White Paper of the

DQ Institute™
Global Standards for Digital Intelligence

on

# DIGITAL-ESG:

## NEW SUSTAINABILITY STANDARDS FOR THE DIGITAL ECONOMY

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# WHY DIGITAL-ESG?

## Open call to national and industry leaders in the digital economy

Imagine the world in 2030. What will it look like?

The digital economy already accounts for 30% of the global economy in 2022, or USD 30 trillion,[2] after the COVID-19 pandemic triggered a rapid digital transformation. And this digital transformation has already changed the reality of the world that we are living in. With the advent of the Metaverse, rapid advancements in AI, and other emerging technologies, along with the fast digitization of traditional brick and mortar companies, the physical and digital worlds are becoming more and more tightly interwoven. Most companies, if not all of them, will soon move into and operate in this multi-dimensional reality of the physical-digital world (the phygital world) and become players of the digital economy.

**What is sustainability in the phygital world?** The current UN Sustainable Development Goals (SDG) as well as environmental, social, and corporate governance (ESG) goals mainly focus on sustainability issues of Earth, such as climate change, pollution, and waste. Yet every day we hear about various ***digital-related risks*** such as phishing, online sexual abuse of children, crypto Ponzi schemes, massive customer data leaks, and more. These problems are analogous to being confronted with impure water, plastic waste, and polluted air. To sustain human society, we need to confront not only physical factors that affect humans and the planet, but digital ones as well. Moreover, the digital transformation efforts of traditional non-ICT (information and communications technology) companies often fail due to a lack of mature situational awareness and limited capacity to tap into ***digital-related opportunities***. Unless we solve sustainability issues in the digital world, achieving the 2030 UN SDG and ESG goals will be impaired.

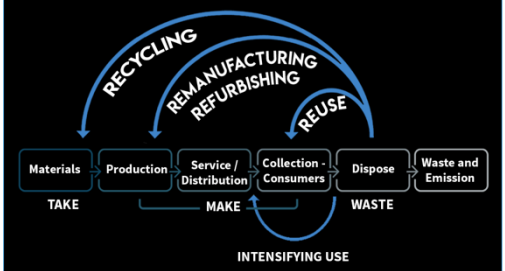
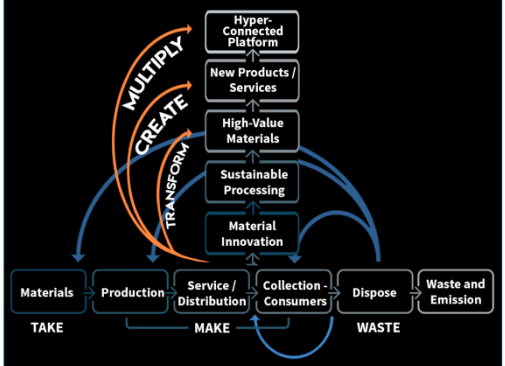
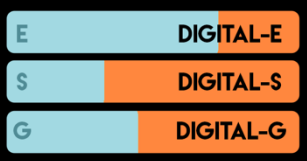
**The Digital-ESG is the ESG designed for the digital economy**—that is, the collection of economic activities that occur in this phygital world.[3, 4] This White Paper introduces the following three new concepts.

1) ***Beyond-Sustainability*:** A new concept of sustainability for the phygital world
2) **Cross Economy:** A new economic model for *Beyond-Sustainability*
3) **Digital-ESG Criteria:** A set of expanded ESG criteria for companies and investors to achieve *Beyond-Sustainability* in the phygital world through Cross Economy

Digital-ESG does not replace the existing ESG framework but rather serves as an extra layer that adapts it to the digital world and specifies its interaction with the physical world. These concepts will enable you to design a comprehensive strategy to grow priority industries and enhance digital capabilities to maximize business opportunities while mitigating digital-related risks. In particular, these concepts can benefit "traditional" companies undergoing digital transformation, helping them to reap digital-related opportunities. At the same time, they can help digital platforms and ICT companies to better manage digital-related risks.

This White Paper is a concept note that has been written to introduce you to some novel and useful ideas. But it is also an invitation to use these concepts to take the lead to create market-driven practical tools that fit your needs. As a first step, we also introduce the first version of the **Taskforce on Digital-related Financial Disclosures (TDFD) Guidelines.** It will serve as a starting point for discussion of a management disclosure framework that businesses can adopt to report and act to achieve Digital-ESG goals. We invite you to contribute to evolving the Digital-ESG concepts and frameworks and apply them in your own domain.

# DIGITAL-ESG AT A GLANCE

| | SUSTAINABILITY | BEYOND-SUSTAINABILITY |
|---|---|---|
| | Section 1: Digital Transformation | |
| **Section 2:** Worldviews | LIMITING GROWTH IN<br>  <br> | ETHICAL GROWTH IN<br>  <br> |
| **Section 3:** Supporting Economic Models | CIRCULAR ECONOMY<br>REDUCE, REUSE, RECYCLE<br>  <br> | CROSS ECONOMY<br>TRANSFORM, CREATE, MULTIPLY<br>  <br> |
| **Section 4:** Enabling Tools |  <br> |  <br> |
| **Section 5:** Action Guidelines | • TCFD (Task Force on Climate-related Financial Disclosures) | • TDFD (Taskforce on Digital-related Financial Disclosures) |

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# THE COMPANIES OF THE DIGITAL ECONOMY

## Definition of the Digital Economy

The "digital economy" is no longer an area dominated by information and communications technology (ICT) companies or digital platforms such as MAANG - Meta, Amazon, Apple, Netflix, and Google.[5] We adopt the common definition of "digital economy" that was proposed in the OECD and G20 report,[6] so that we can develop consistent measurements for the Digital-ESG for businesses. The digital economy can be understood as the sum of values added by producers and providers within the following tiers:

- **Core:** Economic activity of businesses that specialize in ICT goods and ICT information services;
- **Narrow:** Economic activity of businesses that rely on digital inputs, including digital technologies, digital infrastructure, digital services and data;
- **Broad*:** Economic activity of businesses significantly enhanced by digital inputs ; and
- **Digital Society:** Other activities that rely on or are significantly enhanced by digital inputs

* Following an international consensus, we will define the digital economy as a *broad* concept throughout this White Paper. This *broad* definition of digital economy is especially relevant to the post-COVID-19 era, where digital transformation takes places quickly in every sector worldwide.

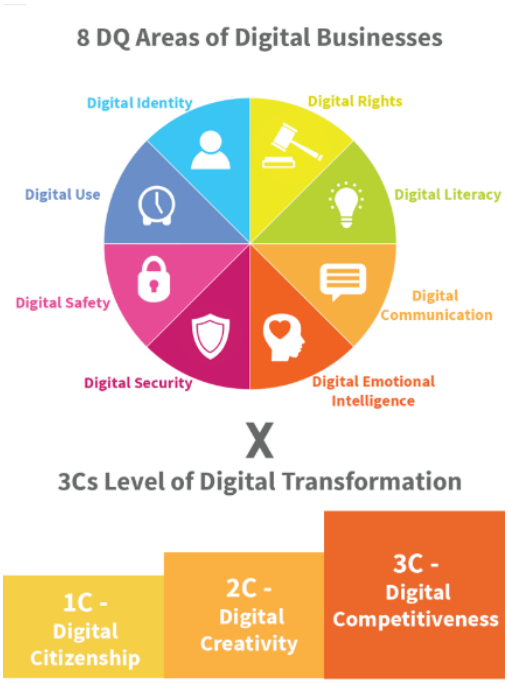
## 3Cs Classification: Companies' Degrees of Digital Transformation

*Digital transformation is a strategy to enable business innovation by incorporating digital and other technologies into an organization's operations, products, and solutions as well as interactions with vendors, customers, and other stakeholders.*

Digital transformation impacts all sectors, from finance, healthcare, education, employment, manufacturing, and trade to energy, agriculture, culture, and tourism. In alignment with the IEEE DQ Global Standards[7] (Figure 1), we classified industries into three groups according to the degree of their digital transformation in Figure 2. The 3Cs are digital citizenship, digital creativity, and digital competitiveness; each of these categories is associated with a specific digital transformation.

### Digital Intelligence (DQ)[1]:

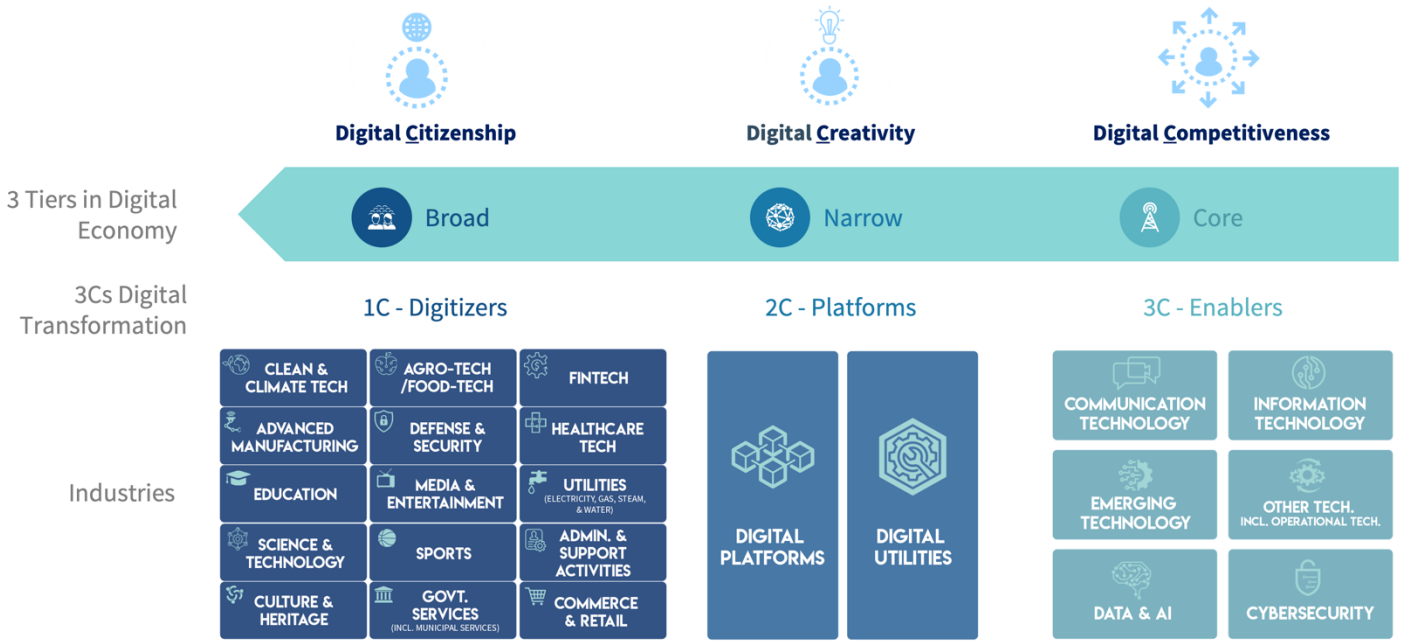
**Figure1: DQ Framework for Companies**




*The Digital Intelligence (DQ), a comprehensive set of digital competencies, is the global standards for digital literacy, digital skills, and digital readiness (IEEE DQ Global Standards [3527.1™]). It was originally developed for individuals' digital competency building. The underlying structure of the IEEE DQ Global Standards has been extended to the level of the digital capacities of companies, as well as those of nations.*

*The framework explains the digital competencies of companies across two dimensions – 3Cs Level of Digital transformation that are applied to industry classification and 8 Areas of Digital businesses that are applied to Digital-ESG topics.*

**Figure 2: 3Cs industry classification based on companies' degree of digital transformation**




- **1C – Digitizers:** Companies that digitize their products, services, and brands.
- **2C – Platforms:** Companies that provide or participate in a platform in the digital ecosystem to create, distribute, and consume content, applications, and services. Platform companies include digital intermediary platforms, digital services, and sharing economy platforms as well as digital utilities. Super-platform companies integrate several platforms into one integrated service. An example of a super platform is a virtual assistant that incorporates shopping, payment, transportation, and communication services into one user-friendly feature.
- **3C – Enablers:** Companies that provide physical infrastructure systems and networks for connectivity that enable digital ecosystems. Enabler companies include hardware, software, and services in telecommunications, emerging technologies, data and AI, cybersecurity, and operational technologies.

