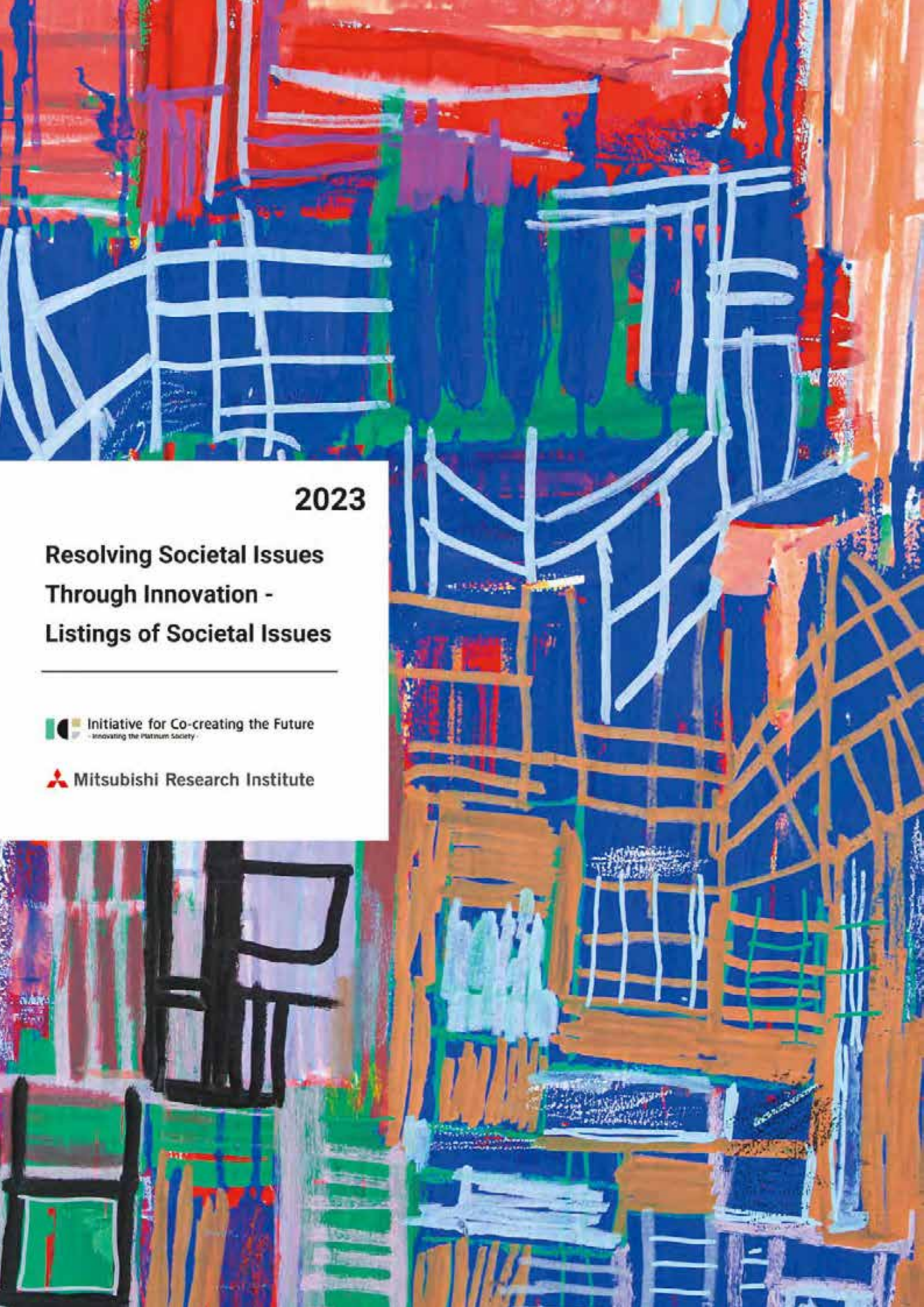

2023

Resolving Societal Issues Through Innovation - Listings of Societal Issues

Initiative for Co-creating the Future
- Innovating the Platinum Society -

Mitsubishi Research Institute

Resolving Societal Issues Through Innovation

2023 Listings of Societal Issues

Issue: January. 2024. Ver. 1

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ISBN978-4-943853-25-1 C0400 ¥2000E

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Design / Space-Time Inc.

On the Initiative for Co-creating the Future

The Initiative for Co-creating the Future (ICF) started anew in April 2021 by merging two existing networks and their member bases that the Mitsubishi Research Institute had cultivated: the *Platinum Society* Research Association (PSRA) and the Innovation Network for Co creating the Future (INCF).

Established in 2010 PSRA had been advocating the concept of the Platinum Society, a social model for the 21st century where material affluence is realized and people's concept of values are diversified The Innovation Network for Co creating the Future (INCF), inaugurated seven years later in 2017 had additionally advocated for resolving societal issues through open innovation in order to design and materialize innovative solutions and business models.

