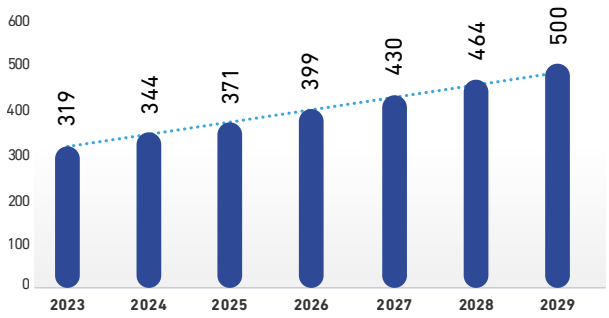
The escalating scale and frequency of these cyber-attacks emerged as a significant cause of concern for governments, businesses, and civil society, prompting prioritization of cybersecurity and garnering substantial investments toward bolstering cybersecurity measures.

Cybersecurity has assumed a pivotal role in today's digital landscape in guarding and actively fortifying our digital ecosystems against the fast-evolving modern digital threats such as cloud vulnerability, data breaches, mobile attacks, crypto-jacking, and IoT attacks[60].

The significance of cybersecurity has been amplified in the current era, marked by the exponential growth of interconnected devices and the continuous evolution of increasingly sophisticated cyber-attack methodologies. A robust cybersecurity technical and legal framework is essential for facilitating the secure acceptance and widespread adoption of advanced technological solutions within the Digital Economy of civil societies and organizations.

The global cybersecurity market, valued at USD 319 Bn in 2023, is anticipated to soar to USD 538.3 Bn by 2030[61].

Cybersecurity Market Value



Source: *Statista*

Global cybersecurity job opportunities surged 350% escalating from 1Mn positions in 2013 to 3.5 Mn in 2021. Cybersecurity Ventures predicts the sector will encounter 3.5 Mn vacant positions by 2025[62].

> 70% of company boards will include one member with cybersecurity experience by 2026[63].

Success to Date

How has cybersecurity Responded to Modern digital Threats?

Responding to cybersecurity threats such as cloud vulnerability, data breaches, mobile attacks, crypto-jacking, and IoT attacks has been different across various stakeholder groups – governments, businesses, and civil society. While businesses lead cybersecurity technical solutions through innovation, collaboration, and capacity building, governments primarily shape the cybersecurity landscape through regulations, technical standard setting, international cooperation, and law enforcement. Governments play a vital role in enhancing cybersecurity by enforcing robust standards domestically while fostering regional and global collaboration to protect critical infrastructure[64].

Enforcing Cybersecurity through Regulatory Impetus and Industry Alliances

Recognizing the critical role of cybersecurity, regulatory bodies worldwide have implemented rigorous cybersecurity and data protection frameworks. These measures not only bolster security in the digital realm but also safeguard privacy and individual rights.

The EU Cybersecurity Act establishes a unified system for certifying the cybersecurity of ICT products, services, and processes across the European Union. Its primary goal is to enhance cybersecurity protection within the EU. The Cybersecurity Act (CSA) facilitates using a single, mutually recognized certificate by manufacturers and service providers throughout the EU. Before the CSA, various EU states had implemented their own national cybersecurity certification regulations, leading to discrepancies in standards and a lack of mutual recognition. To overcome such divergence, the CSA certification schemes were developed to supersede existing national-level certification schemes, assuming they align closely in scope. To comply with the CSA, each EU member state must designate at least one National Cybersecurity Certification Authority (NCCA). The European Network and Information Security Agency (ENISA) is poised to play a crucial role in establishing and maintaining the European cybersecurity certification framework[65].

The NIS2 Directive, an EU-wide legislation, strives to fortify cybersecurity in the region by ensuring that Member States are appropriately equipped to address cyber threats. It also fosters strategic cooperation and information sharing among these states, while also instilling a culture of security across critical sectors that heavily rely on digital technologies[66].

The US NIST Cybersecurity Framework (NIST CSF) comprises standards, guidelines, and best practices aimed at enhancing cybersecurity for organizations. It is crafted to provide flexibility, allowing seamless integration with the existing security processes of any organization. The framework not only simplifies the language of cybersecurity, making it accessible to everyone but also makes cyber risk management easier for organizations, enabling them to make informed decisions[67].

The American Institute of Certified Public Accountants developed the **Service Organization Control Type 2 (SOC 2).** SOC 2 is a cybersecurity compliance framework that ensures third-party service providers securely store and process client data[68].

ISO/IEC 27000 standards provide effective information security management systems (ISMS) specifications. ISO standards offer comprehensive guidelines for cybersecurity, allowing organizations to establish a framework encompassing best practices across data protection and cyber resilience. These standards empower organizations, regardless of their sector or size, to oversee the security of assets, such as financial information, intellectual property, employee data, and information entrusted by third parties[69].

The ASEAN Cybersecurity Cooperation Strategy (2017-2020) was a roadmap for regional cooperation to achieve a safe and secure ASEAN cyberspace. The second edition of the strategy (2021-2025) will create cyber recommendations that align with ASEAN's digital ambitions[70] .

The OECD Policy Framework on Digital Security helps policymakers understand cybersecurity's economic and social aspects. It also highlights the OECD's approach to digital security policy. The framework encourages policymakers to use OECD digital security recommendations to develop better policies[71] .

The EU's Cybersecurity Strategy for the Digital Decade aims to protect citizens and businesses from cyber threats. The strategy was released in December 2020 with three primary areas of action: Resilience, Technological sovereignty and leadership, and Operational capacity to prevent, deter, and respond[72]. Apart from the above, a UN cybercrime treaty is also being explored to be signed.

Contemporary Technological Solutions to Mitigate Cyber Threats

The necessity for enhanced security has spurred innovation, leading to solutions such as a zero-trust framework, Multi-Factor Authentication (MFA), encryption, DevSecOps, behavioral analytics, and insider threat prevention mechanisms.

Zero Trust, as a strategic cybersecurity approach, aims to mitigate cyber threats by enforcing rigorous identity verification for all individuals and devices.

This approach rejects inherent trust based on location or assets and upholds the principles of "Never trust, always verify." Businesses must implement Zero Trust security as a strategic and robust measure against cyber threats. Through the implementation of strong authentication, network segmentation, and strict access policies, Zero Trust aims to minimize attack surfaces, prevent lateral movement of threats, and reduce the risk of data breaches[73]. The global Zero Trust market, valued at USD 31.1 billion in 2023, is projected to reach USD 67.9 billion by 2028, growing at a CAGR of 16.9%[74].

Use Case Spotlight

Johnson Controls implemented Zero Trust amid the shift to work from home. By deploying Zscaler Private Access for secure connections between users and apps and integrating it with Azure Active Directory (AD), they adopted a model that constantly verifies user and device access to bolster security[75].

Elevating Security and Verification through **Multi-Factor Authentication** (MFA) enables additional layers of authentication and restricts unauthorized access to systems in case of a compromised password. MFA employs multiple intermediate steps for user authentication, demanding two or more distinct methods to confirm a user's identity for accessing a resource.

Tools like Google Authenticator and Microsoft Authenticator have fortified organizational cybersecurity by elevating security measures, lowering risks, and providing a seamless user experience, particularly in remote work setups[76].

Proactive security integration with DevSecOps enhances the software development lifecycle for the ICT sector by identifying vulnerabilities across the development and delivery phases. This methodology integrates security measures throughout the entire software development lifecycle, encouraging collaboration among developers, security specialists, and operational teams.

Its objective is to help create efficient and secure software while shifting an organization's focus from reacting to security breach incidents to actively fortifying its overall security, centered on "security by design."

Behavioral analytics forms a preemptive and protective approach centered on individuals, employing sophisticated Machine Learning algorithms to examine data from users and entities throughout an organization.

Its goal is to flag any atypical behavior and reveal unprecedented threats that might indicate a security breach. This technology is versatile, identifying threats like insider risks, persistent advanced threats, and zero-day attacks.

Use Case Spotlight

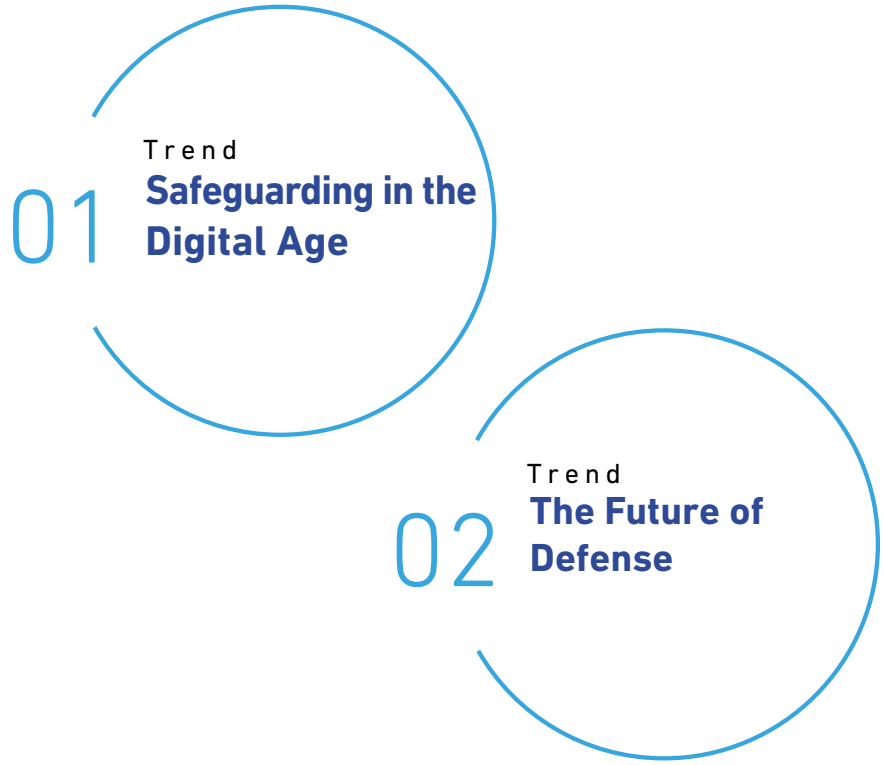
Safeway, a grocery delivery service, adopted Exabeam's user and entity behavior analysis solution to detect uncommon behaviors within both corporate and retail networks. This integration enhanced Safeway's security operations, enabling analysts to conduct incident investigations more efficiently by associating such behaviors with specific users[77].

Envisioning 2024
Charting the Course to Combat Tomorrow's Challenges

Cybersecurity plays a significant role in ensuring a reliable and trustworthy cyberspace. Robust cybersecurity frameworks cultivate trust and confidence among consumers and businesses, encouraging increased use of ICT and participation in online activities, which drives digital economic growth.

Simultaneously, promoting international cybersecurity standards, cyber hygiene, and digital inclusion is instrumental in upholding trust in the digital ecosystem; thereby fostering innovation and digital transformation by providing businesses the confidence to adopt modern technologies and explore new digital avenues.

Cybersecurity is anticipated to create opportunities across two key areas that directly address some of the 2024 world agenda:



Trend 1:

Safeguarding in the Digital Age

As the cyber threat landscape rapidly expands, integrating innovative emerging technologies into cybersecurity practices becomes imperative to combat modern threats. The cybersecurity market continues to grow, with innovations like Artificial Intelligence and Machine Learning poised to enhance technological solutions, making them smarter, quicker, and more accurate, facilitating a safer and more efficient digital environment. Looking ahead to 2024, cybersecurity powered by emerging technologies like AI and computing is expected to witness much traction, further revolutionizing the cybersecurity space by providing advanced threat detection, response capabilities, and adaptive defenses, thus reinforcing the resilience of digital infrastructures.

AI-enhanced cybersecurity offers the potential to proactively identify and address cyber threats in real-time and forecast and prevent potential threats. AI's market value in cybersecurity pegged is projected to grow at a CAGR of 19.43% and reach USD 102.78 Bn by 2032[78]. As more Machine Learning (ML) algorithms are leveraged in cybersecurity systems and cyber operations, the following trends emerge at the nexus of AI and cybersecurity[79].

AI and ML software integration with cyber operations is shaping cyber defense strategies. Misuse of AI can amplify cyber vulnerabilities, introducing privacy risks and empowering malicious actors with innovative attack methods. However, the significant role of AI in bolstering cybersecurity must not be overlooked. AI software is expanding in cyber operations, detecting anomalies, automating cybersecurity tasks, and identifying malware. Employing proactive strategies with ML models like neural networks, deep reinforcement learning, and autoencoders becomes critical in preventing cyberattacks.

Use Case Spotlight

MobileIron synergizes Zimperium's machine learning-driven threat detection into its security and compliance engine. This integration addresses a critical mobile security challenge enterprises encounter: rapidly identifying device, network, and application threats and executing automated protective measures for enterprise data, all without dependence on cloud queries[80].

Predictive Threat Intelligence, empowered by AI, plays a significant role in anticipating and proactively mitigating potential threats, including identifying sophisticated, advanced, persistent threats and insider risks.

AI is instrumental in boosting security defenses and optimizing analysts' time through AI-powered solutions that accelerate threat detection, expedite responses, and safeguard user identity and datasets, all while ensuring cybersecurity teams stay informed and in control[81]. By analyzing vast datasets, AI swiftly identifies nuanced patterns characteristic of these advanced attacks, often overlooked by conventional security protocols.