The digital-related risks and opportunities can be generally grouped according to these digital transfo rmations, namely whether a company is a digitizer, platform, or enabler. The 3Cs industry classificatio n helps companies navigate their risk management and strategic planning for digital-related opportu nities specific to their industry.

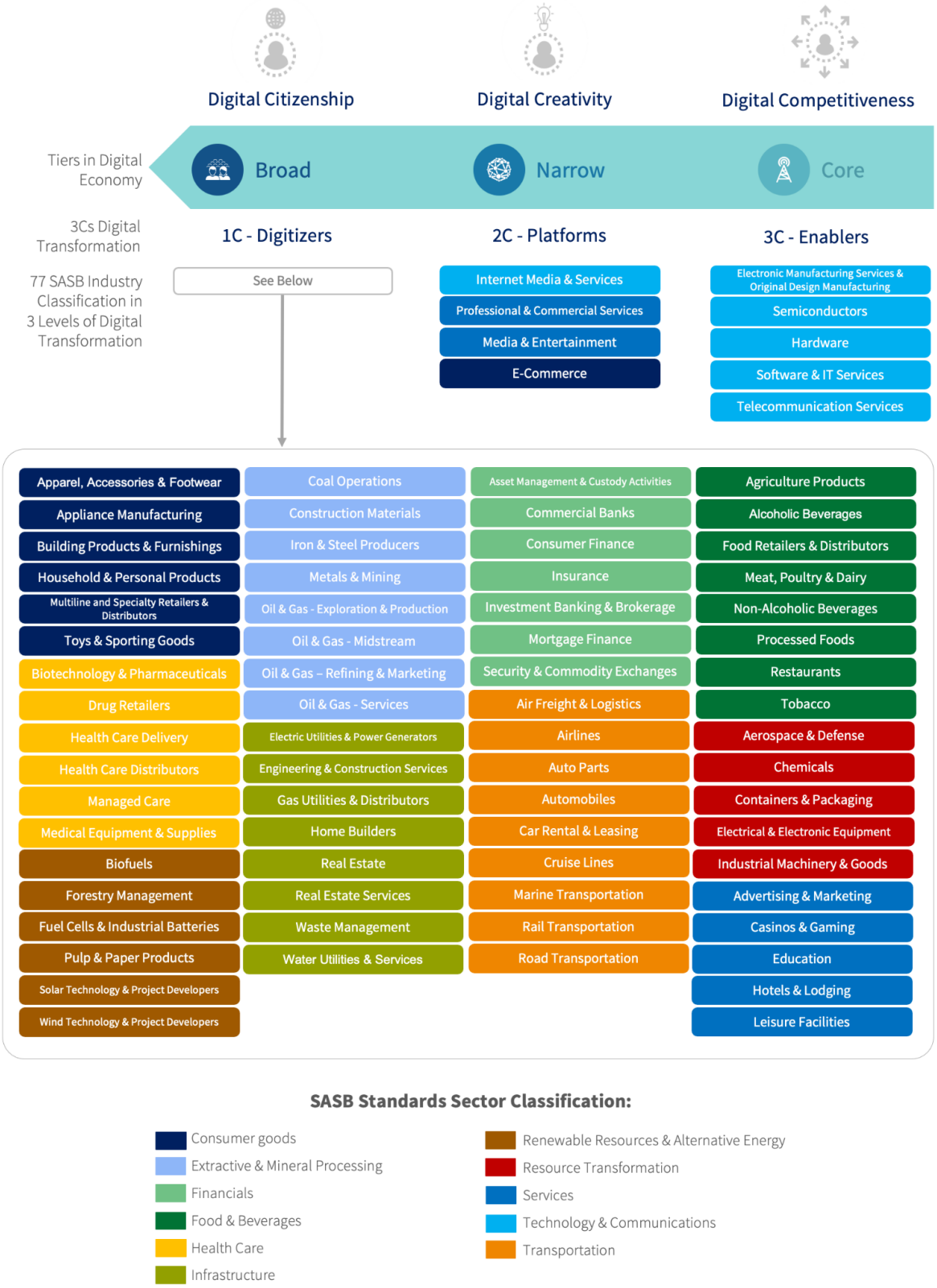
## 3Cs and SASB Industry Classification

The Sustainability Accounting Standards Board (SASB) Standards is an international standard to guide the disclosure of financially material sustainability information by companies to their investors. Broadly, the SASB groups 77 industries into the following 11 sectors: technology and communications,

services, consumer goods, extractives and minerals processing, financials, food and beverage, healthcare, infrastructure, renewable resources and alternative energy, resource transformation, and transportation.

Every business listed in 77 industries of the SASB Standards[8] can be re-categorized into 3Cs industry classification according to its level of digital transformation. Figure 3 shows how the 77 industry classifications[9] can be transformed using the 3Cs model. You can find where a company lies in terms of SASB Industry Classification as well as in terms of the 3Cs industry classification.

**Figure 3: 77 SASB Industry Classification to the 3Cs Model of Digital Transformation**



# WHY BEYOND-SUSTAINABILITY?

With digital transformation, we understand that *every* company is operating, or soon will operate, not only in the physical world, but also in the digital world and be part of the digital economy. Now, the question is how we define *sustainability* in the context of the digital economy. In this section, we will first examine the concept of *sustainability* in the physical world before discussing to what extent the concept of earthly *sustainability* is relevant to the digital world as well as to the phygital world where the physical and digital worlds are intertwined.

## Sustainability of the Physical World

What is *sustainability*? The concept of sustainability has been developed over many years. However, it appealed to the public in the 1970s due to concerns about the state of the earth's environment. The UN embraced the concept in 1972 at the UN Conference on the Human Environment.[10]

One of the early concepts of *sustainability* originated with the concept of "Spaceship Earth," coined by Kenneth Boulding and Buckminster Fuller in the late 1960s.[11, 12] It brought a fundamental change in perspective from the one that was originally assumed in economics—that of the Earth having an endless supply of natural resources available to a manageable population of humankind—to one where we have to live within the boundaries and limits of the planet.[13] Such a transition in the economic

view of the Earth from an open system to a closed system emphasized the importance of a "state of global equilibrium" through deliberately controlled growth.[14]

Now, we need to ask ourselves: "Does this economic view of the world as a closed system still hold true in the digital world and phygital world of the 21st century and beyond?" The answer is "No". The closed system view of the physical world simply cannot be applied to the digital world.

## Sustainability in the Digital World

What is the digital world?

Here, we define the digital world[15] as an integrated and interconnected virtual environment for individuals to interact with it and each other. It is:

- connected seamlessly across devices, content, applications, and services, and other immersive technologies;
- created by various digital ecosystems provided by interdependent companies jointly delivering integrated products and services; and
- enabled through internet and mobile networks and connectivity infrastructure systems.

Then, what is sustainability in the digital world (*digital sustainability*)?

Much of today's discussion on digital sustainability has been mere applications of earthly sustainability issues, using digital tools or an extension of corporate social responsibilities of ICT companies. However, this is not appropriate as the nature of the digital world is fundamentally different from that of the physical world. Thus, the concept of sustainability and the approaches needed to achieve it in the digital world are bound to be very different from those of the physical world. To understand *digital sustainability*, we highlight the different nature of the digital world and its sustainability issues.

### Distinct Characteristics of the Digital World

#### 1. An Ever-Evolving Built Environment

The biggest distinction between the digital world and the physical world is that the digital world is not a closed system. Because it is artificial and is constantly evolving and being disrupted—thanks to competition and new innovations—it is an open system. When technological disruption occurs, it is like an old world disappears and a new one is created at the same time. And this transformation can render obsolete business models, policies, and regulations designed for the old world.

Today's Internet is called Web 2.0—the dynamic, interactive digital world represented by social media, e-commerce, and online platforms. The Metaverse and Web 3.0 are considered the next generation of

the Internet. They leverage machine learning, AI, 3D graphics, virtual and augmented realities (XR), and blockchain to make the internet augment and enhance real-life human communication, making it more decentralized, with greater utility for users. Compared to Web 2.0, Web 3.0 demands more transparency, decentralized ownership, and highly user-centric approaches to business.

As Web 3.0 develops, we expect to see significant changes in the laws and regulations governing the internet, especially related to intellectual property, privacy, and AI. When it comes to a decentralized internet, new questions are bound to arise, such as who owns data, how and to whom individual laws are applied, and whether this new internet can or should become a jurisdiction of its own. Existing legal frameworks may apply in some cases, but in other cases, existing laws and regulations focused on centralized accountability for data protection, management, and technical problem-solving will prove insufficient or unsuitable in the context of Web 3.0.[16]

**2. Dynamic and Proliferating Stakeholders**

The value chain of the digital ecosystem cannot be as static or linear as that of traditional businesses. Such dynamics bring new value propositions, but at the same time, new threats to companies. For instance, super platforms typically have at least ten million partners across at least ten different industries, interacting with them in dynamic ways.[17] Moreover, the roles and responsibilities of stakeholders in value chains can also dynamically change. For instance, Web 3.0 allows any end user, including children, to be creators of content or technology, or a contractual vendor of a company. For example, Roblox is a global platform valued at USD 20 billion, and users—almost half of whom are aged 13 and under—are both a labor source and target consumers. On the other hand, even a volunteer or intern can easily make a company vulnerable to a cybersecurity threat, simply by clicking a link in a phishing email.

**3. Conflicting Interests of Human-Machine Interactions**

"Data is the new oil"—this is a controversial statement that illustrates the conflicting interests of the different entities that maintain the digital world. Oil can be a commodity as well as an asset, whereas data relates to privacy—a fundamental human right of companies' end-customers. Let's consider a personalized targeted service for end users using AI and advanced analytics. From the human perspective, AI exists to serve human purposes—enhanced convenience fitting to their individual needs—but from the AI perspective, humans are not just an entity to serve but are a convenient feeding source for data and information from whom consent can frequently be unwittingly obtained or coerced.[18]

## Universal Moral Values

***"Technology is nothing more than the collective soul of those who build it."***
***- Tracy Kidder[19]***

The digital world is made by and for people, and every issue that arises within the digital world is about people. The sustainability issues of the digital world—privacy, security, safety, trust, and AI ethics, to name a few—thus have been centered on human values and integrity that impact individuals and societal wellbeing. Therefore, the fundamental principles of digital sustainability lie in universal moral values. Similar to the approach of the UN SDG, we recommend adopting the underlying values of the UN Universal Declaration of Human Rights[20] as the guiding moral principle. It starts from agreement on this simple statement: every human being has intrinsic worth. Thus, every individual needs to be respected with dignity, regardless of gender, religion, region, culture, or ideology.

For the digital world to be sustainable, its creators need to act ethically. In other words, the scientists, technologists, and industry and government leaders participating in the development of emerging technology and construction of the digital world need to act ethically. Do they follow the ethics of the medical profession, which is 'First, do no harm'? They need to be able to intelligently navigate the promise and perils of innovation and resulting societal impacts when creating technology. They need to also adjust, or even curtail, its development if the innovation leads to undermining the common good.

