

SUSTAINABLE QUALITY – A CHALLENGE FOR GAINING NEW KNOWLEDGE FOR ACHIEVING A CLIMATE-RESILIENT FUTURE IN THE COMING YEARS

Cvetanka Velkoska , page 69-89

ABSTRACT

This paper presents the identified conditions, strategies and public policies expected to stimulate the development of scientific and practical findings with a view of improving the global eco-system by smartly shifting towards long-lasting solutions and success, through integrated and joint efforts by researchers, practitioners, decision-makers, regulatory bodies, and civil societies. With the growth of knowledge-based society, we should strengthen our climate capabilities, institutions, knowledge, skills, and learning about all facets of the sustainability, with a view of providing a climate-resilient future. The need of sustainable products viewed through the environmental, economic, and social prism, should stimulate the development of new values, attitudes, and behavior in society which will proactively mitigate and eliminate the consequences arising from pollution and global warming, ozone depletion, energy intensity, toxicity, etc. It is inevitable to devise a road map of actions along the science-policy-society axis, as well as new metrics to overcome the momentum coming in the following decades, especially because of the pressure of the intensive digitalization on the demand and the exploitation of rare metals which will open the topics of technical and technological procedures for their recycling and disposal. The science of sustainability must strengthen.

Keywords: sustainable quality, Industry 4.0, sustainability, climate-resilient, rare metals.



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INTRODUCTION

Understanding of quality

Historically and meritoriously quality, as an attribute and an essential feature of the existence of entities (products, activities, processes, systems, etc.) is subject to constant and intensive observations and articulations. The understandings and dependencies of the components participating in the building of the understanding of quality, expectedly vary with time and can become more or less significant or even disappear, while others appear and develop. This justifies the existence of different definitions of quality since they apply to different conditions and environments (Reeves and Bednar 1994).

Figure 1. provides the definitions and the understanding of quality by renown theoreticians in the area of quality, representing the existing and proven accumulated knowledge for the development of future trends in the understanding of quality (Martin, Elg, and Gremyr 2020).

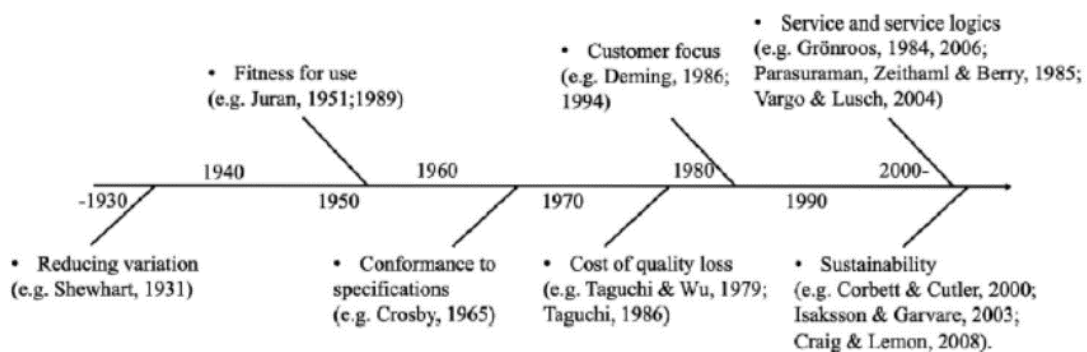


Figure 1. Timeline of key perspectives and meanings and definitions of quality

The concept of quality, by definition is not a constant concept. The new trends of the 21st century and the incorporated contemporary understandings of quality, at this momentum affect the not only the survival of companies, but impact the other stakeholders as well mostly the societal community which faces the globally imposed obligation and responsibility to deal with the consequences generated by the lack of quality of a product (the loss of quality) throughout the life of the project,

in particular the development (engineering) phase, the production phase, the utilization and the end of the life-cycle of product (Schoggl, Baumgartner, and Hofer 2017).

The appearance of the contemporary paradigm of quality – a concept of sustainable quality, mobilizing scientific and practical knowledge and experience with a view to minimizing the adverse effects of loss of quality on the overall life of present and future generations, focuses on and emphasizes the impact of the protected product quality on the quality of the overall work and life of the community (Watson 2015).

This contributes to the inclusion in the quality concept, of the three dimensions of the sustainability phenomenon, i.e., the environmental, the economic and the social dimension. These dimensions contribute, in an integrated fashion, considered in all phases of the product life, to effective and efficient utilization of the human and natural resources of the planet (Schoggl, Baumgartner, and Hofer 2017). A key factor in acquiring sustainable quality is the application of contemporary knowledge, human creativity, innovation genius, and humanity in solving the contemporary issues related to the reduction of material waste and pollution (Watson 2015).

Sustainability criteria are not only an imperative, but also an obligation in the product design process – internationalization of the long-term sustainability when the product designers, since the very beginning, must assess the future negative impacts of the designed product throughout its life-cycle. Sustainable products, usually labeled as “design for the environment,” “eco-design,” “design for sustainability,” “life cycle design,” can be developed by reengineering of the industrial process, promotion of the understanding of the sustainability phenomenon and a systematic application of the design for sustainability (DFS) tools to the products. However, this begs the question whether it is possible to secure all of the relevant data about the product design from the point of view of sustainability, in the early stage and with the required accuracy and timeliness (Schoggl, Baumgartner, and Hofer 2017).

