Technology and Innovation Strategy Center Report

TSC Foresight

July 2024

Future Vision: Nature Symbiotic Economy

TSC is the abbreviation for Technology and Innovation Strategy Center.

New Energy and Industrial Technology Development Organization
Technology and Innovation Strategy Center (TSC)

Executive Summary

Chapter 1 Causes and Efforts to Resolve Social Issues

Humans have been developing industries that impose various burdens on the global environment. The burdens within the Earth system are increasing year by year, and social issues, including climate change, natural resource depletion, and biodiversity loss, are expanding.

To resolve these social issues and realize a sustainable society, efforts toward realizing carbon neutrality and circular economy are increasing, and in recent years, efforts toward realizing nature positive are attracting attention, as well.

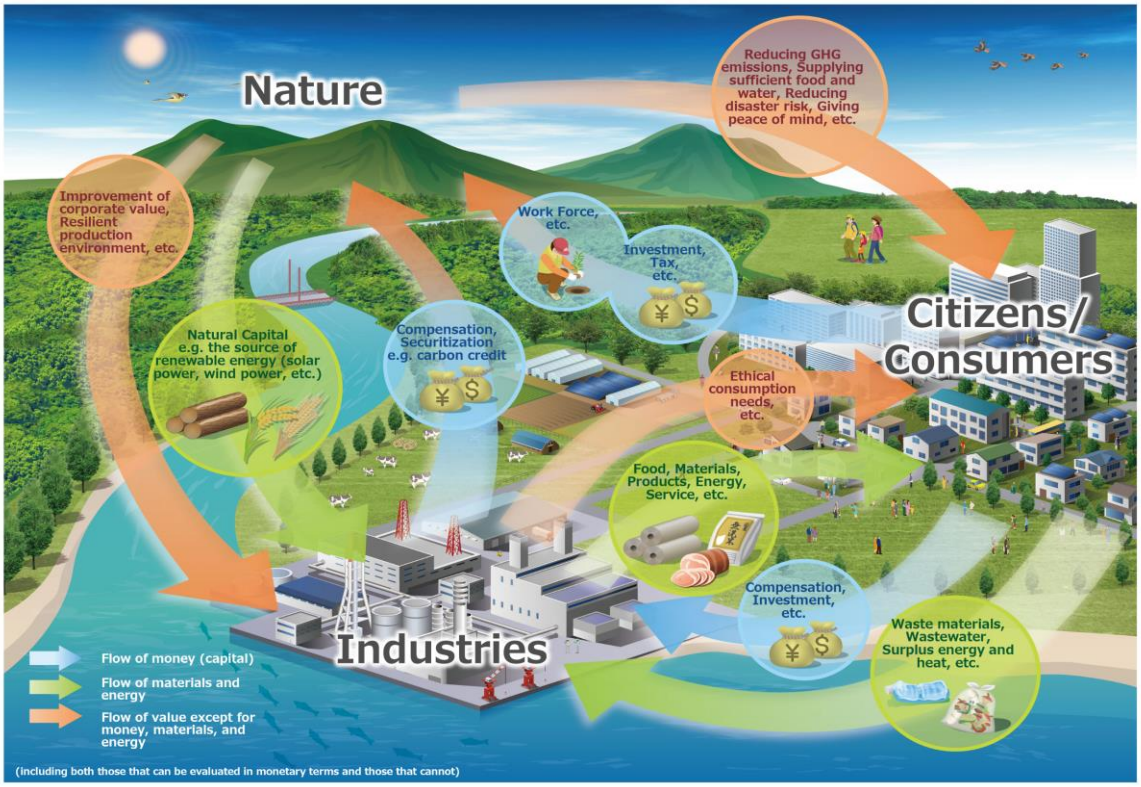
Efforts to realize carbon neutrality, circular economy, and nature positive have synergistic and trade-off relationships with each other. Therefore, their mutual effects must be taken into consideration.

Chapter 2 Future Vision for Resolving Social Issues

- **Future vision: Nature Symbiotic Economy**

Given efforts toward realizing carbon neutrality, circular economy, and nature positive based on relations among industries, citizens/consumers, and nature, which play central parts in economic activities, it is clear that efforts by industries and citizens/consumers for nature are insufficient. A sustainable framework is required to create motivation, including funds for promoting these efforts.

Therefore, this report suggests circular economy (where industries, citizens/consumers, and nature complement one another), thereby increasing their total value, resolving social issues, and achieving sustainable economic growth. This is the future vision of a Nature Symbiotic Economy.



Overview of Nature Symbiotic Economy

• Actions for realizing the future vision

To realize a Nature Symbiotic Economy, certain effective actions must be taken to ensure that industries, citizens/consumers, and nature can complement one another. Specific actions include the following: (1) Utilization of renewable natural capital, (2) Resource recovery from waste and improvement of resource circularity, and (3) Maintenance and restoration of nature.

It should be noted that each of these actions influences not just one but multiple aspects of carbon neutrality, circular economy, and nature positive.

• Creation, enhancement, visualization, and indexing of the value to realize the future vision

The gap between the incurred cost and the obtained value (cost gap) is a challenge in implementing actions to realize the future vision. Therefore, it is necessary to reduce the cost of these actions and, at the same time, enhance the value of the product or service so as to eliminate the cost gap. To achieve this, an effective approach is to clarify environmental and other forms of value and turn them into economic value with the aim of creating and enhancing value. Clarifying environmental value and turning it into economic value requires

visualizing and indexing the outputs to realize carbon neutrality, circular economy, and nature positive.

For carbon neutrality, specific targets have been set and efforts are continuing for visualization and indexing so as to achieve these targets. However, significant challenges for the future include developing cross-sectional evaluation techniques for circular economy and promoting visualization and indexing for nature positive. Also, when discussing indexes, visualization and indexing must be discussed in consideration of interactions among carbon neutrality, circular economy, and nature positive, as well.

Chapter 3 Scenario for Realizing the Future Vision (Bioeconomy)

In the Japan Bioeconomy Strategy, bioeconomy is defined as a concept of expanding sustainable, renewable, and circular economy and society by utilizing biotechnology and biological resources. Efforts in the field of bioeconomy are considered vital as they can contribute to realizing carbon neutrality, circular economy, and nature positive.

Therefore, the scenario for promoting the realization of the future vision in the field of bioeconomy has been discussed. In this scenario, it is essential to grow the economy while conserving and restoring natural capital through actions to realize the future vision. In other words, it would be possible to not only achieve sustainable economic growth but also create a flow to increase the happiness of citizens by promoting actions to realize the future vision through value creation and enhancement and allowing the natural and industrial ecosystem to grow in a virtuous cycle.

Proceeding with this scenario requires studying the target region's industrial structure, reserves of renewable resources, and population size and composition while also implementing appropriate actions according to the actual situation of each region. In addition, a regional autonomous system can be expected to be established by encouraging multiple local governments and businesses in each region to work together in the most suitable form while taking advantage of the characteristics of that region.

Introduction

With the global population now surpassing 7 billion and predicted to reach 9.8 billion in 2050, human society is facing various crises. Because of geopolitical factors, including Russia's invasion of Ukraine, and increased burdens on the global environment due to human activities, new crises have emerged in food, energy, and other fields.

In 2020, NEDO compiled TSC Foresight: Comprehensive R&D Principle for Sustainable Society 2020[1] to show its future vision for overcoming these environmental issues, achieving harmony among the environment, economy, and society, and realizing a society where new value is continuously created and sustainable growth is achieved. This report suggests that three social systems—circular economy, bioeconomy, and sustainable energy—must grow sustainably as social systems, especially to realize a decarbonized society. It is essential to lead these three social systems to disruptive innovation while also implementing them in society with economic rationality and considering them in an integrated way.

In recent years, discussions have been active from the perspective of both biodiversity and decarbonization. At the United Nations Biodiversity Conference (COP15), which was held in December 2022, the Kunming-Montreal Global Biodiversity Framework[2] was adopted and some specific numerical targets were announced. As a result, the need for efforts to realize nature positive is increasing to halt and restore biodiversity loss.

Therefore, this report suggests a Nature Symbiotic Economy as part of the future vision for realizing all of the carbon neutrality, circular economy, and nature positive to ensure a sustainable society. This report then presents the actions required to achieve a Nature Symbiotic Economy and the strategies needed for these actions. Also, this report suggests how to proceed with such actions as a scenario in the field of bioeconomy.

[1] Comprehensive R&D Principle for Sustainable Society 2020 (NEDO, 2020)
https://www.nedo.go.jp/content/100964351.pdf
[2] 15/4. Kunming-Montreal Global Biodiversity Framework (UN Environment Programme, 2023)
https://www.biodic.go.jp/biodiversity/about/treaty/files/kmgbf_en.pdf

Chapter 1 Causes and Efforts to Resolve Social Issues

1-1 Social Issues

Since the Industrial Revolution, humans have been developing industries that impose various burdens on the global environment. The burdens within the Earth system are increasing year by year, and associated social issues are becoming increasingly serious. The concept of planetary boundaries,[3] as suggested by Johan Rockström et al., indicates that the Earth system is in a critical situation mainly due to climate change and a high rate of extinction. Also, in the Global Risks Report 2023,[4] published by the World Economic Forum, natural disasters, extreme weather events, biodiversity loss, ecosystem collapse, and natural resource depletion are assumed to be serious environmental risks.

(1) Climate change

Climate change is one of the most pressing social issues in recent years. Global greenhouse gas (GHG) emissions were recorded as 54.5 $GtCO_2e$ (gigatons of CO_2 equivalent) in 2020 (Fig. 1), with the average emissions reaching the highest ever in the last decade. Today, weather disasters associated with heavy rain, high temperatures, extratropical cyclogenesis, and other harsh conditions have been reported all around the world. Since global warming is progressing due to GHG emissions, the risk of heavy rain and extreme heat is expected to increase further. Climate change, which can lead to weather disasters, is said to be one of the serious social issues that must be resolved for the sustainable growth of human society.

[3] Planetary boundaries (Stockholm Resilience Centre)
https://www.stockholmresilience.org/research/planetary-boundaries.html
[4] https://www3.weforum.org/docs/WEF_Global_Risks_Report_2023_JP.pdf

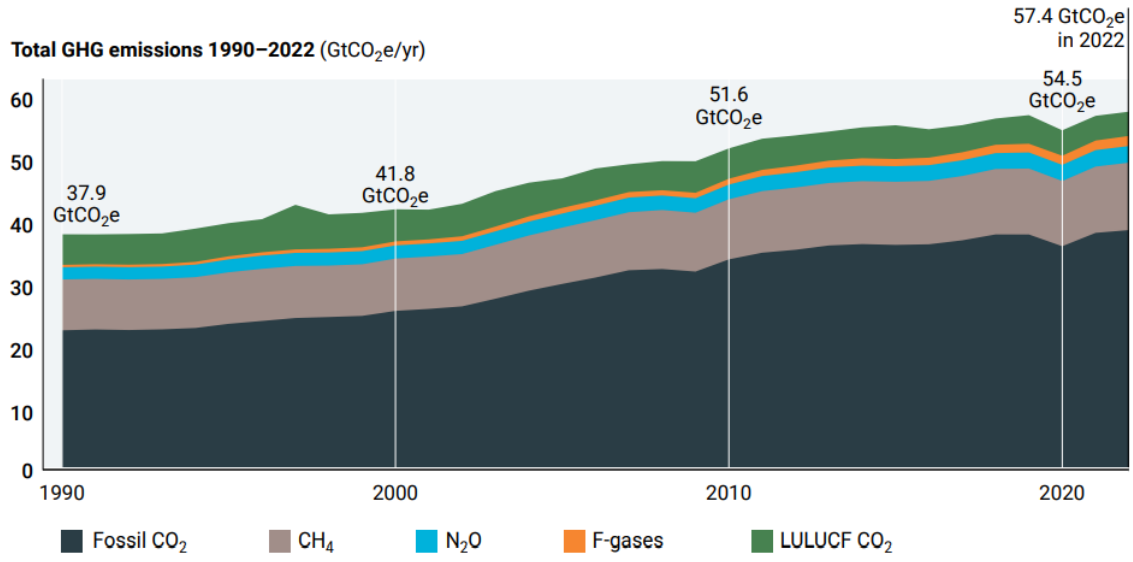


Fig. 1 | Total net anthropogenic GHG emissions 1990–2022

Source: UNEP "Emissions Gap report 2023"[5]

(2) Natural resource crisis

Humans have been exploiting various natural resources[6] on the Earth system to support growing populations and industries, but these resources have been consumed in an unsustainable manner. The measurement results of the Ecological Footprint[7] and global biocapacity[8] show that, as of 2020, the Ecological Footprint (resource demand of economic activities) is 1.75 times greater than the biocapacity (resource production capacity of the ecosystem). This indicates at least 75% overuse of global resources by humans. The total global Ecological Footprint and biocapacity between 1961 and 2022 are as indicated in Fig. 2.