Use Case Spotlight

Vectra's Cognito, an AI-powered threat detection platform, employs advanced ML and security-enhanced metadata for real-time attack detection. Notably, it aided ED&F Man Holdings Ltd. in defeating various man-in-the-middle attacks targeting invoice frauds and stopping a crypto mining scheme in Asia.
The platform significantly enhances security operations by boosting threat detection accuracy while minimizing security alerts[82].

AI-powered autonomous threat detection and response systems continuously monitor organizations' networks and systems, promptly identifying anomalies and potential threats as they surface. Operating in real-time, these systems independently trigger responses to counter and mitigate the hazards, all without the need for human intervention. This proactive approach reduces response times and mitigates the impact of attacks. By assuming routine surveillance tasks, AI-driven systems enable security professionals to concentrate on more impactful activities, such as investigating intricate threats, orchestrating incident response strategies, and collaborating with other teams.

Quantum computing, while posing a risk of compromising encryption techniques, offers more resilient and compelling opportunities for safeguarding critical and confidential data than currently available alternatives. Quantum computers possessing significant computing capabilities can open new avenues for enhancing cybersecurity. For instance, quantum-era cybersecurity can identify and neutralize cyber threats before they inflict damage. Quantum-enhanced Machine Learning could enhance the effectiveness of cybersecurity, while quantum random number generation can enhance cryptography[83].

With **digital assets,** such as customer metadata, the Internet of Things, and NFTs, being created in every domain to benefit civil societies, businesses, and governments, preserving these important creations, inventions, and confidential information would be prioritized by public and private sector organizations through implementing more rigorous cybersecurity measures.

Cybersecurity uses access restrictions, firewalls, intelligent encryptions, secure wallets, and discovery systems to prevent unauthorized individuals from accessing private and confidential data.

There is potential for improvements in cybersecurity measures to avoid pump-and-dump schemes for manipulating prices of NFTs, counterfeits of NFTs, and phishing in the metaverse. These can include improvements in smart contract programs, disclosure standards, anti-fraud, market surveillance and price manipulation measures built into the market mechanisms such as stop-loss.

Interoperability in emerging technologies like IoT networks, smart contracts, and edge computing can improve transparency, traceability, and efficiency in healthcare, energy management, agriculture, and transportation sectors[84]. Interoperability ensures compatibility and standardized protection measures against cyber threats. Enhanced visibility, on the other hand, allows for better monitoring of activities across interconnected devices or platforms.

Trend 2:

The Future of Defense

The frequency, complexity, and destructiveness of cyber threats are rising, posing significant risks to national security. In the ongoing battle within cyberspace, there's a constant stream of malicious events, ranging from basic to highly advanced attacks[85].

Nations are actively bolstering their capabilities to detect, prevent, and combat malicious cyber activities. Governments must implement robust countermeasures to safeguard network operations against the escalating sophistication of cyber threats and establish intergovernmental cooperation between computer emergency response teams (CERT) among nations.

In 2024, governments are anticipated to adopt innovative strategies, such as proactive defense, combining cyber capabilities with other instruments of national power, employing cyberspace operations to disrupt adversaries' activities[86] to counter the evolving landscape of cyber warfare, ensuring the resilience and security of their digital infrastructures in the face of emerging threats.

The use of Cyber Warfare is increasing and involves deliberate attacks orchestrated by a nation or organization, targeting the digital networks of other countries or institutions. These attacks utilize computer viruses or denial-of-service attacks aimed at espionage or disrupting digital infrastructure.

The consequences can be devastating, impacting government and civilian systems and causing disruptions to critical national infrastructure, such as financial systems,

and public infrastructure, such as power grids, safety systems, and military resources or entities[87].

Recognizing the need for robust defense against cyber threats, countries understand that bolstering conventional cybersecurity capabilities alone is insufficient.

Governments should prioritize proactive cybersecurity strategies by leveraging cutting-edge technologies to develop sophisticated mechanisms that are even more capable of identifying, analyzing, and neutralizing potential cyber threats before they can cause harm.

Public sector organizations are implementing comprehensive national policies, regulatory frameworks, and cybersecurity regiments[88] and investing in offensive and defensive capabilities.

Diplomatic efforts are undertaken to set norms for responsible state behavior in cyberspace, contributing to global cybersecurity.

Approaching 2024
What are the Key Enablers that drive cybersecurity in 2024 and beyond?

Advancements in Technology

As cyber threats expand in scale and sophistication, defense mechanisms evolve similarly, leveraging innovative technologies. With the rapid proliferation of connected devices, it is becoming easier for malicious agents to access networks and more challenging for security experts to identify and respond to cyberattacks. The number of IoT devices reached 15.14 Bn in 2023 and is anticipated to surge to 29.42 Bn by 2030[89]. As digitalization rises, organizations can look forward to employing advanced automation for managing routine tasks and lower-risk processes.

Digital identity is the cornerstone of access management, authentication, and authorization, facilitating a safe and secure online environment and enabling essential cybersecurity and data protection measures. There is a need to strengthen digital identity management by adopting advanced authentication methods, such as biometrics and adaptive authentication. This ensures a higher level of assurance in verifying the identity of users.

Emerging technologies advance rapidly, gaining significant capabilities that enable them to tackle the growing complexity of cyber threats. Advancements include various innovative tools such as Artificial Intelligence, Machine Learning, blockchain, and advanced encryption methodologies. The synergy of these technologies such as quantum enhanced machine learning, can amplify their strengths. In return this helps to enhance the defense capabilities against complex and dynamic modern cyber threats.

Effective Policy and Regulatory enforcement

Progressive cybersecurity regulations centered on international cybersecurity standards are integral to a robust cybersecurity framework. As the digital landscape evolves, many cybersecurity regulations emerge, crafting a complex network of compliance obligations for organizations worldwide. These regulations span industries and jurisdictions, aiming to set standards and protocols that safeguard sensitive data, mitigate cyber threats, and protect consumer and organizational interests. It is pivotal for organizations to effectively adhere to these regulations as it demonstrates a commitment to safeguarding sensitive information and upholding data integrity while also fortifying their IT systems and instilling trust among users. Further, an impetus is required to formulate new regulations or increase the ambit of the current rules to ensure threats are taken care of. Regulatory harmonization to streamline pertinent regulations should be emphasized to simplify implementation and compliance for businesses and government agencies.

On cyber defense, several institutions advocate for investing in active cyber defense capabilities, but the legal and political framework governing their use needs more clarity. Public data collection to track the development of cyber threats and state responses, as conducted by the European Repository of Cyber Incidents, can make an essential contribution toward ensuring that cyber defense considerations are discussed responsibly and democratically[90].

Multilateral Collaboration and Investment

Cyberspace transcends national and regional boundaries, making it imperative for governments public and private enterprises to collaborate on cybersecurity to achieve tangible outcomes. This collaborative effort involves sharing information regarding threats, vulnerabilities, and best practices, coordination for policy standardization, capacity building for enhancing cybersecurity capabilities through training, technology transfer, knowledge sharing, and collaboration in addressing cyber threats. Several multilateral organizations, such as the **European Union Agency for Cybersecurity, ASEAN Cybersecurity, and International Telecommunication Union's Global Cybersecurity Agenda** promote multilateral cooperation for cybersecurity.

Cybersecurity Talent Development

Talent development initiatives are crucial to bridge the persistent cybersecurity skill gap. Beyond bridging the skills gap, they also foster innovation in the cybersecurity landscape. Trained professionals bring diverse perspectives and creative approaches to address complex cybersecurity issues. By nurturing a continuously evolving talent pool through education, capacity-building programs, mentorship, and industry collaborations, cybersecurity gains the agility and expertise required to stay ahead of sophisticated threats. Talent development investment is fundamental in building better cybersecurity practices that safeguard critical national infrastructures, sensitive data, and digital ecosystems.

Key Takeaways

How to address potential cybersecurity implications in 2024?

Implications and Recommended Actions for the Public Sector

Public Awareness

Implications

The rise of online activity and digital technologies like AI and cryptocurrency expands opportunities for attackers to launch sophisticated cyberattacks, steal data, disrupt critical systems, and spread misinformation. Since there is a lack of cybersecurity awareness, individuals, businesses, and governments are at risk, hence, highlighting the need for stronger security and awareness measures.

Recommended Actions

The public sector must prioritize boosting public access to e-learning resources on cybersecurity. This includes tailoring awareness campaigns for vulnerable groups, like senior citizens, children, and small businesses, focusing on areas like digital asset management, password security, and encryption. Additionally, they should issue national cybersecurity advisories on emerging threats and propose relevant cybersecurity readiness initiatives to safeguard critical national infrastructure.

Cybersecurity Skillsets

Implications

The global labor market currently faces a shortage of 3.4 Mn cybersecurity professionals[91]. This shortage is exacerbated by the rapidly evolving nature of cyber threats, requiring continuous skill updates and specializations, particularly in areas like cloud security, mobile security, and threat intelligence. Meeting this rising demand is crucial to tackle the ever-expanding cyber threat environment. Implementing innovative systems may not be sufficient to tackle evolving cyber threats; a skilled cybersecurity workforce is equally essential.

Recommended Actions

The public sector should take appropriate measures to build and retain a cybersecurity skilled workforce within governments. This can be achieved through different scenarios, including revision of HR policies, mandating competitive pay and benefit structures to attract the required technical expertise, particularly in cybersecurity-related areas.

Additionally, public-sector organizations can encourage educational and specialized certification programs in cybersecurity, establish centers of excellence, and promote collaboration between industry and academia with mentorship and human capital development programs.

Regulatory Considerations

Implications

Given the highly dynamic environment, cybersecurity regulations might quickly become outdated, potentially exposing valuable resources and assets to various threats. This dynamic nature necessitates a mechanism for continuously reviewing and adapting cybersecurity strategies and policies in response to new and emerging threats.

Recommended Actions

The public sector should proactively develop and evolve national cybersecurity plans, addressing future cyber threats. They should conduct regular updates based on international best practices and constantly engage relevant stakeholders, including the private sector, to avoid lagging behind or over-regulation. In addition, public sector stakeholders shall establish integrative reporting platforms, including a national database on cybersecurity threats, to aid citizens and organizations in identifying and reporting cyber risks promptly [92].

Implications and Recommended Actions for the Private Sector

Investment in digital and technology readiness

Implications

Obsolete and outdated technology may expose potential vulnerabilities, elevating the risk of cyber-attacks and complicating integration with modern cybersecurity solutions. This can also result in a competitive disadvantage in the market.

Recommended Actions

Private sector organizations should build their technology systems through a security-by-design approach. They should periodically upgrade their software and digital infrastructure to reduce vulnerabilities and enable the integration of modern cybersecurity solutions.

Additionally, cybersecurity teams should not work in siloes, but work in tandem within their entire organization so that the cybersecurity strategy considers organizational priorities and the required cybersecurity related investments.

Compliance with cybersecurity regulations

Implications

Failing to adhere to prevalent cybersecurity regulations puts businesses' internal systems at risk and jeopardizes the security of their customers' data, exposing them to potential threats. This non-compliance can also result in significant legal and financial penalties.

Recommended Actions

Private sector organizations should go beyond compliance with existing cybersecurity regulations, frameworks, and standards (e.g., ISO/IEC 27032), by taking proactive steps to implement advanced cybersecurity measures to safeguard their systems, data, and customer information.

They should also conduct regular audits and compliance checks to ensure ongoing adherence to these regulations and identify any improvement areas.

Implications and Recommended Actions for Inter-Governmental Organizations (IGOs), International Organizations (IOs), and others

Global collaboration & standardization of regulations

Implications

As cyber threats advance and grow more sophisticated, working in silos might not be adequate to address these evolving challenges effectively. Governments must recognize the growing cyber warfare threat and include this as a crucial component of a multi-pronged national security strategy. Lack of coordinated efforts can lead to fragmented responses to global cyber threats which can pose a huge challenge in areas such as policing ransomware.

Recommended Actions

It is recommended for IGOs and IOs to foster cooperation and collaboration at various national, regional, and global levels among relevant cybersecurity stakeholders, to address advanced cyber threats through regulatory, technical, and capacity-building efforts.

They should advocate for cybersecurity digital solutions to comply with international standards through multi-stakeholder cooperation and be compatible with existing public/private sector digital systems.

Smart Ecosystems

Trends

01 Industry 5.0 and the **Circular Economy**

02 Interconnected **Digitized Cities**

03 Risk-averse **IoT**

Smart Ecosystems

Navigating toward sustainability and smarter cities with the power of secure IoT for enhanced livability

The Evolution of Smart Ecosystems

A Smart Ecosystem is an IoT-enabled network of interconnected digital technologies, platforms, and services that interact with each other to create value for government, businesses and consumers[93].

Smart Ecosystems utilize emerging technologies, such as IoT, and comprise web-enabled smart devices that utilize embedded systems, such as processors, sensors, and communication hardware, to collect, send, and act on the data acquired from their environments. IoT and other emerging technologies like Artificial Intelligence and Machine Learning facilitate more straightforward and dynamic data collection processes[94].

The vast amounts of data generated by IoT devices offer numerous opportunities for data-driven insights and promoting a sustainable Digital Economy by boosting productivity, creating new markets and revenue streams for businesses, stimulating job opportunities, and creating additional tax revenue.

The origins of IoT stretch back many decades, marked by the advent of the first IoT device, a soft drink vending machine. This innovation, which went operational in 1982, enabled computers connected to the University's ethernet to remotely ascertain the availability in the machine and identify which cans were chilled[95].

