ESG Management Science and Technology for a Sustainable and Inclusive Society

Yuriko Tanaka, Xiaoxi Zhang, and Machiko Shinozuka

Abstract

We introduce ESG (environmental, social, and governance) Management Science and Technology for achieving a sustainable and inclusive society with respect to recent climate changes and problems related to human rights. We also analyze the relationship between the global environment and socio-economic systems to predict the future and identify long-term corporate risks as well as opportunities for corporations to generate new revenue and enhance their corporate value.

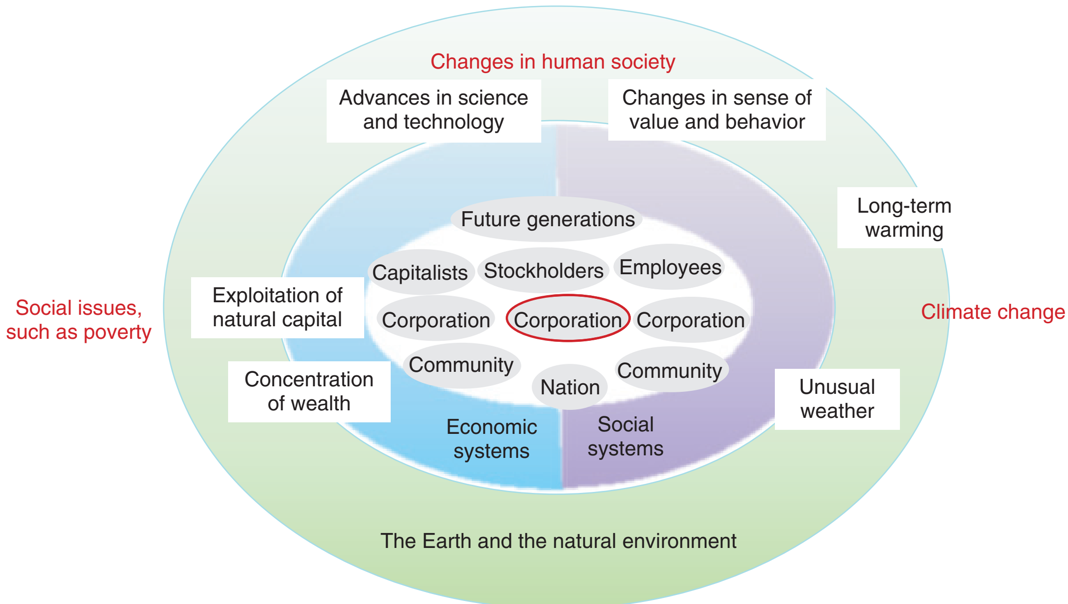
Keywords: ESG, future prediction, corporate value

1. Overview of ESG Management Science and Technology

Increasing attention has been paid to the Sustainable Development Goals adopted by the United Nations and how to respond to problems caused by changes in the natural environment (including climate change), poverty, and other social problems. Amid the global COVID-19 pandemic, we are faced with the need to re-examine how society and the economy operate. Solving these problems requires an approach that integrates environmental, social, and economic aspects and identifies correlations and causal relations among them [1]. As shown in **Fig. 1**, which presents a global view, the Earth and humans are closely and intricately related, as evidenced by climate change and social problems, such as poverty, caused by the concentration of wealth particularly in capitalist societies and the exploitation of natural capital[*1]. These problems could result in an unprecedented crisis in 5 to 10 years [2]. Due to changes in demographics and economic growth, social changes through science and technology and changes in people's values and behavior, the future is not necessarily an extension of the present. Corporate activities are also impacting the environment and society. Business strategies and actions developed from a long-term perspective are critical for ensuring a sustainable business environment. Therefore, corporations are attaching importance not only to their financial information but also their non-financial information, such as environmental, social, and governance (ESG) information. However, they still fall short of evaluating and verifying the impact of their ESG strategies and actions.