[5] https://www.env.go.jp/policy/hakusyo/r05/pdf/full.pdf
[6] In general, natural resources are a collective term for materials and energies that exist in nature and are used for human life and production activities. In this report, food is included in natural resources, as natural resource depletion has a great influence on food production.
[7] Demand for ecological services that are needed mainly to produce resources, including food and fiber, and the absorption of CO_2.
[8] Biological productivity. Inherent productivity of the Earth's natural capital was represented in hectares. https://www.wwf.or.jp/activities/activity/4033.html

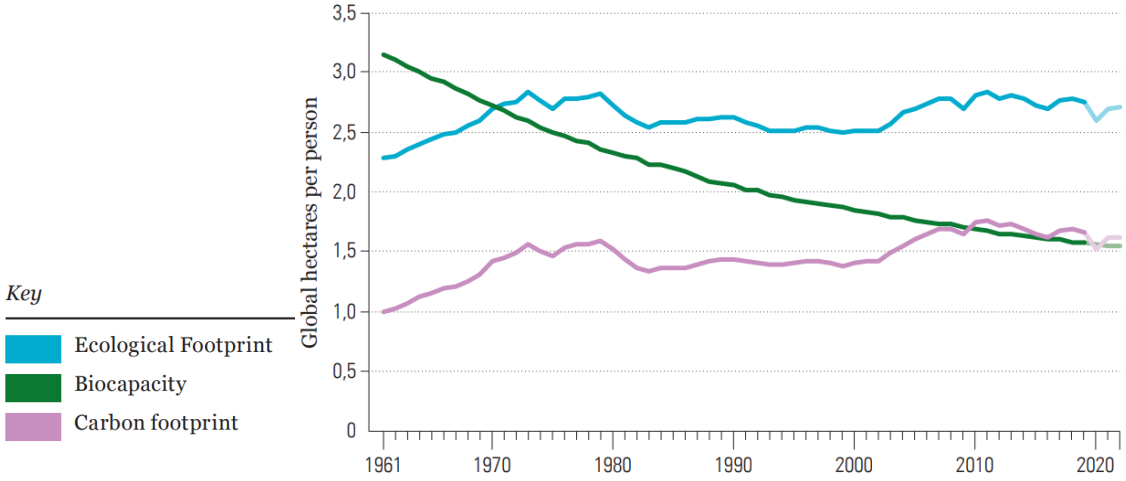


Fig. 2 | The global Ecological Footprint and biocapacity from 1961 to 2022 in global hectares per person

Source: WWF "Living Planet Report 2022"[9]

Focusing on food, which is one aspect of natural resources, it is clear that food crises are caused by poor harvests due to abnormal weather and growing populations. In recent years, the international prices of major food supplies have skyrocketed due to Russia's invasion of Ukraine, and a stable supply of food cannot be secured in developing countries.

Taking measures to address such natural resource depletion is essential to achieving a sustainable society. In particular, strengthening supply chains in consideration of geopolitical risks is a critical issue.

(3) Biodiversity loss

Recently, there has been an increasing interest in problems associated with biodiversity. Human society has been growing by exploiting global resources, which has unfortunately resulted in biodiversity loss. The Living Planet Index (LPI), which is an index for measuring the health of nature and biodiversity, fell by 69% between 1970 and 2018 (Fig. 3) while the freshwater LPI fell by 83% (Fig. 4). Climate change associated with global warming is also considered to be affecting biodiversity. Biodiversity loss is expected to increase further because climate change is destroying appropriate habitats.

[9] https://www.wwf.or.jp/activities/data/20221013lpr_02.pdf

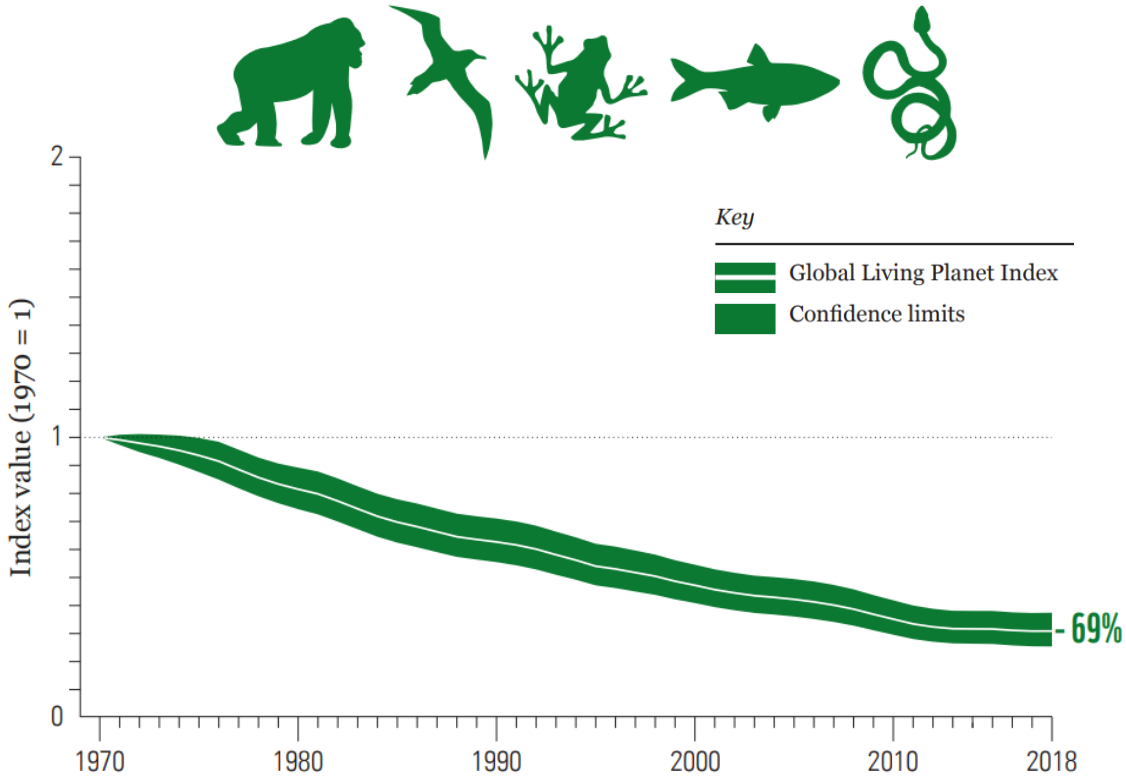


Fig. 3 | The global Living Planet Index (1970–2018)

Source: WWF "Living Planet Report 2022"[10]

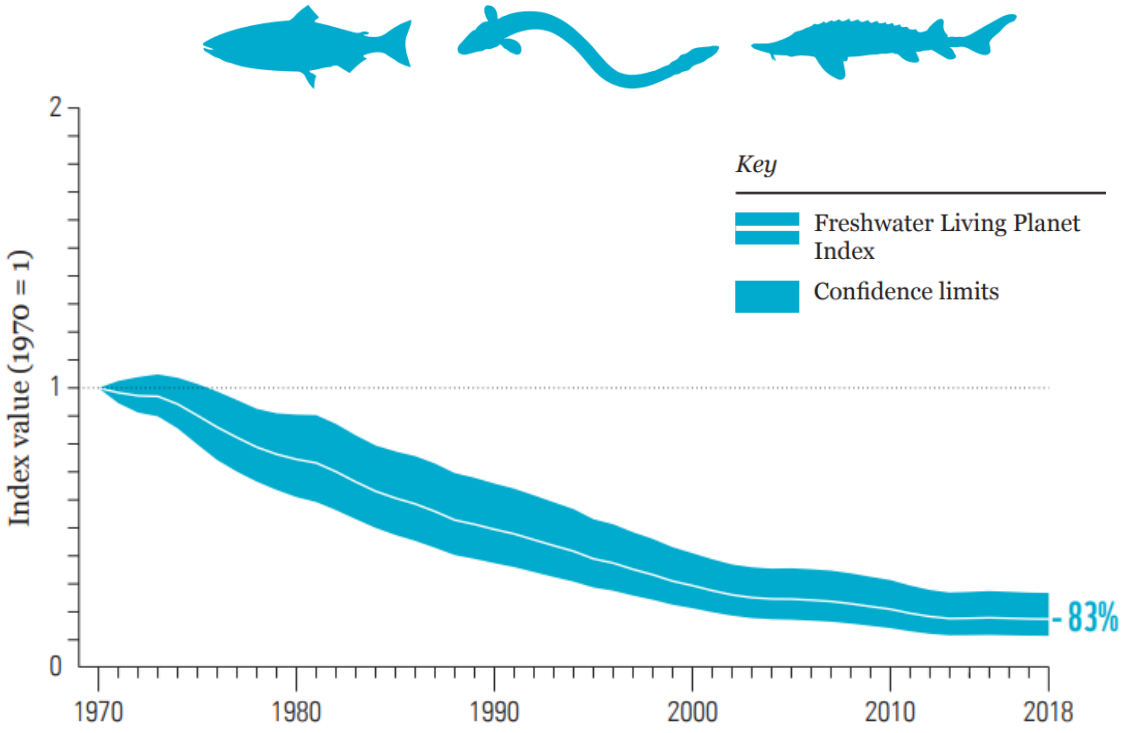


Fig. 4 | The Freshwater Living Planet Index (1970–2018)

Source: WWF "Living Planet Report 2022"[10]

[10] https://www.wwf.or.jp/activities/lib/5153.html

1-2 Efforts to Resolve Social Issues

As the social issues mentioned in 1-1 are becoming apparent, efforts for planetary health [11] are being undertaken to analyze and address the effects of human activities on all lives on the Earth based on the assumption that the Earth system and humans do not exist separately but are interacting with each other. Also, the sustainable development goals (SDGs) in the 2030 Agenda for Sustainable Development,[12] which was adopted at the 2015 UN Summit, suggest goals toward realizing a sustainable environment and economic society. Such a movement indicates that efforts toward nature positive, as well as carbon neutrality and circular economy, are important to realizing a sustainable society.

(1) Carbon neutrality (CN)

Carbon neutrality is the process of reducing to zero the amount calculated by subtracting from GHG emissions the amounts absorbed and removed.

The Paris Agreement, adopted in 2015, suggested the 2°C goal (1.5°C if possible) and the balance of emission and absorption for the first time as an international agreement. Efforts toward these goals are accelerating throughout the world (Fig. 5). As of the end of COP26 in 2021, over 150 countries had pledged to achieve carbon neutrality. In October 2020, the Japanese government declared the realization of a carbon-neutral society by 2050.

Furthermore, when the global average temperature hit a record high in July 2023, United Nations Secretary-General Guterres urged the developed countries to take immediate action to commit to net-zero emissions by 2040, suggesting the need for further efforts toward carbon neutrality.

[11] https://www.planetaryhealthalliance.org/planetary-health
[12] https://www.mofa.go.jp/mofaj/files/000101401.pdf

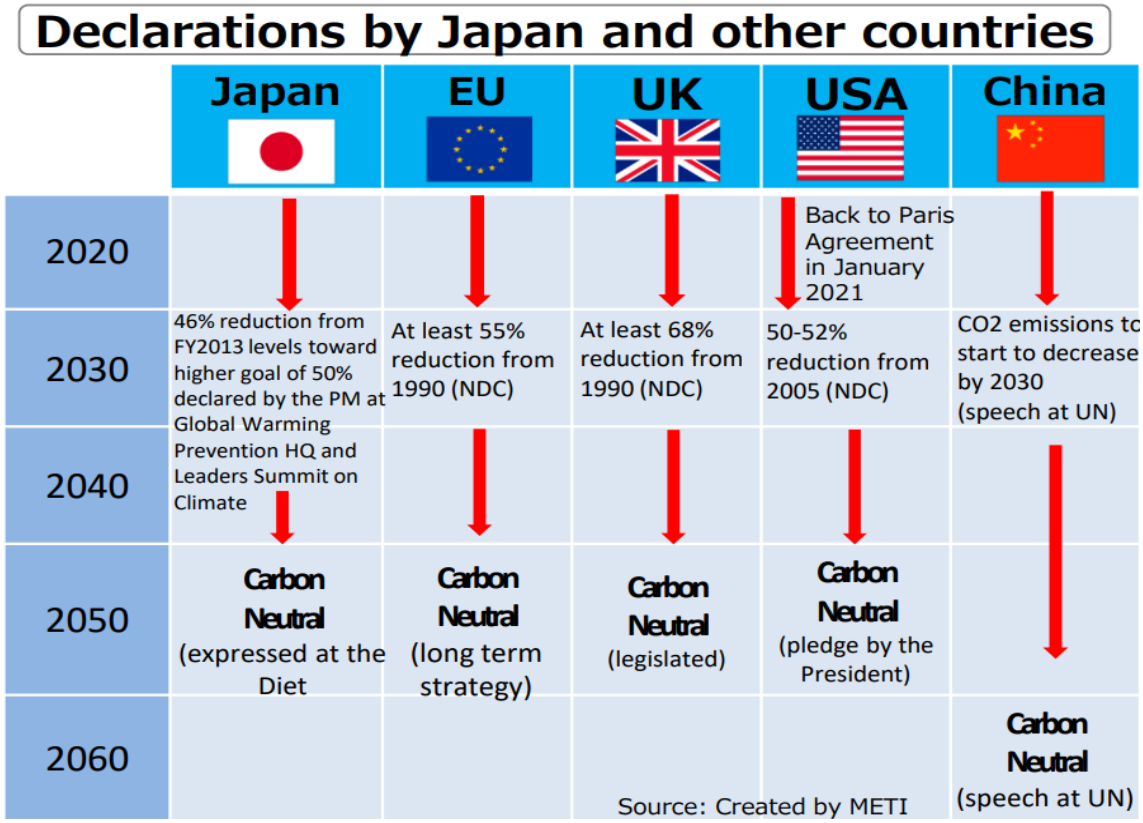


Fig. 5 | Declarations by Japan and other countries

Source: METI "Energy White Paper 2021 (Summary)"[13]

(2) Circular economy (CE)

A circular economy is an economic model that departs from the linear economic model of mass production, mass consumption, and mass disposal and instead maximizes the added value of resources by promoting efficient and circular utilization of resources while reducing resource input and consumption in every economic activity, as shown in Fig. 6.