Two years after the merger between the PSRA and INCF, the network now consists of over 500 diverse members from industrial, academic, public, and private sectors, including startups and venture companies ICF members share the common goal of co creating a future society where sustainable affluence is realized in terms of both quantity and quality They also respect each other as equal partners The initiative will evolve into an unparalleled platform, or ecosystem, that aims to integrate knowledge and co create value.

The participation of many members and stakeholders makes it possible to increase scope, scale, and speed thus enabling the creation of collective impact to resolve major societal issues. ICF aims to contribute to the realization of a sustainable society where 10 billion people can live in affluence to the age of 100.

Cover Artwork: Heralbony, Inc.

The art featured on the cover is by Yu Takada, a contract artist for the ICF member HERALBONY Co., Ltd and an artist member of Jinenjo Club, Ibaraki Prefecture. The work is titled "Maze." HERALBONY Co., Ltd. signs contracts mainly with artists with intellectual disabilities all over Japan and is developing a variety of businesses with the intent to expand the scope of welfare. These include licensing business centered on the copyright management of over 2,000 pieces of high-resolution art data and operation of the art lifestyle brand "HERALBONY," which incorporates the works into products such as fashion and interior products.

Artist: Yu Takada (Jinenjo Club - Ibaraki)

Yu Takada has a rich sensitivity and imagination, possessing a wide range of expressions as a performer in taiko drumming, painting, and dancing. He is a true Disney fan and creates works inspired by parades and magic carpets. Other than Disney, he likes to draw mazes as well. The multi-layered mazes, gradually formed by connecting line after line, lure people into a labyrinth. With a laid-back personality, he enjoys adorning his favorite books in his room and around his bed, having a leisurely atmosphere surrounding him.

In preparing this document

The United Nations adopted The Sustainable Development Goals (SDGs), targets for achieving a world where progress leaves no one behind, at its summit in September 2015. The 17 goals span both quantitative and qualitative measures. The world is halfway to the global deadline for the goals as of 2023. This has spurred on various discussions among nations, which are now accelerating their concrete measures. In the ultralong run, however, 2030 is not the finish line. Across a 30, 50, even 100-year span, it is also time to start considering, reviewing, and revising the goals once again.

The world, however, is complex and becoming increasingly uncertain, often summed up as the VUCA era: volatility, uncertainty, complexity, and ambiguity. Changes are occurring rapidly while problems intertwine, expand, and spread across the world all at once.Furthermore, because the world lacks existing successful examples, issues must be resolved through substantial trial and error.

New and sweeping trends across many societies will provide the insight necessary to understand these problems.Specifically, these trends provide a starting point for unraveling the structure of a problem. This in turn will allow us to anticipate future and potential problems, as well as problems that are already present and impactful.

For example, one of the important trends is represented by the keyword division. In addition to divisions between countries, there is an increasing number of situations where people create divisions of various sizes due to differences in thought, values, amount of information, and information sources. If left unaddressed, this could readily give way to new disparities and conflicts.

It is also important to regularly maintain knowledge on the state of technological innovation. The development of vaccines, for example, gained significant attention during the covid pandemic. The rapid penetration of generative AI has also been a remarkable modern trend. Innovation is moving very fast; combining technologies can create new innovations that will expand the range of solutions.

Resolving Societal Issues Through Innovation—Listings of Societal Issues (the Listings), published by ICF, identifies and organizes societal issues that promise to have a large impact on the world. It raises relevant alerts about what is happening in the world today, what is important, and what drives these problems, while also providing clues to solutions. The Listings aims to create opportunities to resolve these issues in a concrete manner. To this end, it presents each problem by analyzing its context and causes, identifying its importance and priorities, setting issues for solution, and providing clues to tangible and impactful solutions.

This is the sixth edition of the Listings since its inception in 2017. ICF hopes that this Listings will contribute to co-creatio n activities with those who are working to resolve issues as a common agenda for realizing a sustainable society where ten billion people can live in affluence to at least the age of 100.

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II Societal issues by field

How to explore this booklet

How to search

Search by category of societal issues

We organize and structure societal problems in Japan and around the world by focusing on the following six main fields: “Wellness,” “Water and Food,” “Energy and Environment,” “Mobility,” “Disaster Prevention and Infrastructure,” and “Education and Human Resource Development.”

Each of these fields contains 4 to 7 specific topics covering societal problems, societal issues, and clues to solutions (technological and regulatory trends). Please take a look at the table of contents and explore the field or specific topic that interests you.

Search by SDGs

If you are interested in specific SDGs, please check “Which societal problem/issue aligns with this SDGs?” from the SDGs Index at the end of the booklet.