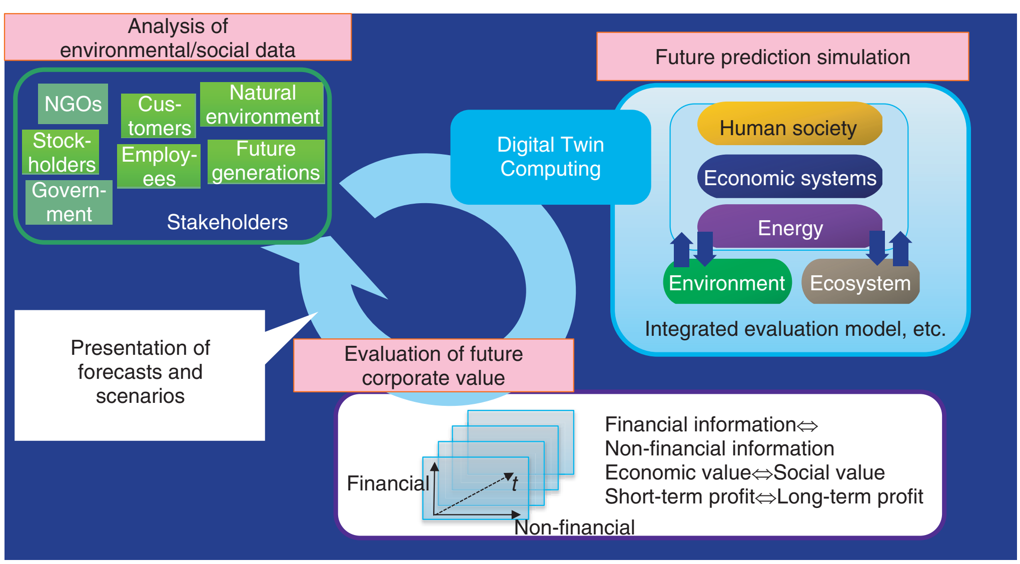
An overview of the ESG Management Science and Technology we are developing is shown in **Fig. 2**. Future prediction simulation uses environmental and social information as input data. Such data include the sense of value and situations of individual stakeholders in a corporation and is an important element in formulating an ESG strategy. Such simulation will use a model that represents causal relations among various environmental and social events, such as U.S. presidential elections, decarbonization strategies, disasters, and corporate performance. We will develop simulation systems as part of global-scale Digital Twin Computing (DTC) [3] and combine these systems with existing integrated evaluation models and new models to predict the future. We will evaluate the prediction results to make further predictions by

*1 Natural capital: A capital produced by nature, such as forest, soil, water, atmospheric air, and natural resources.



Note: Created by the authors based on References [1] and [2]

Fig. 1. Challenges and changes in the global environment and socio-economic systems.



NGO: non-governmental organization

Fig. 2. Overview of ESG Management Science and Technology.

using DTC and identify ways to achieve future transformation. We aim to indicate forecasts and future scenarios that will help corporations formulate their ESG strategies with a clear picture of their future. For this purpose, we will undertake research and development of future evaluation methods that will help enhance corporate value and reinforce the concept of corporate value from viewpoints that involve non-financial information, social value, and long-term profit. We intend to evaluate corporate well-being*2

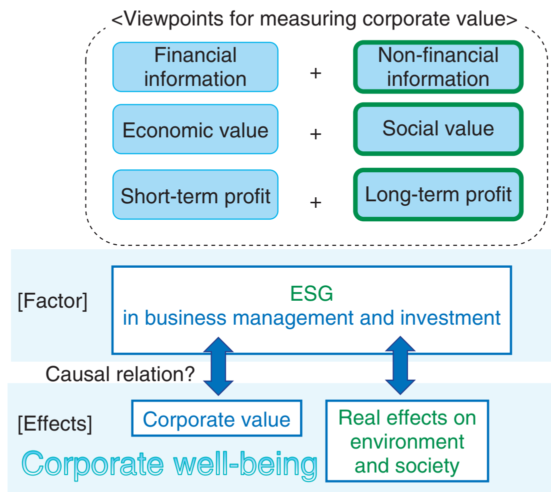


Fig. 3. Corporate value and ESG.

by clarifying the causal relations between factors in corporate actions and their effects on the environment and society (**Fig. 3**). In the next section, we describe future-prediction technology focusing on ESG for enabling future prediction simulation.

2. Future-prediction technology focused on ESG

One of the potential approaches to making a future prediction is to first predict social changes at the country level, then, on the basis of the previous prediction, predict changes that can affect corporate management. To predict social changes at the country level, our ESG Management Science Group began to collaborate with National Institute for Environmental Studies and four other research organizations*3 from fiscal year 2020. Taking climate change and the aging population, coupled with the declining birthrate faced by Japan, into consideration, we are developing several future visions that reflect various aspects of Japanese society and technology for predicting social, economic, and environmental changes quantitatively. One of the important visions we are developing is "a human-centered society that balances economic advancement with the resolution of social problems by a system that highly integrates cyberspace and physical space," as stated in the government's Society 5.0 [4] document. By determining changes in the economy, the environment, and people's lives before they occur, we will formulate NTT's ESG management strategy to maximize positive effects on society and the global environment while avoiding as many negative effects as possible. By reflecting predicted macroscopic social, economic, and environmental changes in NTT's management strategy, we can formulate an even more proactive strategy.

With the aim of predicting what the future will look like with information and communication technology (ICT) including the Innovative Optical and Wireless Network (IOWN)*4, the following section describes prediction technology focused on production and consumption.