In 2015, the EU announced its policy package on a circular economy.[14] Since then, efforts toward a circular economy have expanded globally, and other countries have announced their policies accordingly.

Many countries have set specific goals, including a recycling rate of 50% in the US's National Recycling Strategy (2021)[15] and France's Anti-waste and Circular Economy Law (2020),[16] which requires the sale of disposable plastic packaging to be discontinued by 2040. Earlier than other countries, Japan began working toward the transition to a circular

[13] https://www.enecho.meti.go.jp/about/whitepaper/2021/html/1-2-2.html
[14] Closing the loop: Commission adopts ambitious new Circular Economy Package to boost competitiveness, create jobs and generate sustainable growth (European Commission, 2015) https://ec.europa.eu/commission/presscorner/detail/en/IP_15_6203
[15] National Recycling Strategy (US Environmental Protection Agency, 2021) https://www.epa.gov/system/files/documents/2021-11/final-national-recycling-strategy.pdf
[16] Loi du 10 février 2020 relative à la lutte contre le gaspillage et à l'économie circulaire (Republique Française, 2020) https://www.vie-publique.fr/loi/268681-loi-10-fevrier-2020-lutte-contre-le-gaspillage-et-economie-circulaire

society based on the Circular Economy Vision 1999 (formulated in July 1999) and the Basic Act on Establishing a Sound Material-Cycle Society (enacted in 2000). In May 2020, Japan formulated the Circular Economy Vision 2020 in light of global trends toward a circular economy. After that, due to the restricted supply of resources that started with the COVID-19 pandemic and then continued with Russia's invasion of Ukraine, Japan formulated the Growth-oriented Resource Independent Economy Strategy[17] in March 2023. This strategy aims to make domestic resource circulation systems autonomous and more robust and capture the global market mainly through the updating of policies on the resource circular economy.

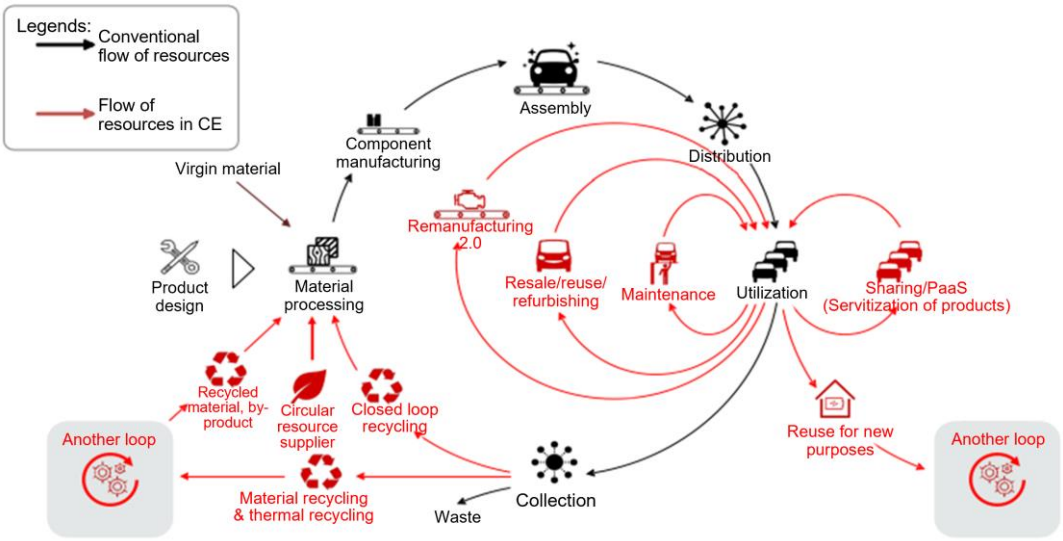


Fig. 6 | Circular economy

Source: Circular Economy Vision 2020 (Ministry of Economy, Trade and Industry, 2020)[18]

(3) Nature positive (NP)

Nature positive (nature restoration) is a global social goal of halting nature loss by 2030 and restoring nature completely to 2020 levels by 2050.[19] This concept is attracting considerable attention, as are the previously mentioned efforts toward carbon neutrality and circular economy. In Japan, the National Biodiversity Strategy[20] (Ministry of the Environment, 2023) defines it as the process of halting and restoring biodiversity loss (for more details on such actions, see Fig. 7).

[17] Growth-oriented Resource Independent Economy Strategy (Ministry of Economy, Trade and Industry, 2023)
https://www.meti.go.jp/press/2022/03/20230331010/20230331010-2.pdf
[18] https://www.meti.go.jp/shingikai/energy_environment/junkai_keizai/pdf/20200522_02.pdf
[19] A GLOBAL GOAL FOR NATURE (Nature Positive Initiative, 2024)
https://www.naturepositive.org/
[20] https://www.env.go.jp/content/000124381.pdf

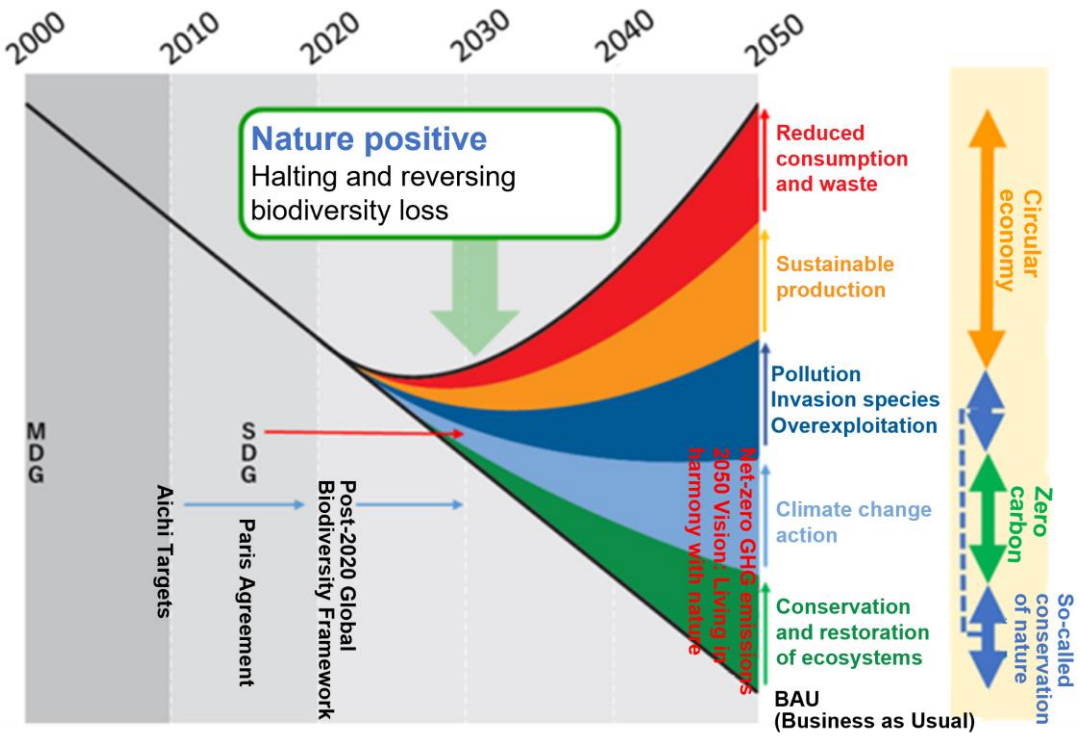


Fig. 7 | Actions for reducing and restoring biodiversity loss

Source: Toward Realizing a Nature Positive Economy (Ministry of the Environment, 2023)[21]

In 2010, at the United Nations Biodiversity Conference (COP10), living harmony with nature was set as the vision for the medium- and long-term strategy for 2011 to 2020. As a result of continuous discussions, the Kunming-Montreal Global Biodiversity Framework was adopted at COP15, held in December 2022, and specific numerical targets for 2030, including 30 by 30,[22] were announced. In accordance with this framework, each country has begun discussing specific policies.

Based on the Kunming-Montreal Global Biodiversity Framework, Japan also formulated the National Biodiversity Strategy 2023–2030 in March 2023, which is aimed at achieving nature positive by 2030. Under this strategy, further discussions were held on realizing a nature positive economy, which was suggested as a basic strategy for achieving the 2030 mission. In March 2024, the Nature Positive Economy Transition Strategy [23] was formulated.

[21] https://www.env.go.jp/content/000116996.pdf
[22] A target involved in preserving 30% or more of land and sea by 2030. This is one of the targets for the 2030 Mission in the Kunming-Montreal Global Biodiversity Framework.
[23] Nature Positive Economy Transition Strategy (Ministry of the Environment, 2024) https://www.env.go.jp/content/000213033.pdf

(4) Importance of correlation among carbon neutrality, circular economy, and nature positive for resolving social issues

Efforts toward carbon neutrality and circular economy are becoming increasingly active around the world, and efforts toward realizing nature positive are also becoming more active, as well. Based on this situation, the Ministry of the Environment has suggested the importance of considering three factors in an integrated manner because the efforts toward realizing them have synergistic and trade-off relationships[24] (Fig. 8). For example, efforts toward realizing carbon neutrality have a synergistic relationship with nature positive, by which ecosystems are maintained and preserved by mitigating climate change. However, there are also concerns about trade-off relationships with nature positive. For example, a lack of consideration toward nature when installing photovoltaic panels may lead to biodiversity loss.

Therefore, it is necessary to promote efforts that create synergy while paying attention to trade-offs.

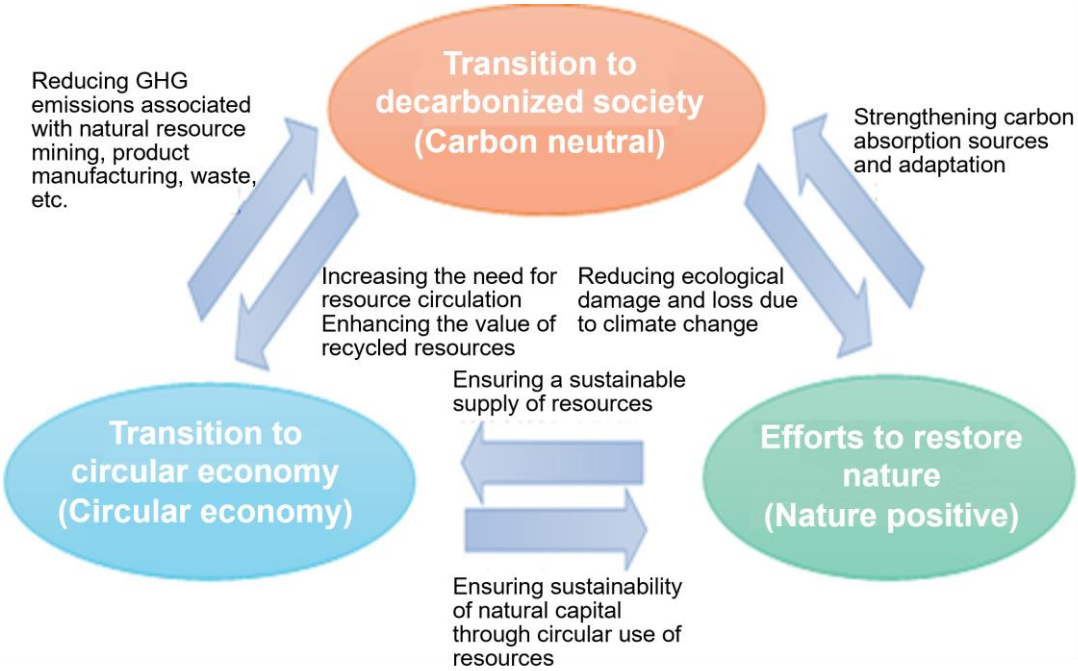


Fig. 8 | Relationships among carbon neutrality, circular economy, and nature positive

Source: Toward Realizing a Nature Positive Economy (Ministry of the Environment, 2023)[24]

[24] Toward Realizing a Nature Positive Economy (Ministry of the Environment, 2023) https://www.env.go.jp/content/000116996.pdf

Chapter 2 Future Vision for Resolving Social Issues

2-1 Relationships Among the Actors in Resolving Social Issues

The following summarizes relationships among industries,[25] citizens/consumers,[26] and nature [27] as the actors who play central roles related to economic activities in order to discuss how to promote efforts toward carbon neutrality, circular economy, and nature positive.

Nature provides industries with natural capital as resources; industries use natural capital to provide energy, food, products, services, and other goods to citizens/consumers; and citizens/consumers pay consideration for their value to industries. This causes a circulation of money to flow, thereby forming an economic society.

The relationships among industries, citizens/consumers, and nature in conventional economic activities are shown in Fig. 9. However, given this linear economic model, the natural capital will be depleted without being recovered, making sustainable economic growth impossible.