Empowered by technological advancements and machine-to-machine communication, the interconnection of devices began to find applications in industries and households for remote monitoring and controlling of appliances across refrigerators and thermostats, enabling smart living.

IoT can be classified into two broad categories: Consumer IoT and Enterprise IoT. While consumer IoT primarily focuses on improving the daily lives of individuals through smart devices for personal use, Enterprise IoT aims to improve operational efficiency, decrease costs, and enable data-driven decision-making for businesses and industries.

The growing interconnections in networks of devices and systems have facilitated the development of modern IoT applications, spanning across industries and serving diverse purposes – commonly referred to as Smart Ecosystems.

Some of its applications include smart homes with voice assistants, biomedical applications with fitness trackers, industrial integration in

manufacturing and logistics, and smart city applications for improved traffic management, pollution monitoring, and waste management.

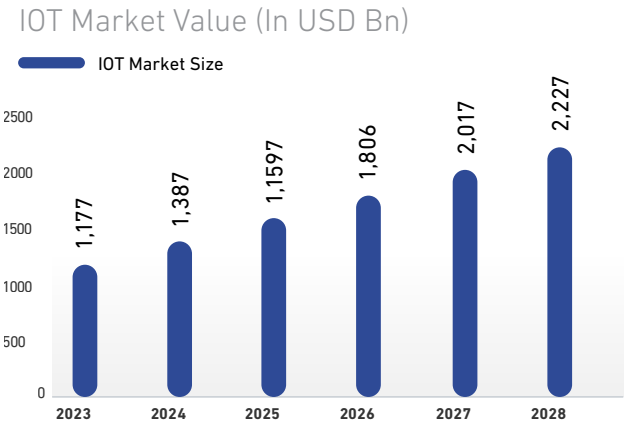
Integration with modern connectivity capabilities such as 6G, Bluetooth Low Energy (BLE), Zigbee, NB IoT, and Blockchain can drastically increase the potential of IoT, enhancing decision-making abilities and advancing automation through personalization with improved security.

The rapid growth of IoT devices, especially in smart cities, necessitates 6G over 5G due to the increased demand for reliable network connectivity. 6G networks are crucial for applications requiring high data transfer rates, low latency, and cellular network robustness, as these attributes pose challenges for 5G in supporting emerging technologies[96].

Smart services based on the Internet of Everything (IoE) are gaining considerable popularity due to the ever-increasing demands of wireless networks, an extension of the IoT concept emphasizing machine-to-machine communications, describing a more complex system encompassing people and processes[96].

The Outlook of the global IoT market is optimistic, driven by the potential for IoT's transformative impacts to revolutionize the Digital Economy. The worldwide IoT market revenue is expected to reach USD 2,227 Bn by 2028 at a CAGR of 13.60% between 2023-2028[97].

> Projections also indicate a significant rise in the number of IoT-connected devices globally, which is expected to reach 29 Bn devices by 2030, almost double the number of devices in 2023[98].



Source: *Statista*

Success to Date
IoT's Transformative Influence Across Sectors

Smart ecosystems powered by integrated IoT devices and connectivity are a significant trend, shaping various businesses, governments, and civil societies, driving innovation and digital transformation. Its transformative impact spans various domains across consumer-focused retail and healthcare, where IoT solutions are employed to improve consumer convenience, health, wellness, and safety.

Moreover, IoT solutions have enhanced efficiency in industrial sectors such as transportation, agriculture, and manufacturing.

Use Case Spotlight

Carnival Cruise is revolutionizing the cruise experience through IoT, transforming ships into smart cities at sea.

Prioritizing a customer-centric approach, the Carnival Cruise mobile app offers passengers seamless control over exploration, trip planning, and dining. These apps also notify staff about guest allergies, ensuring personalized service. Carnival Cruise is navigating toward a future where each passenger's journey is uniquely tailored and effortlessly enjoyable[99].

Increasing prevalence of IoT applications in the Consumer Sector

IoT forms the fundamental technology for smart home automation, encompassing a range of automated functionalities that streamline and optimize household tasks and improve energy efficiency. These systems empower consumers by allowing them to monitor and control appliances through connected devices.

IoT-enabled devices such as thermostats, lighting, security cameras, door locks, appliances, and entertainment systems communicate and interact with each other to create a technology-enabled, comfortable, and secure environment for consumers.

Use Case Spotlight

Home automation platforms such as Google Home and Alexa Smart Home serve as comprehensive smart home automation platforms, integrating a variety of compatible devices, including thermostats, smart speakers, Wi-Fi routers, light bulbs, window sensors, smart door locks, smart TVs, and security cameras.

These platforms provide users with a unified interface, empowering them to efficiently monitor, control, and streamline the performance of appliances, as well as manage routine tasks seamlessly[100].

IoT-powered smart wearables such as smartwatches and Smart glasses transform how we work, communicate, and manage our well-being. In addition to offering enhanced convenience features such as managing calls and texts, these devices also provide users with health monitoring and safety features. By seamlessly integrating health-tracking sensors and advanced safety mechanisms, these wearables empower users to monitor their fitness levels, track vital health metrics, and even receive emergency alerts. A new wearable technology category for businesses

is wearable cognitive support, designed to improve human efficiency and cognition. This technology not only guides users through applications, but also ensures that every action has been performed correctly.

To achieve this, real-time computer vision based on Machine Learning, edge computing, and 5G/6G cellular technology, combines low latency, high bandwidth throughput, compute-intensive processing, and wearable cognitive support systems.

Use Case Spotlight

The Apple Watch, beyond providing essential features such as calls, text management, and health monitoring tools like fitness and activity tracking, also enables users to create a Medical ID.

This ID, visible on the watch's lock screen, provides vital information about the individual, such as their blood type, medical conditions, and allergies, to attendees in emergencies[101].

Unlocking Efficiencies and Novel Opportunities across Governments and Businesses

Industry 4.0 completely changes how businesses produce, enhance, and market their goods/services across multiple sectors. IoT-powered infrastructures facilitate the optimization of operations, providing safety enhancements through interconnected devices and systems.

This has led to the rise of the Industrial Internet of Things (IIoT), constituting an ecosystem of devices, sensors, applications, and associated networking equipment that collect, monitor, and analyze data from industrial operations[102]. IIoT also gives industries enhanced control and visibility, enabling better real-time monitoring and control of factory machinery and inventory.

In addition, the data collected by IoT sensors provide valuable insights for enhancing efficiency, reducing time to market, reducing downtime through predictive maintenance, and improving overall productivity in industrial processes.

Use Case Spotlight

Motorcycle manufacturer Harley Davidson converted its plant into an IoT-enabled facility by linking the devices and processes integral to its production operations, resulting in a USD 200 Mn drop in operating costs, 3% growth in productivity, reduced downtime, and increased production efficiency[103].

Digital Twin is a real-time virtual model of a real-world entity, leveraging data from connected IoT sensors to create a digital representation, enabling remote monitoring and analysis. This technology is employed for various purposes, including performance analysis, problem monitoring, and pre-implementation testing.

The insights derived from digital Twins facilitate rapid responses to enhance operational efficiency, production quality, and customer satisfaction[104].

The worldwide prevalence of IoT devices in healthcare is increasing, leading to transformative changes across remote monitoring, telemedicine, and preventive healthcare.

IoT-enabled devices enable continuous monitoring and timely interventions, ensure patient safety, and empower physicians for superior care. IoT is also enabling

enhancements in patient care in hospital settings through innovations such as smart beds, which adjust the angle and pressure based on patient presence and monitor vital parameters such as weight, body temperature, and heartbeat.

Use Case Spotlight

A collaborative effort between Telenor, the Danish Heart Association, and Seluxit produced an IoT device that addresses the widespread issue of flawed defibrillators in Denmark due to insufficient maintenance.

This device, equipped with sensors and a communication module, continuously monitors defibrillators, detecting faults or power deficiencies, and promptly alerts service technicians through a platform for immediate intervention[105].

Use Case Spotlight

IoT is evolving toward applications involving brain-computer interfaces, as demonstrated by Neuralink.

The application assists individuals with paralysis in communication by enabling remote control of devices through brain activity. Neuralink leverages IoT to enhance user memory and cognitive abilities, restores motor functions, and addresses neurological disorders by improving sensory and visual functions[106].

The transformative effects of IoT in the automotive industry make mobility safer and more convenient. IoT enhances vehicle management capabilities to establish smart, safe connections among transport systems, drivers, pedestrians, and vehicles. IoT has enabled novel applications in the automotive industry, such as connected vehicles and autonomous mobility, to advanced driver monitoring systems that track driver behavior to prevent accidents through timely notifications. Cellular Vehicle-to-Everything connectivity is a connected mobility platform that enables solutions such as vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), vehicle-to-pedestrian (V2P), and vehicle-to-cloud (V2C) communication, connecting individual vehicles and the broader transport ecosystem, facilitating intelligent transport systems to reduce pollution and congestion.

Use Case Spotlight

Volvo Cars collaborated with Telenor Connexion to develop Volvo On Call, a subscription-based service offering an app connecting Volvo owners to their vehicles continuously.

This app allows remote monitoring and control of the car, providing various additional remote functionalities besides seamlessly incorporating emergency and roadside assistance into the integrated services[107].

Empowering Smart Cities for a Smarter and Sustainable World

Smart cities leverage emerging technology such as IoT, green technologies, and AI-based data-driven solutions to improve people's quality of life.

They make urban operations and services more efficient and boost their competitiveness while ensuring the city meets present and future generations' economic, social, environmental, and cultural needs[108].

Smart cities draw synergies among these advanced technologies and optimize transportation, energy, healthcare, waste management, and public safety operations.

One significant example of smart systems being visible in everyday life is in the traffic management of motor vehicles.

For smart cities to be 'livable,' culture is an important aspect to consider. It needs to galvanize the population and avoid taking a top-down approach with the available technologies.

Smart city traffic management solutions use sensors, cameras, and IoT devices to collect real-time traffic conditions data, optimizing traffic flow. Authorities adjust signals, manage lanes, and reroute vehicles based on the insights from the analyzed collected data, thereby reducing traffic congestion and carbon emissions.

Integrating traffic management systems with public transport enhances synchronization and reduces wait times. The accumulated traffic data aids in identifying accurate trends, predicting traffic patterns for future evidence-based planning.

Use Case Spotlight

Barcelona has implemented a sensor-based parking system, helping drivers locate vacant parking spots. This has been achieved by embedding sensors in the asphalt to detect if a vehicle is parked in the location.

This initiative has reduced congestion and emissions, and within a year of its introduction, the city processed 4,000 parking permits per day through the application[109].

Smart city sustainability initiatives encompass a range of programs to promote environmental sustainability and resource efficiency, essential to improving people's quality of life. Currently, more than half of the world's population lives in cities, estimated to rise to 70% by 2050. Cities consume 60–80% of the world's energy and produce more than 70% of its carbon emissions[110].

Additional problems brought about by rapid urbanization include socioeconomic inequality, street gridlock, water poisoning, and related health problems.

These environmental sustainability initiatives leverage technology, data, processes, and innovative solutions through smart cities, address various sustainability challenges, and encompass initiatives such as renewable energy integration, better traffic management to reduce pollution, waste management, and energy-efficient sustainable infrastructure.

Smart city waste management involves integrating smart ecosystem technology such as IoT and innovative strategies to optimize waste collection, sorting, recycling, and disposal to enable a Sustainable Smart City (SSC)[111]. IoT devices embedded in waste bins emit signals when they are nearing capacity, optimizing collection routes for efficiency, and reducing unnecessary pickups.

Use Case Spotlight

Fukuoka in Japan has pioneered a unique approach to sustainable energy by producing hydrogen from city sewage to fuel vehicles. This innovative technology aims to create a low-carbon society.

The hydrogen energy extracted from household sewage is used as a fuel source for cars, motorcycles, and delivery trucks. Fukuoka's future plans involve expanding the use of this eco-friendly energy source for transportation and fulfilling various energy needs across the city[112].