3. Predicting the impact of the environment and economy on society

First, we introduce the prediction method from the viewpoint of production. It goes without saying that ICT boosts the economy by improving productivity and substituting human labor. Though it has a negative environmental effect because the use of ICT devices produces environmental loads (such as greenhouse gas emissions through electric power consumption), improved efficiency in production and consumption leads to dematerialization and a reduction in the use of raw materials, which lower environmental

*2 Well-being: A state of being well physically, mentally, and socially, or a concept related to spiritual richness or satisfaction.

*3 This study is supported by the Environmental Research and Technology Development Fund of the Environmental Restoration and Conservation Agency of Japan (JPMEERF20201002).

*4 IOWN: The concept of a next-generation communication infrastructure being pursued by NTT with the aim of commercial implementation around 2030.

Table 1. Evaluated ICT and direct effects of their introduction.

Evaluated ICT	BAU	Case 1	Case 2	Case 3	Direct effects of their introduction
Farming robots/ self-driving tractors	—	○	◎	●	Substitution for human labor Improved productivity
Plant factories/sensors	—	—	◎	●	Stable production
Food-distribution platform	—	—	—	●	Reduced transport distance (local production for local consumption), reduction in food waste

Note: ○, ◎, and ● indicate that the penetration level is respectively low, medium, and high.

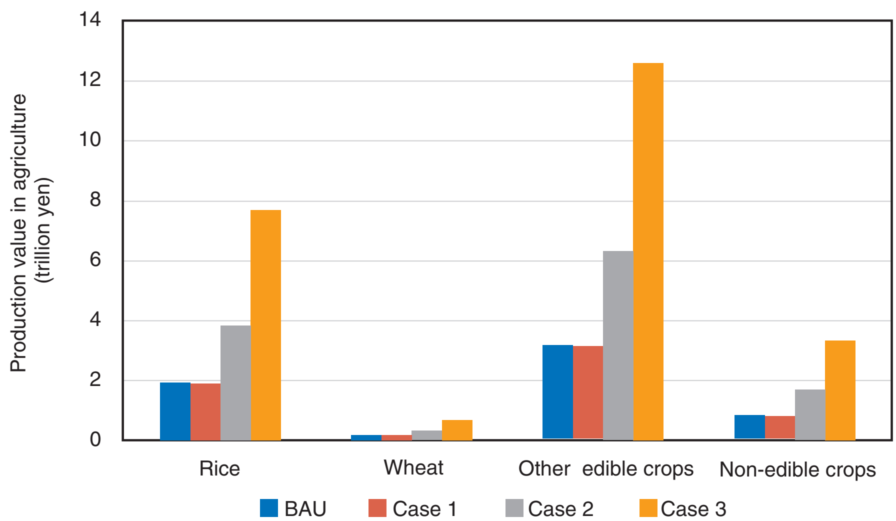


Fig. 4. Production value in each case (2050).

loads. This method simulates the macroscopic economic state (production and consumption), energy consumption, and greenhouse gas emissions of a future scenario using a computable general equilibrium model [5] based on Japan's input-output table [6]. First, we simulate the state in a baseline scenario on the basis of basic pre-conditions, such as the changes in population and gross domestic product (GDP) growth ratio. We then consider the direct effects of ICT penetration in industries (reduction in the use of raw materials, reduction in movement, improvements in productivity, etc.). We reflect these effects into the model and simulate the macroscopic economic state, energy consumption, and greenhouse gas emissions in the ICT-accelerated scenario.

The effects of introducing several types of ICT in agriculture up to 2050 are described as an example. **Table 1** shows the ICT we are focusing on, its penetration levels, and the direct effects of its introduction. We conducted calculations for four cases. In the baseline scenario (BAU), the penetration of ICT is assumed at current levels. To evaluate the effects of introducing further ICT, we considered three cases in which the penetration of farming robots/self-driving tractors, plant factories, and food-distribution platforms is set at different levels (low, medium, and high). **Figures 4** and **5** show the simulation results on the effects (change in production value and greenhouse gas emissions) due to the introduction of ICT. In Case 1, in which the ICT-penetration level is low, the production value in the agriculture sector is almost the same as that in BAU, while the greenhouse gas emissions slightly decrease. In Cases 2 and 3, in which the ICT penetration level is higher, production increases, boosting the country's food self-sufficiency, but the greenhouse gas emissions are also likely to