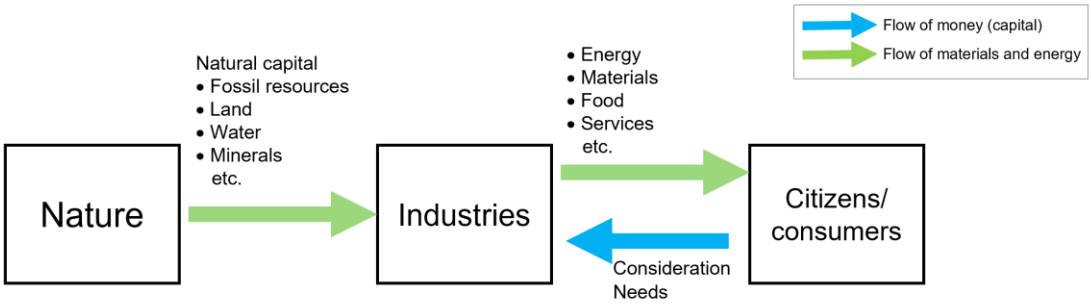


Fig. 9 | Relationships among industries, citizens/consumers, and nature in conventional economic activities

In recent years, however, efforts toward realizing carbon neutrality, including carbon neutrality declarations in various countries, are accelerating, and economic activities are shifting toward a sustainable society. Economic activities are shifting from the production of energy and materials with fossil resources, which cause greenhouse gases, to the use of renewable resources, such as sunlight and biomass. Also, efforts toward a circular economy are becoming active, by which the consumption of natural capital (including fossil resources)

[25] Here, industries refer to work for the production of goods or economic activities for adding human power to natural things in order to change their shapes or move them to create or increase their value in use.
[26] Here, citizens/consumers refer to a combination of citizens and consumers as defined below:
Citizens refer to members of the public having a capacity to take part in national administration or those who are autonomously or voluntarily involved in forming public space. Consumers refer to those who consume goods.
[27] Here, nature refers to everything within this world, with the exception of humans and those modified by humans, such as mountains, rivers, and trees.

is reduced by reusing waste from activities by citizens/consumers as resources. In addition to resources in nature, other forms of value are attracting an increasing amount of attention. For example, volunteers from citizens/consumers are working on nature conservation, and industries are making efforts toward corporate social responsibility (CSR) that incorporate environmental considerations. Fig. 10 shows relationships among industries, citizens/consumers, and nature, including recent efforts toward resolving social issues.

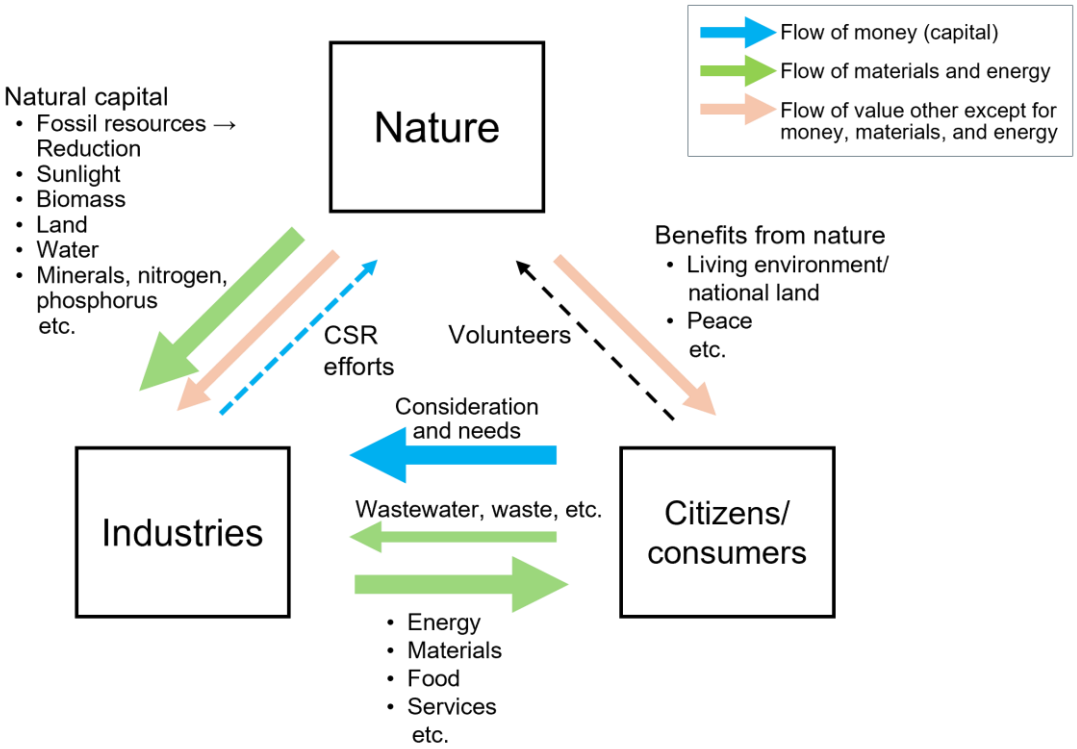


Fig. 10 | Relationships among industries, citizens/consumers, and nature in efforts toward resolving social issues

Efforts toward carbon neutrality and circular economy must be accelerated, which means that the consumption of natural capital is expected to increase further, though its breakdown will change. However, the utilization of natural capital without considering sustainability could damage or deplete it.

The efforts currently made by industries and citizens/consumers for nature, such as those toward CSR and those by volunteers, are not enough to continue the sustainable use of natural capital. Expanding and enhancing efforts for nature requires the following: assessing the natural capital accurately, understanding its contribution and value, and establishing a system where the cycle of creating motivation, including funds; utilizing natural capital as economic activities; and maintaining and restoring nature is repeated continuously.

2-2 Future Vision: Nature Symbiotic Economy

To continue sustainable utilization of natural capital, it is desirable to recognize the value of nature, establish a system where value is created as capital, and maintain and restore nature as economic activity. An ideal state is defined as a Nature Symbiotic Economy, and this is shown in Fig. 11. In a Nature Symbiotic Economy, the capital in nature is provided to citizens/consumers through industries in the forms of material and energy. At this time, a flow of money is created between industries and citizens/consumers not only for the materials and energy but also for the value of nature, thereby promoting efforts for nature. Also, the effective utilization of wastewater, waste, and surplus energy by citizens/consumers forms a circular economy where nature-based resources can be utilized more effectively.

In a Nature Symbiotic Economy, as described above, industries and citizens/consumers must enhance the value of materials and services as well as the value of nature itself by utilizing benefits from nature effectively in the most suitable form, thereby increasing the total value in the entire society.

Therefore, in this report, a Nature Symbiotic Economy is defined as follows:

> A circular economy in which industries, citizens/consumers, and nature complement one another to enhance their total value, thereby resolving social issues and achieving sustainable economic growth

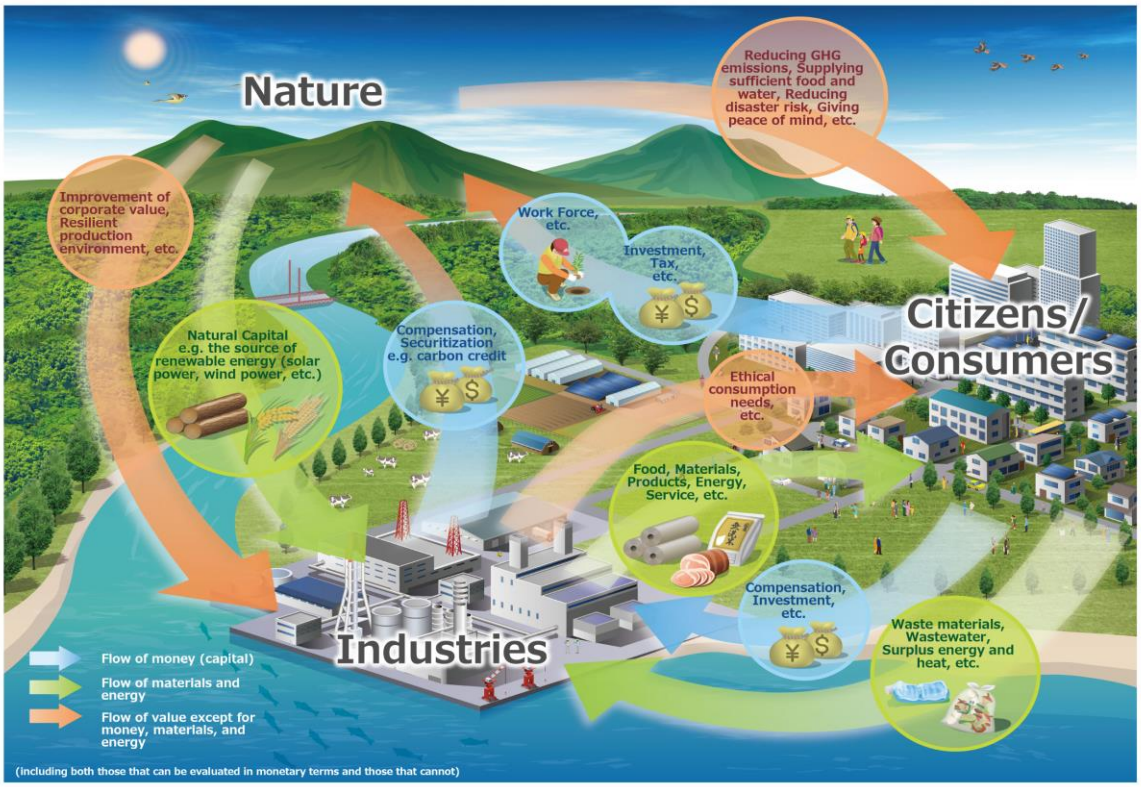


Fig. 11 | Overview of Nature Symbiotic Economy

2-3 Actions for Realizing the Future Vision

(1) Actions required to realize the future vision

A Nature Symbiotic Economy is required to achieve sustainable economic growth while realizing carbon neutrality, circular economy, and nature positive to resolve social issues. To achieve this state, effective actions (Fig. 12) must be taken for the actors—or industries, citizens/consumers, and nature—to complement one another and enhance the total value.

The first action is "(1) Utilization of renewable natural capital," in which food, materials, products, and energy that industries produce by using renewable capital in nature are used or consumed by citizens/consumers. Here, it is important that industries and citizens/consumers not only obtain nature-based materials and energy but also value other than money, materials, and energy; for example, enhancing the corporate value of industries, maintaining the production environment of industries, and meeting the ethical consumption needs of citizens/consumers. Creating the flow of money, such as consideration and investments that include such value, can be an effective action.

The second action is that in addition to waste from industries, waste and other materials from citizens/consumers are recovered and recycled by industries and then used and consumed by industries and citizens/consumers, while also ensuring products that can easily be recycled are developed. "(2) Resource recovery from waste and improvement of resource circularity" also creates value other than money, materials, and energy. It is essential to create the flow of money, such as consideration and investments that include such value.

The third action is "(3) Maintenance and restoration of nature," by which industries and citizens/consumers understand the value obtained (for example, by reducing GHG emissions in nature and ensuring a rich supply of food and water) and then spend money and labor to maintain and enhance the value. As described, it is important to associate the benefits obtained through the maintenance and restoration of nature with various forms of economic activities, such as investments.

Enhancing the total value of industries, citizens/consumers, and nature through these actions is said to lead to the realization of a Nature Symbiotic Economy.

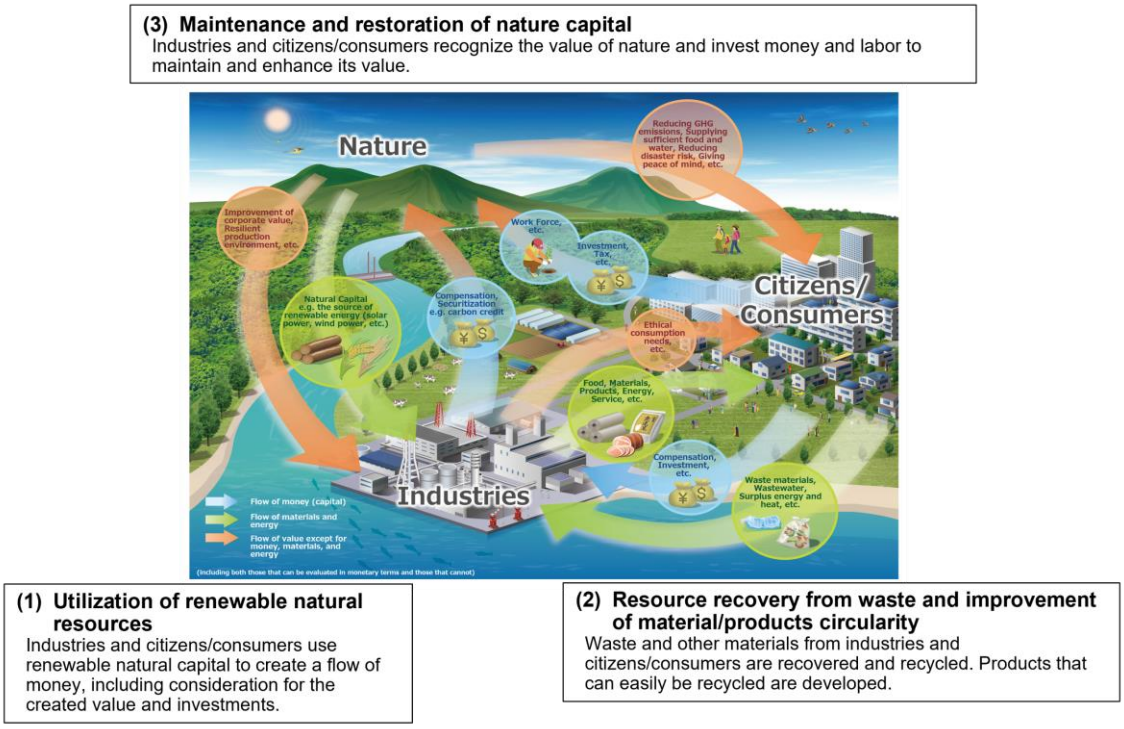


Fig. 12 | Actions required for realizing a Nature Symbiotic Economy

(2) Specific examples of actions for realizing the future vision

The three actions mentioned above are aimed at realizing the future vision and contributing to the realization of carbon neutrality, circular economy, and nature positive. These actions influence not just one but multiple aspects of carbon neutrality, circular economy, and nature positive. Therefore, they must be implemented in the form most suitable for all of them. The following gives specific examples of these actions.