Envisioning 2024

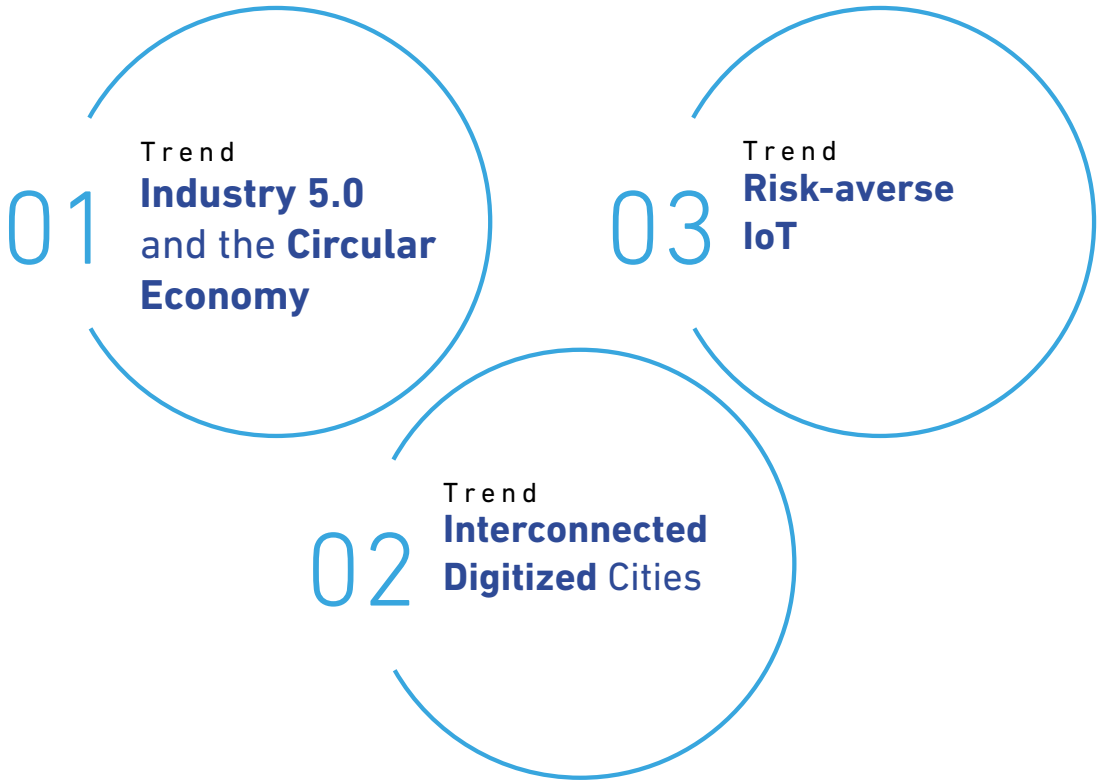
An Overview of Key Trends Shaping Smart Ecosystems in 2024

IoT is poised to become more integrated within the Digital Economy, evolving from standalone technology to a function that unifies among smart ecosystems.

As technology advances, smart ecosystems are on the verge of experiencing substantial growth in both scope and scale, amplifying their capabilities, and enabling more sophisticated applications.

The evolution of IoT offers numerous opportunities for innovation, market expansion, efficiency improvements, and enhanced user experiences. However, IoT also brings challenges, particularly regarding interoperability and compatibility among heterogeneous technologies used in the network of IoTs. IoT also generates huge volumes of data and extracting conclusive insights from Big Data is a challenge, due to its complexity.

The disruption in the smart ecosystem is anticipated to create opportunities in the following areas: Environmental Sustainability, Customer Experience and Regulation, Policy, Governance, and e-governance. Furthermore, these areas will emerge into the following three key trends that directly address some of the 2024 world agenda items:



Trend 1:

Industry 5.0 and the Circular Economy

In the era of Industry 5.0, the convergence of cutting-edge technologies like the Internet of Things is poised to revolutionize manufacturing, creating a paradigm shift toward a circular economy. This transformation optimizes resource usage, minimizes waste, and fosters a holistic approach to environmental sustainability by integrating intelligent systems that monitor, adapt, and enhance industrial processes, focusing on reducing ecological impact.

Industry 5.0 builds upon the existing principles of 'Industry 4.0' by emphasizing research and innovation to facilitate a shift toward a sustainable, human-centric, and resilient industrial landscape. It prioritizes the well-being of workers and harnesses new technologies to foster prosperity while respecting the Earth's production capacities[113].

The circular economy is a model of production and consumption, which, in contrast to the linear economy, involves sharing, leasing, reusing, repairing, and recycling existing products to extend their life cycle[114]. **IoT will play a crucial role in the circular economy** as it enhances visibility and provides better control over the manufacturing and distribution process, facilitating the generation and management of data necessary to meet the intricate requirements of **circular supply chains.**

Through Industry 5.0, an intelligent product manufactured would hold information on the materials made from and the carbon embedded in the product/ component and released during its manufacture. The amount of carbon emitted may be recorded by the product produced. Similarly, the product can also report its energy use patterns and estimates of carbon emissions produced to the manufacturer.

At end-of-life, the product provides a manifest with material details, carbon footprint, and disassembly instructions[115].

Interconnectivity in such areas enables smarter recycling and reduces waste and energy consumption.

It offers a means to safeguard the environment and utilize natural resources more prudently, foster the growth of new industries, generate employment opportunities, and cultivate innovative capabilities.

Data collected from interconnected devices enables decision-making and automation, making IoT a fundamental element for Industry 5.0.

Use Case Spotlight

Hearts For the Homeless Foundation diverts clothing and textiles for reuse. They partnered with Enevo to fit wireless fill-level sensors that transmitted data for analytics and logistics planning. This resulted in powerful data analysis, better forecasting, and dynamic adjustments in collections and routes, significantly reducing site visits, preventing overfills, and minimizing resident complaints[116].

Trend 2:

Interconnected Digitized Cities

According to the World Economic Forum, 68% of the world's population will inhabit urban areas by 2050, up from the current level of 55% [117]. This increase in urban population will impact the urban infrastructure, economy, society, and the surrounding environment. Advancements in IoT, Big Data, and AI technologies are **reshaping smart cities by leveraging data-centric technologies to enhance customer experience,** revolutionize transportation systems, and promote sustainable practices. These emerging technologies will likely enhance the capabilities of smart cities, integrating more data-driven systems, AI, and connectivity to enable these cities to optimize their resource usage better, improve sustainability, and prioritize efficiency and convenience.

Use Case Spotlight

Saudi Arabia's smart city, NEOM, aims to utilize Tonomus' (a subsidiary of NEOM) digital infrastructure to utilize accurate, protected resident-shared data to offer personalized and predictive services tailored to individuals' daily requirements. The solutions will rely on advanced computing capabilities, Artificial Intelligence, and immersive technologies[119].

The city will have its own operating system, Neos, which will bring together various data points to run services efficiently. For instance, Neos will streamline travel by anticipating flight details and hotel bookings and arranging timely shuttles for visitors. It will also monitor residents' well-being, responding to emergencies with drones and rerouting vehicles for medical attention when needed[120].

A robust, secure, and interoperable telecommunications infrastructure is essential for smart, sustainable cities to support a massive number of ICT-based applications and services. **This includes connectivity infrastructure such as 5G and 6G, sensors, data analytics capabilities, and open data platforms and policies[118].**

This enhanced online and offline digital connectivity between applications will unlock the full potential of IoT to provide seamless user experience through the facilitation of real-time data analysis, seamless communication between devices, and the development of innovative solutions; this supports addressing urban city challenges around energy efficiency, safety, mobility, housing, and government services.

Ultimately, the convergence of such IoT-enabled technologies is expected to drive the evolution of smarter, livable, more interconnected cities with improved economic growth, providing residents with a seamless experience and enhanced quality of life.

Key areas where interconnected smart ecosystems can play a role in improving residents' living standards are **user experience, climate change resilience and monitoring, mobility, accessible infrastructure, public health and safety, government services, and air, water, and waste management.**

Use Case Spotlight

The IMO State University in Nigeria has designed a system for automatic crime reporting and immediate response that is developed based on system integration combining Raspberry Pi, Microsoft IoT, mobile applications, and web applications. Their research aims to lower Nigeria's crime rate by creating a framework using big data and the Internet of Things to detect and monitor crimes and criminalities online in real-time[121].

Trend 3:

Risk-averse IoT

The expansion of IoT devices has heightened the risk of businesses and civil societies facing cybersecurity and data privacy threats. Regulation of IoT security standards is crucial to enable a safe digital environment and nurture trust among Business and civil society users.

Standardization of IoT devices plays a crucial role in establishing universally accepted specifications and protocols, enabling seamless compatibility among devices and applications. This uniformity ensures cost-effective solutions, fosters interoperability and compatibility of IoT devices, unlocks new opportunities, and maximizes the market's potential[122].

Additionally, standardization enables device compatibility, enhancing the user experience and attractiveness to end users while fostering competition among manufacturers.

Considering the data security issues arising from the proliferation of IoT devices, the Ministry of Industry and Information Technology in China has formulated guidelines outlining basic security standards for IoT.

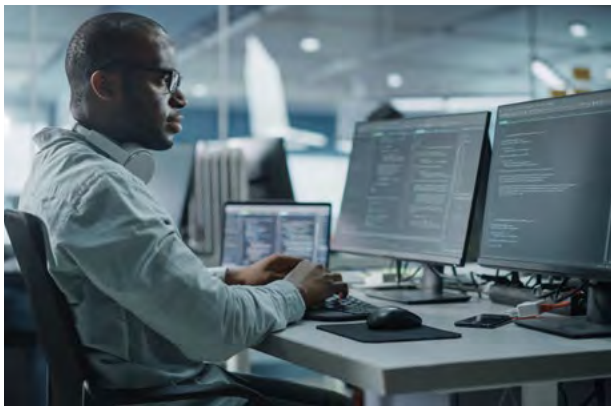
The initiative will be implemented in two phases from 2022 to 2025. The draft specifies major standards for IoT basic security, highlighting key areas and directions encompassing standard systems, terminal security, gateway security, platform security, and security management[123].

Recognizing the importance of IoT security, the U.S. introduced the IoT Cybersecurity Improvement Act of 2020 to establish minimum security standards for Internet of Things devices owned or controlled by the Federal Government and for other purposes[124].

With a 2021 executive order, The White House initiated pilot programs for labeling IoT products to educate the public on the security capabilities of Internet-of-Things (IoT) devices and software development practices. It also urged exploring incentives to encourage manufacturers and developers to join these initiatives[125].

Furthermore, the country's **National Cybersecurity Strategy for 2023** has made it a strategic objective to drive the development of secure IoT devices aimed at enhancing IoT cybersecurity through Federal research and development, procurement, and risk management efforts while continuing to advance the growth of IoT security labeling programs allowing consumers to compare cybersecurity protection among IoT products. It fosters a market incentive for enhanced security[126].

There is growing interest from public and private entities toward driving a secure IoT-based smart ecosystem. The **National Institute of Standards and Technology (NIST)** has recently chosen a lightweight cryptography algorithm to protect data created and transmitted by IoT and other small devices[127].



Similarly, a prominent open-source software organization, Eclipse Foundation, announced the publication of the Sparkplug 3.0 specification, which enables businesses to deploy complex IIoT systems easily as an international standard for 'Plug and Play' in Industrial IoT[128].

There is a noticeable trend toward implementing IoT-related regulations and industry standards as many regulators and industry bodies acknowledge the urgency of addressing risks associated with this technology. The regulatory landscape is anticipated to undergo a transformative phase in 2024 to establish guidelines explicitly tailored to govern IoT devices.

These regulations will address the risks associated with IoT devices to foster innovation while safeguarding civil societies, businesses, and critical national infrastructure from potential vulnerabilities.

It remains uncertain whether standards for IoT governance based on the lack of data security and privacy in IoT applications will be guided by regulators or shaped by market forces. Yet, actions taken by countries such as China and the U.S. indicate a leaning toward regulatory influence, potentially through enforcement or incentivizing initiatives that advocate IoT security standardization.

Approaching 2024
An Overview of the Key Enablers for Adoption of Smart Ecosystems

In this section, our focus delves into the essential enablers poised to lay the groundwork for the accelerated advancement of the Internet of Things (IoT) throughout the economy, paving the way for a more interconnected and intelligent future.

Connectivity Infrastructure

Continuous, reliable, and seamless connectivity is a fundamental requirement for IoT devices to transfer and process data in real time, perform analytics, and derive valuable insights. Ericsson forecasts that cellular IoT connections are expected to reach around 3 Bn by the end of 2023 and 6.1 Bn by 2029, growing at a CAGR of 12% between 2023 and 2029[129].

The absence of robust and reliable internet connectivity within a smart ecosystem can lead to data exchange disruption, impaired decision-making, and loss of automation, hindering real-time monitoring, communication between devices, and data transmission, as IoT devices rely on continuous data exchange to function optimally.

Governments can invest in robust communication infrastructure, including 5G and 6G networks, to ensure widespread and reliable connectivity for IoT-based smart, livable, and sustainable cities. In addition to this, governments can encourage private sector investments in IoT infrastructure. This will promote higher adoption of IoT devices, and the enhanced, low-latency, near-real-time communication between IoT devices will give rise to advanced applications such as autonomous vehicles and enhanced industrial automation.

Data Processing Capabilities

IoT devices generate massive amounts of data, and modern data processing technologies, including cloud and edge computing, provide the infrastructure to manage, store, and analyze this data efficiently. This ability to collect and analyze real-time data from IoT devices enables informed decision-making, process optimization, and enhanced operational efficiency.

Edge and Cloud computing act as technology enablers. With the growth in real-time systems, local processing needs for IoT, and low-latency closed-loop action based on fast AI/ML algorithms need local processing with Edge. On the other hand, the Cloud infrastructure will lend the scalability required by the Smart Ecosystems.

Operational scalability is also a key consideration encompassing systems for monitoring, fault management, configuration, and performance management that can scale with the user needs.

Since these smart ecosystems will need many technologies to co-exist, visibility in the performances of sensors, devices, and network appliances is essential for seamless business.

Robust data processing capabilities also ensure scalability and data security. Scalability allows systems to handle increasing volumes of data and additional devices without compromising performance, which is essential as the IoT ecosystem expands. Effective data encryption, anonymization, and secure storage can address security and privacy concerns regarding sensitive information collected by IoT devices.

Apart from connectivity and data processing, there is a need for an Integrated Digital Platform that helps orchestrate multiple domains like VLAN, WLAN, IoT, radio access, and essential to deliver the outcomes needed from use cases.