Global warming and the formation of the hole in the ozone layer, the negative impacts of greenhouse gasses and waste initiated, as a consequence, the appearance of the so called “green products”, defined in 2001 by the Commission of the European Communities Green Paper on Integrated Product Policy, as products that “use less resources, have lower impacts and risks for the environment and for which the prevention of

waste creation is still in the design stage”. Environmentally friendly products “strive to protect the natural environment by conserving energy and resources, reducing or completely eliminating the use of toxic substances, pollution and waste”. Through this prism, the users can be viewed as “regular users” and “green users.” “Green users” feature a higher awareness of the environment and a stronger commitment and willingness to pay for the nurturing and the preservation of the quality of the environment. This suggests that the properties of traditional notion of quality, such as power, safety, material consistency, and convenience are complemented by the properties of quality such as energy efficiency, toxicity, and recycling (Zhang et al., 2017).

Elements of the structure of the understanding of sustainable quality

The challenges that managements face in the 21st century like dynamic markets, technological competition and cost benefits impose the need to develop new outlooks, approaches, philosophies, paradigms with a view of building enhanced frameworks and models for quality management (Beaujean, Kristes, and Schmitt 2008), which will contain complex social and material aspects from the supply side (vendors), the demand side (users) and the side of all other stakeholders, such as the community, with a view of increased efficiency and effectiveness in integrating sustainability in the work of the companies. Management is familiar with the initiative-taking approach of the Total Quality Environmental Management (TQEM) which by definition represents an “economically led, systemic and integral approach to reducing and eliminating all the losses related to designing, production, use and disposal of the products and materials.” (Curkovic and Sroufe 2007).

The analysis of the literature identified and presented several building blocks of the structure of the understanding of sustainable quality. The first element relates to the basic principle of quality which suggests that quality is not controlled, but rather it is incorporated (figure 2), which implies that the planned, designed, and incorporated quality enables the control of the process, rather than the control of the results. The second element relates to the framework for understanding sustainable quality (figure 3), viewed through the prism of the design and the compliance quality on one hand and the three dimensions of the sustainability phenomenon – economic, environmental, social, on the other hand.

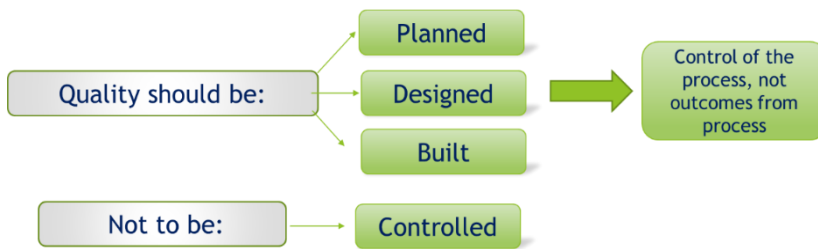


Figure 2. Basic principle of quality

The third element relates to the understanding of optimal quality. Namely, Ishikawa's definition of optimal quality, which represents the intersection between designed, achieved quality, quality requested by the customers and quality requested by the society (Allur et al. 2018), can be expanded with the conclusion that the product quality should be seen through the prism of all phases of its life, i.e., the engineering phase, the production phase, the use phase and in the end-of- life phase of the product (figure 4). This suggests that quality goes beyond the boundaries of the product and no longer relates only to the product, but also to how this product will be integrated in the “sustainable system”, in other words the focus is on maximizing the results of the incorporated quality, which is possible only when observing quality throughout the life-cycle of the product, especially in the phase of product recycling and disposal (Kambanou and Lindahl 2016).