(1) Utilization of renewable natural capital

Utilization of renewable natural capital means shifting from fossil resources used and consumed by industries and citizens/consumers to natural capital, which is more carbon-neutral.

Specific ongoing actions include power generation using renewable energies, such as sunlight and wind, and biomanufacturing (Table 1).

Table 1 Examples of actions for the utilization of renewable natural capital

Examples	Description
Photovoltaic power generation	Energy from sunlight is absorbed and converted directly to electricity. Efforts are underway (for example, to install facilities in business facilities, residential houses, and other buildings or use infrastructure space). Also, technological development is underway for innovation.
Wind power generation	For power generation facilities using wind power, efforts are underway to introduce onshore and offshore wind power generation.
Hydroelectric power generation	In the long term, hydroelectric power generation supplies electric power at the lowest cost with an extremely long facility life. Efforts are underway to expand the use of hydroelectric power generation to realize carbon neutrality.
Solar thermal system	Solar heat generates hot water and air. This system is used for hot water supply as well as cooling and heating in individual houses and commercial facilities.
Biomanufacturing	Efforts to produce useful compounds by using renewable raw materials and the abilities of living organisms, such as microorganisms. Efforts include producing ethanol locally from unused biomass.

The utilization of renewable natural capital contributes significantly to realizing carbon neutrality. Furthermore, it influences the realization of circular economy and nature positive as well, which must be considered when promoting the utilization of renewable natural capital. For example, when large-scale photovoltaic power generation is introduced, a large amount of natural capital is consumed, including minerals necessary for equipment. For this reason, the recycling of equipment must also be considered in terms of the circular economy. Also, in terms of nature positive, it is necessary to assess the impact of deforestation for installation and soil in installation locations on the surrounding environments.

(2) Resource recovery from waste and improvement of resource circularity

Resource recovery from waste means that in addition to waste from industries, waste from citizens/consumers are recovered and then reused and consumed by industries and citizens/consumers. Improving resource circularity means developing products that can easily be recycled in industries. These actions also reduce the consumption of natural capital.

Specifically, ongoing efforts toward the improvement of resource circularity include the development of technologies to recycle waste plastic and organic waste, product design that assumes recycling, and visualization of supply chains (Table 2).

Table 2 Examples of actions for the resource recovery from waste and improvement of resource circularity

Examples	Description
Recycling of waste plastic	Used waste plastic is recovered and recycled into new plastic products and chemical raw materials. Fundamental technologies (for example, material recycling, chemical recycling, and advanced sorting technology) are under development.
Conversion of organic waste to useful materials	Efforts are underway to convert food residue, sludge, livestock excreta, and other organic waste materials that have been incinerated or buried to methane gas and other useful materials.
Product design that assumes recycling	It is difficult to recycle products made of composite materials, such as multi-layer films and fabric products. Therefore, easy-to-recycle design, such as the replacement of composite materials with mono-materials, is under discussion.
Visualization of supply chains	Efforts to visualize entire supply chains through the utilization of digitalization tools (such as blockchains) contribute to enhancing resource circularity. These efforts are implemented in the third period of SIP.

This action contributes significantly to realizing a circular economy while also influencing the realization of carbon neutrality and nature positive, which must be considered when promoting resource recovery from waste and improving resource circularity. For example, promoting recycling is expected to require a large amount of energy to be consumed. In terms of carbon neutrality, there is concern that increased consumption of fossil resources will raise CO_2 emissions. Also, in terms of nature positive, there are environmental issues, including concern that the consumption of natural capital will increase since water is used for cleaning.

(3) Maintenance and restoration of nature

The maintenance and restoration of nature involve maintaining the original state of nature while restoring the lost state. This action is implemented by industries and citizens/consumers.

Specifically, ongoing efforts toward the maintenance and restoration of nature include tree planting activities, which contribute to realizing nature positive, conservation and restoration of marine ecosystems, and sustainable city planning (Table 3).

Table 3 Examples of actions for the maintenance and restoration of nature

Examples	Description
Tree planting activity	Businesses are logging and replanting trees in a planned manner to rejuvenate forests while protecting ecosystems with the aim of increasing wood use and CO_2 absorption.
Conservation and restoration of marine ecosystems	Efforts are underway to conserve and restore seagrass and seaweed beds in specific regions, increase the catches of aquatic animals around these regions, and promote blue carbon activities.
Sustainable city design	It is important to increase optimal biomass in consideration of regional characteristics (urban areas, rural areas, etc.). In terms of city design, efforts are underway for the urban bioeconomy, including roof greening.
Regenerative agriculture	Farming method by which the natural environment is restored by using the intrinsic power of soil for soil restoration. This method has been widely adopted in the US and Europe.
Payment for Environment/Ecosystem Services (PES)	A system where the costs for maintaining and managing ecosystem services as the functions of nature are borne by the beneficiary is under discussion and development.

The maintenance and restoration of nature contribute to realizing not only nature positive but also carbon neutrality and circular economy. For example, in tree planting activities for conserving and restoring forests, the immobilization of CO_2 by forests contributes to realizing carbon neutrality. It also contributes to circular economy in terms of the circulation of carbon and nitrogen.

(3) Efforts that combine the three actions

To realize the future vision, efforts that combine the three actions are also important. Efforts that combine these three actions are utilizing biomass as fuel or raw material for manufacturing (utilization of renewable natural capital and resource recovery from waste) and, at the same time, spending the profits to conserve and manage forests (maintenance and restoration of nature). For example, in Maniwa City, Okayama Prefecture, the local forest cooperative, laminated wood manufacturer, and other organizations established a biomass power generation company[28]. The company aims to use waste wood, including wood from thinning and wood left in local forests, and offcuts from timber mills, as fuels while using the revenue from electric power sales to improve the forest environment, including planting. These combined efforts make it possible to utilize natural capital and waste and conserve and manage natural capital simultaneously, which means they must be promoted and implemented proactively.

[28] Form of Community That Creates Local SDGs (Ministry of the Environment)
http://chiikijunkan.env.go.jp/assets/pdf/shiru/localsdgs.pdf

2-4 Creation, Enhancement, Visualization, and Indexing of the Value to Realize the Future Vision

(1) Need for creation, enhancement, visualization, and indexing of the value

In promoting the three actions as mentioned in 2-3, it is clear that there is a gap between the cost incurred by the actors of the actions—or industries and citizens/consumers—and the obtained value (cost gap). Therefore, it is essential to reduce the cost required for each action and procure the funds required to fill the unavoidable cost gap. In particular, procuring funds is a challenge for continuing "(3) Maintenance and restoration of nature."

Procuring funds requires enhancing the value of products and services. To achieve this, it is effective to clarify their environmental value and socially recognize the economic value of things that have not been identified as economic value (value creation)[29] or enhance the value of things that have already been identified as economic value (value enhancement).[30]

Clarifying environmental value and converting it to economic value requires specific visualization of the effects and influence of the three actions on carbon neutrality, circular economy, and nature positive, which requires indexes as standards.

Visualizing and indexing outputs for the realization of carbon neutrality, circular economy, and nature positive adds the environmental value of the efforts for realizing them as new economic value and increases the funds, thereby promoting the three actions and accelerating the realization of the Nature Symbiotic Economy (Fig. 13).

[29] A possible case of value creation is that the peace of mind from nature or other things that have not been recognized as economic value, such as waste that has been disposed of as garbage, are recognized socially as economic value mainly because of technological advancements or changes in society.
[30] A possible case of value enhancement is that the value of things that have been recognized as resources, such as biomass, is enhanced further, mainly because of technological advancements or changes in society.

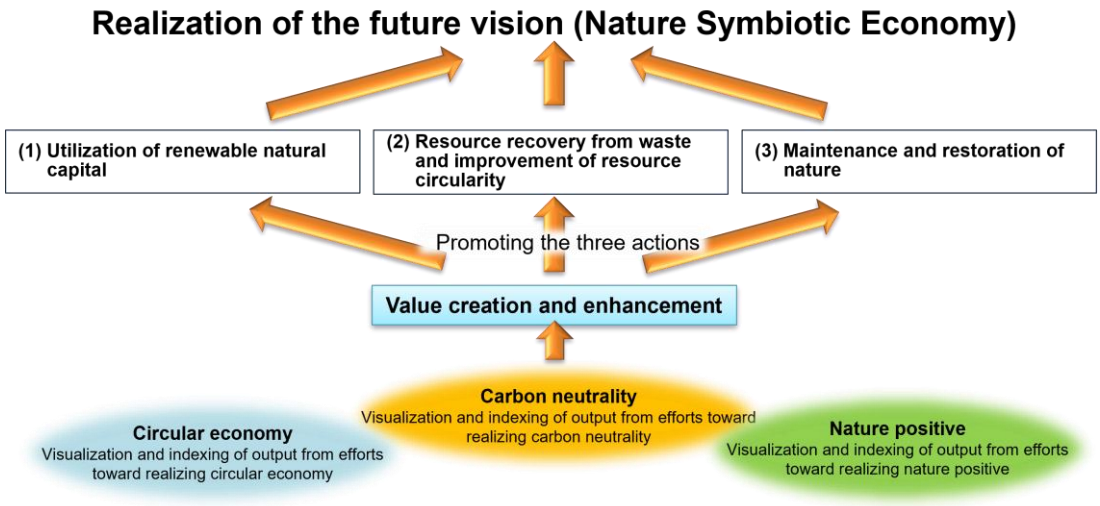


Fig. 13 | Relationships between the value creation and enhancement by visualization and indexing and the actions for realizing the future vision

(2) Current situation of visualization and indexing

In (1) above, the importance of visualization and indexing of outputs for realizing carbon neutrality, circular economy, and nature positive has been described. The current state of the visualization and indexing for each output is as follows.

a) Current situation of visualization and indexing for carbon neutrality

Visualization and indexing for carbon neutrality have progressed to some extent. For example, the targets for temperature and GHG emission reduction have been set. Efforts are underway for further sophisticated visualization and indexing, including the development of criteria for verifying the degree of achievement. For example, ISO 14068-1:2023[31] was published in November 2023. This international standard provides principles, requirements, and guidance for achieving and verifying carbon neutrality. In Japan, Yamato Transport Co., Ltd. underwent verification for carbon neutrality based on this standard and acquired third-party verification reports that certify that its three door-to-door delivery services conform to ISO 14068-1:2023 and are carbon neutral.[32]

Also, NEDO is estimating the CO_2 reduction potential and CO_2 abatement cost of new technologies to promote visualization and indexing for carbon neutrality.[33]

[31] https://www.iso.org/obp/ui/en/#iso:std:iso:14068:-1:ed-1:v1:en
[32] TA-Q-BIN, TA-Q-BIN Compact, and EAZY have been certified as carbon neutral in accordance with the international standard ISO 14068-1:2023 (Yamato Transport Co., Ltd., 2024) https://www.yamato-hd.co.jp/news/2023/newsrelease_20240130_1.html
[33] Comprehensive R&D Principle for Sustainable Society 2023 (NEDO, 2023) https://www.nedo.go.jp/content/100964787.pdf

b) Current situation of visualization and indexing for circular economy

In terms of international efforts for visualization and indexing for the circular economy, circularity indicators have been presented in ISO 59020, as shown in Table 4 Overview of circularity indicators in the international standard (ISO/DIS 59020). As an example of efforts by individual countries and regions, Europe has established a monitoring framework as a group of indexes for evaluating the progress of the Circular Economy Action Plan[34] (2020) in each EU country, and a database has been created for this.[35] In the US as well, the standardization of indexes is clearly stated in the National Recycling Strategy.

Furthermore, as an example of efforts within the business world, the World Business Council for Sustainable Development (WBCSD) has been offering standard indexes and guidance for businesses to monitor, analyze, and improve their situation for a circular economy (CTI: Circular Transition Indicators) since 2020.[36]

These efforts are currently underway, but according to the Circular Economy Association, the development of evaluation techniques that can be applied cross-sectionally to communities, organizations, products, and services can be problematic. Although some challenges remain, discussions will continue.[37]

Table 4 Overview of circularity indicators in the international standard (ISO/DIS 59020)

	Category	Proposed circularity indicators (ISO/DIS 59020)
Core indexes	Resource inflow	• Average percentage of reuse, average percentage of recycling • Average percentage of resources derived from renewable raw materials
	Resource outflow	• Product and material life compared with industry's averages: Ratio to industry's average • Percentage of reused resources, percentage of recycled resources • Percentage of resources circulated with a biological cycle
	Energy	• Percentage of renewable energies
	Water	• Percentage of circular resources to intake water, percentage of wastewater that conforms to water quality standards, percentage of circular use of water
	Economy	• Revenue share of circular resources (RSCR) • Material productivity (MP): Revenue from use of circular resources / Consumption of non-circular resources • Resource intensity index (RII): Annual GDP volatility / Annual resource input volatility
Additional indexes	*Compiled as indexes for supplementing the core indexes (e.g., energy recovery)	

Source: Document 3, 9th Subcommittee on Resource Circulation Economy, Committee on Industrial Science and Technology Policy and Environment, Industrial Structure Council (Ministry of Economy, Trade and Industry, 2023)[38]

[34] Circular Economy Action Plan (European Commission) https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en
[35] https://ec.europa.eu/eurostat/web/circular-economy/monitoring-framework
[36] https://www.wbcsd.org/resources/circular-transition-indicators-v4/
[37] Circular Economy International Standardization Annual Report, ISO/TC 323 (Circular Economy) Activity Report (2022) (Circular Economy Association) https://www.ce-association.org/wp/wp-content/uploads/2022/11/c90beb78e4ae55ab5b1ccbe4b5085cc9.pdf
[38] https://www.meti.go.jp/shingikai/sankoshin/sangyo_gijutsu/resource_circulation/pdf/009_03_00.pdf

c) Current situation of visualization and indexing for nature positive

To realize nature positive, discussions are underway on visualization and indexing to recognize the value of nature. For example, the Taskforce on Nature-related Financial Disclosures (TNFD)[39] was established as an organization that develops a framework for businesses and financial institutions to appropriately assess and disclose risks and opportunities associated with natural capital and biodiversity. The Ministry of the Environment is also encouraging businesses to make decisions and disclose their information according to TNFD's framework. Furthermore, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), which is known as the biodiversity version of the IPCC, was established in April 2012 and compiled guidelines mainly for designing and implementing techniques and processes to evaluate the value of nature in the Methodological Assessment Report on the Diverse Values and Valuation of Nature[40] in 2022.