***"I advocate for a more deliberative, responsible, and careful process in the development and deployment of innovative technologies. A cavalier attitude toward the adoption of technologies whose social impact will be far-reaching and certain is the sign of a culture that has lost its way."***
***- Wendell Wallach[21]***

In addition, technology development and deployment processes need to be transparent and accountable. There must also be governance committees with multi-stakeholders, including regulatory agencies, that can provide a flexible, adaptive, and comprehensive mechanism for the oversight and management of emerging research and technological innovation.

Most importantly, it is not only the ethics of creators that matters, but also the ethics of every end-customer. Given the hyperconnected nature of the digital world, the individuals as the end-customers of digital businesses are not only contributors of the digital world but also feeders of data, which form the core digital infrastructure. Thus, one of the most important human skills today is digital citizenship skills that enable individuals to use, create, and control technology in an ethical way. Nations should build a lifelong learning process that starts from equipping every citizen with digital citizenship to nurturing digital technology experts, rooted in technology ethics.

## Sustainability of the Phygital World

During the COVID-19 pandemic, we experienced an accelerating integration of the physical and digital worlds. The way people live and interact with each other has probably permanently changed, now regularly including virtual meetings, digital communication, and online banking and shopping. Yet this is only a fraction of what a true phygital world will look like.

One of the key technologies for the future of the digital world and the convergence of all things physical and digital is the Metaverse. The Metaverse is essentially a virtual version of the real world that not only mimics and mirrors aspects of the physical world in all its three-dimensional complexity but also extends it to allow the users to experience more than what the physical world can offer. Businesses have already started to use the Metaverse to supplement their activities in the physical world: banking systems, real estate, fashion, music, and sports, as well as marketing, sales, and customer support. We expect to see a significant change in the social dynamics of people, businesses, and governments in the Metaverse.

*The Metaverse is defined as an interconnected environment where social and economic elements mirror reality and users can interact with it and one another simultaneously across devices while engaging with digital assets and using various digital identities.*[15]

What will the phygital world in 2030 look like? Some technology billionaires suggest that the promise of the Metaverse and XR is the ability to virtually create the world that people want, even as the Earth and its inhabitants quickly deteriorate due to climate issues, economic inequality, and a spate of pandemics and disasters.[22] How will interactions between the physical world and the digital world evolve? Despite many predictions—technological utopias and dystopias, the Singularity, etc.—nobody really knows. But that is good news. We still have the power to create the future we want.

Again, the concept of sustainability in the physical world starts from the economic view of the Earth as a closed system with limited resources. Now, the economic view of the phygital world system[23] needs to be updated. The digital world creates a virtual reality that is not limited to the finite physical world. In theory, by combining the digital and physical worlds, the phygital world opens up the possibility of creating new multi-dimensional realities with unlimited transformed resources through technology. For instance, what kind of new multi-dimensional realities will be presented to humankind when space technology, CERN technology,[24] bio-neuro-nano-technology, and quantum computing becomes fully developed, commercialized, and converged? We do not yet fully understand. Thus, it is urgent to define *beyond-sustainability* in the context of the phygital world that goes beyond physical and digital sustainability alone. Otherwise, we run the risk of creating a phygital world that is unsustainable. The *beyond-sustainability* needs to be defined to direct us to create the future-we-want.

Given that technology is a key enabler to build the phygital world, the fundamental principles of *beyond-sustainability* also directly relate to the creators' ethical values, as noted in the earlier section on digital sustainability. Specifically, technology should be designed to achieve the common good of supporting earthly sustainability and enhancing human wellbeing, and at the same time, facilitating new resource creation and promoting economic growth.

Thus, we define the ***beyond-sustainability*** that we aim to achieve in the phygital world as using technology to create economic prosperity at the same time to enhance sustainability and wellbeing.

However, in order to achieve this, we need to use technology ethically. In a business context, we need to achieve "ethical growth". Ethical growth is a continuous process in which a company enhances its profitability and market performance while reducing and/or removing negative impacts on societal and environmental resources and human wellbeing; it does this in the course of its commercial activities by deliberately designing and using technology from an ethical perspective. See Figure 4 for comparison of the physical, digital and phygital worlds on several variables.

**Figure 4: Sustainability of the Physical, Digital, and Phygital Worlds**


| | | | |
|---|---|---|---|
| WORLDVIEW | • Closed system | • Virtual system | • Multi-dimensional system |
| RESOURCES | • Finite earthly resources | • Unlimited digital resources | • Unlimited transformed resources |
| SUSTAINABILITY PRINCIPLE | • Limiting growth attaining equilibrium | • Universal moral values attaining human wellbeing | • Ethical growth attaining sustainability and wellbeing |

Many people may perceive that there is a tension between a company acting ethically and being profitable. The conventional business goal has been maximizing shareholder interests (shareholder capitalism). By and large, companies have pursued maximum profit with lesser focus on the negative consequences their businesses may generate, including environmental damage and social injustice. They may consider corporate social responsibility (CSR) or ESG activities as peripheral approaches driven by compliance. However, ethical growth is practical and achievable. The academic research behind the economics of mutuality[25] is a good example. It has demonstrated that companies can perform better when they adopt a fair and purposeful form of capitalism than operating with today's purely financial version.

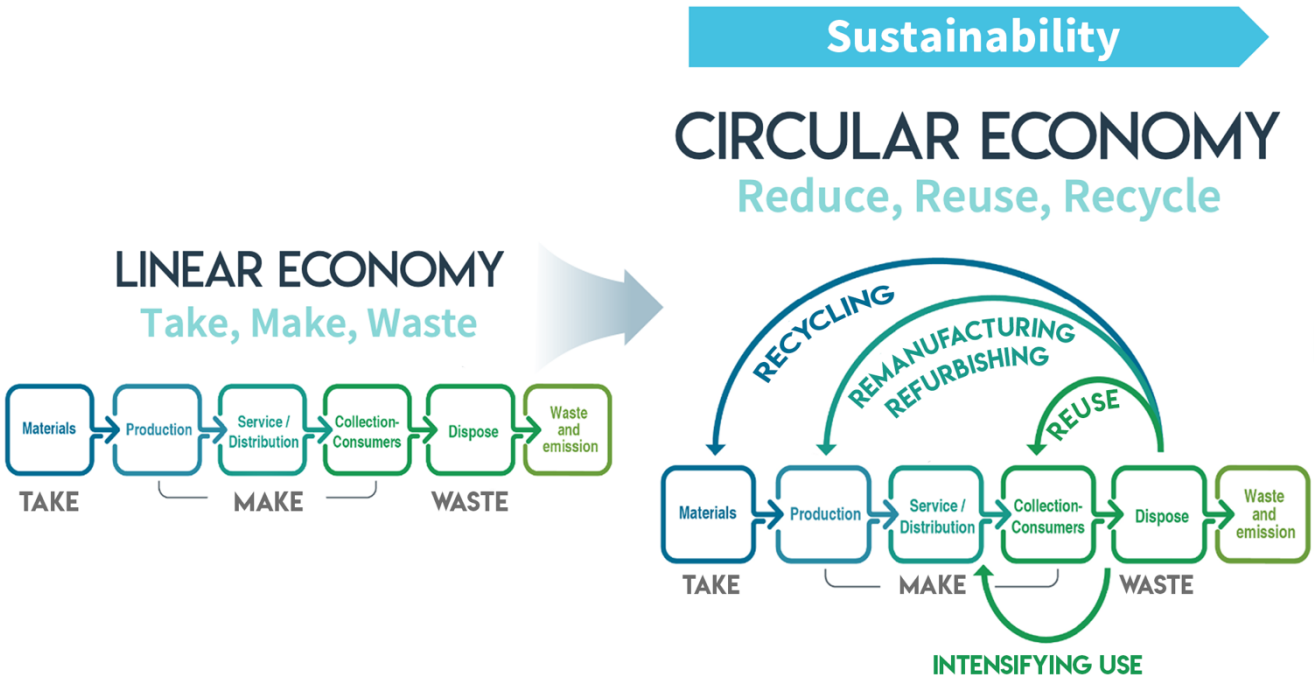
In the next section, we will introduce a new economic model, called the cross economy, that promotes the goals of *beyond-sustainability* - ethical growth that enhances prosperity, sustainability, and wellbeing through technological innovations.

# WHY "CROSS ECONOMY"?

## Limitations of Circular Economy

To achieve *sustainability* goals, businesses have strived to find ways to avoid waste and pollution by turning to recycling and greater resource efficiency, moving away from the traditional linear economy to the circular economy as shown in Figure 5. In the circular economy, the manufacturing and consumption stages focus on sustainable practices to minimize overuse of materials and recycle product materials rather than discard them as waste.[26, 27] Furthermore, manufacturing processes are ideally developed to minimize energy consumption.[28]

**Figure 5: Visualization of the Linear- vs. Circular- Economy Concepts**



Nevertheless, the circular economy model is still not perfectly poised to achieve the goals of *beyond-sustainability*. Let's examine a series of challenges associated with it.

First, there are limitations placed on repeated recyclability and material durability along with continuing overconsumption of materials.[29-31] Only a fraction of materials is recycled, and hence the problem of large-scale waste, for example plastics, persists.

Second, global inclusivity of circular economy is challenged, and its adoption rate has been naturally varying across advanced and growing economies. The circular economy transition from the linear economy requires a concerted effort by policymakers, businesses, and consumers at the national, regional and global levels.[34] Especially for businesses, the technology and infrastructure transformation towards a circular economy involves significant capital investment and can be energy intensive.[35] It also requires manpower expertise to efficiently lead and manage the transformation process. Hence, businesses may perceive such move to be counterproductive or even impractical as they view environmental sustainability and economic growth to be conflicting.[36]

As a result, advanced economies (i.e., global north countries) have greater capacity to support the transition, especially in terms of financing the technology and infrastructure transformation. They are also in a better position to sustain it in the long run through the establishment of a comprehensive research ecosystem aimed at continually developing novel technologies through close collaborations between the government, academia, and industry. In contrast, growing or emerging market economies (i.e., global south countries) prioritize economic growth and heavily rely on industrial and manufacturing activities (i.e., the 'make' phase of the linear economy) as well as high levels of product consumption as primary drivers of their economy. Hence, the transition towards circular economy is not only disruptive but unrealistic especially considering the significant amount of capital investment that needs to be set aside to realize the technology and infrastructure transformation.[36, 37]