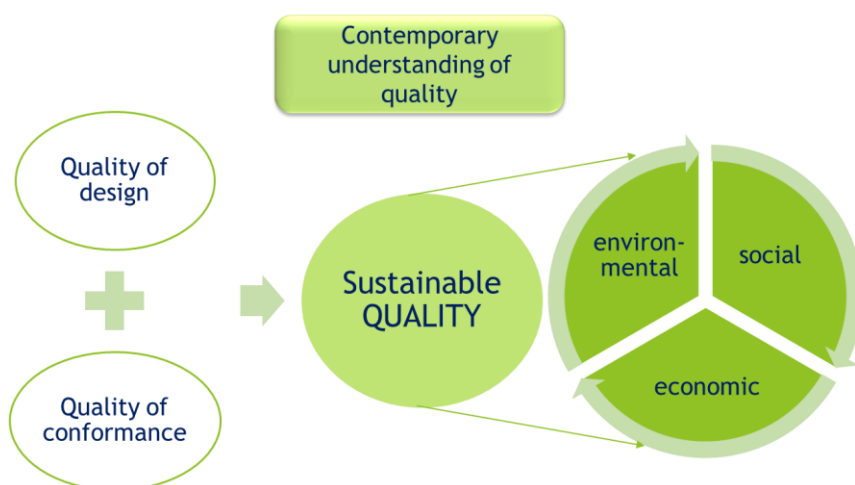


Figure 3. A Framework of contemporary understanding of quality

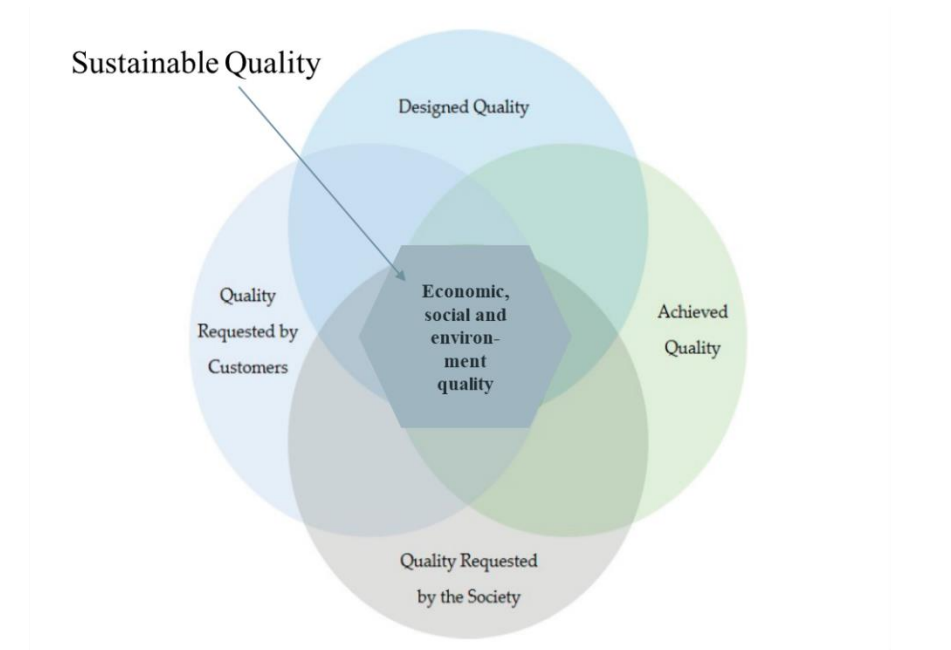


Figure 4. Economic, social and environmental quality in the whole life cycle of the product (Allur et al., 2018)

Industrial development strategies

National economies have always been supported by industrial developments, production systems and production technologies. According to the study of Phuyal, D. Bista, and R. Bista, (2020) the continuous industrial development features the four known industrial revolutions (figure 5). The contemporary Smart Manufacturing System, represents a product of the fourth industrial revolution, featuring interconnectivity through IoT, machine learning, artificial intelligence, automated robots, flexible manufacturing automation systems, additive manufacturing, the processing of real-time data to make intelligent decision for on-demand manufacturing, product customization and maintain the demand and supply ecosystem more efficient.

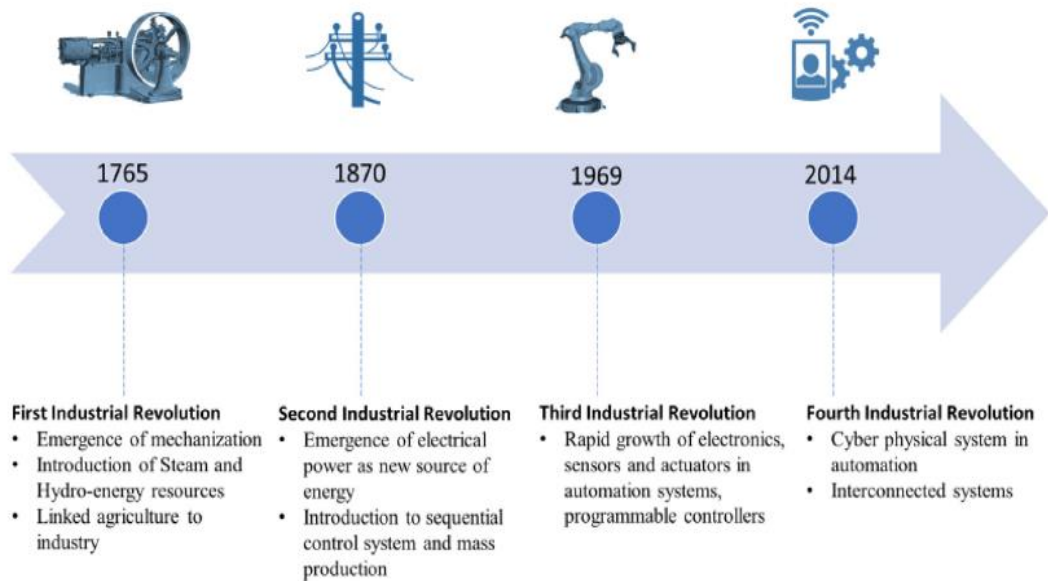


Figure 5. Evolution of the industrial development

The leading world economies, as global drivers of development, have established their emerging strategies, technologically based on the Internet and the interconnected devices and process control through fewer human interventions (figure 6). On the other hand, all these strategies are unified by the focus on the human, material, methodological and cultural resources, as well as the focus on data management which represents an important resource (raw material) in contemporary industries. The sustainability paradigm urges companies to identify, collect, analyze, archive product data and information, as well as to enrich their organizational knowledge with data and knowledge related to the product sustainability throughout its life, which should be accurate, relevant, and easily accessible (Aschehoug and Boks 2013).

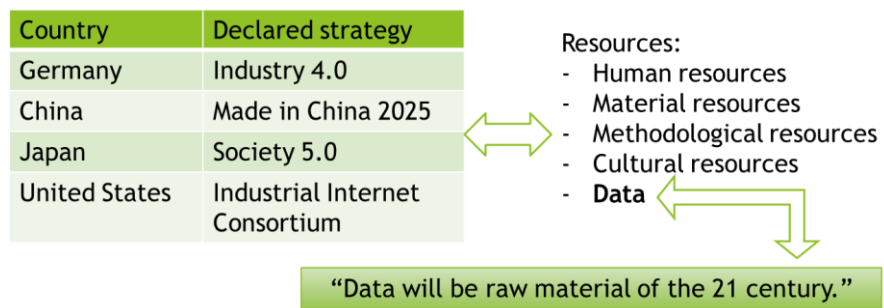


Figure 6. Strategies by different countries for the next industrial development

Industry 4.0 known as smart manufacturing has the potential of becoming the global language of production has a great long-term global strategic impact, because its integrates manufacturing processes at both intra- and inter-organizational levels and relies on smart devices. Despite advancements in the field of the industry 4.0 some key challenges including the technical aspects of technology, security and privacy, and standardization are still in the focus of the attention (Xu, E. L. Xu, and Li 2018).