As described above, discussions are underway to visualize and index nature positive, but such discussions tend to focus on negativeness, including risks. Announced in March 2024, the Nature Positive Economy Transition Strategy[23] suggests that it is key to consider the transition to nature positive as an opportunity for growth and, at the same time, create a positive impact. It is desirable to expand and enhance efforts to visualize and index positiveness.

(3) Visualization and indexing that takes interactions among carbon neutrality, circular economy, and nature positive into consideration

As mentioned in Chapter 1, efforts towards realizing carbon neutrality, circular economy, and nature positive have synergistic and trade-off relationships with one another. Therefore, it is important to evaluate synergistic and trade-off interactions when visualizing and indexing the output of each effort.

For example, although the efforts to install photovoltaic power panels and utilize renewable energy are evaluated based on the positive contribution to carbon neutrality, it must be possible to assess the trade-off effects on nature positive at the same time if such efforts cause a loss of the natural capital where they are installed. However, the positive contribution to a circular economy, such as the ease of recycling in photovoltaic panel design and the consumption of resources obtained by recycling waste from production, will secure the sustainability of natural capital. Therefore, it is essential to quantitatively evaluate the synergistic effects on nature positive. To assess such interactions

[39] Recommendations of the TNFD (TNFD, 2023) https://tnfd.global/wp-content/uploads/2024/02/%E8%87%AA%E7%84%B6%E9%96%A2%E9%80%A3%E8%B2%A1%E5%8B%99%E6%83%85%E5%A0%B1%E9%96%8B%E7%A4%BA-%E3%82%BF%E3%82%B9%E3%82%AF%E3%83%95%E3%82%A9%E3%83%BC%E3%82%B9%E3%81%AE%E6%8F%90%E8%A8%80_2023.pdf

[40] https://www.iges.or.jp/jp/pub/ipbes-values-spm-j/en

quantitatively, it is consequently important to prepare a large amount of data on the evaluation items and utilize the data effectively.

2-5 Summary of the Future Vision

Chapter 2 summarizes relationships among industries, citizens/consumers, and nature to realize all of the carbon neutrality, circular economy, and nature positive and then suggests the future vision of a Nature Symbiotic Economy. Specific actions for realizing a Nature Symbiotic Economy suggest the following: "(1) Utilization of renewable natural capital," "(2) Resource recovery from waste and improvement of resource circularity," and "(3) Maintenance and restoration of nature." Furthermore, promoting these actions requires creating and enhancing value by converting environmental value in the output from the actions to economic value, so there is a need to visualize and index the outputs for realizing carbon neutrality, circular economy, and nature positive. As future challenges, it is key to establish techniques to evaluate circular economy in a cross-sectional manner, enhance positiveness evaluation indexes for nature positive, and consider the interactions in visualization and indexing.

Chapter 3 Scenario for Realizing the Future Vision (Bioeconomy)

Chapter 2 suggests a Nature Symbiotic Economy as the future vision for realizing carbon neutrality, circular economy, and nature positive. Significant efforts toward realizing a Nature Symbiotic Economy include efforts in the field of bioeconomy. These utilize biological resources and their functions, which are representative resources of natural capital. Chapter 3 then discusses the scenario for promoting the realization of the future vision in the field of bioeconomy.

3-1 Bioeconomy

(1) What is bioeconomy?

In 2009, the Organisation for Economic Co-operation and Development (OECD) suggested the concept of bioeconomy in the Bioeconomy to 2030: Designing a Policy Agenda.[41] Since then, efforts toward bioeconomy have been made around the world.

The markets and strategic fields covered by bioeconomy differ depending on the natural resources, technologies, natural resource infrastructure, and economic and trade policies of each country or region, so there is no globally recognized definition of bioeconomy. In Japan, however, bioeconomy is defined as a concept of expanding sustainable, renewable, and circular economy and society by utilizing biotechnology and biological resources, as described in the Japan Bioeconomy Strategy.[42] In other countries, the scope and roles of bioeconomy are considered to include not only biotechnologies and biological resources but also bioecology, which focuses on the ability to promote biodiversity, conserve ecosystems, and provide ecological services.[43]

(2) Relationships between bioeconomy and carbon neutrality, circular economy, and nature positive

The bioeconomy mentioned above has many of the same keywords that describe the future vision of a Nature Symbiotic Economy. As also mentioned in the government's Japan Bioeconomy Strategy, this means that bioeconomy has strong relationships with the realization of carbon neutrality, circular economy, and nature positive, which are required for a Nature Symbiotic Economy.

---

[41] https://www.oecd-ilibrary.org/economics/the-bioeconomy-to-2030_9789264056886-en
[42] Japan Bioeconomy Strategy (Cabinet Office, 2024)
https://www8.cao.go.jp/cstp/bio/bio_economy.pdf
[43] What Is the Bioeconomy? A Review of the Literature, Sustainability (Markus M. Bugge, Teis Hansen and Antje Klitkou, 2016)
https://doi.org/10.3390/su8070691

The bioeconomy and carbon neutrality are related in that replacing fossil resources with renewable natural capital (including biomass) leads to the reduction of CO_2 emissions. The bioeconomy and circular economy are related in that recycling organic waste and other waste and utilizing them effectively causes the circulation of resources. Furthermore, the bioeconomy not only utilizes natural capital as resources but also maintains and restores nature through economic activities. The concept of bioeconomy is very similar to that of nature positive. Such relationships of efforts in the field of bioeconomy with the contributions to realizing carbon neutrality, circular economy, and nature positive can be seen in Fig. 14.

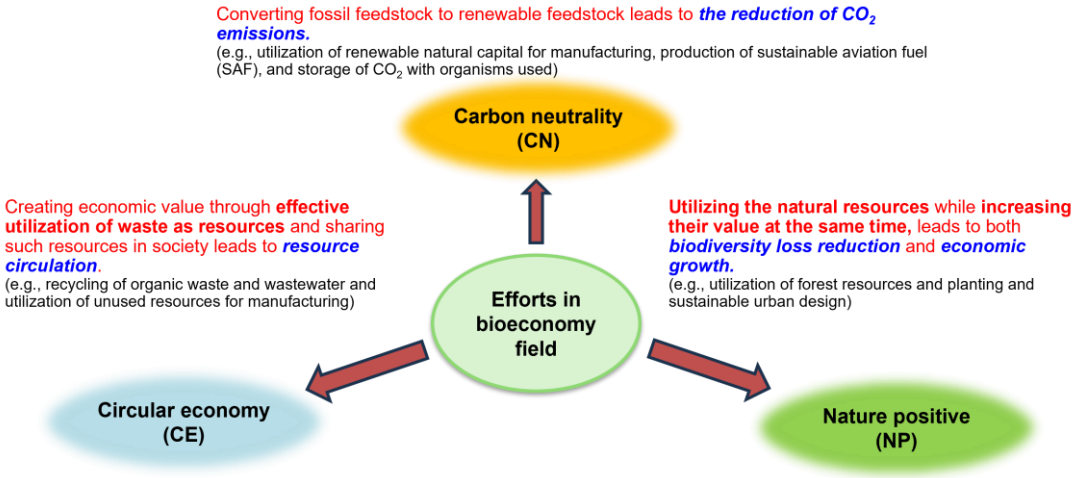


Fig. 14 | Relationships of bioeconomy with CN, CE, and NP

(3) Examples of efforts in the field of bioeconomy related to the actions for realizing the future vision

Bioeconomy is also closely related to the three actions that are required to realize the future vision. The following gives examples of efforts in the field of bioeconomy related to these three actions.

a) Examples of efforts in the field of bioeconomy related to the utilization of renewable natural capital

Efforts related to the utilization of renewable natural capital include those for manufacturing.

For example, efforts are underway to replace conventional aviation fuels with sustainable aviation fuels (SAF). These efforts contribute to carbon neutrality through the shift from crude oil-based aviation fuels to renewable resource-based aviation fuels, such as biomass. In NEDO, a project related to production technologies for bio-jet

fuels[44] is underway to establish a supply chain for manufacturing and delivering SAF (Fig. 15) by around 2030.

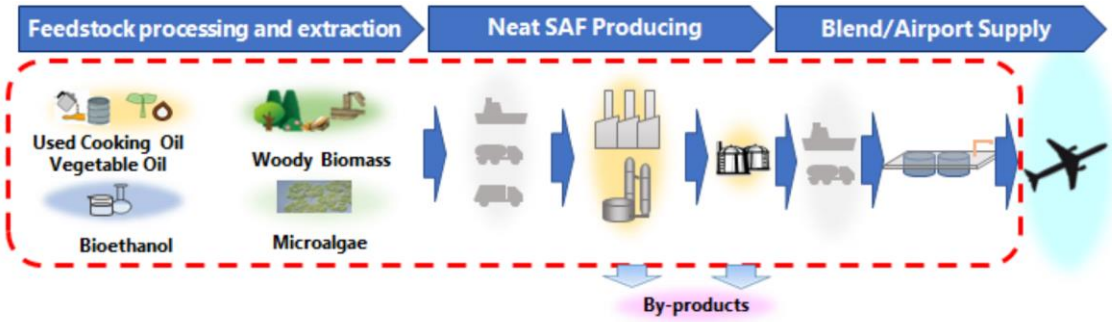


Fig. 15 | Imaged diagram representing a supply chain of SAF

Source: NEDO's homepage[45]

Furthermore, efforts related to manufacturing through the use of biomass include the project named Development of an Agri-Bio Smart Chemical Production System, which was implemented in the second phase of the Strategic Innovation Promotion Program (SIP). This project is aimed at transforming components contained in non-edible agricultural residues into multiple useful components with added value or high-quality biomaterials at high yields, thereby enabling a low-cost and stable supply of basic compounds obtained at the same time. A business model has been suggested that C6 sugar, which can be used as a raw material for basic substances in the chemical industry, should be supplied at a price of 30 yen/kg by using rice straws and chaff as raw materials (Fig. 16).

[44] Toward a Sky of Carbon Neutrality—NEDO Technology Development for SAF (NEDO, 2022) https://webmagazine.nedo.go.jp/movies/202202-03-biojet/
[45] Development of Production Technologies for Biojet Fuels (NEDO, 2023) https://www.nedo.go.jp/activities/ZZJP_100127.html

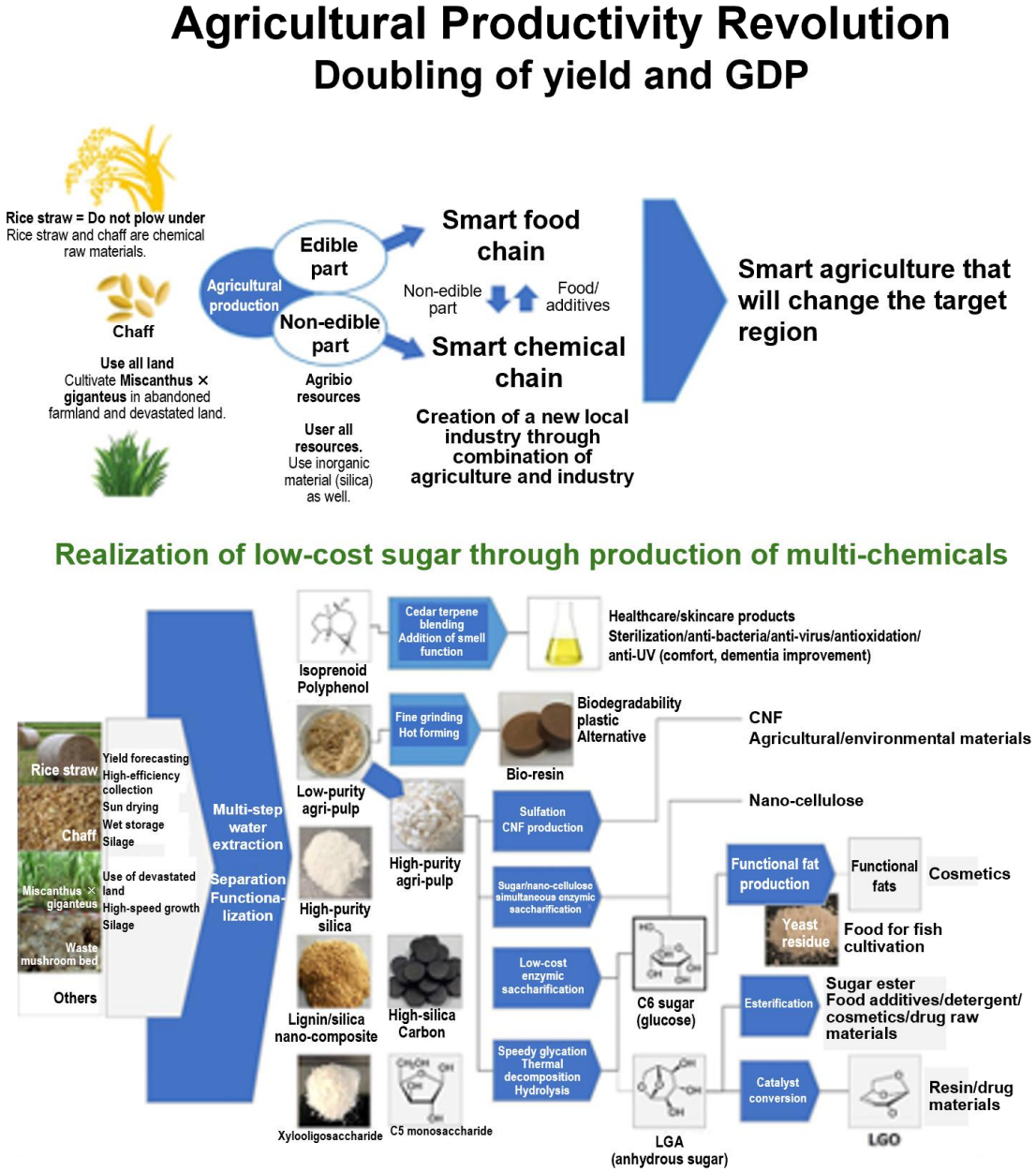


Fig. 16 | Project overview of agri-bio smart chemical production systems

Source: Homepage of Agribio-Chemical System Consortium[46]

b) Examples of efforts in the field of bioeconomy related to resource recovery from waste