Search by technology

If you have a particular interest in certain technology, please refer to the Technology Index at the end of the booklet and explore “Which societal problem/issue could this technology help or potentially help resolve?"

Search by keyword

The Table of Societal Issues at the end of the booklet contains a comprehensive list of societal problems/issues and key points for issue resolution. If you have specific keywords of interest, please refer to the corresponding section in the main text.

Legend

World
Potential impact estimates

World・Japan
Potential Impact Estimation

Japan
Potential impact estimates

We have estimated the potential impact of each societal problem in both Japan and around the world. For the details of methodology, please refer to the "Preface" on page 12.

How to read each issue

Even if you are not an expert in a particular field, we make the content of this booklet ccessible to everyone, as when you read it, you will have thoughts like "I didn't know that before, there is such an issue existed!" "The impact of this issue is so substantial!" or "There are these technological development that may help us resolve this problem."

We hope that this booklet will spark your ideas as you consider what you and your company/organization could do to contribute to resolving these societal problems.

This section visualizes the overall picture of societal problems, societal issues, and pathways to resolution with illustrations.

This section provides an overview of societal problems in Japan and worldwide and offer a quantitative presentation of the impact of each problem.

This section offers structured explanation of societal issues and expresses key points for issue resolution by each category.

This section highlights noteworthy technological trends in Japan and worldwide that serve as pathways to resolving societal issues.

This section presents the timeline for the practical application (commercialization) of technologies in three phases (up to 2025, up to 2035, and beyond 2035).

This section shows Japan's domestic and international regulatory trends worth considering as pathways to resolving societal issues.

This section introduces case studies in Japan and worldwide related to technological trends

This section specifies the SDGs that are most closely associated with this societal problem.

Introduction

1. How the Listings Perceives Societal Issues

(1) Global changes and societal issues

Over the past few years, more and more people have begun to feel as if the world is constantly changing and moving. The covid pandemic sparked rapid changes in life and work. Russia's invasion of Ukraine created a divided political and economic system on a world scale. These are critical vents that remain ongoing. In addition, the progress and penetration of digital transformation, represented by generative AI, are improving the efficiency of information production, but on the other hand are exacerbating the flood of information and widening the digital divide. Meanwhile, companies around the world are adapting management styles that aim to achieve both economic and social value, driven by the SDGs as well as by demands from the capital market.

Such a style of management focuses on business development and corporate valuation that also considers societal impact. These shifts are all characterized by both the rapid speed of change itself as well as the rapidity with which they spread and take hold throughout the world.

Major changes are accompanied by new and unknown experiences, which in turn cause disproportionate anxiety and fear from a lack of accurate predictions of the future. If this is left unresolved, the anxiety of individuals could spread systematically across society.

To minimize the possibility of this happening, it is essential to capture the world's movements and changes as appropriately as possible.

As a result, it is exceedingly important to regularly assess what is happening in the world, including causes and potential ripple effects, and to share these findings globally. These efforts are not meant to act as merely a warning; they must incorporate perspectives on each problem and provide a sense of direction toward solutions. In order to achieve this, it is important to carefully investigate individual events, analyze them, and identify the major trends behind them. Perspectives that delve into the structure of problems, new approaches to setting issues for problem-solving, and a steady understanding of the potential of advanced technologies and innovations will be our strongest tools in resolving societal issues.

ICF's efforts to organize societal issues, analyzing their structure and setting an agenda for resolving them, which are the starting point of ICF activities, play the same role as above. The following provides an overview of how ICF goes about defining societal issues, the foundation of the Listings.

(2) New trends surrounding societal issues

In recent years, the social environment in which we live and the various problems that arise within it have been characterized by the many unprecedented phenomena occurring and by the tendency for multiple issues to intertwine with each other and create additional problems. Moreover, the rapid pace of change, and the fact that the effects of such changes spread and diffuse over a wide area all at once, make it even more difficult to understand the problems.

For example, the issue of the aging society poses significant difficulty. The core problem is that the rapid aging of the population places a huge strain on social security costs and makes people anxious about the future. It is extremely difficult to find a way to resolve this problem that will satisfy everyone. It is obviously desirable that older people stay healthy and enjoy longer lives. However, if they need more medical care, greater burdens, financial or otherwise, will persist for themselves and those around them. Moreover, trying to find an easy way out by increasing the burden on the working-age population will only exacerbate the problem. This is exactly how attempts at resolving societal problems

can inadvertently trigger other problems or create a chain of negative impacts instead of the intended chain of positive impacts.

The environment surrounding us has changed significantly in an extremely short period of time since the outset of the covid pandemic.

Work style reform, which had been slow to change, has rapidly progressed with the spread of online meetings and remote work. Another change involves the lowered barriers for online education and medical care, which has helped to reduce inconvenience and disparities that existed in the past.