The New Industrial Strategy for Europe from March 2020, presented its ambitions to support industry to shift towards climate neutrality and to build a more circular economy. The strategy was updated in May 2021 to ensure that its industrial ambition takes full account of the new circumstances following the COVID-19 crisis and helps to drive the transformation to a more sustainable, digital, resilient and globally competitive economy. A new Circular Economy Action Plan introduces measures along the entire life cycle of products, with the aim of ensuring that the resources used are kept in the EU economy for as long as possible (Sustainable development in the European Union, Monitoring report on progress towards the SDGs in an EU context, 2021).

Sustainability challenges and actions in public policies

The issues, possibilities, alternatives, and problems related to the environment have always related to two opposing states, i.e., the state of a “polluter” and the state of “polluted.” This seems like a question that needs to be answered through a new system of values, a new way of thinking about the organization and the analysis of the understanding of

sustainable quality. The section below provides a brief description of the current developments in the world related to sustainability.

1. There is a well-known and established need of embedding sustainability concerns into the quality assurance of the performance of the activities and processes (Ramanathan 2020).

2. The UN General Assembly adopted the 2030 Agenda for Sustainable Development (UN, 2015), to shift humanity towards a sustainable and resilient path (Transforming our world: The 2030 Agenda for sustainable development).

3. Globally, in the last two decades the world is challenged and committed to satisfying the energy needs and to reducing energy intensity by exploiting and using renewable energy sources. The facts suggest that within the last decade the use of solar energy has increased sevenfold and wind energy use has increased 44 times

<https://www.newscientist.com/article/mg24933190-400-why-using-rare-metals-to-clean-up-the-planet-is-no-cheap-fix/#ixzz6lIhuewYB>).