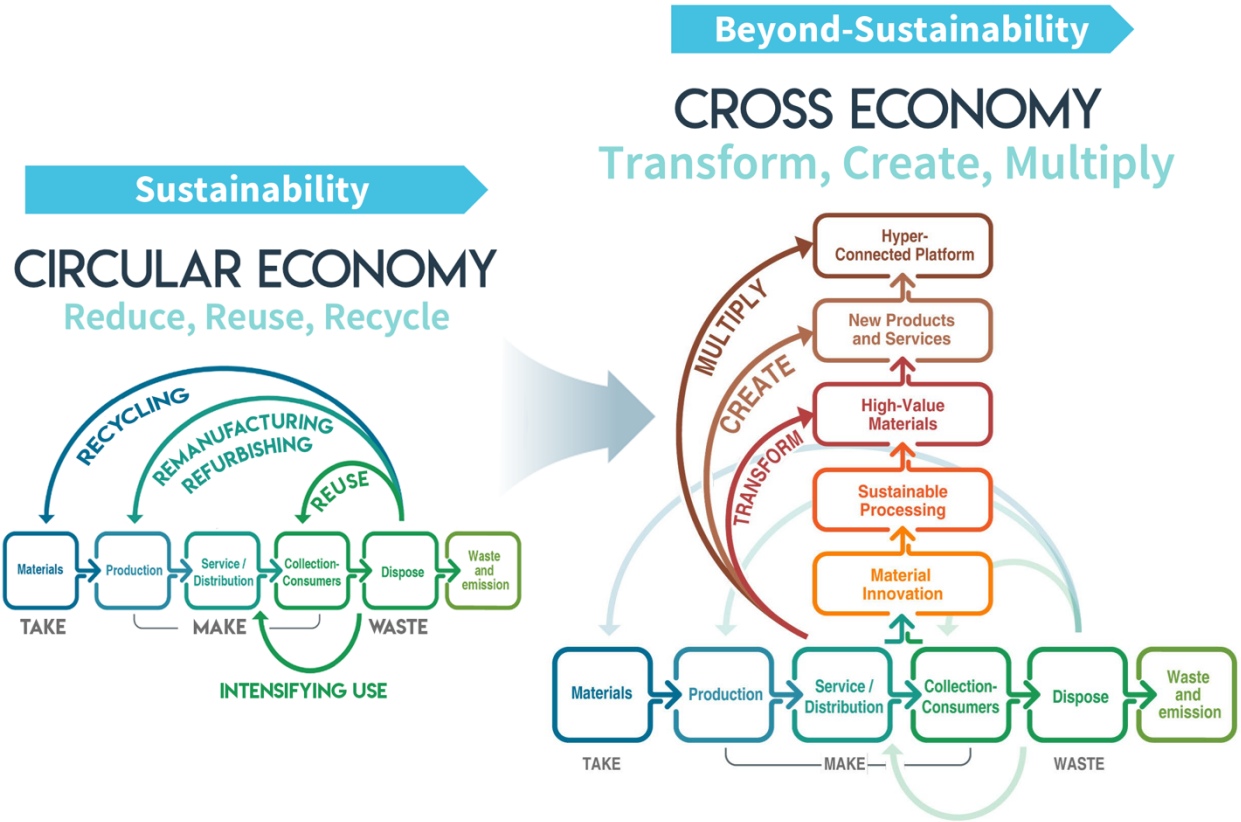
Moreover, the system-views of the world that underlie the paradigms of both linear and circular economies are inadequate for promoting *beyond-sustainability*. The catchphrase for the circular economy, "Reduce, Reuse, Recycle", reflects a global business management model demanded by an economic view of the Earth as a closed system with planetary boundaries and limited resources. The catchphrase for linear economy, "Take, Make, Waste", on the other hand reflects an old economic view of the Earth as an open system with an endless supply of natural resources. As noted in the previous section, in the context of the phygital world, the nature of the system-view has changed. The digital world and technology have opened up new realities for growth potential across industries while protecting the sustainability of the physical world. Such a fundamental shift in worldview arising from digital transformation demands a paradigm shift in a supporting economic model in order to overcome these challenges.[32, 33]

## Cross Economy, *beyond* Circular Economy

What is an overarching economic model for businesses to achieve *beyond-sustainability*? In this section, we introduce a new concept called the ***cross economy*** that addresses some of the shortcomings of the circular economy and is better adapted to realizing *beyond-sustainability*.

The *cross economy*, a term originally coined by Nam-Joon Cho and Yuhyun Park, describes an economic model that meets the demands of the phygital world, with the catchphrase: "Transform, Create, Multiply."[38] The key idea is not simply to recycle, but rather to create something new based on waste or other resources that are not considered to have value.

**Figure 6: Visualization of the Circular- vs. Cross Economy Concepts**




More precisely, the cross economy concept described in Figure 6 posits a process in which a company strives to:

- Transform the fundamental nature of materials, such as by transforming "waste" into high-value materials;
- Create new products, services, and value propositions from these transformed materials; and
- Multiply wealth by using new hyperconnected platforms to scale-up businesses.

The concept of the cross economy presents a fresh approach to support materials innovation through a sustainability lens by reimagining what is possible to achieve with so-called "waste" materials. Rather than recycling waste materials based on the circular economy, the cross economy approach focuses on transforming waste into high-value materials through technology. In addition to waste materials, this same approach applies to other neglected materials that are not considered to have economic value.

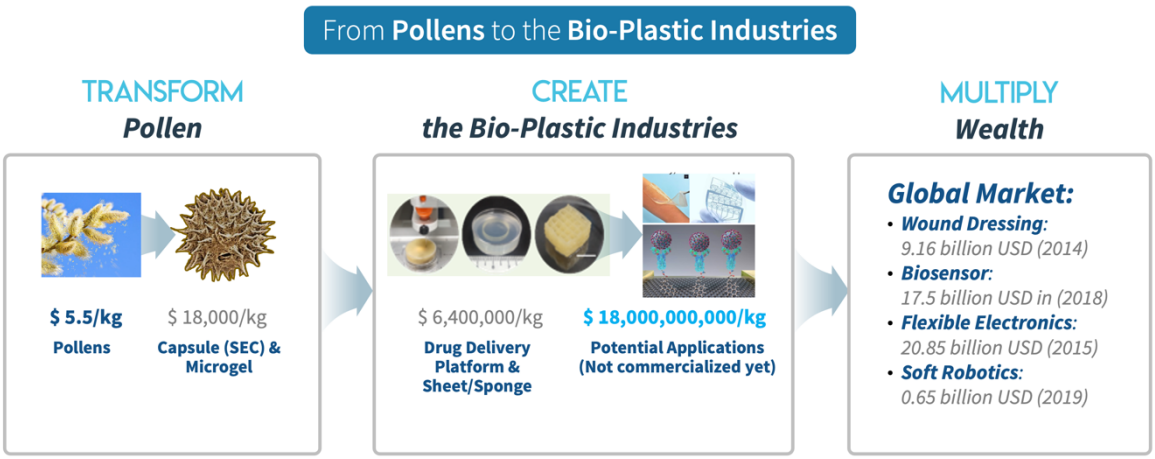
This approach is grounded in utilizing fundamental science and engineering principles based on material innovation and sustainable processing combined with digital technology to construct more harmonious and prosperous ecosystems and networks.

## Cross-Dimensional Technologies

Transformation of no- or low-value physical materials or resources into new high-value products or services through cross-dimensional technologies is a key concept of the cross economy. By "cross-dimensional technologies" we mean the technologies that pave the way for the creation of a new vertical value chain (either based on an existing value chain or an entirely new one) for new products and services that are completely different from the horizontal existing value chain for the original materials/products. One example is the transformation of quartz sand into single-crystalline silicon wafers. This process paved the way to produce microchips for electronic devices, which effectively led to the realization of the ICT industry.

Thus, an important aspect of cross-dimensional technology is **material transformation**. The central idea of material transformation is that raw materials, including waste and discarded items, are transformed using **sustainable processing** methods into products with high economic value (i.e. high value products). Such items are not simply inputs to be returned to the original manufacturing process but provide the basis for the creation of new, innovative materials. Sustainable processing is a set of affordable and traditionally adopted processing technologies such as $CO_2$/emission reduction, energy/material efficiency, and material/fuel substitution.[39]

**Figure 7: Material Transformation of Pollen**




A good example of material transformation is demonstrated by the raw plant pollen in Figure 7. It is naturally produced in excessive quantities to ensure plant reproduction and has been considered merely as an allergen and biological waste that does not bring any economic or societal benefit. By subjecting it to material transformation with sustainable processing, pollen can turn into different forms of material building blocks, including microgel, paper, sponge, and bioplastics.[40] These novel building blocks turn into eco-friendly, high-value material innovations that can replace a synthetic class of polymers and realize hyperscale market opportunities across various traditional and emerging applications.[41]

**Digital technologies**[42] such as cloud computing, big data, autonomous intelligent machines, mobile apps, artificial intelligence (AI), machine learning (ML), Internet of Things (IoT), XR, blockchain, and

others are intrinsically cross-dimensional technologies. They transform physical business activities into digital activities and significantly reduce the use of earthly resources.[43] Meanwhile, the deployment of digital technology makes possible new, digitally enabled products and services with improved quality and enables optimal resource allocation, resulting in faster processing times, improved learner operations, and better customer satisfaction. By tapping into real-time interactive data, digital technologies can facilitate coherent and seamless integration of customers, partners, employees, suppliers, and external entities across value chains. Such integration creates new value greater than the sum of its parts.

The combination of these cross-dimensional technologies—such as material transformation, sustainable processing, and digital technology—promises great growth, especially in the following industries: energy/clean-tech, health-tech, agro-tech, and advanced industry manufacturing tech, all of which have been classified as 1C—Digitizers.

For instance, eggshells are typically abandoned in a food market. However, they can be further processed to yield raw fatty acids or lipid building blocks,[44] which can be a valuable resource for other industries such as those involved in cosmetics or pharmaceuticals. Further purification and sustainable processing (e.g. self-assembly) of these lipid materials can also yield building blocks for manufacturing advanced nanomedicines, such as next-generation cancer treatments and lipid nanoparticles for nucleic acid-based vaccine delivery. Clearly, the transformation of raw eggs to self-assembled lipids and lipid-based vaccine carriers creates enormous value addition at every step. Within this context, it is also worthy to note that the combination of sustainable processing methods with computational simulations aided by digital tools promote sustainable production via two routes. Firstly, it enables efficient optimization of the drug design parameters (e.g. related to composition and nanoscale architecture) to produce highly potent drugs with minimal amount of raw materials. Secondly, AI-based digital tools can also be used to perform big data analytics to quantitatively anticipate the demand for the drug in real time and optimize its production output in a coordinated fashion. Taken together, this will shorten the time for drug development as well as reduce material wastage at different stages of the drug's life cycle. These innovations represent broadly useful platform technologies applicable to a wide range of application needs, such as neurological disease, cancer, infectious diseases, and genetic disorders.

## Business Growth Potential

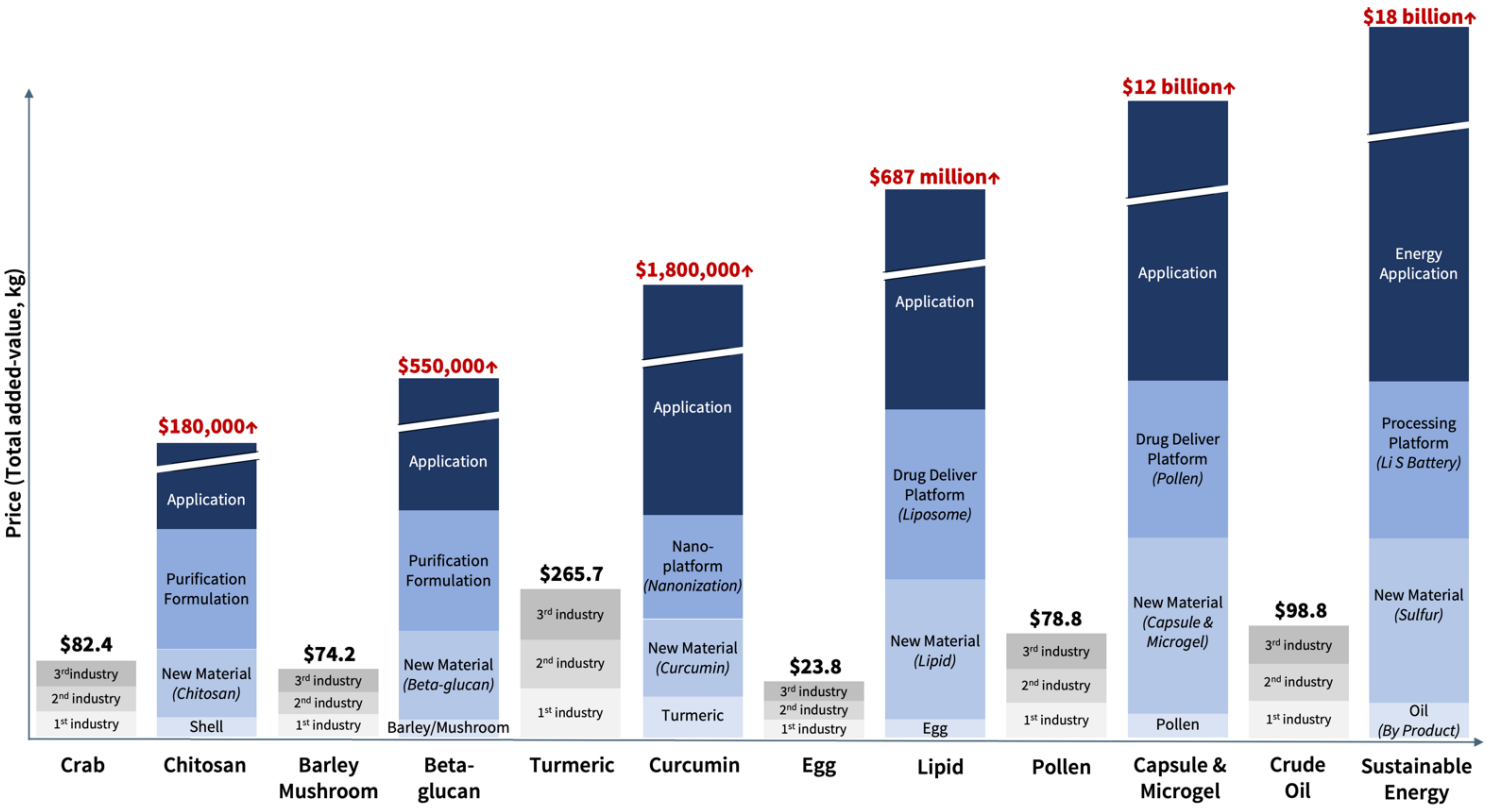
Figure 8 illustrates some business applications of the cross economy. It shows the value chains of new product development based on the transformation of some exemplary raw materials in the agro-/clean-tech industries into high-value products. It also provides the comparison between the market values that can be generated from the transformed materials and resulting high-value products versus that obtained by the sales of the raw materials. For instance, the aforementioned example of eggs-turned-nanomedicine materials demonstrates hyperscale market opportunities whereby they can be manufactured and introduced to the market through various distribution channels. Such an approach