A positive impact chain is exemplified in how certain long-standing issues were resolved immediately by a series of policy decisions. A negative impact chain may also be amplified, however, as the world faces rapid and widespread change as a result of the intertwining of societal problems. Examples of adverse and unintended effects of extended work-from-home include increased loneliness and inequality. As the world fumbles for solutions to current issues, new ones may arise while sights are focused elsewhere.

It is paramount to recognize that societal problems have entered a new phase.

Because of this, new issues should be identified along with a structural analysis of their causes and situational factors. The collective path to resolving complex problems can be found only by careful study and understanding at the onset of our effort.

(3) A new stage in defining societal issues

In past, high-growth periods, the problems in industrialized societies were relatively clear, and many of them could be solved through technological innovation. For example, air pollution problems caused by rapid motorization clearly necessitated the goal to reduce the concentration of pollutants in exhaust. Moreover, the technical issues needed to overcome these problems were also apparent, and this led to immediate and tangible solutions.

With clear goals, there was less need to explicitly create an agenda for setting issue-resolving measures and efforts.

However, many of the problems that must be addressed now cannot be resolved independently of each other. It is necessary to look at the intertwined groups of related problems to grasp structurally what, how, and in what order to proceed, as well as the path to impactful solutions. Only after going through the process of establishing issues from the larger problems can we start working toward a solution.

When agenda setting, it is important to approach problems with a sense of direction for future solutions.

Simply posing a problem and issuing a warning do not result in a concrete move toward a solution.

Doing so may only incite social unrest that otherwise would not occur. Efforts should be organized to serve as a starting point for discussions among those who undertake solutions.

In addition, there are an increasing number of problems for which simply restoring the original status quo is not an acceptable solution. Post-pandemic recovery is not the equivalent of restoring the pre-pandemic status quo, and certain problems, including the environmental and energy crises, can never be truly restored to the pre-industrial era. Furthermore, solutions need to be sustainable. Agenda setting must apply perspectives spanning 10, 50, even 100 years.

(4) Accelerating the solution of issues

Agenda setting and crafting solutions requires the mobilization of a wide range of technologies and stakeholders. The degree of this mobilization determines the magnitude of societal impact that can be realized.

The first thing to focus on is the diversity of technological innovations that can contribute to impactful solutions. While the structure of societal problems is becoming more complex, available technologies are also steadily increasing. Expectations are growing for the practical application of the technologies comprised by the digital transformation, including generative AI. Innovations in optical technology too show promise to overcome the limits of ever-increasing data distribution volumes. For example, the Innovative Optical and Wireless Network (IOWN) initiative for 2030, led by NTT, Intel, and Sony, aims to realize a new world of overwhelmingly low power consumption, ultra-high speed, high capacity, and low latency by connecting everything with light. Research is being conducted to implement this change by involving many other companies. In

addition, technological innovations in fields such as quantum life science may lead to new scientific responses to aging and dementia, which are mainly addressed only by improving lifestyle habits.

It will take a lot of trial and error to select applicable technologies from among these many candidates and formulate the ideal solutions. This is where more stakeholders are expected to engage in various forms of co-creation. To make a collaborative co-creation mechanism work, it will be more effective if the vectors of individual activities are aligned. If people with different values can share a common understanding of issues, they can work with the same purpose and direction, which will ultimately result in a significant impact on society. In order to achieve a greater societal impact, it is also important to broaden the options for solutions through backcasting. Backcasting is a way of planning that starts with thinking about the ideal future before looking back from that vantage to the present and delineating a path to reach it. This type of thinking is characterized by its lack of contemporary constraints. The best path can be chosen from a variety of options and perspectives.

Resolving societal issues has long been recognized as mainly the responsibility of the government. In recent years, however, the private sector has been increasingly required to play a proactive and leading role in this field. The private sector plays an essential role in its ability to provide optimal solutions based on a variety of advanced technologies in unconventional ways and to implement these solutions in a speedy manner. In particular, expectations for startups have been increasing in terms of their speed and innovative thinking, which has led to national policies that nurture startups. In the future, it will be important to ensure that the policy and business aspects of a sustainable market mechanism are coordinated to encourage societal implementation.

To this end, a new style of public-private partnership should and will be formulated.

In moving public-private partnerships to a new stage of development, it is important to reaffirm and even rediscover the importance of social value. People have begun to recognize and appreciate activities that, despite their low economic value, have high social value. In some specific areas, these activities have incited a large number of supporters to join together to help ensure steady progress toward resolving societal issues. A good example is the creation and expansion of opportunities for labor, work, and activities for the elderly and people with disabilities—people who were previously thought to have difficulty participating in society. This is primarily due to a shift in societal values from the traditional emphasis on economic growth to a focus on quality of life.