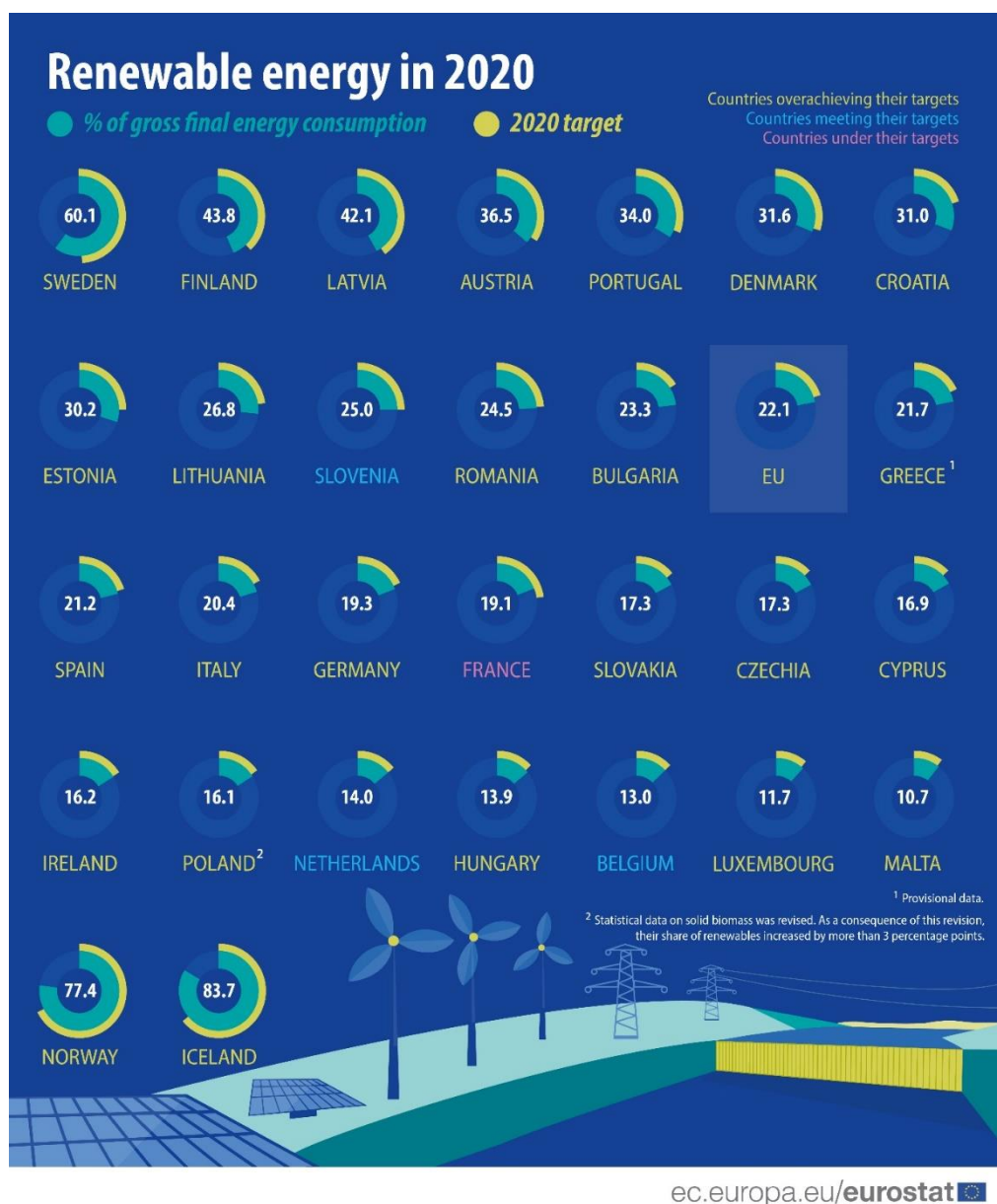


Figure 7. Renewable energy in 2020

At European level, the share of gross final energy consumption from renewable resources reached 22% in 2020. This is 2 percentage points above the target level for 2020, as included in Directive 2009/28/EC on the promotion of the use of energy from renewable sources. This is a major achievement and an important milestone in the EU's path towards climate neutrality by 2050 (figure 7)

(<https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220119-1>).

4. The intensity of the construction of wind and solar power plants with the necessary plant equipment implies an increased materials and rare metal raw materials. Rare metals have been called “vitamins of industry” and their importance in industry has been recognized for some time. However, recently, the industry has become highly dependant on products that can not be made without using rare metals so that they are becoming “the lifeline of industry”. As well as, rare earth elements are used in a wide range of consumer products, from iPhones to high-tech devices and electric car motors, as well as military jet engines, satellites and lasers. The exploitation of rare metals, as well as all metals in the periodic system of chemical elements, has enormously increased (Rare Metals – National Institute of advanced Industrial Science and Technology AIST).

The example of China, the world’s largest rare-earth producing country, who works its way to global domination on the global economic and digital stage by controlling 95% of the rare market metals, making between 80% and 90% of the electric vehicles batteries and satisfying more than half of the demand for wind turbine and electrical engine magnets, paid a price of having heavy metal pollution of 10% of the tillable land, 80% of the underground waters and an increased annual death rate. (<https://www.newscientist.com/article/mg24933190-400-why-using-rare-metals-to-clean-up-the-planet-is-no-cheap-fix/#ixzz6llhewYB>).

The example involving lithium exploitation in Bolivia which together with Chile and Argentina form South America, represent the so called “lithium triangle,” will be the next story from which the world will learn about challenges. The U.S. Geological Survey estimates that Bolivia has 9 million tons of identified lithium resources (of the white metal key to electric vehicle batteries), which in itself causes interest having in mind the defined strategic plans of the different countries in the world, especially in the automobile industry

(<https://www.reuters.com/article/us-bolivia-lithium-exclusive-idUSKBN1ZE2DW>)

5. The ranking of countries according to the Human development Index for 2020, brought Norway to the first place

(<https://hdr.undp.org/en/content/latest-human-development-index-ranking>).

Norway is working closer to meeting its national goal of transitioning to an entirely zero-emission fleet of new cars by 2025 — an initiative the government backs with lucrative tax incentives (Sæle and Petersen, 2018). At the same time, the country has 1,681 hydropower plants, which, at the beginning of 2021, provided 88 % of electricity supply, wind power currently accounts for 10 % of the production capacity, and thermal power plants accounted for about 2 % of total production capacity. Norway has the highest share of electricity produced from renewable sources in Europe, and the lowest emissions from the power sector (<https://energifaktanorge.no/en/norsk-energiforsyning/kraftproduksjon/>).

4. Despite of the Industry 4.0 technologies and their applications are still in their infancy, challenges about dimensions of the sustainability have to be immediately involved in the future researches (Xu, E. L. Xu, and Li 2018), especially for the degradation of natural resources and their disappearance, electrical intensity, toxicity, recyclability and disposal opportunities.

The number of concerning topics continuously following the global socioeconomic order has increased mainly due to the increasing digitalization of the different industries. This digitalization is also related to proper and timely exploitation and utilization of rare earth metals on one hand and the caused adverse climate changes on the other.

Earth Overshoot

During the last five decades the world has continuously faced a massive degradation of its natural resources and the destruction of ecosystems and the biodiversity of the Earth. Since the 1970s, the annual demand for resources has exceeded the biocapacity of the Earth. Today, humanity uses 1.7 Earths to provide for the resources that we use and to absorb the waste of the planet. Humanity is in a global environmental overload (figure 8). Because we use more natural resources than nature can regenerate, this means that the Earth now needs a year and eight months to regenerate what we used in just one year

(<https://www.overshootday.org/newsroom/past-earth-overshoot-days/>).