Consumer and Industry Demand

The surge in consumer interest and demand for connected devices has been a driving force behind the rapid expansion of IoT in the consumer segment. A notable example would be the popularity of IoT and connectivity in the automotive industry, with growing demand for connected cars driven by consumers' desire for convenience and seamless technology integration. This rising demand may be attributed to several factors, including the need for convenience and automation, safety, enhanced focus on health and wellness monitoring, and rising awareness of sustainability through energy savings, giving rise to smart and sustainable cities. Continuous improvements to IoT devices, including enhanced functionalities, improved integration, and affordability, contribute to increased consumer interest and adoption. The industrial sector's growing interest in IoT is driven by several factors, including the rise in operational efficiency enabled by automation, real-time monitoring, predictive maintenance to reduce unplanned downtime and maintenance costs, supply chain optimization, and industrial safety. The increasing adoption of IoT is a catalyst for ongoing innovation in the sector, particularly in developing more advanced and energy efficient IoT devices to create comfortable, secure, livable smart cities.

Key Takeaways

How will Smart Ecosystems affect the Digital Economy in 2024?

Implications and Recommended Actions for Public Sector

Cyber Security and Regulatory Considerations

Implications

The exponential growth of IoT devices increases cybersecurity concerns due to the sheer volume of connected devices, which expands the attack surface, providing more entry points for cyber threats to exploit. The annual number of IoT malware attacks worldwide in 2022 amounted to 112.29 Mn, a significant increase of over three times from 2018 when the number stood at 32.7 Mn[130]. The diverse range of IoT devices also comes with varying levels of security standards and capabilities, where weaker links can serve as entry points for hackers to conduct Distributed Denial of Service (DDoS) attacks like through botnets. Extensive data generated by IoT devices, often including sensitive information, and the lack of security measures make it a lucrative target for vulnerabilities if not protected through appropriate levels of encryption.

Recommended Actions

Governments should set comprehensive guidelines for security regulatory standards for IoT devices, promoting a baseline level of security that devices shall meet. For example, regulations to IoT based on cellular technology considering SIM card integration. Additionally, the public sector should focus on promoting a security-aware culture, by providing transparent information about the security features of IoT devices, empowering citizens to make informed decisions, and by promoting ongoing capacity-building programs for relevant stakeholders on best IoT security practices.

Public Private Partnerships (PPP)

Implications

The public sector alone may be unable to keep pace with new-age technology, research, and funding linked to IoT, as it may surpass its capabilities. The available capital might not be sufficient to fund the extensive infrastructure needed to enable seamless connectivity for widespread IoT adoption. A robust public-private partnership (PPP), which involves a collaborative agreement between a public or a private sector company, is essential.

Recommended Actions

The public sector shall promote collaborative initiatives with ICT regulators, and private sector organizations, including telecommunications service providers and technology organizations, to leverage collective strengths and resources. By fostering a collaborative environment, stakeholders can capitalize on the advanced technological capabilities of the private sector while harnessing the financial resources of the public sector. This synergy will facilitate large-scale investments in IoT infrastructure and technology, ultimately accelerating the advancement and adoption of IoT solutions.

Implications and Recommended Actions for the Private Sector

Transforming Market Landscape and New Business Opportunities

Implications

IoT is contributing to meaningful transformation across sectors, including healthcare, automotive, and manufacturing by revolutionizing processes and changing business models. In addition to this, the proliferation of IoT devices creates a vast landscape for innovation and market growth, offering opportunities for businesses to develop new products, services, and solutions that cater to the evolving needs of a connected world, such as IoT solutions and services, analytics and AI-driven services that extract valuable insights from IoT generated data.

Recommended Actions

To thrive in the evolving landscape of the Internet of Things (IoT), businesses should take a strategic approach focusing on three key pillars: infrastructure, talent, and adaptation.

Firstly, private sector organizations should prioritize high-speed connectivity to ensure seamless integration and operation of IoT devices. They should also implement stringent data security protocols along with adopting innovative platforms for effective data analysis and utilization.

Secondly, the private sector shall invest in enhancing their employees' expertise in critical smart ecosystem enabling areas such as data analytics, cybersecurity, cloud computing, and IoT-specific technologies.

Lastly, private sector organizations shall adapt their strategies dynamically based on emerging smart ecosystem trends to stay competitive in the IoT landscape.

Research and Development

Implications

IoT devices are expanding in scale and functionality, driven by customer expectations. Customers' ever-increasing demands are reshaping the landscape of IoT solutions, driving the need for enhanced functionality, quick and seamless integration, personalization, and improved user experience that demand intuitive interfaces and effortless interactions with IoT devices. In addition, the proliferation of IoT devices can lead to the generation of vast volumes of data. Statista forecasts that the total worldwide data volume of IoT devices will reach 79.4 zettabytes by 2025, a significant growth from 13.6 zettabytes in 2019[131].

Recommended Actions

The private sector shall invest in R&D for customer-centric solutions and adaptable IoT systems to enhance customer convenience and stay relevant in the market. In addition, mastering big data through robust management, analytics, and AI is key to unlocking valuable insights and scaling for future demands. Therefore, the private sector shall focus significant investments firstly in cloud, to enable scalability for flexible storage and processing capabilities. Secondly, they should invest in AI and data analytics, to analyze big data collected from IoT devices and deriving insights.

Implications and Recommended Actions for Inter-Governmental Organizations (IGOs), International Organizations (IOs), and others

Interconnectivity and Interoperability

Implications

The physical backbone of IoT is made up of gadgets that collect data from the real world and take appropriate action, like actuators, smart sensors, and networked devices. Such systems use multiple codes that must be synchronized to enable data collection, transfer, and processing to produce insights. Connecting various devices, sensors, and systems requires interoperability and compatibility among heterogeneous technologies. This complexity arises when companies try to expand their IoT implementations across several sites or interface with pre-existing legacy infrastructure. Different elements of the IoT ecosystem use different connectivity options, such as Bluetooth, cellular networks, Wi-Fi, Zigbee, and more, to provide seamless data transmission in various settings.

Recommended Actions

In collaboration with various IOs, proactive efforts should be undertaken to identify and address any gaps in existing standards for smart devices. To contribute to promoting seamless interoperability across various devices from different manufacturers, the implementation of IP (Internet Protocol) technology within smart devices is recommended. This is due to IP's inherent compatibility with established communication standards. Additionally, leveraging cloud and open-source platforms can significantly improve communication management. Furthermore, IoT gateways can play a crucial role in facilitating communication between devices and the cloud, further enhancing overall system efficiency.

Internet of Things (IoT) Security

Implications

The market is seeing an increase in the introduction of IoT devices with a limited level of security. Consequently, this may result in vulnerabilities such as data breaches or cyber-attacks. This has also made threats more dangerous and less location-specific, with far-reaching effects on businesses, including enterprises, governments, and civil society. As a result, it is essential to establish an ecosystem that is safe from conception to disposal - a task that calls for an international strategy. Therefore, effective IoT cybersecurity policies are urgently needed worldwide to build a comfortable, secure environment.

Recommended Actions

To enhance the security of the Internet of Things (IoT) ecosystem, IGOs must address smart ecosystems related cybersecurity challenges. This requires the provision of critical information and guidance to key stakeholders, including policymakers, regulators, executives, and the Chief Information Security Officers (CISOs). In addition, the following three key areas must be prioritized: (i) establishing an IoT evaluation and certification regime that considers diverse applications, scheme requirements, and harmonization; (ii) building a secure and reliable supply chain across various domains, including consumer goods, innovative IT sectors like healthcare, and smart mobility; and (iii) developing a trusted identity framework encompassing hardware security solutions and unique device identification.

Green Economy

Trends

01 **Green Technologies**

02 **Sustainable Agri-Tech**

03 **Regulation** for **Green Transition**

Green Economy

Harnessing the power of green technology in driving sustainability

The Evolution of Green Economy

'Green Economy' is a broad term originally coined in the 1980s and is a holistic collection of ideas and solutions that emphasizes the relationship between economic development, people, and environmental sustainability.

As per the United Nations Sustainable Development Goals (UN SDGs), the Green Economy is considered one of the important tools available for achieving sustainable development, one that is inclusive and can drive economic growth, employment, and poverty eradication while maintaining the healthy functioning of the Earth's ecosystems.[132]

The United Nations Environment Programme (UNEP), stated Green Economy creates a new focus on the economy into investment, capital and infrastructure, employment and skills, and positive social and environmental outcomes.[133]

The advancement of Digital Economy enablers, like digital infrastructure and digital transformation, is crucial for fostering innovative applications that integrate technology with the environment. This facilitates the creation of new green technologies and industries, amplifying the overall positive influence on sustainable development[134].

Public and private organizations, and intergovernmental bodies have collaborated to promote the Green Economy through various initiatives, including digital innovation, digital transformation, and Research and Development (R&D) initiatives. Most of such initiatives are strategies focused on developing and **adopting a technological approach to environmental solutions.**

Green tech encompasses many technological practices, all geared toward safeguarding the environment. From harnessing renewable energy and eco-friendly transportation to revolutionizing agriculture, Green Tech addresses climate change by reducing greenhouse gas emissions and promoting a circular economy.

This transition toward a greener future prioritizes sustainability through resource optimization, waste reduction, and recycling.

In addition, green tech also ensures a nature-positive transition to a green economy that includes climate resilience and the protection of biodiversity. Adopting green tech is essential to improve well-being and health, offering benefits like clean air, water, soil, energy-efficient buildings, affordable and healthy food, and creating future-proof jobs for a resilient industry transition.

The Green Tech and Sustainability market is valued at USD14.3 Bn in 2022 and is projected to reach USD 83 Bn by 2032 with a CAGR of 19.5%[135].

Driven by the rising awareness of climate change, advancements in enabling technologies, and stricter regulatory mandates by governments, investments in Green Tech have surged, propelling rapid growth in the green tech market.

For instance, the EU (all 27 member states), has dedicated itself to transforming the region into the first climate-neutral continent by 2050, and pledged to reduce emissions by at least 55% by 2030 as compared to 1990 levels[136].

To achieve the goals set by the European Green Deal, the EU Commission has committed to mobilize at least EUR1 Trn in sustainable investments over the next decade[137].

Similarly, at the United Nations Climate Change Conference (COP-28), the United States pledged USD 3 Bn to the Green Climate Fund. This financial instrument channels climate funding to developing countries[138].

Success to Date
Modern Sustainability Practices

Renewable Energy Solutions

A global shift toward increased dependence on renewable energy sources like solar, wind, hydroelectric, geothermal, green hydrogen, or biomass, and reduced reliance on fossil fuels is being witnessed. The global energy crisis, marked by elevated fossil fuel prices, has heightened the economic appeal of renewable power technologies.

This shift will reap benefits not only on the climate change front but will also positively impact the global economy. The IEA's main case forecast is to install 56 GW of renewable energy during the period 2022-27[139].

> In the COP-28 climate summit, [110] countries signed a pledge agreeing to triple global renewable energy installed capacity by 2030[138]. This surge in capacity will bring about substantial opportunities for the global economy.

Circular Economy

Circular economy practices such as recycling, reusing, and remanufacturing contribute significantly to reducing waste and landfills while reducing the strain on natural resources by keeping materials in use for a more extended period, helping decrease the need for extraction and processing of raw materials. Successful circular initiatives hold immense business potential to create additional revenue from existing products, drive innovation, reduce operating costs, and product/service differentiation. Studies show that by 2030, the circular economy will present a USD 4.5 Trn opportunity to boost global GDP by 1.1%, create more jobs, and make the economy more resilient[140].

Use Case Spotlight

Canon maximizes value by collecting used equipment from the market, remanufacturing it, and re-selling it with the same high-quality guarantee as original products. In reusing at least 80% of the materials, Canon also reduces product greenhouse gas emissions [141].

Promotion of Sustainable practices in various Sectors and Industries

Green Mobility

Green mobility involves utilizing transportation technologies like electric vehicles, hybrids, and vehicles running on alternative fuels, all designed to minimize their environmental impact. As battery and charging technology progresses, electric vehicles are becoming increasingly affordable and convenient for daily use. Conversely, electric vehicles are the incubator for battery technologies.

The rising adoption of these technologies has the potential to decrease greenhouse gas emissions, encourage sustainable energy consumption, enhance air quality, and reduce reliance on fossil fuels especially if the grid being used to charge the electric vehicles is based on an increasing percentage of

renewable energy to produce electricity. From 2017 to 2022, electric vehicle sales globally surged from approximately 1 Mn to exceeding 10 Mn, showcasing exponential growth[142].

Use Case Spotlight

The Norwegian government's primary focus was encouraging the adoption of alternative energy sources in transportation, particularly through incentives for electric vehicles.

These incentives included zero import duties, VAT exemptions, and road tax benefits. Additionally, plug-in cars enjoyed toll-free travel, and publicly funded charging stations were established. Consequently, Norway boasts the highest per capita number of battery-only electric cars globally, and in 2021, a remarkable 80% of new passenger vehicles sold in the country were electric[143].

Green Information Technology

Green Information Technology (Green IT) refers to adopting environmentally sustainable computing practices, striving to curtail energy usage, mitigating the technology sector's impact on global emissions, and combatting climate change.

Green IT involves various measures such as energy-efficient hardware, data centers, HVAC systems, server virtualization, IoT-powered monitoring systems, and e-waste disposal.

Use Case Spotlight

Meta's Lulea, Sweden, data center utilizes freezing external air to naturally cool down the digital infrastructure while the server-generated hot air is circulated. Axial fan walls are employed to maintain consistent temperatures[144].