From a corporate perspective, too, social value and economic value are not inherently at odds with each other. They can co-exist, particularly in sustainability management. Sustainable growth cannot be an expected result of focusing simply on sheer profit. This has led to the widespread acceptance of a new way of thinking, in which the sphere of corporate activity is expanded through a better balance of priorities. This effort follows the principles of ESG and impact investments where market value is prioritized in tandem with social value. This trend is one of the major factors accelerating the solution of societal issues.

There are several things to keep in mind when attempting to resolve societal issues and create collective impact. For example, one effective measure is to gather a group of people who share a common purpose.

Such colleagues can be gathered by making clear the new value to come from their new connections. The prevailing trend to emphasize both economic value and social value is also expanding the range of societal issues that can be addressed.

In addition to building relationships that recognize and respect diverse values, co-creation activities must involve those with diverse ways of thinking and various experiences. Without this, the activities will not be sustainable. The Listings serves as a starting point for these co-creation activities, as well as a roadmap for identifying and resolving societal issues.

2. Overview of the Listings

(1) History of the Listings

The Listings was first published by INCF, a predecessor of ICF, in the summer of 2017. The FY 2018 edition saw the addition of global perspectives, and technological and regulatory trends were added as clues to solutions in the FY 2019 edition. The FY 2020 edition paid special emphasis to the effects of the covid pandemic and also incorporated perspectives on the pursuit of new definitions of affluence.

Since the most recent FY 2021 edition, ICF has taken over the Listings from INCF and made multiple revisions, addressing new societal problems in each focus area (e.g., "worsening harm caused by loneliness and isolation" and "lack of diversity in human resources"). In 2022, the Listings was not updated. Instead, the Societal Issues Portal, which aggregates the results of ICF's efforts and societal issues research, was published with walk-through videos on the ICF website.

In this 2023 edition of the Listings, various issues have been updated in consideration of current global events, including the covid pandemic and Russia's invasion of Ukraine. The design of the Listings has also been renewed to incorporate visuals as a means for scientific communication.

(2) Use cases of the Listings

The Listings annually compile the various societal issues that the world is either experiencing or newly creating. The Listings also re-visits issues that still need to be addressed and re-prioritizes them through potential impact assessments. This is the starting point of ICF activities that aim to resolve societal issues through business with open innovation.

The Listings will help identify societal issues and present an agenda for their solution. The goal is to present common objectives to the various stakeholders who are working to resolve those issues—ultimately setting all on the course to create collective impact.

Specifically, the Listings are envisioned to be of use in the following ways:

- Provide clues on how to create new businesses that contribute to resolving societal issues and achieving the goals of the SDGs
- Apply in-house technologies to help develop businesses in new fields and resolve societal issues
- Encourage open innovation by utilizing the technologies and knowledge of other companies

For example, the Listings is intended to help companies that are considering new business developments by incorporating societal issues and SDG perspectives into their business strategies. The objective of the Listings will be fulfilled if readers are able to recognize issues that their technologies could resolve, or that the companies described in the examples are likely to possess key issue-resolving technologies that they lack.

(3) Highlights of the 2023 Listings

Perspectives spanning six focus areas

The 2023 Listings features special exhibits showcasing perspectives that cut across the six focus areas.

Since societal problems are intricately intertwined, there are many factors that affect each other across multiple areas. Among them, this edition focuses on the following four:

- Thinking about innovation from the book The Narrow Corridor: States, Societies, and the Fate of Liberty
- Digital transformation and resolving societal issues
- Water resources as a double-edged sword
- Societal implementation and public affairs

For example, water is an important topic in not only the Water & Food area, but also the Disaster Prevention & Infrastructure, and the Energy & Environment areas. This is a topic that cannot be constrained to a single area due to its various roles

and risks across multiple categories. The exhibits and relevant sections offer a unique perception of something as commonplace as water.

Graphical abstracts

The Listings structures each theme into three steps: presenting the problem, identifying societal issues, and providing clues to solutions. The 2023 Listings adopts a method of visual abstraction to make this structure easier to understand. The graphical abstract is a tool originally developed in the US and Europe to visually represent the background, methods, and results of research in three frames. ICF has visualized all 31 societal issues within the Listings through graphical abstracts. This visualization allows everyone, even those who would not consider themselves educated on the subject, to understand the structure of the issues at a glance and encourages them to read the full text about the issues they are interested in.