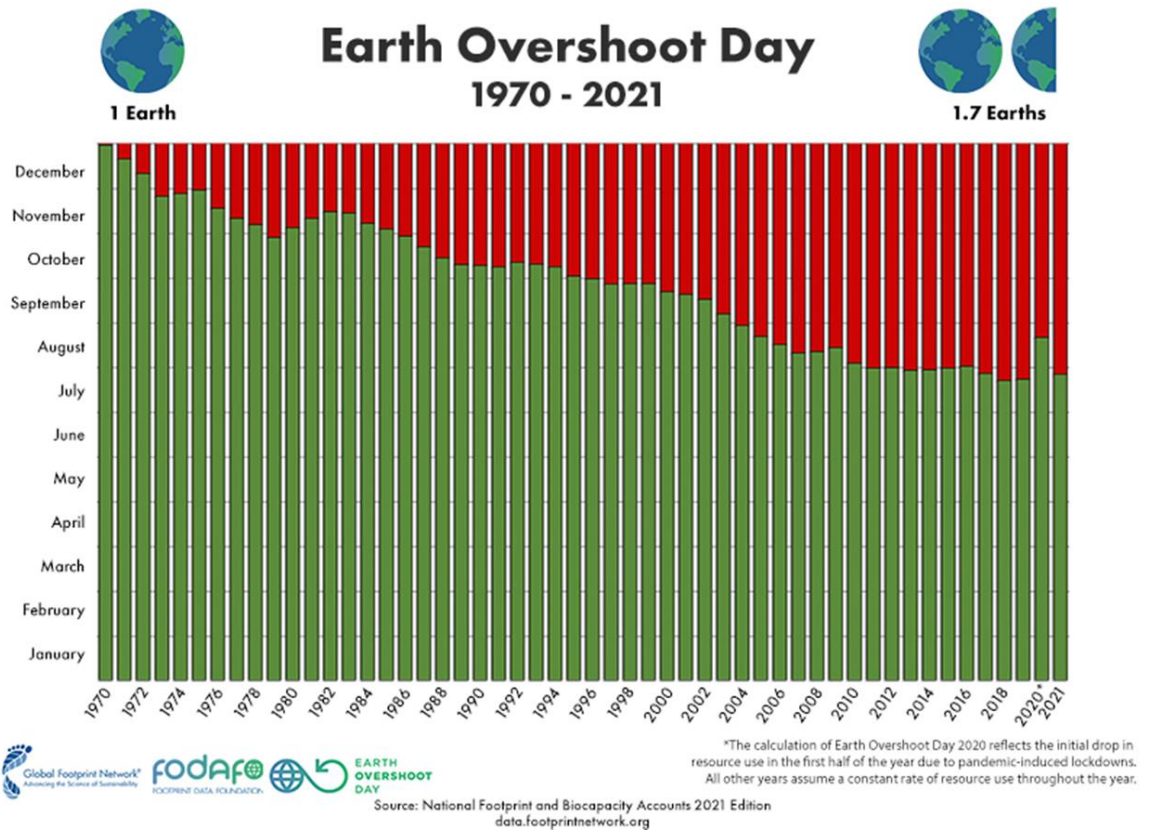


Figure 8. Earth overshoot day

Assessment of Sustainable development

According to Global Footprint Network, sustainable development can be assessed with two indicators. “The first indicator is the United Nations' Human Development Index (HDI), which measures how well a country's citizens live by tracking the country's achievements in longevity, access to education, and income. An HDI higher than 0.7 is high human development. The second indicator is the Ecological Footprint, which measures whether humanity lives within the means of nature. An Ecological Footprint of less than 1.6 global hectares per person makes the resource demand globally replicable”. For comparison are given figure 9 (Our Next Revolution – Rethinking improvement, productivity and value) and figure 10

(<https://data.footprintnetwork.org/#/sustainableDevelopment?cn=all&yr=2017&type=BCpc,EFCpc>).

The Ecological Footprint can be measured in "Number of Earths" (figure 11), which represents how many Earths would be required to support humanity of everyone had that Footprint

(<https://data.footprintnetwork.org/#/countryTrends?cn=5001&type=earth>).

Finite resources

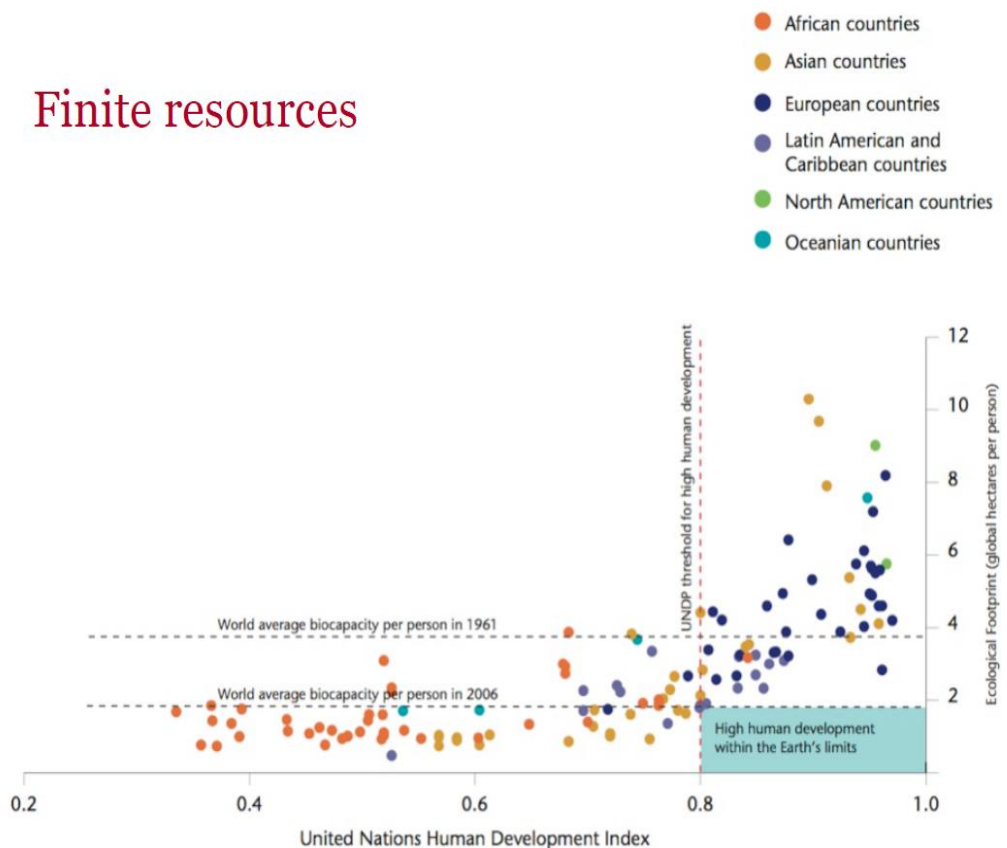


Figure 9. United Nations Human Development Index and ecological footprint

Human Development Index and Ecological Footprint (2017)