Green Architecture

Green architecture integrates eco-friendly and resource-efficient practices, prioritizing building design, construction, operation, and maintenance to minimize environmental impact. With a focus on environmental responsibility and resource efficiency, green architecture also considers the life cycle of a building, from planning and design to construction, operation, maintenance, renovation, and demolition. Renewable energy sources include solar panels, efficient insulation, passive heating and cooling techniques. For instance, Building Information Modeling (BIM) can be used to create a Digital Material Passport that provides information on the composition and location of building materials and components, facilitating the deconstruction and reuse of those materials to condense environmental impacts[145].

Use Case Spotlight

Apple's corporate headquarters, 'Apple Park' in Cupertino, California, spans 175 acres and operates entirely on renewable energy, primarily sourced from an on-site low-carbon central plant. The site also boasts extensive solar installations, with a significant portion of the solar roof dedicated to electricity generation[146].

Carbon Capture and Storage Technologies

Carbon capture and storage (CCS) involves capturing carbon dioxide emissions from industrial activities or burning fossil fuels in power generation. This technique prevents the release of carbon dioxide into the atmosphere, curbing its contribution to global warming. Different technologies are used for CCS, including direct air capture and mobile air capture, where carbon dioxide is either recycled or securely stored where it cannot escape, offering a significant method for cutting emissions and addressing the challenge of global warming.

Use Case Spotlight

ExxonMobil's Shute Creek Gas Processing Plant in Wyoming, USA, operates as a CCS facility. It captures around 365 Mn cubic feet of carbon dioxide daily, utilized in oil recovery efforts across multiple oil fields[147].

Envisioning 2024

Empowering a Sustainable Future: Green Tech innovations in upcoming years

The green economy is considered essential for promoting sustainable development due to its focus on addressing environmental challenges, encouraging social equity, and fostering economic prosperity.

The global agenda for sustainable development has become a prevalent subject, paving the path for rapid expansion of the green economy and the ever-evolving landscape of green technology.

Research by Oxford Economics estimates that the transition to a net zero emissions environment by 2050 will create new industries worth USD 10.3 Trn for the global economy[148].

This is anticipated to create opportunities across focus areas – "Environmental Sustainability and Regulation, Policy, Governance, and e-Governance." Further, these focus areas will emerge into the following three key trends that directly address some of the 2024 world agenda items:

Trend 1:

Emerging Green Technologies and Smart Systems

Green Tech encompasses a broad spectrum of technologies and practices designed to promote sustainability, energy efficiency, data management and the responsible use of resources. One facet of green technology is smart energy systems, which include the implementation of smart grids.

The relevance and growth of green tech will witness a strong uptake driven by rising electricity demand, integration of renewable energy, and larger commitment from the public sector to establish the necessary green tech-related policy and regulatory frameworks and businesses to adopt affordable, secure, and sustainable solutions.

Smart grids are integrated with advanced IT systems, sensors, controls, automation, and technologies to oversee and digitally manage electricity distribution, adapting and swiftly responding to fluctuating demands.

Many benefits can be reaped from the use of smart grids, such as enhanced transmission efficiency and decreased energy loss, while providing the ability to swiftly restore power after disturbances. Smart grids facilitate two-way communication between utilities and consumers, creating a more dynamic electrical grid. For instance, when consumers generate power through renewables and connect to a smart grid, they receive credit on their bills for contributing excess energy.

This data-driven model also enables providers to be infrastructure and energy consultants.

Use Case Spotlight

The European Commission's 'Digitalizing the Energy System' action plan anticipates approximately EUR 584 Bn (USD 633 Bn) in investments toward the European electricity grid by 2030.

The action plan aims to transform the energy infrastructure, facilitating greater integration of renewable energy sources and supporting decarbonization[149].

Smart energy systems like smart HVAC (Heating, Ventilation, and Air Conditioning) systems leverage IoT to activate devices like air conditioning based on preset schedules, monitor environmental conditions, offer insights into energy usage, and finely tune heating/cooling in spaces according to occupancy and temperature.

It also measures energy usage and provides highly granular data for analysis. This data-driven approach enhances energy efficiency while ensuring occupants enjoy optimal comfort.

Use Case Spotlight

StorHub Self Storage, a self-storage platform, has implemented an HVAC solution in its Toa Payoh facility in Singapore by integrating an HVAC solution in its building.

This incorporates outdoor units that closely monitor temperatures and humidity levels. This precision reduces energy wastage[150].

Emerging technologies are playing an increasingly significant role in the global fight against climate change and the evolution of sustainable economies.

The use of **AI and ML** in climate modeling enables precise simulations and predictive analytics, which are crucial for devising effective climate change mitigation strategies to contribute to achieving the goal of a climate-neutral planet by 2050.

Blockchain's decentralized and tamper-proof ledger system can increase data transparency and decrease transactional costs through trustworthy peer-to-peer transactions.

It can also significantly increase carbon credit integrity, impact carbon credit monitoring, incentivizing climate finance and incentivize sustainable practices across industries through an amalgamation of tax breaks, laws and regulations and reporting requirements.

Furthermore, leveraging blockchain and NFTs in the supply chain for e-waste, biomass, carbon and sustainable forest products management ensures enhanced traceability and reduces carbon emissions, serving as a global governance tool for impact assessment.[151]

Extended Reality introduces concepts like digital twins, which revolutionize the assessment of climate change impacts by facilitating immersive simulations and representations of real-world environments, increasing efficiency, reducing resource usage, and enabling detailed assessments of ecological changes and their consequences, which can offer valuable insights for policymakers, researchers, and environmentalists to mitigate the effects of climate change.

Trend 2:

Sustainable Agri-Tech

Revolutionary agricultural technologies are paving the way for innovative and regenerative food production methods, from vertical farming, hydroponics, automated harvesting, and robotics in food processing to developing alternative proteins such as cultured meat and dairy substitutes.

The **food industry contributes to approximately 26% of global greenhouse gas emissions,** while around 70% of the world's freshwater withdrawals are allocated for agricultural purposes[152].

Advancements in agricultural technologies are reshaping the landscape of agriculture and food production by optimizing resource use, conserving the environment, and promoting economic growth. It boosts productivity, reduces costs, and fosters green innovation, contributing to food security, rural development, and climate change mitigation.

Precision Agriculture powered by IoT involves utilizing technologies such as drones, sensors, and IoT devices for agricultural and environment monitoring for vital parameters such as temperature, humidity, air quality, soil moisture, nutrient levels, crop health, pest presence, and water levels.

Utilizing such technology enables the collection of rich and high-quality data points across multiple parameters while employing data analysis techniques like statistical modeling and Machine Learning to extract patterns and insights for well-informed decision support. Such **data-centric approach** allows for precise input application, minimizing waste and enhancing overall efficiency.

Use Case Spotlight

Black Gold Farms, a major potato producer in the US, has partnered with Agremo and used their Plant Counting Tool to access precise field stand to count data.

This collaboration offers insights into optimal seed sources and types that thrive in their environments. Embracing precision agriculture methods, they anticipate a 20% reduction in lower-yielding seeds by eliminating or minimizing their use.[153]

Trend 3:

Regulations for Green Transition

As parties to the Paris Agreement, and as defined in their Nationally Determined Contributions (NDCs), over 140 countries have set a net-zero emissions target, covering about 88% of global emissions, 92% of the global Gross Domestic Product, and 89% of the global population[154].

This calls for actions in the form of regulatory impetus across sectors such as energy, transportation, industry, and agriculture, to reduce greenhouse gas emissions. As of 2021, 135 countries have set renewable power targets, with 156 countries enacting regulatory renewable power policies.[155]

The regulatory landscape for the green economy consists of a wide range of national and international regulations, policies, laws, acts, and framework agreements.

Some of the most prominent examples are EU environmental law, the US and Australian environmental sustainability policies, and other reporting frameworks provided by supranational agencies.

For example, the EU's goal is to achieve climate neutrality by 2050, aiming to take a leading role in investing in realistic technological solutions.

This involves empowering stakeholders and aligning efforts in critical areas like industrial policy, finance, and research, all while ensuring fairness for a smooth transition and maintaining social balance[156].

Aligned with the net-zero emission objective, the EU introduced the 2030 climate and energy framework.

This framework encompasses a series of proposals to align the climate, energy, transport, and taxation policies, aiming to achieve a minimum 55% reduction in net greenhouse gas emissions by 2030, in comparison to levels recorded in 1990[157], giving rise to the 'Fit for 55' package which is an initiative aimed at updating existing legislation and introducing new policies to help achieve the EU's 2030 target.

The European Parliament and Council's agreement to end the sale of new CO2-emitting cars in Europe by 2035 can be seen as a significant regulatory reform in this direction. Frans Timmermans, Executive Vice-President for the European Green Deal, said,

> "The agreement sends a strong signal to industry and consumers: Europe is embracing the shift to zero-emission mobility. European carmakers are already proving they are ready to step up to the plate, with increasing and increasingly affordable electric cars coming to the market."[158]

Similarly, Saudi Arabia has pledged a net-zero target by 2060. With three overarching targets and 77 initiatives, the Saudi Green Initiative was launched as part of The Kingdom's Vision 2030 agenda and is a step in this direction.

Saudi Arabia's target to transform the domestic energy mix to have 50% of its power generated from renewable sources by 2030 is a part of this initiative[159].

As an increasing number of countries pledge to climate change targets, they will be supported by regulations to support their efforts in reaching these specific climate goals.

Implementing regulations becomes a cornerstone in their efforts to translate these aspirations into tangible actions and outcomes.

Developing regulations for green tech enables widespread accessibility, attracts investments, provides market certainty, and encourages commitment to adopting green technology.

The FDI toward sectors impacting climate change significantly increased from USD88 Bn in 2015 to USD252 Bn in 2022 at a CAGR of 16%[160].

Approaching 2024
An Overview of the Key Enablers for Adoption of Green Tech and Growth of the Green Economy

UNCTAD highlights the growing economic opportunities presented by green tech and underscores the need for a multi-pronged approach to ensure the success and growth of the green economy.

Heightened attention to green tech policies, targeted investment in capacity building, facilitating R&D funding, international collaboration, inclusive financing models targeted toward small enterprise funding, and enabling an international trading environment is pivotal for developing economies to capture these economic opportunities.

However, green tech faces several barriers for widespread adoption. These include shortage of economically viable green technology projects, infrastructure incompatibility, limited public awareness regarding environmental sustainability practices, limited capabilities across green economy value chain, unclear government policies, and challenges in securing finance for green technology initiatives and programs.

To overcome these challenges, public sector, including regulators, must focus on creating resilient regulatory frameworks to foster the green economy, establishing robust institutions, designing standardized tariffs, developing infrastructure, fostering public awareness, and providing subsidies and guarantees. Similarly, private sector organizations need to prioritize financial viability, investment and funding, job creation, and technical innovation to foster the growth of green economy.

Regulatory enforcement, Penalties, Financial Incentives, and Subsidies

Regulatory impetus through accountability, compliance, disclosure requirements, and incentivization are crucial factors for the transition toward environmentally sustainable practices and embracing green technologies. Heightened awareness of sustainability issues, coupled with ambitious environmental targets, has led to a rising number of regulations about carbon emission reduction targets, renewable energy mandates, circular economy, including waste management regulations, and sustainable production practices designed to encourage and accelerate the adoption of green technologies and facilitate the transition toward more sustainable practices across industries.

Governments are increasingly implementing penalties such as carbon tax and green tax for excessive carbon emissions, serving as a deterrent and encouraging industries to reduce their carbon emissions and adopt greener practices. Regulators are also incentivizing efforts to reduce emissions, including reduced tax liability and grants and subsidies for research projects. For example, the Science Based Targets Initiative (SBTi) defines and promotes best practices in emissions reductions and net-zero targets in line with climate science. This standard provides guidance, criteria, and recommendations for companies to set science-based net-zero targets that align with limiting global temperature rise to 1.5°C[161].

Infrastructure Development

The transition toward a greener economy is facilitated by infrastructure development, which includes promoting renewable energy infrastructure, smart grids, energy storage, renewable energy-to-grid integration, circular economy practices, waste disposal management, and green transportation infrastructure like electric vehicle charging stations, among other initiatives. Governments, the public, and the private sector support infrastructure development to enable a wider reach of Green Technologies through various initiatives, including enabling climate finance.

Data

Data transparency is essential, fueling informed decision-making, fostering innovation, and playing a central role in shaping contemporary economic activities in the green economy. A comprehensive data-driven approach is imperative for accountability, transparency, and efficacy in the green economy.

The foundation of this paradigm shift lies in accountability, where data enables a transparent chain of responsibility. Standardized taxonomy, facilitated by data, provides a common language for diverse stakeholders, fostering better understanding and implementation of green strategies. Real-time tracking mechanisms, supported by data analytics, monitor resource consumption and emissions, empowering decision-makers to evaluate their initiatives, adjust strategies, and meet sustainability targets.

Data-sharing platforms encourage collaboration, facilitating collective problem-solving and innovation among governments, businesses, and research institutions, promoting environmental sustainability, and tackling climate change. While the measures mentioned above are key to developing a green economy, they are not at the cost of privacy being compromised.

Privacy measures are crucial in this data-sharing ecosystem, balancing transparency and individual confidentiality to build public trust.

Global Cooperation

Global cooperation is paramount in addressing sustainable development challenges and transitioning toward a green economy.