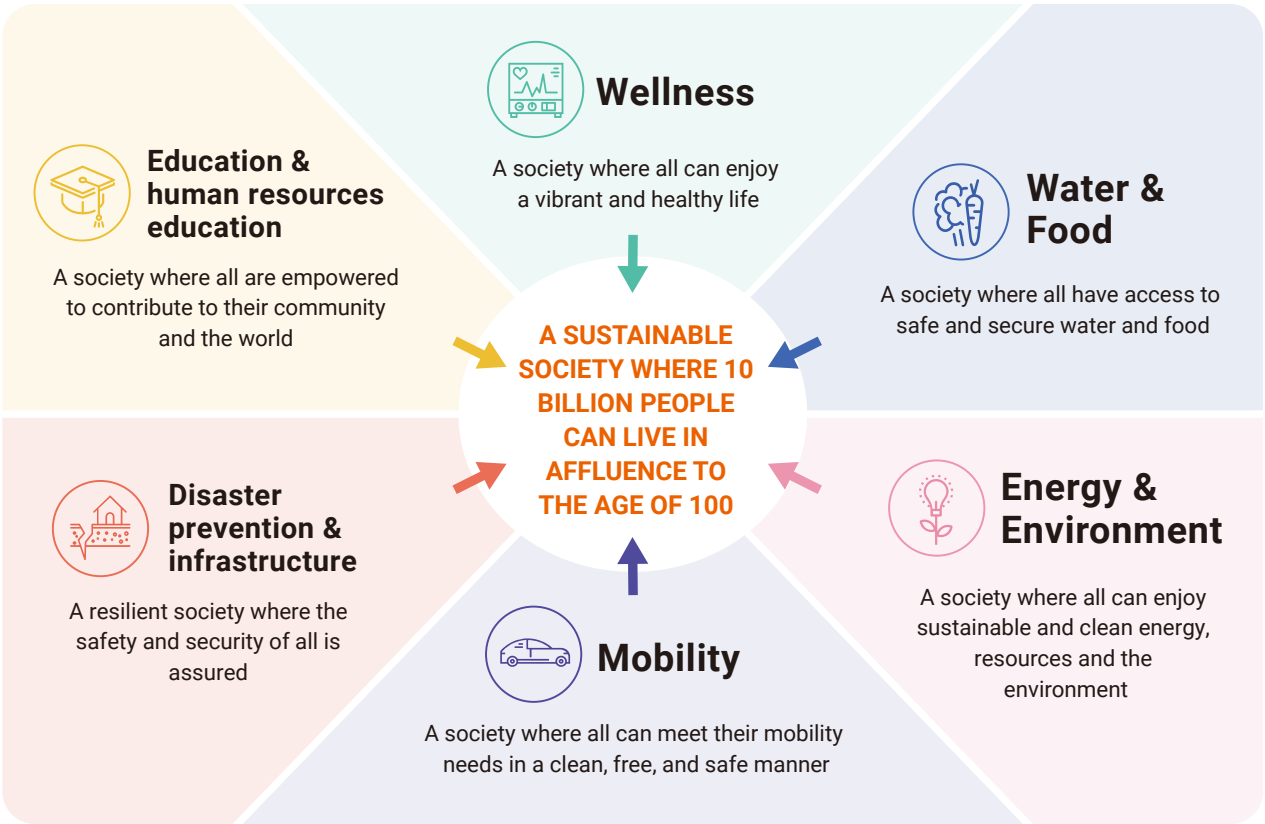
Putting the results of ICF activities to work

With more than 500 members, ICF has been continuously discussing many societal issues. ICF's Future Co-creation Projects (FCPs), in particular, have set themes for societal issues that need to be resolved and have worked hard to create societal impact through regular workshop activities. FCPs conducted from 2022 to 2023 include Dietary Innovation, Climate Change Measures, and Wellness. Some of the results of these activities are reflected explicitly in the Listings. For example, Shared Dining, a new theme focused on in the Dietary Innovation FCP, has been incorporated in the Water and Food area. Discussions in other ICF activities, such as the Societal Issue Discussions and the Co-Creating Member Forum, have also been reflected in the focus areas of the Listings. The Listings incorporate not only Mitsubishi Research Institute's insights, but also ICF members' broad awareness and knowledge of problems, into the following sections: Key Points for Resolving Issues, Technological Trends, and Regulatory Trends.

(4) Framework of the Listings

Identifying societal issues in the six focus areas set by ICF

ICF has organized and structured societal issues throughout the world, including Japan, from a macro-level perspective and identified six focus areas: Wellness, Water & Food, Energy & Environment, Mobility, Disaster Prevention &



Goals set by ICF in the six areas

Infrastructure, and Education & Human Resource Development. The Listings identifies problems and defines issues to be addressed based on these six focus areas.

Identifying societal problems

The Listings covers major societal problems in the six focus areas, derived from an overview and analysis of the macro-environment, including political, economic, social, and technological trends, and megatrends, or the broader and long-term future prospects and portents, of each area. The ICF updates the Listings while studying the emergence of new societal problems, the resolving of problems, and the development of new technologies and business models.

Societal issues are organized along two axes: the potential degree of impact from resolving problems and the potential for commercialization.

ICF highlights problems by emphasizing those found in the upper right quadrant, where both impact is large and business creation possibilities are plentiful. However, attention should also be given to the lower left quadrant where evaluations of the potential impact and businesses are low.