can lead to significant multiplications of wealth (e.g. some 29 million times the value compared to the value creation through the sales of eggs).

It should be also noted that the focus industry does not need to be at the end of the value chain: the economic benefits of value creation can be garnered at every step of the value chain. It will be a strategic decision based on one's priority industries as to how the business should plan to realize the cross economy.

Crucially, these business opportunities of the cross economy promote the goals of *beyond-sustainability* – ethical growth that enhances prosperity, sustainability, and wellbeing through technology innovation.

**Figure 8: Market value comparison across the value chain of new product development for the transformation of raw materials into high-value goods.**




The cross economy concept represents a new vision for *beyond-sustainability*, to not only create what we need but also to imagine what is possible. Now, we need practical tools for business and investor communities to adopt the cross economy concept; we need to develop ways that a company can successfully implement the cross economy concept as part of their digital transformation, as well as ways that investors can evaluate a company's digital capabilities to implement the cross economy and its potential, resilience, and vulnerabilities amid the digital transformation. In the next section, we will introduce the Digital-ESG criteria, similar to the ESG criteria, that aim to support companies to mitigate digital-related risks and maximize digital-related opportunities to achieve *beyond-sustainability*.

# DIGITAL-ESG FRAMEWORK

The Digital-ESG framework (DESG) is designed to serve the digital economy. Through the concept of the cross economy, Digital-ESG also aims to provide criteria that business and investment communities need to consider enhancing *beyond-sustainability* in the phygital world.

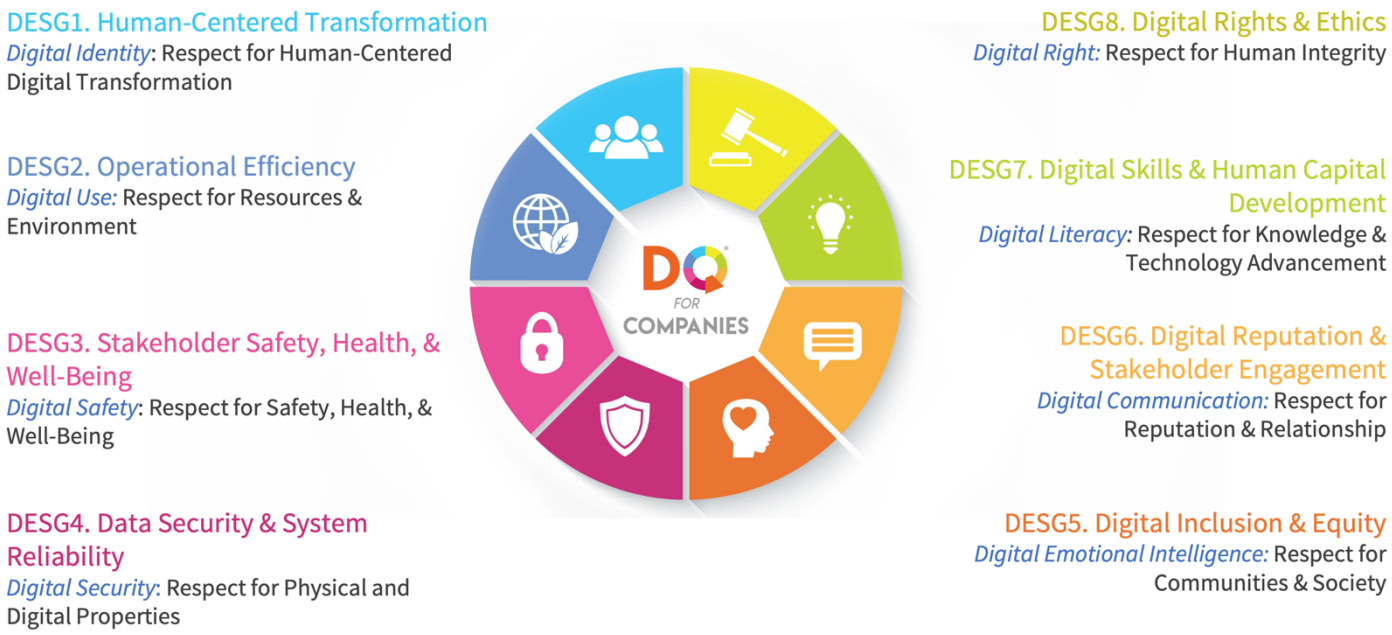
It is important to note that Digital-ESG is not designed to replace the existing ESG framework, but to serve as an extra layer on it. Although commonly adopted ESG frameworks and standards such as the Sustainability Accounting Standards Board (SASB),[45] Global Reporting Initiative (GRI),[46] and Task Force on Climate-related Financial Disclosures (TCFD),[47] have advanced the environmental agenda, there have been concerns raised about the following points: 1) their guidelines are in general risk-focused and downplay the opportunities that can potentially be created by industries; 2) their guidelines along the social and governance dimensions may not be universally applicable due to cultural differences across different regions and cultures, and 3) their guidelines on the disclosure of social and business risks related to the world's rapid digital transformation remain inadequate.

Digital-ESG aims to compensate for those areas where ESG falls short—especially in managing 1) *digital-related risks* with greater focuses on the social (S) and governance (G) dimensions and 2) *digital-related opportunities* through cross-dimensional technologies to enhance environmental sustainability (E). Considering that all digital- and technological-related matters are universal in nature, the enhancement of S and G dimensions with digital-related risks add values to the current ESG Framework with less controversial, culture-neutral, and more objective standards for businesses.

## Eight Digital-ESG Criteria for *Beyond-Sustainability*

Aligned with the IEEE DQ Global Standards (IEEE 3527.1 ™) with 8 DQ areas, and with guiding moral principles based on the UN *Universal Declaration of Human Rights*,[20] the Digital-ESG framework (Figure 9 and Table 1) outlines the following eight criteria that companies can follow to achieve *beyond-sustainability*.

**Figure 9: Digital-ESG Criteria based on DQ Framework**




Each criterion also corresponds to one of the three components of Digital-ESG:

- **Digital-E** stands for a company's impact on environmental sustainability issues through its digital economic activities
- **Digital-S** refers to the personal, interpersonal, and social impact of a company's digital economic activities
- **Digital-G** constitutes a set of principles defining the rights, responsibilities, and expectations of stakeholders in the governance of a company's digital economic activities

**Table 1: Digital-ESG Criteria based on DQ Framework**

| DQ Area and Guiding Principle | Digital-ESG Criterion | Description | Type |
|---|---|---|---|
| **Digital Identity:** Respect for Human-Centered Digital Transformation | DESG1. Human-Centered Transformation | Company integrates innovative cross-dimensional technologies (e.g. digital technology, material transformation) in a responsible manner | Digital-G |
| **Digital Use:** Respect for Resources and Environment | DESG2. Operational Efficiency | Company achieves operational efficiency through technology while considering environmental sustainability and healthy human-machine relationships | Digital-E |
| **Digital Safety:** Respect for Safety, Health, and Wellbeing | DESG3. Stakeholder Safety, Health, & Well-being | Company considers the health, safety, and wellbeing of all stakeholders when using technology | Digital-S |
| **Digital Security:** Respect for Physical and Digital Property | DESG4. Data Security & System Reliability | Company ensures digital security and the reliability of its data, systems, and networks | Digital-G |
| **Digital Emotional Intelligence:** Respect for Communities and Society | DESG5. Digital Inclusion & Equity | Company integrates values of social responsibility in its implementation of technology | Digital-S |
| **Digital Communication:** Respect for Reputations and Relationships | DESG6. Digital Reputation & Stakeholder Engagement | Company ensures responsible digital communication and stakeholder engagement across value chains | Digital-G |
| **Digital Literacy:** Respect for Knowledge and Technological Advancement | DESG7. Digital Skills & Human Capital Development | Company empowers its workforce with digital literacy and skills based on strategic human capital development | Digital-S |
| **Digital Rights:** Respect for Human Integrity | DESG8. Digital Rights & Ethics | Company responsibly upholds the digital human rights and ethics of all stakeholders | Digital-G |

## Digital-Related Risks and Opportunities

The phygital world is full of new opportunities and new risks, both for businesses and consumers. *Beyond-sustainability* demands greater levels of digital intelligence for responsible businesses to manage and act on digital-related risks and opportunities.