Initiatives such as the UN SDG have been successful through cooperation efforts from 193 member states with diverging goals across economic, social, and environmental aspects. Collaborative efforts among governments, businesses, and international bodies foster the exchange of knowledge, resources, practices, and technologies, enabling nations and communities to tackle environmental issues.

The United Nations Framework Convention on Climate Change (UNFCCC) hosts an annual Conference of the Parties (COP), where the member nations collaboratively address climate change issues and take necessary climate actions to limit global warming.

The G7 and G20 summits unite major industrialized nations to coordinate green technologies, climate finance, and sustainable development policies.

The International Renewable Energy Agency (IRENA) facilitates global renewable energy research and deployment collaboration. These examples illustrate the diverse efforts to address environmental challenges collectively, recognizing the interconnected nature of global sustainability issues.

The UN Biodiversity Conference (COP-15) held in December 2022 was aimed at halting and reverse nature loss, critical to meeting the SDGs and limiting global warming to a 1.5-degree Celsius target[162]. Expanding Public Awareness and Market Demand.

Raising public awareness is a cornerstone in catalyzing the widespread adoption of green technologies toward transitioning into a green economy.

As consumers become more informed about the environmental impact of their choices, they drive demand for inclusive and just policies, sustainable products and practices, influencing market trends and encouraging businesses to prioritize eco-friendly solutions.

Key Takeaways

Potential implications and recommended actions of Green Economies for stakeholders

Implications and Recommended Actions for the Public Sector

Infrastructure Development

Implications

Robust infrastructure is essential for executing the green energy transition in emerging markets. However, the pace and scale of infrastructure development lag throughout the value chain, causing a gap between the need for sustainable energy solutions and the current inadequacies in the requisite support systems and facilities. The non-availability of infrastructure is one of the reasons for the delayed acceptance of green technologies such as electric vehicles and smart grids.

Recommended Actions

The public sector should focus on developing and continuously updating relevant regulations to encourage pre-submission consultations while scaling up requisite infrastructure, to boost sustainable energy solutions.

Additionally, the public sector should consider creating specialized structures where relevant agencies collaborate, share information, and collectively contribute to the swift and effective approval of processes for infrastructure development.

Institutional development

Implications

Constant developments and the dynamic, inter-governmental nature of green technology requires dedicated policy focus by the government to drive initiatives, develop guidelines, and enable dedicated research and development.

Recommended Actions

Governments should accelerate progress to achieve NDCs and SDGs by establishing specialized institutions or departments that focus on the green economy, such as renewable energy. The proposed specialized institutions can act as liaisons for inter-governmental cooperation, fostering collaboration at a local, national and international scale.

Climate Finance

Implications

By 2025, developing countries are estimated to need ~USD 1 Trn annually, rising to ~USD 2.4 Trn annually between 2026 and 2030 for climate finance. They must harness various financial sources across public, private, domestic, and international finance to close this financing gap.[163]

Governments play a crucial role in addressing the climate financing gap by providing resources and sharing sustainable best practices with low-income countries and emerging economies, and by implementing instruments that attract diverse funding sources and ensure transparent fund utilization in sustainable projects.

Recommended Actions

The public sector should promote domestic investments and Foreign Institutional Investor (FII) pathways through capital market instruments such as stocks, climate bonds, FDI, export credit, syndicated loans, guarantees from Green Investment Banks[164], and aid from organizations such as IMF and World Bank, to scale up climate finance effectively.

Additionally, the public sector should implement carbon pricing for better risk management and utilize innovative financing instruments to broaden investor participation[165]. Quality climate data, disclosure standards, and network engagement are important to fortify the climate information architecture and enable funding, especially through digital platforms, by assessing creditworthiness.

Implications and Recommended Actions for the Private Sector

Realign priorities, strategy, and business model

Implications

The Green Tech industry's projected substantial and disruptive growth in the next five years presents significant opportunities for private sectors. This expansion will create a competitive landscape, driving innovation and attracting private investment.

Recommended Actions

Private sector organizations should strategically position themselves by implementing Environment, Social, and Governance (ESG) practices, adapting to market demands, and capitalizing on the emerging opportunities within the Green Tech sector. In addition, they should proactively identify priority use cases for existing and potential clients. Further, businesses should focus on understanding the needs of clients, demand creation, aligning offerings with sustainability goals, and developing green economy-related solutions that position the business as a leader in the evolving landscape of green economy and retaining the leadership by building green skill-based expertise and specialized talent.

Green Skills and Capabilities Development

Implications

The renewable energy sector and other industries are experiencing increased demand for upskilling and reskilling, with workers being either absorbed from similar industries such as construction[166]. According to the International Labor Organization, an estimated 24 Mn new jobs by 2030 could be created worldwide. This is also substantiated by an 8% year-on-year growth in green job postings on LinkedIn in the past five years. Meanwhile, the global share of 'green skilled talent' has grown by 6% each year[167].

Recommended Actions

To ensure a pipeline of green skilled talent for future business needs, the private sector should actively engage in on-the-job learning initiatives and establish partnerships with educational and professional capacity building institutes. Collaborating with government-rolled-out schemes can further enhance these efforts, fostering a synergy between industry requirements and educational institutions to address the evolving demands of the workforce[168].

Implications and Recommended Actions for Inter-Governmental Organizations (IGOs), International Organizations (IOs), and Others

Standardization and Taxonomy

Implications

Globally, the rise of green finance calls for developing green taxonomies to drive funding, financing, taxation and policy action toward green economies[169]. A cohesive and comprehensive taxonomy is indispensable for effectively categorizing green industries and clarifying their environmental impact and economic potential. Green taxonomies can significantly influence how goods are classified within the international harmonized tariff system, impacting tariffs, trade incentives, and the promotion of environmentally sustainable practices and products.

Standardization of green taxonomy further enhances precision in measuring and comparing green practices, enabling governments and businesses to harmonize their strategies for sustainable development.

Recommended Actions

IGOs and IOs should foster the international harmonization of green taxonomy and standards, promoting transparency, benchmarking, and a more coordinated approach across sectors and regions. Additionally, they should encourage the strengthening of international cooperation for the development and implementation of standardized methodologies for data collection and reporting, to enhance the reliability and consistency of sustainability data. This enables accurate and meaningful cross-sector and cross-country comparisons.

IGOs and IOs should also strategically address trade barriers for environmental technologies within the International Harmonized Tariff System (IHTS) using green taxonomies to promote the adoption and trade of these technologies while ensuring consistency and alignment across nations.

Implications and Recommended Actions for Inter-Governmental Organizations (IGOs), International Organizations (IOs), and Others

Research and Development (R&D) and Knowledge sharing

Implications

The markets of green technologies have been expanding at unequal rates worldwide, with disadvantages for developing countries.

As per UNCTAD, there is a large divide in spending and focus on R&D for environmental sustainability between middle and high-income countries[170]. Most top suppliers are businesses from developed countries like the United States and China. Also, China and the United States dominate knowledge creation, accounting for 30% of global publications and almost 70% of patents[171].

Recommended Actions

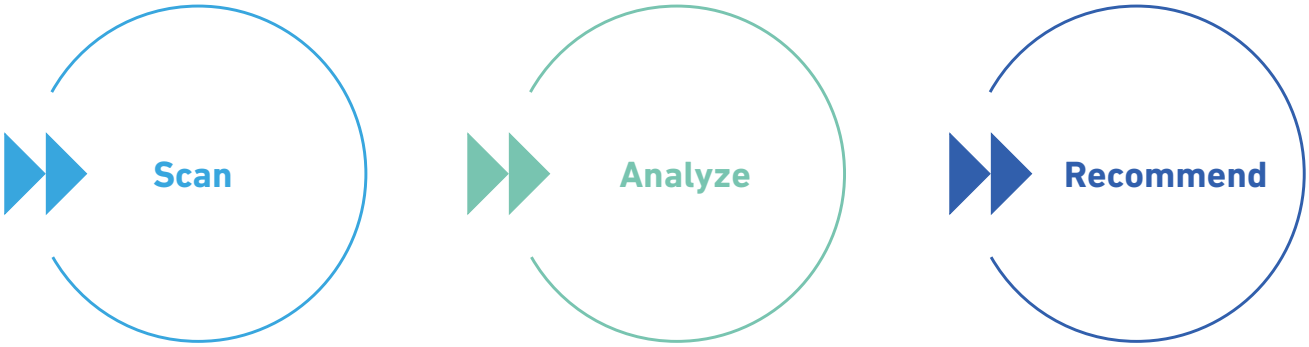
IGOS, IOs and others shall collaborate with relevant stakeholders including private sector organizations, to develop dedicated funds to invest in green initiatives and emerging technologies.

Additionally, IGOs and IOs should establish common platforms facilitating seamless creation and exchange of technical knowledge to bridge potential gaps in green tech know-how between nations or regions.

05. METHODOLOGY

The success and reliability of any trends report hinge upon developing and implementing a well-defined and thorough methodology, which ensures accuracy, credibility, and actionable insights for informed decision-making.

The DCO's Digital Economy Trends 2024 report has been developed through a systematic methodology, centered on desk research, surveys, and semi-structured interviews to gather secondary and primary data to identify, short-list, and validate digital economy trends. This methodology consists of three main steps: Scan, Analyze, and Recommend, as portrayed:



This adopted methodology for the Digital Economy Trends 2024 employs the active involvement of relevant technical and digital economy experts and a thorough analysis of thought leadership from the world's leading think tanks across the global digital economy landscape.

This allows the DCO to come forward with trends along with their corresponding implications and actions for digital economy stakeholders that are credible, reliable, and instilled with a sense of reality.

In the 'Scan' step, a team of experts performs secondary research by identifying and reviewing the relevant data sources – including policy reports, technology and economic trend reports, research articles, relevant think tank publications, databases and thought leadership from recognized multilateral bodies – to identify an exhaustive list of digital economy trends. The team subsequently conducts surveys with international subject-matter experts and global digital economy leaders to substantiate the secondary research findings. An extensive dataset with an exhaustive list of trends categorized by multiple parameters is created as an outcome of this step.

In the second step, 'Analyze,' the expert team develops a quantitative and qualitative evaluation framework, formulated with the support of leading global experts, to short-list the identified trends, employing four criteria: Impact, Risk, Disruption, and Scalability. The output of this exercise would provide each trend with a score and corresponding rank, enabling the DCO to determine the criticality of each trend and confirm a shortlist for inclusion in this report. The resultant list of trends is validated through several semi-structured interviews with global think tanks and experts in relevant digital economy areas. As an outcome of this step, a final ranked short-list is created with trends, organized in six themes. This edition's themes include Artificial Intelligence, Digital Reality, Trust Economy, Cybersecurity, Smart Ecosystems, and Green Economy.

Lastly, in the 'Recommend' step, the expert team synthesizes insights gained from the 'Analyze' step and provides actionable suggestions and guidance, in respect to the trends shortlisted.

These include insights on critical challenges, enablers, implications, and recommendations for relevant stakeholders across the digital economy.

Consequently, the structure of this year's edition of the report encompasses up to three trends per theme, considering the current and future use cases, enablers, implications, and recommended actions.

Trends have been further mapped against our **Digital Economy Trends Blueprint** to support the reader in navigating this report and enable the DCO to perform longitudinal analysis, tracking how digital economy trends, themes, and enablers emerge, transform, and evolve over time.

Analyzing past digital economy trends will facilitate the generation of comprehensive insights and perspectives on their evolution and impact over the coming years. The expert team will continuously monitor and capture all themes and trends in the database and fine-tune the methodology to align with global best practices.

TERMINOLOGY AND GLOSSARY

Term	Definition
Attack Surface[172]	An attack surface is the sum of all possible security risk exposures in an organization's software environment.
Augmented Reality (AR)[173]	AR refers to the real-time use of information in the form of text, graphics, audio, and other virtual enhancements integrated with real-world objects.
Autoencoders[174]	An autoencoder is a type of artificial neural network used to learn efficient coding of unlabeled data, typically for the purpose of dimensionality reduction.
Blockchain[175]	Blockchain is a shared immutable ledger of transactions is maintained across computers that are linked in a peer-to-peer network.
Bn[176]	Bn is an abbreviation, which stands for billion.
Botnet[177]	Botnet refers to a group of computers which have been infected by malware and have come under the control of a malicious actor.
Carbon Capture and Storage (CCS)[178]	CCS is a set of technologies aimed at capturing, transporting, and permanently storing CO2 that would otherwise be emitted into the atmosphere.
Carbon Footprint[179]	Carbon footprint is a measure of the amount of carbon dioxide emissions attributed to the activities of an individual, organization, or community.
Carbon pricing[180]	Carbon pricing curbs greenhouse gas emissions by imposing a fee on emissions or providing rewards for emitting less, thus helping shift consumption and investment patterns, aligning economic growth with climate protection.
Carbon tax[181]	A carbon tax is a type of penalty that businesses must pay for excessive greenhouse gas emissions, which is usually levied per ton of greenhouse gas emissions emitted.
Cellular Vehicle-to-Everything (C-V2X)[182]	A connected mobility platform that allows vehicles to interact with their surroundings, such as other vehicles, cyclists, pedestrians, road infrastructure, or mobile networks.
Circular Economy[179]	Circular economy is an economic system based on the reuse and regeneration of materials or products to continue production in a sustainable or environmentally friendly way.
Climate modeling[183]	A climate model is a computer simulation of the earth's climate system used to recreate the past climate or predict the future climate.
Climate neutrality[184]	Climate neutrality refers to the idea of achieving net zero greenhouse gas emissions by balancing emissions with the planet's natural absorption.
Cloud-based Solutions[185]	Cloud-based solutions utilizes cloud infrastructure to efficiently fulfill business needs, often at a lower cost and with enhanced operational efficiency.
Compound Annual Growth Rate (CAGR)[186]	CAGR represents the average annual growth rate between two years, assuming growth takes place at an exponentially compounded rate.
Crypto Mining[187]	Crypto Mining is the process by which networks of specialized computers generate and release new Cryptocurrency and verify new transactions.
Cryptocurrency[179]	Digital currency in which transactions are verified and records are maintained by a decentralized system using cryptography.
Cryptojacking[188]	Cryptojacking is the unauthorized use of people's devices such as smartphones and computers to mine for cryptocurrency.
Cyberspace[189]	Cyberspace is the environment in which communication over computer networks occurs.
Decentralization[190]	In blockchain, decentralization refers to the shift in control from a single entity such as an individual to a distributed network, reducing the need for absolute trust among participants and limiting their ability to exert authority over others.
Decentralized Finance (De-Fi)[191]	DeFi is an umbrella term for peer-to-peer Financial Services on public blockchains.
Deep Reinforcement Learning[192]	Deep learning is a variant of ML algorithms. It uses multiple layers to solve problems by extracting knowledge from raw data and transforming it at every level.
DevSecOps[193]	DevSecOps is the integration of security into emerging agile IT and DevOps development as seamlessly and as transparently as possible.
Digital Divide[194]	Digital divide refers to the gap between those with internet access, able to utilize the World Wide Web services, and those without access.