Problems related to inclusion, for example, require significant attention and include topics across many fields such as broader independence of those with disabilities, terminal stage medical treatment, and child poverty and abuse. In addition, the emergence of new technologies and business models may increase the possibility of commercialization, and the impact of changes in the social environment may increase the potential for problem-solving.

The FY 2021 edition of the Listings addresses the new theme of loneliness and isolation, which has been aggravated by the pervasive pandemic. Concerns have also been raised by a recent study that has suggested that loneliness and isolation may increase health risks such as dementia and stroke.

Estimating potential impacts

Potential Impact is defined and quantified as the difference between the base-case scenario, where current problems are left unchanged, and the best-case scenario, where said problems are completely resolved. The impacts are measured by damage, loss, or societal cost, depending on the nature of the problem. Estimates are shown either in population numbers or in monetary terms.

Potential for new business opportunities

MRI quantitatively evaluates the negative impact of each societal issue through an approach of either (A) or (B) that are described below and by referring to previous research.

- (A) Base case: the maximum financial, human, and societal impact by about 2030 in a scenario in which no new measures are taken
- (B) Worst case: the maximum financial, human, and societal impact by about 2030 in a scenario in which the worst events that can currently be foreseen take place

In some cases, such as within themes related to the pursuit of new types of affluence, the impact of new surpluses (market, welfare, etc.) that appropriate measures and solutions could bring is estimated by referencing previous studies or through MRI research and indicated as (C).

Example of estimation: Approximately 20 million metric tons of timber and branches after tree thinning are left neglected annually on forest land. If the neglected wood was used for biomass power generation, the total fuel value would be equivalent to JPY 160 billion per year. In addition, the CO2 reduction would be 4.3 million metric tons per year (0.4% of Japan's total CO2 emissions), which is equivalent to JPY 2.8 billion per year in carbon credits.

Defining societal issues

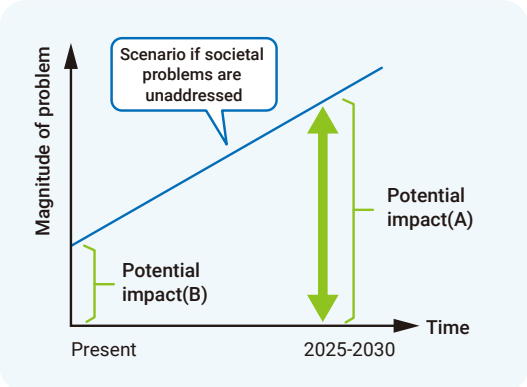
Following the identification of a problem and the estimation of its potential impact, societal issues are defined in terms of the themes to be addressed or in terms of short-term goals by considering the necessary elements, viewpoints, and directions for solution. The Listings explicitly distinguishes the term problem from issue and describes them separately.

In relation to the SDGs, ICF's hallmark philosophies, solutions through innovative technology and solutions through business, can be applied to 64 of the 169 targets across 17 goals. The Listings identifies these targets to better organize and define societal issues.

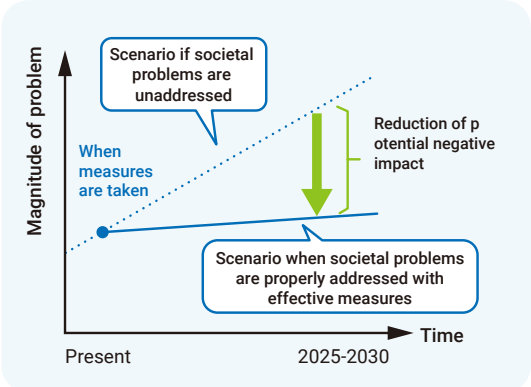
Clues to solutions

For each group of issues, the Listings provide clues to solutions from the perspectives of relevant technological and regulatory trends, including specific examples and timelines for practical use. The ICF makes every effort to collect and update potential clues to specific actions in as much detail as possible.

As described in the previous section, the basic concept of ICF activities is to co-create solutions through business and innovation by following logical steps, starting from the societal issues themselves. The societal issues set and defined in the



Method of potential impact estimation (A or B)



Successful scenario where potential impact is reduced by taking effective measures

Listings, along with specific solutions, ideas, and innovation introduced herein, are expected to effectively contribute to creating the ideal future. The ideal future is achieved not by only resolving problems and issues or remedying effects from negative to neutral, but by also inciting changes from a neutral state to a positive world.

Special Column
1

Thinking about Innovation from the Famous Book "THE NARROW CORRIDOR"

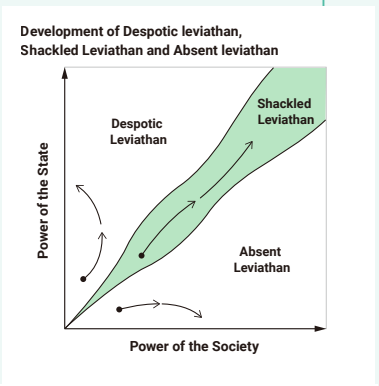
What is needed for innovation is "dreaming up new problems." It is based on protection of individual liberty and requires a balance of power between the state and the society.