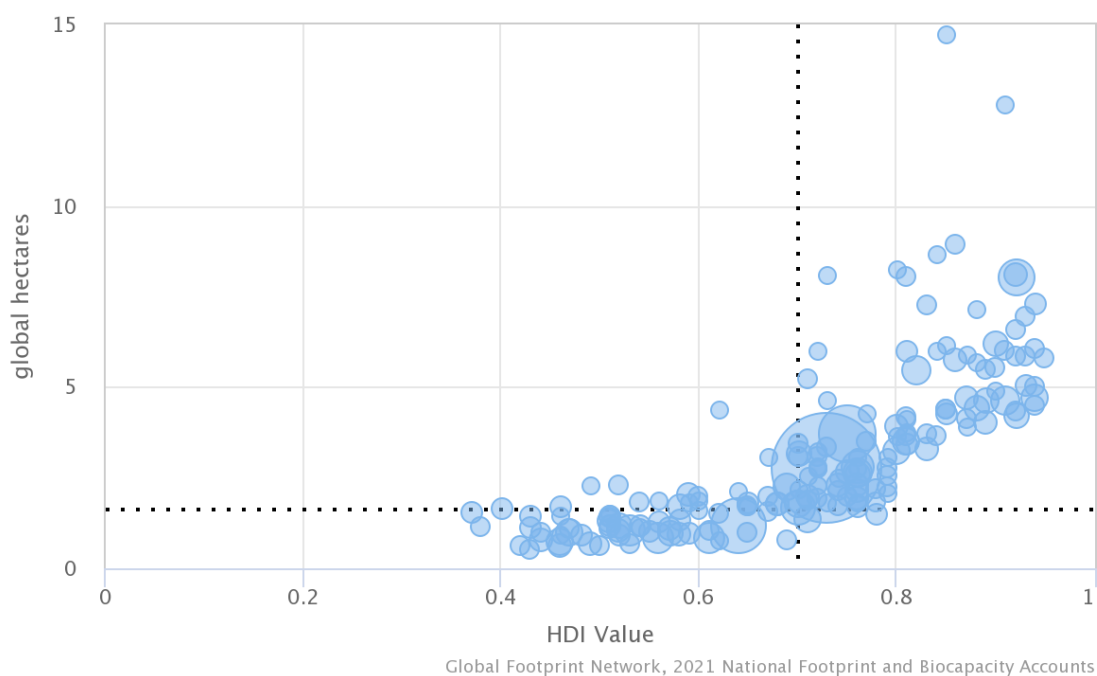


Figure 10. United Nations Human Development Index and ecological footprint for 2017