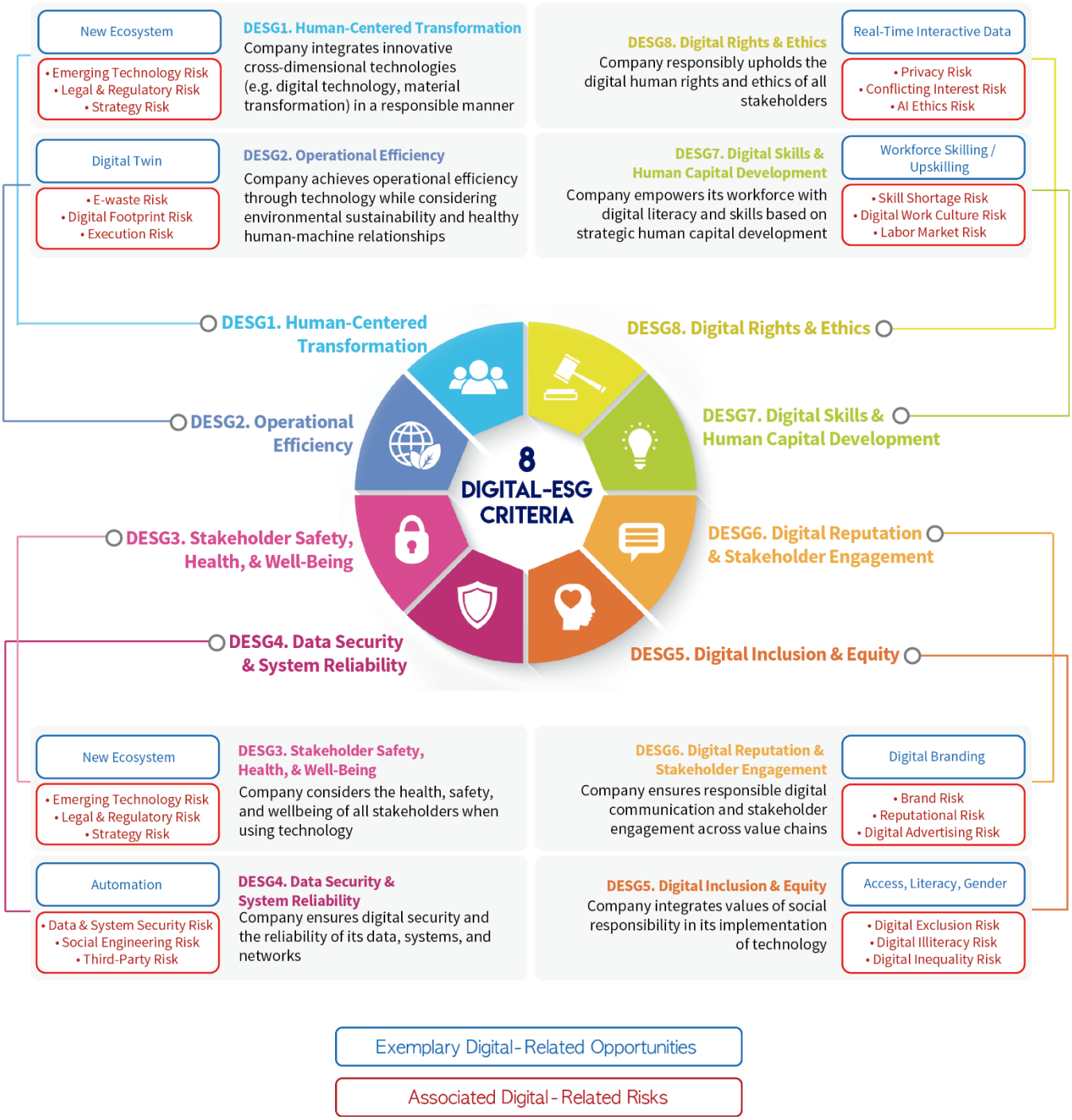
What, then, are the digital-related risks that need to be mitigated and acted upon, and the digital-related opportunities that need to be tapped into, in order to ensure technologies empower the *beyond-sustainability* of the phygital world?

Digital-related risks refer to unexpected and undesired outcomes that may result from digital transformation . On the other hand, digital-related opportunities refer to improvement of financial

performance and other strategic, operational, and social benefits from digital transformation by adopting cross-dimensional technologies. We have identified 40 types of digital-related risks that can occur in any company across the categories of 1C to 3C in the digital economy (Appendix). These risks continue to evolve as technology progresses, but they can be turned into opportunities if managed effectively. Identifying, evaluating, and addressing these risks and opportunities will be vital to ensuring the sustainability, resilience, and long-term prosperity of businesses and the entire ecosystem in the phygital world.

Here, we showcase some of the most common yet significant types of opportunity and their associated risks for each of the eight Digital-ESG criteria in Figure 10 and Table 2.

**Figure 10: Examples of Digital-Related Risks and Opportunities for Digital-ESG Criteria**



## Table 2: Digital-Related Opportunities and Associated Risks

| Type | Digital-ESG Criterion | Digital-Related Opportunity | Description | Associated Digital-Related Risk |
|---|---|---|---|---|
| Digital-E | DESG2. Operational Efficiency | **Digital Twin** | Use data-driven decision-making to optimize performance and minimize emissions | • E-waste Risk<br>• Digital Footprint Risk<br>• Execution Risk |
| Digital-S | DESG3. Stakeholder Safety, Health & Wellbeing | **Safety by Design** | Embed safety & ethics measures (e.g. content moderation, user empowerment tools) throughout value-chains to ensure the safety, health, & wellbeing of end users and other stakeholders | • 4C (Content, Conduct, Contact, Contract) Risk<br>• Fake Information Risk<br>• Technology Overuse Risk |
| | DESG5. Digital Inclusion & Equity | **Access, Literacy, Gender** | Close digital gaps in the communities that a company operates in, such as digital access, digital literacy, and digital gender gaps as part of corporate social responsibility | • Digital Exclusion Risk<br>• Digital Illiteracy Risk<br>• Digital Inequality Risk |
| | DESG7. Digital Skills & Human Capital Development | **Workforce Skilling / Upskilling** | Build digital capabilities among workforce and an agile digital mindset and culture in a company | • Skills Shortage Risk<br>• Digital Work Culture Risk<br>• Labor Market Risk |
| Digital-G | DESG1. Human-Centered Transformation | **New Ecosystem** | Participate in or create a new digital/business ecosystem by adopting cross-dimensional technologies (e.g. digital technologies, material innovation) | • Emerging Technology Risk<br>• Legal & Regulatory Risk<br>• Strategy Risk |
| | DESG4. Data Security & System Reliability | **Automation** | Improve cost-efficiency and enterprise operations along the value-chains by automation | • Data & System Security Risk<br>• Social Engineering Risk<br>• Third-Party Risk |
| | DESG6. Digital Reputation & Stakeholder Engagement | **Digital Branding** | Build positive digital reputation and branding through proactive & strategic communication and stakeholder engagement | • Digital Advertising Risk<br>• Brand Risk<br>• Reputational Risk |
| | DESG8. Digital Rights & Ethics | **Real-Time Interactive Data** | Tap into power of real-time interactive data utilizing AI analytics, IoT, and sensors to expand the network and product portfolio and optimize customer experience | • Privacy Risk<br>• Conflicting Interest Risk<br>• AI Ethics Risk |

# TASKFORCE ON DIGITAL-RELATED FINANCIAL DISCLOSURES (TDFD) GUIDELINES

The previous sections introduced 1) *beyond-sustainability*, which is a new concept to think about *sustainability* in the context of the phygital world, 2) a new economic model, *cross economy*, as the next step beyond the *circular economy,* and 3) a new framework of Digital-ESG that complements and expands on traditional ESG.

This White Paper is only the starting point. The vision is to co-create the phygital world with *beyond-sustainability*, *ethical growth* that creates economic prosperity and enhances sustainability and wellbeing through technology innovation, for future generations. This audacious vision requires tight multi-stakeholder collaborations to develop the goals as part of the efforts for ESG and UN SDG and practical implementation plans.

As the first step to implement Digital-ESG, we invite you to co-create the Taskforce on Digital-related Financial Disclosures (TDFD) Guidelines. The goal is to develop international standards guidelines that provide investors and other capital market participants with information about companies' digital-related risks and opportunities and help them make informed decisions related to their digital economy activities. The TDFD Guidelines will fill the gap by providing guidance on relevant Digital-ESG matters that should also be disclosed.

The TDFD adopted the principles of the Task Force on Climate-related Financial Disclosures (TCFD)[48] as well as approaches for effective disclosure to help guide current and future developments in digital-related financial reporting. Along these lines, we propose structuring disclosures around the four themes that represent core elements of how companies operate: governance, strategy, risk management, and monitoring.

Figure 11: 4x4 TDFD Guidelines


## Recommended Disclosures: Governance

Disclose the organization's governance related to digital-related risks and opportunities.

1. Describe the **board's** oversight of risks and opportunities related to Digital-ESG criteria.
2. Describe **management's** role in assessing and managing risks and opportunities related to Digital-ESG criteria.
3. Describe **employees'** understanding of risks and opportunities related to Digital-ESG criteria and their importance.
4. Describe **stakeholders'** involvement (partners, non-government organizations, academia, and regulators) in enhancing the management of risks and opportunities related to Digital-ESG criteria.

## Recommended Disclosures: Strategy

Disclose the impacts of digital-related risks and opportunities on the organization's businesses, strategy, and financial planning.

1. Describe the digital-related risks and opportunities the organization has **identified** over the short, medium, and long term.
2. Describe the impact of digital-related risks and opportunities on the organization's **businesses, strategy, and financial planning**.
3. Describe the resilience of the organization's strategy for **risk prevention and intervention**.
4. Describe the extent of the organization's strategy for **opportunity promotion and provision**.

### Recommended Disclosures: Risk Management

Disclose the organization's processes to manage digital-related risks and to turn them into opportunities. *(Refer to the Appendix for the definition and examples of 40 digital-related risks identified by the DQ Institute.)*

1. Uncover any business activities of the organization and associates that could pose threats to stakeholders.
2. Assess opportunities from technology developments and government incentives and the relevant addressable market of the related products and services.
3. Engage various stakeholders including partners and regulators and form industry partnerships.
4. Escalate to the appropriate authorities to address potential value creation and/or the opportunity cost of inaction.

### Recommended Disclosures: Monitoring

Disclose how the organization monitors the progress.

1. Disclose the metrics used by the organization to assess digital-related risks and opportunities. The materiality of metrics to assess risks and opportunities in digital transformation will vary with each industry. They depend on risk exposures in the organization's scope of digital economy activities and the maturity levels discussed earlier.
2. Describe the targets used by the organization to manage digital-related risks and opportunities. Targets should be in line with an organization's strategy and risk management process. Processes for monitoring these metrics should also be laid out.
3. Describe the strategic response and resource allocation decisions to address gaps.
4. Describe what, where, and how the company will present its disclosure in line with the TDFD disclosure recommendations. The organization should consider how the target audience can benefit from using these metrics. This will determine the frequency of measurement and the presentation format—whether as data analytics or as part of annual financial reports.

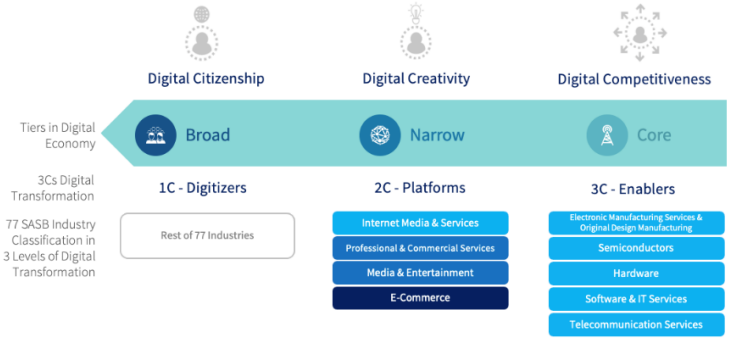
The 4X4 TDFD Guidelines in Figure 11 provide a framework for integrating Digital-ESG into a company's sustainability strategy. For the next steps, we would like to invite investors, industry leaders, and standards setters to co-create the practical Digital-ESG indicators and measurements that effectively support corporate risk management as well as help to generate successful return-on-investment in the digital economy. Moreover, we would like to invite the academic and non-profit communities to develop collaborative research on the cross economy and cross-dimensional technologies to pioneer innovative ways to enhance *beyond-sustainability*. Lastly, and not least, we also invite policymakers to embed *beyond-sustainability* in designing innovative strategies to realize successful digital transformation and to build agile and efficient regulations and policies related to digital technologies and innovations for addressing crucial issues such as child online safety, data protection, AI ethics, and many more.