Efforts related to resource recovery from waste include those associated with the recycling of organic waste.[47]

[46] Agribio-Chemical System Consortium (Strategic Innovation Promotion Program, Cabinet Office) https://agribioconso.cm.kyushu-u.ac.jp/project/

[47] For example, livestock excreta, organic sludge from food production industry, waste from food processing, household kitchen waste, sewage sludge, and human waste/septic tank sludge

Organic waste contains a large amount of water and has a large volume, making it unsuitable for long-distance transportation. Therefore, efforts are underway to recycle waste particular to a specific region and utilize it effectively in that region.

For example, Okoppe Town, Hokkaido, began operating a biogas plant using livestock excreta in November 2016 to establish a resource circulation system. In this system, biogases and liquid fertilizers are produced by using a fermentation technology that uses local biomass resources (such as cow excreta) as raw materials and are supplied locally to dairy farmers and others. At the same time, the town has been working on biogas power generation using the Feed-in Tariff (FIT) system. To continue earning revenue even after the FIT support period ends, the town is aiming to commercialize the technology to produce chemical raw materials and methanol, formic acids, and other materials that can be used as a hydrogen carrier from biogas by applying the technology developed by the Osaka University.[48]

Ushiku City, Ibaraki Prefecture, formulated a biomass town concept in 2008 and has been working to produce biodiesel fuel (BDF) from recovered waste food oil. It also extracts oil from rapeseed cultivated in abandoned farmland, uses the extracted oil for school meals, and then uses the used oil as a raw material for BDF. This city was appreciated for these efforts—along with expanding the related resource circulation through the supply of BDF to neighboring communities—and was recognized as a biomass industrial city concept[49] in 2013.[50]

NEDO is working on resource recovery from waste as part of its project Research and Development of Technologies to Promote Biomanufacturing. In this project, organic materials generated as industrial by-products—such as waste food oil from restaurants, food residue mainly from food processing plants, agricultural residue, forest thinning, waste wood, and waste pulp (including those not used due to excessive supply)—and organic waste (including used clothes, wastepaper, and household garbage and sludge) are exemplified as unused resources and recovered, thereby utilized as raw materials. Also, research and development has been conducted on matter production using microbial processes (Fig. 17).

[48] Efforts Toward Advanced Utilization of Biogas (Okoppe Town)
https://www.town.okoppe.lg.jp/cms/section/kikaku/biomass-methanol.html
[49] Efforts Toward Biomass Industrial City Concept (Ministry of Agriculture, Forestry and Fisheries)
https://www.maff.go.jp/j/shokusan/biomass/b_sangyo_toshi/b_sangyo_toshi.html
[50] Ushiku City Recognized as Biomass Industrial City Concept (Ushiku, 2020)
https://www.city.ushiku.lg.jp/page/page003074.html

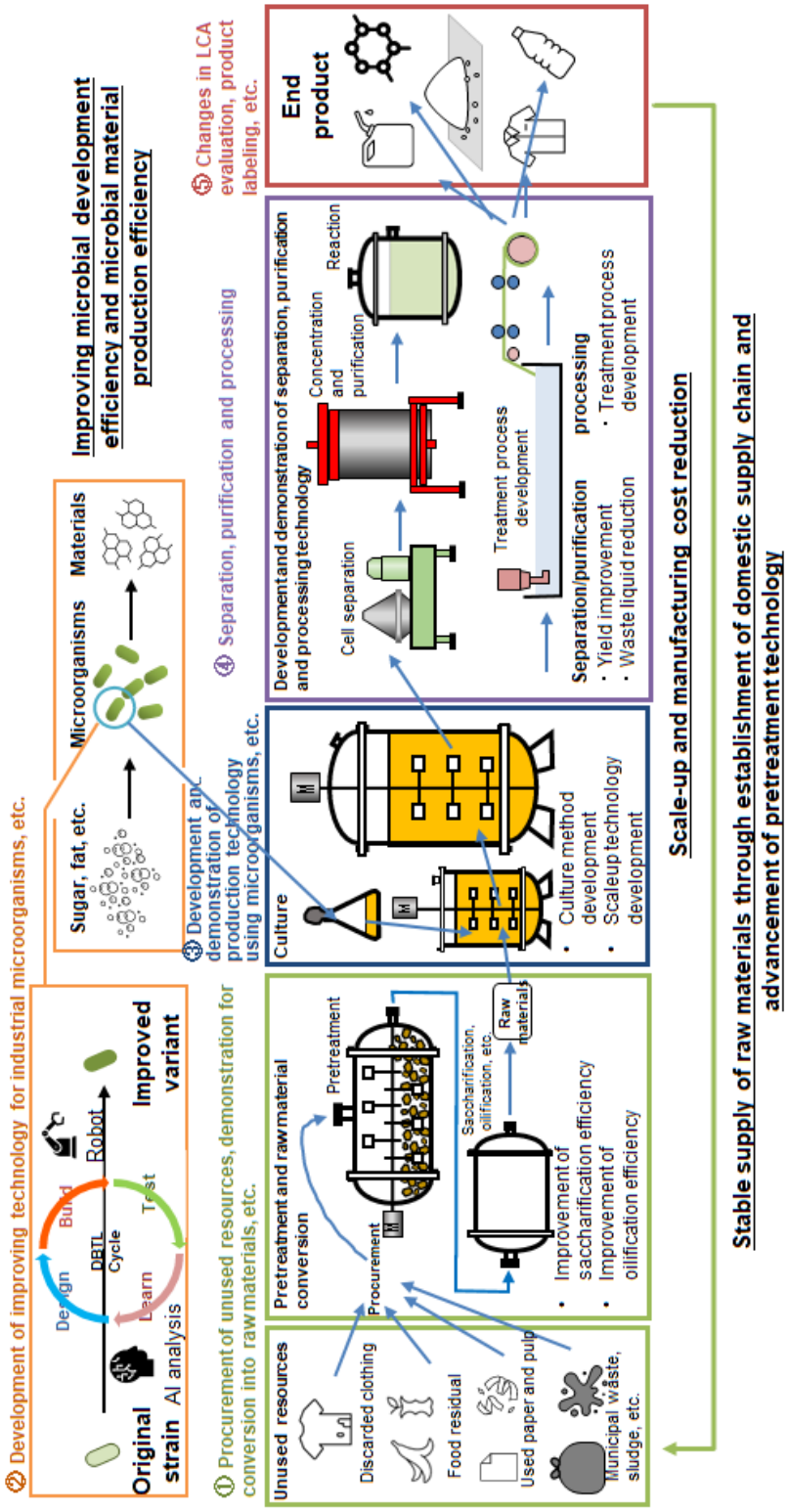


Fig. 17 | Manufacturing flow of products by bio-manufacturing (image)

Source: NEDO's homepage[51]

[51] Research and Development of Technologies to Promote Biomanufacturing (NEDO) https://www.nedo.go.jp/activities/ZZJP_100246.html

c) Examples of efforts in the field of bioeconomy related to the maintenance and restoration of nature

Efforts related to the maintenance and restoration of nature include those focusing on nature's functions, such as providing raw materials necessary for economic activities, absorbing carbon dioxide and preventing global warming, and avoiding natural disasters. Efforts are made to maintain and enhance these functions.

To promote the utilization of wood throughout the entire society and contribute to decarbonization for sustainable forest management, Sumitomo Forestry Co., Ltd. is logging and replanting trees in a planned manner,[52] with the aim of rejuvenating forests while protecting ecosystems and increasing CO_2 absorption. Oji Holdings Corporation is also planting, growing, and logging trees in forests with a large area of 573,000 ha that it owns and manages in Japan and other countries. It utilizes the logged trees mainly to produce wood, plywood, chips for papermaking, and wooden biomass fuels and is replanting forests for sustainable forest management.[53] Nippon Steel Corporation is working to restore seagrass beds and separate and store CO_2 in blue carbon ecosystems by creating seagrass beds with towns and villages in Hokkaido and Chiba Prefectures. The aim is to conserve and restore marine ecosystems.[54]

[52] Sustainable Forest Management (Sumitomo Forestry Co., Ltd.)
https://sfc.jp/information/sustainability/environment/forest/domestic.html
[53] Healthy Forest Development and Resource Circulation (Oji Holdings Corporation)
https://ojiholdings.disclosure.site/ja/themes/215/
[54] Nippon Steel acquired J Blue Credit Certification for three new projects following on from the previous fiscal year: Joint Application in the Blue Carbon Project in the Offshore of Hokkaido Mashike Town, Tomari Village, and Kimitsu City (Nippon Steel Corporation and other organizations, 2024)
https://www.nipponsteel.com/common/secure/news/20240319_100.pdf

3-2 Scenario for Realizing the Future Vision (Bioeconomy)

As described so far, efforts in the field of bioeconomy are considered to play an important role in realizing a Nature Symbiotic Economy, which means the creation of complementary relationships between the industrial ecosystem formed by various industries and citizens/consumers and nature.

The following discusses the scenario for establishing complementary relationships between the industrial ecosystem and nature to take into account efforts in the field of bioeconomy.

(1) Conventional relationship between the industrial ecosystem and nature

As shown in Fig. 18, the conventional industrial ecosystem has a linear economy model where natural resources are continuously consumed. Most of the natural resources used in the industrial sector are fossil resources, and even in producing agricultural, forestry, and fishery products, which are renewable resources, fossil resources are used mainly to produce necessary fertilizer. Therefore, the industrial ecosystem has had a significant influence on climate change because of large CO_2 emissions. The supply chain of resources, products, utilization, and disposal has a unidirectional flow, and nature, which is a source of resources, is not maintained or restored sufficiently. This type of linear economic model involving mass production, mass consumption, and mass disposal causes the social issues described in Chapter 1.

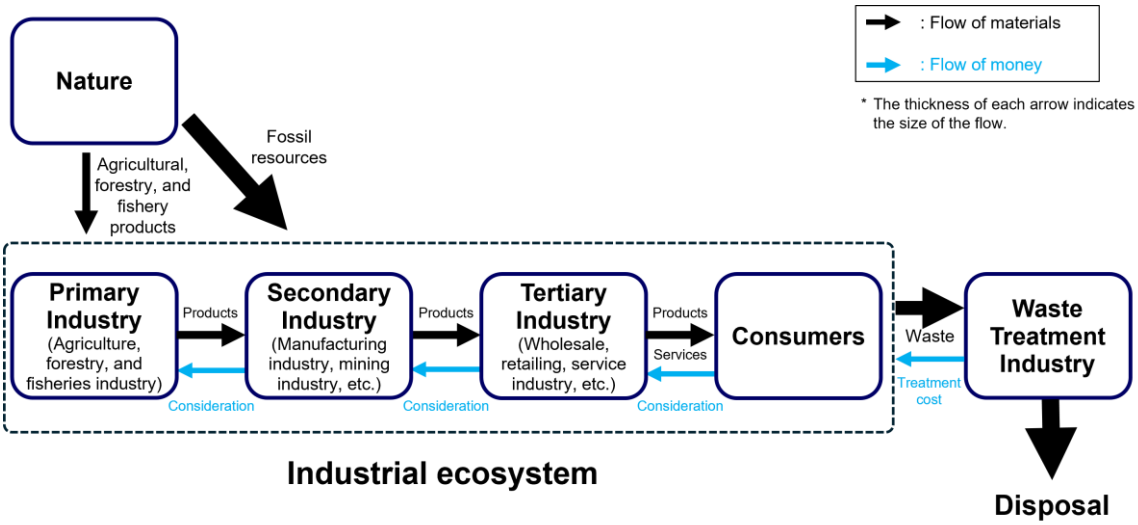


Fig. 18 | Conventional industrial ecosystem

(2) Ideal relationship between the industrial ecosystem and nature

Fig.19 shows the scenario for implementing the actions to realize a Nature Symbiotic Economy in the field of bioeconomy, a departure from the conventional industrial ecosystem that has the problems mentioned above.