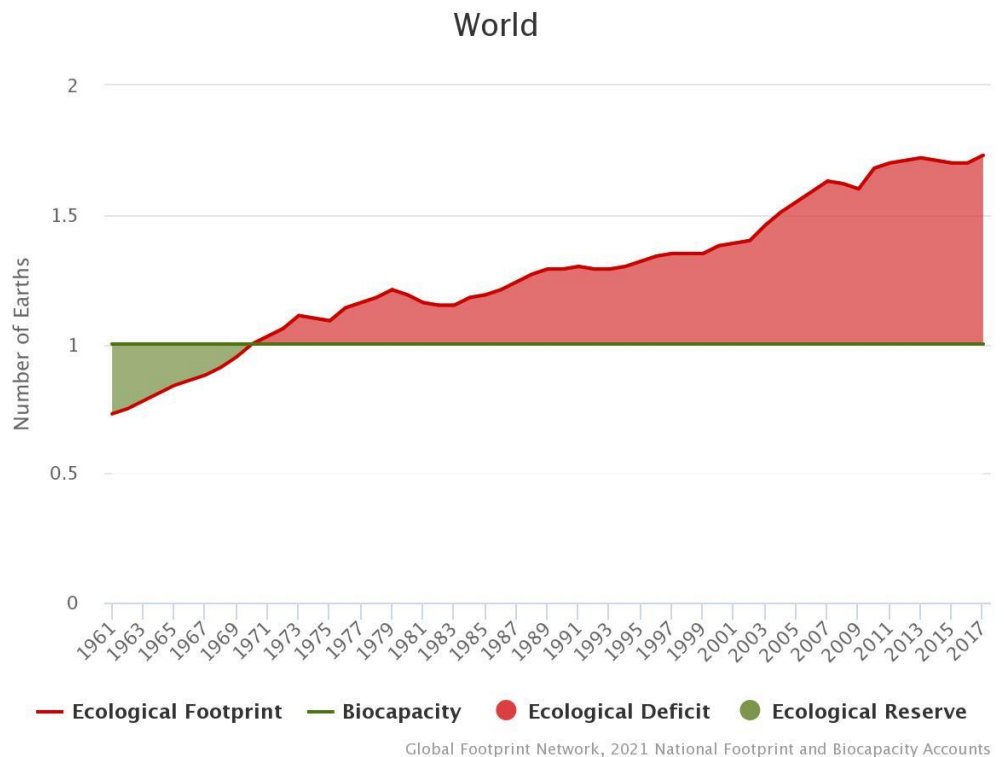


Figure 11. United Nations Human Development Index and numbers of earths for 2017

The UN's Sustainable development Goals (SDGs) are the most significant global effort for global sustainable development. To evaluate the consistency of the SDGs with sustainable development outcome, countries' rankings on the SDG index are marked in a diagram (figure 12) that plots countries according to their development achievements, using the UN's human development index and Global Footprint Network's Ecological Footprint. Ecological Footprint per person and HDI by country indicate how close each country is to basic global sustainable development criteria (high human development, within resource requirements that are globally replicable). The SDG index rankings mimics the conventional development that links higher development achievements with higher Footprints, rather than approaching the global sustainable development quadrant (Wackernagel, Hanscom and Lin 2017).

Ecological Footprint per Person and HDI of Nations with SDG-I Ranking

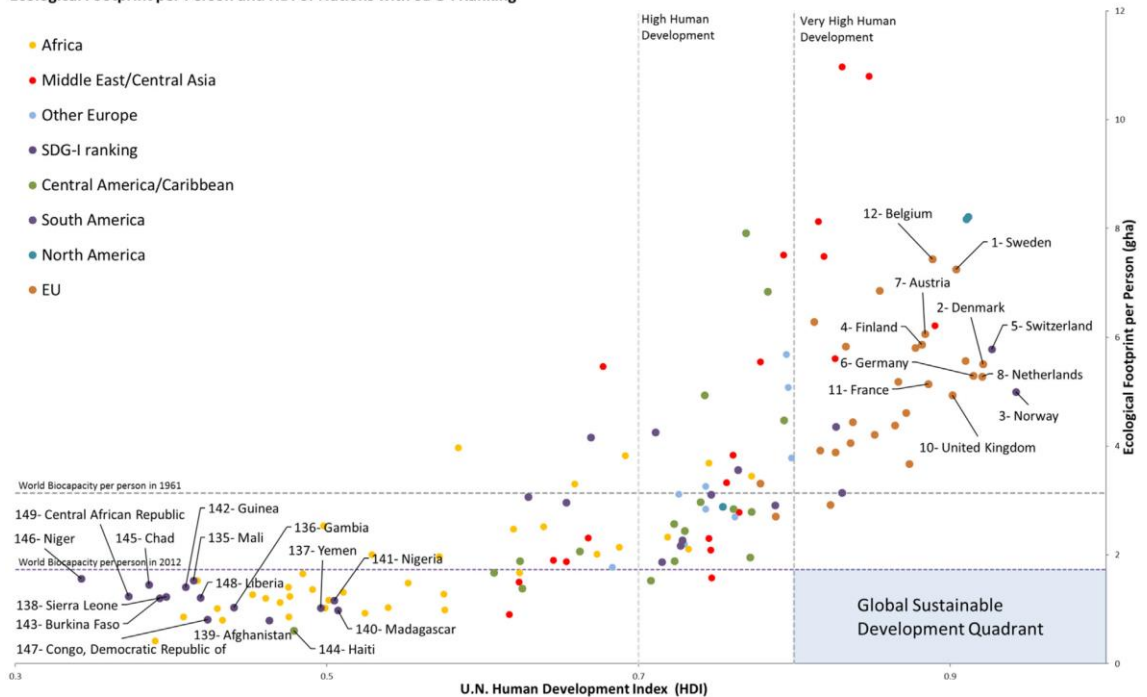


Figure 12. Ecological Footprint and Human Development Index with SDG Ranking for 2017

A climate-resilient future

The world must develop a long-term vision for delivering a climate-resilient future for current and future generations. To achieve it, climate-resilient development pathways by 2030 and deliver net-zero emissions by 2050 to ensure our societies and ecosystems should implies to climate-resilient people living in just, inclusive, happy and poverty-free societies, climate-resilient economies that are net-zero and prosperous, with vibrant and sustainable growth within ecological limits, and climate-resilient landscapes and ecosystems. (LDC 2050 Vision: Towards a Climate resilient future).

CONCLUSION

This paper contributed by presenting an overview of the identified conditions and public policies and documents which should stimulate the development of scientific and practical findings with a view of improving the global eco-system with smart movement towards long-lasting solutions and success, through programs and joint efforts of researchers, practitioners, decision-makers, regulatory bodies, and civil societies. With the growth of the knowledge-based society, we should strengthen our climate capabilities, institutions, knowledge, skills and learning about all facets of the sustainability, with a view of ensuring a climate-resilient future.

From a practical standpoint, undoubtedly, the world abounds with public national and global policies collated in available documents which reflect the policies of the relevant decision-makers. Maybe we need a new road map of actions for the science-policy-society axis which should help cope with the new momentum coming in the next decades, especially considering the pressure Industry 4.0 and the accompanying intensive digitalization exerts on the demand and the exploitation of rare metals, which will in run deepen the thinking about the technical and technological procedures involved in the exploitation, recycling, and disposal of these precious resources.

At the same time, this requires continuous development of varying and rigorous metrics that will track the outcomes of the undertaken actions in order to ensure zero gas emissions.

The conclusion of this research begs several questions that we need to answer in some future research. What kind of knowledge does the world need in order to nurture and improve the three dimensions of sustainability in the 21st century? Does the world continuously face other, new social challenges? How to cope with the fast and dynamic development of the current socioeconomic models driven by the rapid development of digitalization?

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