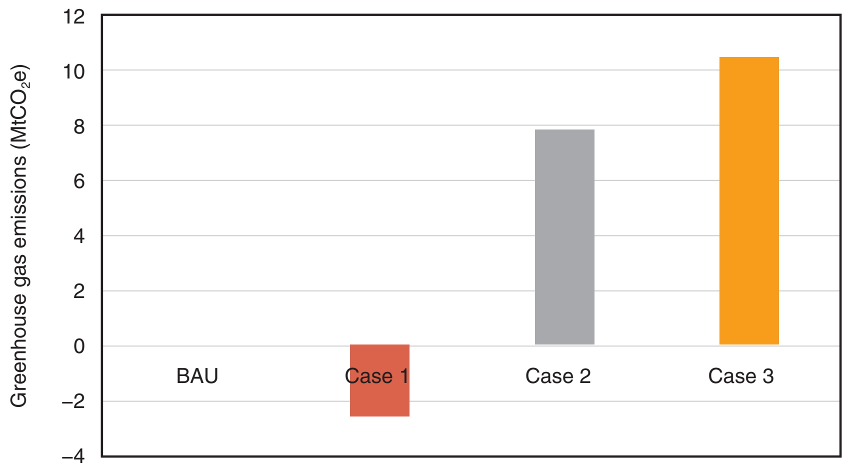


Fig. 5. Difference in greenhouse gas emissions of each case in comparison to BAU in 2050.

increase.

We will apply this analysis and prediction to a wider range of industries and not only evaluate greenhouse gas emissions and GDP but also use DTC to evaluate other indicators, such as resources, land use, and water utilization in an integrated manner and on a global scale.

4. Predicting environmental changes caused by changes in people's lifestyles

We now focus on the behavior of consumers. The use of ICT brings about changes in people's lifestyles and affects the production activities of industries and environmental loads. For example, when teleworking enables people to work at home, the use of private cars and public transportation systems will decrease, reducing environmental loads. On the other hand, the use of lighting and home appliances at home increases electric power consumption, generating environmental loads. Since commuting time is saved, time for new activities, such as hobbies, will increase. Therefore, the use of ICT can reduce environmental loads through reductions in travel time but can also increase them through changes in people's activities that result from changes in their locations and reduction in commuting time.

As an example of using the prediction of social changes caused by lifestyle changes, the following describes the analysis of how the penetration of ICT services, such as teleworking, online shopping, and online education, into consumers' lives affects environmental loads. We focus on how people use their 24 hours. On the basis of statistical data and survey reports, we specifically consider how ICT penetration changes time-usage patterns of consumers. When people switch from commuting to the office to working at home, they increase the time they spend on cooking and leisure activities. Taking changes in their activity locations and the use of ICT tools for reading and learning into consideration, we calculate the duration of their activities and the amount of greenhouse gas emissions per unit of time, as shown in **Table 2**. We calculate the environmental loads in terms of greenhouse gas emissions using the life-cycle assessment method [7]. The amounts of energy and physical material consumed are calculated from the details and durations of activities. We analyze the contribution of each ICT usage (component) to changes in greenhouse gas emissions after ICT penetration and identify those components that are critical in accelerating the decrease of emissions or in slowing the increase of emissions. Since the environmental loads arising from human activities are affected by social conditions, such as lifestyle and the types of electric power sources, it is necessary to reflect in the analysis the relations between such social conditions and the effects of using ICT. We pay attention to the negative effects of ICT penetration, such as people's weariness from working at home, in creating options that will lead to corporate actions to resolve social problems, thereby helping to build a better society.

As part of DTC initiatives, NTT aims to create a future in which a harmonious relationship can be established among the Earth, society, and individuals

Table 2. Examples of impact of ICT penetration.

Activity	Changes after ICT penetration	
	Activity duration	Greenhouse gas (GHG) emissions per unit time (GHG intensity)
Commuting	Decreases as a result of telework	Since commuting methods remain unchanged, the GHG intensity remains unchanged.
Shopping	Travel time is reduced	The GHG intensity increases because electronic devices consume electric power.
Hobbies	Increases as a result of reduction in commuting	Since hobbies remain unchanged, the GHG intensity remains unchanged.
…		

[3]. To achieve it, we are enhancing the purpose of life and the richness of the spirit of the individual expressed as well-being, in a future in which the diversity, opportunities, and possibilities of individuals are expanded and the complexity of the social structure and global uncertainty increase through technologies for exploring the shape of a future society and deriving an inclusive equilibrium solution between the Earth and socio-economic systems.

5. Conclusion

Looking forward, we will build a firm technical foundation for future prediction on the basis of the technologies mentioned above and develop a method for evaluating corporate value and corporate well-being. We will predict a future society in which social structures will become increasingly complex and the uncertainty on a global scale will increase. We will identify the impact of ICT on climate change and other problems and reflect the results in corporate ESG strategies so that corporations can proactively solve the problems identified. Through these efforts, we aim to achieve a sustainable global environment and sustainable and inclusive human society as well as enhance corporate value.

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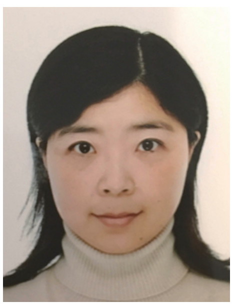

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