Digital Government or e-government[195]	Digital government refers to the process of streamlining government operations spanning information, communication, and transactions among government bodies, and with citizens or businesses using ICT.
Digital Identity[196]	Digital identity is the way a computer stores a record of an external person or system.
Digital Literacy[197]	Digital literacy is the ability to access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital technologies for employment and entrepreneurship.
Digital Twins[198]	A digital twin is a digital representation of a real-world entity or system.
Distributed Denial of Service (DDoS) Attack[177]	A DDoS attack is a malicious attempt to disrupt the normal traffic of a targeted server, service or network by overwhelming the target or its surrounding infrastructure with an excessive volume of Internet traffic.
Distributed ledger technology (DLT)[199]	Distributed ledgers use independent computers to record, share, and synchronize transactions in their own electronic records instead of keeping data centralized as in a traditional ledger.
Edge Computing[200]	Edge computing is part of a distributed computing topology where information processing is located close to the edge, where things and people produce or consume that information.
Electronic waste (e-waste)[201]	e-waste is a generic term used to describe all types of old, end-of-life or discarded electrical and electronic equipment.
Encryption[202]	Encryption, which is essential for security on the internet is a way to conceal information by altering it so that it appears to be random data.
Environmental, Social and Governance (ESG) frameworks[203]	ESG reporting frameworks are used by companies for the disclosure of data covering business operations and opportunities and risks related to the environmental, social and governance (ESG) aspects of the business.
E-sports[204]	E-sports are video games that are played in a highly organized competitive environment.
Extended Reality (XR)[205]	XR is an umbrella term for all the immersive technologies such as augmented reality (AR), virtual reality (VR), mixed reality (MR), and similar future innovations.
Fit for 55[206]	Fit for 55 refers to the European Union's (EU) target of reducing net greenhouse gas emissions by at least 55% by 2030. The proposed package aims to bring EU legislation in line with the 2030 goal.
Foreign Direct Investment (FDI)[207]	FDI is an ownership stake in a foreign company or project made by an investor, company, or government from another country.
GANs (Generative Adversarial Networks)[208]	GAN is a deep neural network framework capable of learning from a training data set and producing new data with the same characteristics as the training data.
General Data Protection Regulation (GDPR)[209]	The EU GDPR is the strongest privacy and security law in the world. The GDPR regulation updated and modernized the principles of the 1995 data protection directive and entered into application on 25 May 2018.
Generative AI[210]	Generative AI learns from data to create new, content, like text, images, videos for many purposes.
Green Architecture[211]	Green architecture is the activity of designing buildings in a way that protects the natural environment, for example by using green energy such as energy produced by wind, water, or the sun.
Green bonds[212]	A green bond, also referred to as a climate bond, is a type of debt security issued by an organization to fund projects that have a positive impact on the environment or climate.
Green Economy[213]	Green economy is defined as low carbon, resource efficient and socially inclusive. In a green economy, growth in employment and income are driven by public and private investment into such economic activities, infrastructure and assets that allow reduced carbon emissions and pollution, enhanced energy and resource efficiency, and prevention of the loss of biodiversity and ecosystem services.
Green Information Technology (Green IT)[214]	Green IT refers to the practice of adopting environmentally friendly approaches and strategies in information technology.
Green Mobility[215]	Green mobility emphasizes modes of transportation that are environmentally friendly and reduce dependence on fossil fuels to promote sustainable transportation practices.
Green skills[216]	Green skills include technical knowledge, expertise and abilities that enable the effective use of green technologies and processes in professional settings.
Green tax[217]	Refers to a form of environmental or ecological taxation that includes taxes on energy, transport, pollution, and resources.

Green Technology/Green Tech[218]	Green Technology is the use of technology to drive clean energy production, particularly the use of technology to create power that is less harmful to the environment than fossil fuels.
Greenhouse Emissions[219]	Greenhouse emission is the release of gases such as carbon dioxide into the atmosphere, contributing to the greenhouse effect.
Haptic Feedback[220]	Haptic feedback is a touch technology that provides simulated physical feedback such as the vibration of the keyboard in a smartphone.
HVAC systems[221]	HVAC stands for Heating, Ventilation and Air Conditioning. HVAC systems provide heating and cooling for residential and commercial buildings.
Hydroponics[222]	Hydroponics is the technique of growing plants using a water-based nutrient solution rather than soil.
Industrial Internet of Things (IIoT)[223]	IIoT is an ecosystem of devices, sensors, applications, and associated networking equipment that work together to collect, monitor, and analyze data from industrial operations.
Industry 5.0[224]	Industry 5.0 is an emerging phase of industrialization where humans collaborate with advanced technology to enhance workplace processes. It emphasizes a human-centric approach, boosting resilience, and prioritizing sustainability.
Information and Communication Technologies (ICT)[225]	ICTs encompass all communication technologies like the internet, wireless networks, computers, cell phones, and various applications enabling users to access, store, transmit, and manipulate digital information.
Information Security Management Systems (ISMS)[226]	ISMS represents an organization's approach to information security and privacy, to shield the organization from security breaches, and identify and address the threats and opportunities around valuable information and any related assets.
Intellectual property rights (IPR)[227]	Intellectual property rights grant creators exclusive rights over their creations for a specific duration.
Internet of Everything (IoE)[228]	IoE is the networked connection of people, process, data, and things.
Internet of Things (IoT)[229]	IoT refers to a network of physical objects embedded with technology to communicate, sense, and interact with their internal or external environment.
IoT Gateway[230]	An IoT gateway is a centralized hub that connects IoT devices and sensors to cloud-based computing and data processing.
IP (Internet Protocol)[231]	IP is a protocol, or set of rules, for routing and addressing packets of data so that they can travel across networks and arrive at the correct destination.
ISO/IEC 27000 family of standards[232]	A series of international standards that provide guidelines and best practices for information security management systems (ISMS) to ensure the confidentiality, integrity, and availability of information assets.
Know Your Customer (KYC)[233]	KYC, is a set of processes that allow banks and other financial institutions to confirm the identity of the organizations and individuals they do business with, and ensures those entities are acting legally.
Low-code-no-code (LCNC)[234]	LCNC is a software development approach empowering people with limited or no coding experience to create applications and software solutions.
Machine Learning (ML)[235]	ML is a subset of AI and computer science which focusses on using data and algorithms to imitate human learning, steadily enhancing accuracy over time.
Malware[236]	Malware, short for malicious software, refers to any intrusive software developed to steal data and damage or destroy computer systems.
Man-in-the-Middle (MITM) Attack[237]	A MITM attack is a cyberattack in which criminals exploit weak web-based protocols to insert themselves between entities in a communication channel to steal data.
Med-Pathways Language Model (PaLM) 2[238]	PaLM 2 is large language model developed by Google for advanced reasoning tasks, multilingual translation, and coding.
Metaverse[239]	The metaverse is a collective virtual 3D space, merging enhanced physical and digital realities for shared experiences.
Mixed Reality (MR)[179]	MR is an immersive computer-generated environment which combines elements of physical and virtual environment.
Mn[240]	Mn is an abbreviation, which stands for million.
Multi-Factor Authentication (MFA)[241]	MFA is a security measure that requires two or more proofs of identity, such as a password and OTP to confirm a user's authenticity.

Multi-pronged approach[242]	A strategy or plan that involves using multiple methods or approaches simultaneously to achieve a goal or address a complex issue.
Nationally Determined Contributions (NDCs)[243]	NDC is a climate action plan by the United Nations to reduce emissions and adapt to climate impacts. Each Party to the Paris Agreement is required to establish an NDC and update it every five years.
Natural language processing (NLP)[244]	NLP is a branch of AI that enables computers to comprehend, generate, and manipulate human language.
Net Promoter Score (NPS)[245]	NPS is a customer satisfaction benchmark that measures how likely a businesses' customers are to recommend the business to a friend.
Net zero emissions[246]	Net zero refer to cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance.
Neural networks[247]	Neural network in an AI method that mirrors the human brain's data processing, enabling computers to tackle complex tasks such as document summarization or facial recognition with improved accuracy.
Non-Fungible Tokens (NFTs)[248]	An NFT is a unique programmable blockchain-based digital item that publicly proves ownership of digital assets such as digital art or music, or tokenized physical assets such as houses, cars or documents.
Penetration Testing[249]	Penetration testing involves ethical hackers scaling planned attacks against a company's security infrastructure to identify security vulnerabilities that need to be patched up.
Phishing[179]	Phishing is the fraudulent practice of sending emails or other messages posing as trustworthy entities to trick individuals into sharing personal details.
Precision Agriculture[250]	Precision agriculture refers to the practice of observing, assessing impact, and strategically responding to subtle variations in elements influencing agricultural production.
Proof-of-work[251]	Proof of work is a technique used by cryptocurrencies to verify the accuracy of new transactions that are added to a blockchain.
Public Investment Fund (PIF)[252]	The PIF is the sovereign wealth fund of Saudi Arabia and is one of the world's largest sovereign wealth funds. PIF is a global and domestic investor.
Quantum Computing[253]	Quantum computing utilizes quantum mechanics to solve exceedingly complex problems that are beyond the capabilities of classical computers.
Ransomware [179]	Ransomware is a type of malicious software designed to block access to a computer system until a sum of money is paid.
Regulatory Sandboxes[254]	A regulatory sandbox is a tool for businesses to try and test new and innovative products, services, or businesses under a regulator's supervision.
Renewable Energy Solutions[255]	Renewable energy is energy produced from sources such as the sun and wind that are naturally replenished and do not run out. Renewable energy can be used for various purposes such as electricity generation, space and water heating and cooling.
RFID (radio frequency identification)[256]	RFID is an automated data collection technology that uses radio frequency waves to transfer data between a reader and a tag to identify, track, and locate items.
Saudi Green Initiative[257]	Saudi Green Initiative is an ambitious national initiative for the Kingdom of Saudi Arabia that aims to combat climate change, improve quality of life and protect the planet for future generations.
Security Patch[258]	Security patch refers to software and operating system updates that aim to fix security vulnerabilities in a program or product.
Smart contracts[259]	Smart contracts are digital contracts stored on a blockchain that are automatically executed when predetermined terms and conditions are met.
Smart Ecosystems[260]	A digital ecosystem is complex network of people, businesses, and systems that use technology to interact with one another.
Smart grids[261]	A smart grid is an electricity network that uses advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users.
Smart Sustainable City (SSC)[262]	A smart sustainable city employs ICT and various methods to enhance quality of life, urban operations, and competitiveness ensuring that it meets the needs of current and future generations' economic, social, environmental, and cultural needs.

Telemedicine [179]	Telemedicine refers to the remote diagnosis and treatment of patients by means of telecommunications technology.
Transformer model[263]	Transformer model is a neural network architecture that converts input sequences such as words in a sentence into corresponding output sequences by learning context and tracking relationships among the elements within the sequences.
United Nations Sustainable Development Goals (UN SDGs)[264]	SDGs are a set of 17 goals adopted by the United Nations which serve as a global framework for addressing pressing challenges and achieving sustainable development by 2030.
United States Dollar (USD)[265]	The USD is the official currency of the United States of America. The USD is considered a benchmark currency and is the most used currency in transactions across the world.
Vertical farming[266]	Vertical farming is the process of growing plants indoors in layers using LED lighting and controlled growing and nutrition systems.
Virtual Reality (VR)[267]	VR creates a computer-generated 3D environment that immerses users through head-mounted displays and responds to users' actions a natural way.
Voluntary Carbon Market (VCM)[268]	VCM is a decentralized market for private parties to voluntarily trade carbon credits that represent certified removals or reductions of greenhouse gases in the atmosphere mechanisms.
Web 3.0[269]	Web 3.0 is the third generation of the World Wide Web, with a vision of a decentralized and open web with greater utility for users.

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