Fig. 19-1 shows the actions that are required for the future vision described in Chapter 2 and the current relationship between the industrial ecosystem and nature. In "(1) Utilization of renewable natural capital," biomass and other unused resources are being utilized, which has led to the diversification of revenue sources and the entry of newcomers in the primary sector. Furthermore, new industries using biomass in the secondary sector are emerging. Also, promoting "(2) Resource recovery from waste and improvement of resource circularity" has created new industries where resources are utilized more effectively by waste disposal companies and, at the same time, brought about various effects (such as product diversification) through the circulation of recycled resources to the industrial sector. Furthermore, owing to "(3) Maintenance and restoration of nature," the restoration of biodiversity in nature has begun.

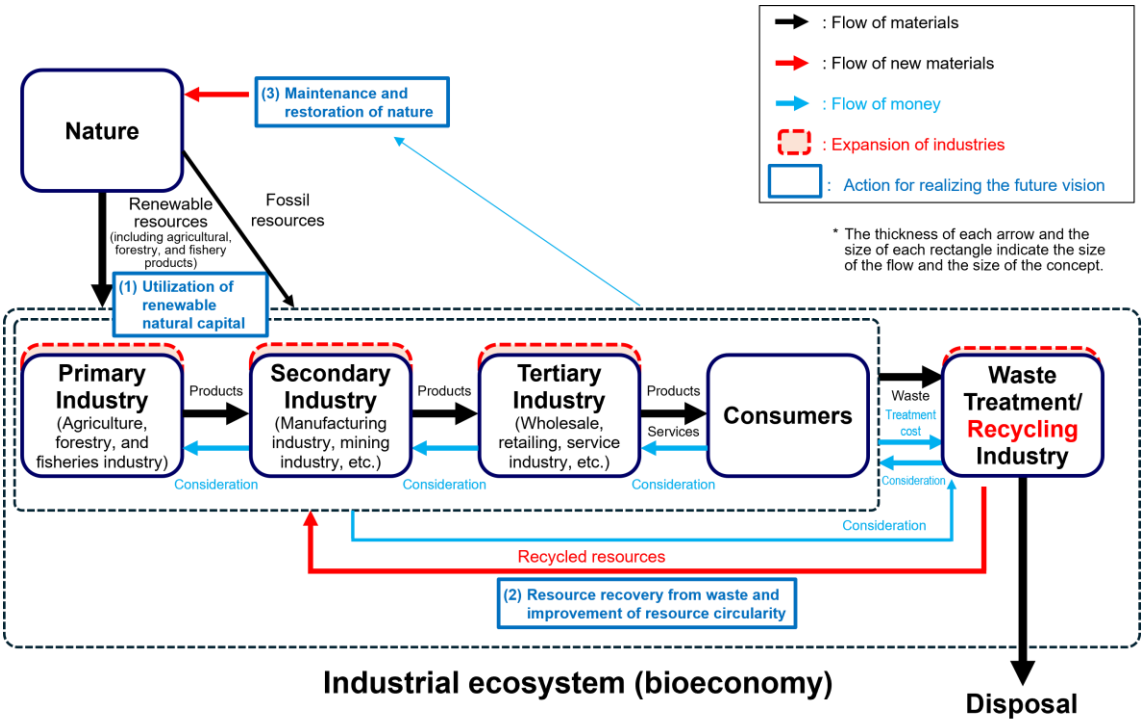


Fig. 19-1 | Current relationship between the industrial ecosystem and nature in implementing the actions for realizing the future vision

However, as described in Chapter 2, there is a cost gap in implementing these actions. Therefore, these actions have yet to be established as economic activities, and their benefits are limited. In particular, the action for maintaining and restoring nature is insufficient. To promote the realization of the future vision, there is a need to create and

enhance value through the visualization and indexing of the outputs of efforts toward realizing carbon neutrality, circular economy, and nature positive and promote the three actions by using the value as funds.

Fig. 19-2 shows the scenario for promoting the realization of the future vision in the field of bioeconomy, where actions are promoted through value creation and enhancement. Converting the environmental value of products derived from natural capital and waste to economic value would further encourage newcomers to enter the primary sector with diversified revenue sources and continue expanding industries using biomass in the secondary sector. Also, value creation and enhancement will lead to the enhancement of the value of services provided by the tertiary sector (including environmental value credits and tourism) and the expansion of industries in the tertiary sector as well as industries that effectively use resources in the recycling sector. Furthermore, value creation and enhancement will lead to the expansion of consumer demand for these products and services. These changes in businesses' and consumers' motivation for nature in the industrial sector, including funds, promote actions by businesses and citizens to maintain and restore nature. This action would further enhance the environmental value of nature through the restoration of biodiversity and the expansion of nature while also promoting actions to realize the future vision.

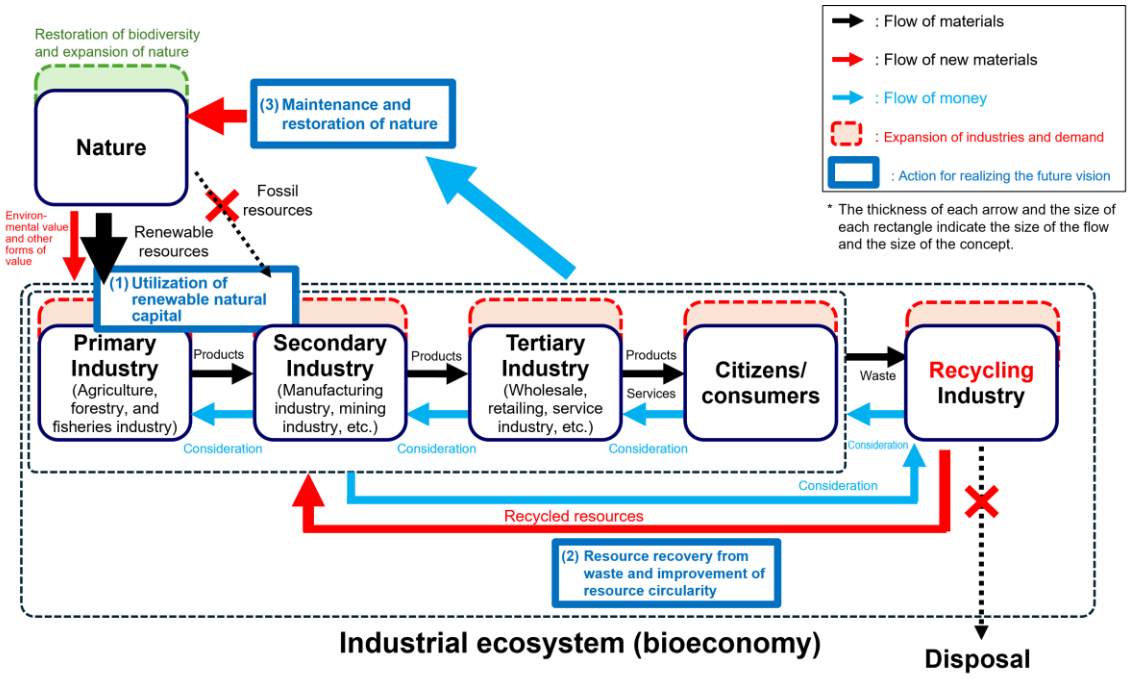


Fig. 19-2 | Promotion scenario in the field of bioeconomy for realizing the future vision

As previously described, value creation and enhancement through the conversion of environmental value to economic value must create a virtuous cycle where nature and the industrial ecosystem have a positive influence on each other, enhance each other's value synergistically, and increase the happiness of citizens/consumers mainly through products and services. This is considered an effective scenario for realizing the future vision.

3-3 Items to Be Discussed for Realizing the Future Vision (Bioeconomy)

In the field of bioeconomy, biomass—which is natural capital—is to be used. However, biomass is unevenly distributed in specific regions, and because of its characteristics, transportation efficiency is relatively low, requiring a large amount of energy and high costs for transportation. Therefore, it is realistic to implement the actions with the aim of realizing the future vision on a regional basis by taking advantage of the characteristics of the regions where biomass exists or where biomass production can be increased. In fact, considering regional circular and ecological spheres as the ideal state of a sustainable society which Japan is aiming for, the Ministry of the Environment is registering and supporting communities and organizations that are intended to resolve environmental, social, and economic issues simultaneously while making maximum use of various local resources. Currently, 203 organizations have been registered.[55]

Nonetheless, to realize the future vision, it is necessary to enhance economic autonomy and sustainability while promoting the scenario in 3-2. Therefore, collaboration among different regions and industries is essential to expanding their regional circular and ecological spheres to the optimal size. Even so, it is necessary to discuss what action should be taken according to the forms of industries, citizens/consumers, and nature throughout the regions collaborating with one another. More specifically, it is important to understand the industrial structure, population size and composition, and amount of renewable resources of the relevant regions, select the best action to maximize the environmental value while sharing that information with the relevant organizations, and promote the action while taking appropriate measures.

3-4 Summary

Focusing on the field of bioeconomy, which could contribute to the realization of carbon neutrality, circular economy, and nature positive, Chapter 3 summarizes the scenario for realizing the future vision—or a Nature Symbiotic Economy—in the field of bioeconomy as the relationship between nature and industrial ecosystem.

As a result of actions taken in the field of bioeconomy, the industrial ecosystem is shifting from the conventional linear economic model to the circular economy model. To promote the realization of the future vision, it is important to convert environmental value to economic value through the visualization and indexing of the outputs of efforts toward realizing carbon neutrality, circular economy, and nature positive so as to create and enhance value and promote the actions. At this time, it is important to realize carbon neutrality, circular economy,

[55] Registration System for Companies and Organizations in Regional Circular and Ecological Spheres (Ministry of the Environment)
http://chiikijunkan.env.go.jp/kigyou/list/

and nature positive in an integrated approach, not just on an individual basis. In doing this way, it is expected to create a virtuous cycle where nature and the industrial ecosystem interact and complement each other, synergistically enhance the value of industries, citizens/consumers, and nature, and increase the happiness of citizens/consumers.

In the field of bioeconomy, it is essential to implement the best action according to the relevant regions in consideration of the characteristics of the resources to be handled. Communities and businesses in the appropriate regions are expected to work together to establish a locally autonomous system that takes advantage of the features of such regions.

Conclusion

Climate change, natural resource depletion, biodiversity loss, and other social issues are expanding, and efforts toward carbon neutrality and circular economy are becoming more active. Japan is also forcefully promoting the Green Innovation Fund Program and the Green Transformation Promotion Program. Recently, the importance of nature positive has also been suggested, and there is an expanding recognition that, for the growth of a sustainable society, it is important to realize carbon neutrality, circular economy, and nature positive in an integrated manner.

This report has suggested the future vision of a Nature Symbiotic Economy as the mechanism of a circular economy. In this case, industries, citizens/consumers, and nature complement one another and enhance the total value to resolve social issues and achieve sustainable economic growth with the aim of realizing carbon neutrality, circular economy, and nature positive. Furthermore, this report also has described the three actions necessary to realize a Nature Symbiotic Economy through certain examples: "(1) Utilization of renewable natural capital"; "(2) Resource recovery from waste and improvement of resource circularity"; "(3) Maintenance and restoration of nature." Also, in order to realize the future vision, it is important to promote these three actions with economic rationality. Therefore, this report shows the importance of converting the environmental value obtained by these actions to economic value through visualization and indexing. In discussing indexes, it is essential to discuss in the future how the efforts toward realizing carbon neutrality, circular economy, and nature positive will interact together. NEDO's Technology and Innovation Strategy Center will continue visualization, indexing, and relevant trend surveys while also sharing and discussing the results with multi-stakeholders, including industries, local governments, academic circles, governmental agencies, and citizens, to promote the activities for realizing a Nature Symbiotic Economy.

NEDO expects that this report will provide opportunities for multi-stakeholders to discuss and bring about changes in their awareness and behavior so as to promote specific measures for resolving many social issues.

Technology and Innovation Strategy Center

TSC Foresight

Future Vision: Nature Symbiotic Economy

Published on July 26, 2024

New Energy and Industrial Technology Development Organization
Technology and Innovation Strategy Center (TSC)

■ Executive Director KISHIMOTO Kikuo

■ Director-General UEKI Kenji

■ Bioeconomy Unit

• Unit Leader	MIZUNASHI Wataru	
• Researchers	YAMAMORI Akihiro	(until March 2024)
	KIMURA Yusuke	
	MIMAKI Yoshiya	(until June 2024)
	KOBAYASHI Kazuki	(until March 2024)
	MINAMI Seiko	(until September 2023)
	IDE Hiroyuki	(until June 2024)
	ISHIKURA Shun	
• Fellows	BABA Yoshinobu	Professor, Institutes of Innovation for Future Society, Nagoya University
	YASOHARA Yoshihiko	Biotechnology Research Laboratories, Pharma & Supplemental Nutrition Solutions Vehicle, Kaneka Corporation
	YUMOTO Noboru	Visiting Professor, Engineering Biology Research Center, Kobe University
	YOSHIKAWA Hirofumi	Professor Emeritus, Faculty of Life Sciences, Tokyo University of Agriculture

● Contact for this report
Tel. +81-44-520-5200 (Technology and Innovation Strategy Center)

● This report can be downloaded from the URL below.
https://www.nedo.go.jp/library/foresight.html