# SUMMARY

## Digital Transformation

### Section 1. The Companies of the Digital Economy

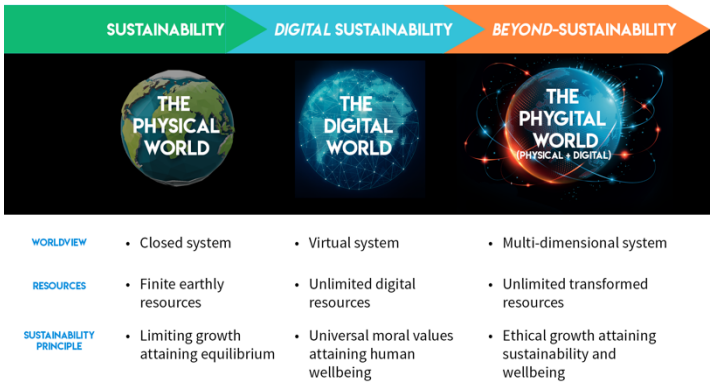
- Every company is now or will soon be operating in the phygital world, taking part in the Digital Economy.
- The companies of the Digital Economy can be classified into 3C industry classification, depending on the degree of digital transformation: 1C-Digitizers, 2C-Platforms, 3C-Enables.
- Each 3C relates to a different scope of digital-related risks and opportunities.




## Worldviews

### Section 2. Beyond-Sustainability

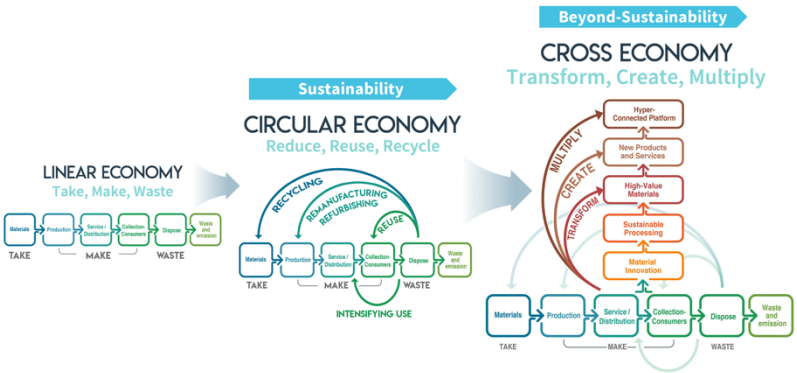
- The current sustainability paradigm does not hold for the phygital world because it neglects the sustainability issues of the digital world and its interaction with the physical world.
- The fundamental principles of digital sustainability lie in universal moral values.
- The sustainability of the phygital world, *beyond-sustainability*, aims to achieve "ethical growth" that enhances prosperity, sustainability, and wellbeing through technology innovation.




## Supporting Economic Models

### Section 3. Cross Economy

- Circular Economy (Reduce-Reuse-Recycle) has intrinsic limitations in the phygital world.
- Cross Economy (Transform-Create-Multiply) enables *beyond-sustainability* – ethical growth in the phygital world.
- Cross-dimensional technologies – material transformation of "waste" into high-value materials combined with digital technology – create new business opportunities while enhancing sustainability and wellbeing.



## Enabling Tools

## Section 4: Digital-ESG

- Digital-ESG is designed for the digital economy, serving as an extra layer to ESG that compensates for the shortage of ESG considerations related to the phygital world.
- Digital-ESG defines 8 areas of digital businesses for companies to achieve *beyond-sustainability* by implementing the cross economy in their digital transformation:
  - DQ1: Human-Centred Transformation, DQ2: Operational Efficiency, DQ3: Stakeholder Safety, Health, & Wellbeing, DQ4: Data Security & System Reliability, DQ5: Digital Inclusion & Equity, DQ6: Digital Reputation & Stakeholder Engagement, DQ7: Digital Skills & Human Capital Development, DQ8: Digital Rights and Ethics.
- Based on the framework, a company can better understand required digital competences to mitigate digital-related risks and maximize opportunities.


## Action Guidelines

## Section 5. Taskforce on Digital-Related Financial Disclosures (TDFD) Guidelines

- TDFD is an actionable tool for investors and other capital market participants to provide information about companies' digital-related risks and opportunities and help them make informed decisions.
- It adopts the principles and approaches of the Task Force on Climate-related Financial Disclosures (TCFD).
- Along these lines, we propose structuring disclosures around the four themes that represent core elements of how companies operate: governance, strategy, risk management, and monitoring.

# APPENDIX: 40 DIGITAL-RELATED RISKS

To help companies assess, monitor, and manage the new risks associated with digital transformation, we have identified 40 different types of digital-related risks to businesses in the context of Digital-ESG.[49-53] Table 3 lists and categorizes those risks into the corresponding DQ areas, while Table 4 provides a brief definition and a few examples of each risk.

**Table 3: 40 Digital-Related Risks**

| DQ Area 1 **Identity** | DQ Area 2 **Use** | DQ Area 3 **Safety** | DQ Area 4 **Security** | DQ Area 5 **Emotional Intelligence** | DQ Area 6 **Communication** | DQ Area 7 **Literacy** | DQ Area 8 **Right** |
|---|---|---|---|---|---|---|---|
| Strategy, Compliance & Financial Risks | Operational & Environmental Risks | Stakeholder Safety & Health Risks | Data, System, & Network Risks | Societal Impact Risks | Communication Risks | Talent & Disruption Risks | Digital Human Rights Risks |
| • Legal Compliance Risk<br>• Emerging Tech Risk<br>• Finance and Fraud Risk<br>• Capital Market Risk<br>• Strategic Risk<br>• AI Black Box Risk | • Environment Risk<br>• Customer Experience Risk<br>• Automation Risk<br>• Execution Risk<br>• Model Risk | • Content-related Risk<br>• Contact-related Risk<br>• Conduct-related Risk<br>• Contract-related Risk<br>• Fake information Risk<br>• Technology Overuse Risk<br>• Metaverse Safety Risk | • Data Security Risk<br>• Social Engineering Risk<br>• System Reliability Risk<br>• Network Reliability Risk<br>• Third-Party Risk<br>• Cloud Risk<br>• IoT Risk | • Digital Exclusion Risk<br>• Digital Illiteracy Risk<br>• Digital Gender Gap Risk | • Brand Risk<br>• Reputational Risk<br>• Digital Advertising Risk | • Workforce Skill Risk<br>• Digital Work Culture Risk<br>• Labor Market Risk | • Privacy Management Risk<br>• Biometric and inferred Data Risk<br>• Conflicting Interest Risk<br>• IP Management Risk<br>• Digital Surveillance Risk<br>• AI-Related Risk |

**Table 4: Definition of Risks**

| DESG Code | Risk | Definition | Examples |
|---|---|---|---|
| DESG.R.1.1. | Legal Compliance Risk | Risks associated with non-compliance to or violation of digital-related legal and regulatory requirements | Oversight, ignorance, or inability to respond to impending legislation |
| DESG.R.1.2 | Emerging Technology Risk | Risks associated with uncertainties about emerging technologies and related regulations | Unfamiliarity with or inability to respond to legislation on emerging technology, incompatibility with emerging technologies, etc. |
| DESG.R.1.3 | Finance and Fraud Risk | Risks associated with financial transactions stemming from fraudulent digital activities of either internal or external actors | Digital payment scams, check tampering, payroll fraud, etc. |
| DESG.R.1.4. | Capital Market Risk | Risks associated with the volatility and liquidity of digital assets | Price volatility of digital assets and the risk of adding them to the company's balance sheet |

| DESG Code | Risk | Definition | Examples |
|---|---|---|---|
| DESG.R.1.5. | Strategic Risk | Risks associated with the development and implementation of digital strategies | Resource allocation, strategy, considerations of whether to adopt certain technologies, etc. |
| DESG.R.1.6. | AI Black Box Risk | Risks associated with the use of AI tools without human supervision and monitoring | Lack of transparency, auditability, and accountability in the AI decision-making, leading to biased data or unsuitable modelling techniques, etc. |
| DESG.R.2.1. | Environmental Risk | Risks associated with negative environmental outcomes of a company's digital activities | Pollution from the production of IT hardware, pollution from e-waste—i.e. used electrical and electronic equipment—pollution from daily digital use, data center energy use, etc. |
| DESG.R.2.2. | Customer Experience Risk | Risks associated with producing and providing digital products and services that fail to satisfy the needs of customers and other users | Digital-only banks or services, online-only stores, online-only reservations, reduction in offline stores and branches, entirely paperless services, etc. |
| DESG.R.2.3. | Automation Risk | Risks associated with incompatible or ineffective automation | Potential operational setbacks, increased complexity, and amplified vulnerability to cyber threats, etc. |
| DESG.R. 2.4. | Execution Risk | Risks associated with ineffective or inadequate execution of digital projects | Challenges with user adoption, institutional buy-in, integration with legacy systems, and organizational structures |
| DESG.R. 2.5. | Model Risk | Risks associated with reliance on flawed model to perform analysis or to guide decision-making | Use of poor quality or unrepresentative data sets, etc. |
| DESG.R.3.1. | Content Risk | Risks associated with harmful content exposed to users due to loopholes in or malfunctioning of preventive and protective measures | Illegal content; age-inappropriate or harmful content; harmful advice; violent or gory content; pornographic content; racist, hateful, or discriminatory content; content advocating unhealthy or dangerous behaviors, such as self-harm, suicide, or anorexia. |

| DESG Code | Risk | Definition | Examples |
|---|---|---|---|
| DESG.R.3.2. | Contact Risk | Risks associated with harmful contact exposed to users due to loopholes in or malfunctioning of preventive and protective measures | Children's participation in adult-initiated online activities; harassment; stalking; unwanted surveillance; extremist recruitment; sexual grooming, abuse, and exploitation; ideological persuasion; personal data misuse, etc. |
| DESG.R.3.3. | Conduct Risk | Risks associated with uncooperative behavior or misconduct of users, typically among peers | Peer-peer perpetrator or victim in peer-to-peer exchange, cyberbullying, trolls, sexual harassment, sexting, etc. |
| DESG.R.3.4. | Contract Risk | Risks associated with potentially harmful contract or commercial interests | Exploitative or age-inappropriate marketing; ill-designed or insecure digital services that leave children open to identity theft, fraud, or scam; contracts made between other parties involving children (trafficking, streaming child sexual abuse) |
| DESG.R.3.5. | Fake Information Risk | Risks associated with incorrect information spreading via social media and internet-mediated methods | Fake news, false content, manipulated content, imposter content, misleading content on social media platforms and news media |
| DESG.R.3.6. | Technology Overuse Risk | Risks associated with excessive time users spend online or using digital devices due to lack of control measures, parental guidance, or user misconduct | Compulsive social media use, excessive screen time, inability to stop, withdrawal symptoms, lost sense of time, preoccupation, etc. |
| DESG.R.3.7. | Metaverse Safety Risk | Risks associated the conduct-, contract-, content-, or contact-related safety issues of the Metaverse | Sexual exploitation, unwanted contact, child labor, etc. |
| DESG.R.4.1. | Data Security Risk | Risks associated with the inability to protect data from unauthorized access and prevent data loss | Ransomware or malware attacks, cyber espionage, phishing, password attack, inadequate oversight, lack of staff, gullibility, weak password rules, software bug, misconfigurations, etc. |
| DESG.R.4.2. | Social Engineering Risk | Risks associated with users being tricked into revealing sensitive information through human interactions and manipulation | Lack of security knowledge or oversharing on social media, leading to phishing, vishing, smishing, baiting, pretexting, etc. |

| DESG Code | Risk | Definition | Examples |
|---|---|---|---|
| DESG.R.4.3. | System Reliability Risk | Risks associated with the loss of confidentiality, integrity, or availability of systems | Data center reliability, legacy technology risk, software attacks, theft of intellectual property, identity theft, theft of equipment or information, sabotage, and information extortion, etc |
| DESG.R.4.4. | Network Reliability Risk | Risks associated with network vulnerability and/or unreliability | Viruses, remote execution, denial of service attacks, network amplification, corruption of time reporting, etc. |
| DESG.R.4.5. | Third-Party Risk | Risks associated with reliance on a third party to perform services or activities | Third-party negligence, third-party misbehavior, third-party unreliability, etc. |
| DESG.R.4.6. | Cloud Risk | Risks associated with data stored online via cloud computing platforms due to lack of control over data and shared servers, etc. | Changes in architecture, implementation, deployment, and/or management of new digital business operations or information technology (IT) systems, cloud outages, data theft, leakage, or deletion, etc. |
| DESG.R.4.7. | IoT Risk | Risks associated with the misuse of Internet of Things (IoT) devices | Denial of service attacks, hacking, malicious use of data by cybercriminals, etc. |
| DESG.R.5.1. | Digital Exclusion Risk | Risks associated with social disparities in terms of access to critical digital products and services like the internet and computers | Difficulty accessing high speed broadband, unaffordable devices, etc. |
| DESG.R.5.2. | Digital Illiteracy Risk | Risks associated with the lack of or limited digital skills in the society leading to disconnection | Lack of technical knowledge of ICT tools, lack of literacy skills and competencies, digital divide and digital exclusion, limited access to jobs and education, etc. |
| DESG.R.5.3. | Digital Gender Gap Risk | Risks associated with the failure to achieve gender equality in digital opportunities for women | Gender divide in digital adoption, use, and leadership |
| DESG.R.6.1. | Brand Risk | Risks associated with the lack of or limited brand building in the digital space | Brand dilution, brand cannibalization, brand stretch, failed digital marketing, etc. |

| DESG Code | Risk | Definition | Examples |
|---|---|---|---|
| DESG.R.6.2. | Reputational Risk | Risks associated with the possible damage to a brand's reputation and overall standing that derives from negative signals regarding the brand in the digital space | Ethics violations, safety and security issues, lack of sustainability, poor quality, lack of or unethical innovation, executive misconduct, employee behavior, regulatory non-compliance, etc. |
| DESG.R.6.3. | Digital Advertising Risk | Risks associated with targeted advertising on digital platforms | Sales pipeline, weak online presence, defamation, lack of research on target audience (added risk of information bombarding the target as well as information being lost in the sea of advertisements on the internet), misleading bot traffic, trademark infringement, omni-channel marketing, intermediary risk in ad placement, etc. |
| DESG.R.7.1. | Workforce Skills Risk | Risks associated with employees and/or talent acquisition | Lack of or limited opportunities to upskill or cross-train staff, skill shortages, high employee turnover |
| DESG.R.7.2. | Digital Work Culture Risk | Risks associated with the misalignment between an organization's values and leader actions, employee behaviors, or organizational systems | Employee negligence and/or malicious acts (intentional or unintentional), employee resistance to digital transformation for fear of losing jobs, etc. |
| DESG.R.7.3. | Labor Market Risk | Risks associated with labor market transition and disruption | Wage inequality, income/wage volatility, mismatch between the supply and demand of jobs, automation replacing jobs, etc. |
| DESG.R.8.1. | Privacy Management Risk | Risks associated with privacy violations (interpersonal, institutional, commercial) and lack of protection of personal information of employees or customers | Inability to protect personal and sensitive information; misuse of such information by cybercriminals, etc. |
| DESG.R.8.2. | Biometric and Inferred Data Risk | Risks associated with privacy breaches of biometric and inferred data | Data leakages and privacy infringement of biometric data, facial recognition data, etc. |
| DESG.R.8.3. | Conflicting Interest Risk | Risks associated with conflicting principles and values in the digital environment | Transparency versus privacy, freedom of expression versus content moderation, etc. |
| DESG.R.8.4. | IP Management Risk | Risks associated with unauthorized use of a company's IP assets | Lack of awareness and education of IP by employees, patent litigations, exposure of trade secrets, open-source software, etc. |

| DESG Code | Risk | Definition | Examples |
|---|---|---|---|
| DESG.R.8.5 | Digital Surveillance Risk | Risks associated with the use of digital technology to control others, citizens, and the life of a nation | Unlawful and arbitrary surveillance, use of technology to monitor employees, digital tracking, etc. |
| DESG.R.8.6. | AI-Related Risk | Risks associated with unethical use, unethical engineering, unethical models of AI | Manipulation of human judgment, biased AI system, etc.; algorithmic bias risks leading to inequalities and discrimination (inclusion/exclusion, exploiting vulnerability, algorithmic bias, predictive analytics, etc.) |

# REFERENCES


1. Park, Y., *IQ EQ DQ: New Intelligence in the AI Age*. Penguin Books: 2021.
2. AI Vital for Digital Economy. Financial Tribune: 2022.
3. Schmid, B. F., What is New About the Digital Economy? *Electronic Markets* 2001, *11* (1), 44-51.
4. Dahlman, C.; Mealy, S.; Wermelinger, M., Harnessing the digital economy for developing countries. 2016.
5. Trupti, J. MAANG Companies 2022. https://scripbox.com/pf/maang-companies/.
6. A roadmap toward a common framework for measuring the Digital Economy. In *Report for the G20 Digital Economy Task Force*, OECD: 2020.
7. IEEE Standard for Digital Intelligence (DQ)—Framework for Digital Literacy, Skills, and Readiness. IEEE Standards Association: 2021.
8. SASB Standards Overview. Sustainability Accounting Standards Board.
9. Ibid.
10. Report of the United Nations Conference on the Human Environment. United Nations: 1972.
11. Fuller, B., *Operating Manual for Spaceship Earth*. Lars Müller Publishers: Zurich, Switzerland, 1969.
12. Boulding, K. E., The Economics of the Coming Spaceship Earth. In *Environmental Quality in a Growing Economy*, Jarret, H., Ed. Resources for the Future/John Hopkins University Press: Baltimore, MD, 1966.
13. Bridges, T.; Eubank, D., *Leading Sustainability: The Path to Sustainable Business and How the SDGs Changed Everything*. Routledge: 2020.
14. Meadows, D. H.; Meadows, D. L.; Randers, J.; Behrens III, W. W., *The Limits to Growth: A Report to the Club of Rome's Project on the Predicament of Mankind*. Universe Books: 1972.
15. Defining and Building the Metaverse. The World Economic Forum: 2022.
16. Privacy and Security—Briefing Paper (Draft). In *Shaping the Future of Media, Entertainment and Sport: Defining and Building the Metaverse*, The World Economic Forum: 2022.
17. Brush, K. Digital Ecosystem. https://www.techtarget.com/searchcio/definition/digital-ecosystem.
18. Richards, N.; Hartzog, W., The pathologies of digital consent. *Washington University Law Review* 2019, *96* (6), 1461-1503.
19. Kidder, T., *The Soul of a New Machine*. Little, Brown and Company: 1981.
20. Universal Declaration of Human Rights. United Nations: 1948.
21. Wallach, W., *A Dangerous Master: How to Keep Technology from Slipping Beyond Our Control*. Basic Books: 2015.
22. Gault, M., Billionaires See VR as a Way to Avoid Radical Social Change. *Wired* 2021.
23. Petro, G., The "Phygital" World: Reinventing the In-Store Experience Digitally. *Forbes* 2021.
24. Conseil Européen pour la Recherche Nucléaire (CERN). https://home.cern/.
25. Economics of Mutuality. https://eom.org.
26. Murray, A.; Skene, K.; Haynes, K., The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. *Journal of Business Ethics* 2017, *140* (3), 369-380.

27. Geissdoerfer, M.; Savaget, P.; Bocken, N. M. P.; Hultink, E. J., The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production* 2017, *143*, 757-768.

28. Lieder, M.; Rashid, A., Towards circular economy implementation: a comprehensive review in context of manufacturing industry. *Journal of Cleaner Production* 2016, *115*, 36-51.

29. Millar, N.; McLaughlin, E.; Börger, T., The Circular Economy: Swings and Roundabouts? *Ecological Economics* 2019, *158*, 11-19.

30. Hansen, S. F.; Arvidsson, R.; Nielsen, M. B.; Hansen, O. F. H.; Clausen, L. P. W.; Baun, A.; Boldrin, A., Nanotechnology meets circular economy. *Nature Nanotechnology* 2022, *17* (7), 682-685.

31. Charpentier Poncelet, A.; Helbig, C.; Loubet, P.; Beylot, A.; Muller, S.; Villeneuve, J.; Laratte, B.; Thorenz, A.; Tuma, A.; Sonnemann, G., Losses and lifetimes of metals in the economy. *Nature Sustainability* 2022, *5* (8), 717-726.

32. Thomas, K. V., Understanding the plastics cycle to minimize exposure. *Nature Sustainability* 2022, *5* (4), 282-284.

33. Lau, W. W. Y.; Shiran, Y.; Bailey, R. M.; Cook, E.; Stuchtey, M. R.; Koskella, J.; Velis, C. A.; Godfrey, L.; Boucher, J.; Murphy, M. B.; Thompson, R. C.; Jankowska, E.; Castillo Castillo, A.; Pilditch, T. D.; Dixon, B.; Koerselman, L.; Kosior, E.; Favoino, E.; Gutberlet, J.; Baulch, S.; Atreya, M. E.; Fischer, D.; He, K. K.; Petit, M. M.; Sumaila, U. R.; Neil, E.; Bernhofen, M. V.; Lawrence, K.; Palardy, J. E., Evaluating scenarios toward zero plastic pollution. *Science* 2020, *369* (6510), 1455-1461.

34. The Circular Economy: Moving from Theory to Practice. McKinsey & Company: 2016.

35. Investment in Circular Economy Leaps Ahead. KPMG: 2022.

36. Prospects for Transitioning from a Linear to Circular Economy in Developing Asia. Asian Development Bank Institute: 2022.

37. Towards a Circular Economy in Asia: Issues and Opportunities. Ellen Macarthur Foundation: 2022.

38. Cho, N.-J., Preparing for tomorrow with materials today. *Materials Today* 2022.

39. Fu, Y.; Kok, R. A. W.; Dankbaar, B.; Ligthart, P. E. M.; van Riel, A. C. R., Factors affecting sustainable process technology adoption: A systematic literature review. *Journal of Cleaner Production* 2018, *205*, 226-251.

40. Fan, T.-F.; Park, S.; Shi, Q.; Zhang, X.; Liu, Q.; Song, Y.; Chin, H.; Ibrahim, M. S. B.; Mokrzecka, N.; Yang, Y.; Li, H.; Song, J.; Suresh, S.; Cho, N.-J., Transformation of hard pollen into soft matter. *Nature Communications* 2020, *11* (1), 1449.

41. Machado, C. G.; Winroth, M. P.; Ribeiro da Silva, E. H. D., Sustainable manufacturing in Industry 4.0: an emerging research agenda. *International Journal of Production Research* 2020, *58* (5), 1462-1484.

42. The Impact of Digital Technologies. United Nations: 2020.

43. Climate-Smart Agriculture. The World Bank: 2021.

44. Su, Y.; Tian, Y.; Yan, R.; Wang, C.; Niu, F.; Yang, Y., Study on a novel process for the separation of phospholipids, triacylglycerol and cholesterol from egg yolk. *Journal of Food Science and Technology* 2015, *52* (7), 4586-4592.

45. Sustainability Accounting Standards Board (SASB). https://www.sasb.org/.

46. Global Reporting Initiative (GRI). https://www.globalreporting.org/.

47. Taskforce on Climate-related Financial Disclosures (TCFD). https://www.fsb-tcfd.org/.

48. TCFD Recommendations. Task Force on Climate-Related Financial Disclosures: 2017.

49. Managing Risk in Digital Transformation. Deloitte: 2018.

50. Future of Risk in the Digital Era: Transformative Change, Disruptive Risk. Deloitte: 2019.

51. Financial Services: Managing Risk to Get Fit for a Digital Future. Deloitte: 2020.

52. McKinsey on Risk: New Risk Challenges and Enduring Themes for the Return. McKinsey & Company: 2021.

53. Why Digital Trust Truly Matters. McKinsey & Company: 2022.