Liberty is Essential for Continuous Innovation

"Can it cultivate innovation without liberty?"

"Diverse and ongoing innovation in a range of fields, essential for future growth, depends not on solving existing problems but on dreaming up new ones... Creativity is the essential ingredient for sustained innovation and critically depends on a large number of individuals experimenting, thinking in their own different ways, breaking the rules, failing, and sometimes..."

("The Narrow Corridor: States, Societies, and the Fate of Liberty" Co-authored by Daron Acemoglu & James A. Robinson, Translated books (Vol.1) pp. 366-367, Publisher: Hayakawa Publishing Corporation)



Modified from "The Narrow Corridor" p126 (Vol.1) fig.1

Without individual freedom, diverse and continuous innovation would not be created. To achieve individual freedom, we need a strong state, originally described by Thomas Hobbes as the 'Leviathan,' that guarantees freedom. However, the authors argued that if the state becomes too strong, it will become a "Despotic Leviathan," and if it becomes too weak, it will become an "Absent Leviathan."

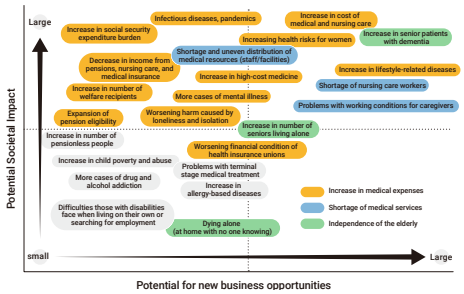
In order to remain in the "Narrow Corridor" (described by the authors as the "Shackled Leviathan") between the "Despotic Leviathan" and the "Absent Leviathan," it is important to balance an active society with a capable state.

Acemoglu and Robinson's book reiterates the importance of a multi-dimensional cooperation among the civil society in order to strengthen the power of society. Meanwhile, we hope that ICF activities will be one of the approaches to strengthening this cooperative relationship.

Balance between the State and Society to Achieve Liberty

ICF divides societal problems into a structure including four quadrants on two axes (see left figure).: potential impact and new business possibilities. In particular, ICF advocates that private companies should focus on resolving societal problems that lie in the upper right quadrant with a huge potential of social impact and new business opportunities. One of the examples is the increasing diseases that are related to lifestyle habits.

Instead, government policy or insititution-based solutions are expected to resolve issues listed in the upper left quadrant, which have large potential impacts yet lower potential for new business opportunities. An example could be increasing the number of welfare recipients.



Societal problem in the field of wellness
See page 11 for original figure.

Yet undoubtedly, those issues in the upper left quadrant should not be simply and completely left to the government. As depicted in "The Narrow Corridor", the society needs to actively monitor the state institutions and support the expansion of state capacity to improve the liberty and welfare of the people.

In the "Listings of Societal Issues", the section on "Technology Trends" lists efforts to resolve societal issues from a diverse range of stakeholders in Japan and abroad, and the "Regulatory Trends" section lists laws, regulations, and support systems in Japan and other countries regarding societal issues resolution.

What is the balance between "the power of society" and "the power of the state" in addressing each societal issue? What is needed to increase the power of each?

We would like to encourage you to explore this book while considering these questions from the perspective of how the civil society should collaborate to resolve these societal issues, and we hope that our book could provide you some insights.

01

A Society Where Everyone Can Enjoy a Vibrant and Healthy Life

Wellness

Over the past half-century, remarkable economic growth and a rapid increase in life expectancy have spread not just throughout developed countries but also to emerging economies.

While longevity is worth celebrating, the increasing number of patients with cancer, dementia, and lifestyle-related diseases, as well as the greater burden of social security due to the growing elderly population, are becoming major societal problems. Another pressing issue is the declining working-age population and the decreasing number of people responsible for social security costs due to the accelerating birthrate decline. . How can we solve the societal issues associated with an aging population? How can we stem the decline in the number of births? How can we deal with the degradation of social infrastructure and communities that will accompany the aging of society and the decline in birthrate?

Under these circumstances, health-conscious management and the concept of well-being have been emphasized in the context of human capital management. Companies are expected to take measures to ensure that valuable human resources are able to work energetically and are physically and mentally healthy. These efforts contribute towards realizing a society where those who wish to get married or have children do not have to sacrifice their careers.

In recent years, as women have entered the workforce, health issues specific to women have become more apparent. Remarkable technological developments have unfolded with gender equality in mind throughout medicine and biochemistry, but movements to adopt this new perspective have begun in other fields.

In addition, not only have the increased health risks associated with loneliness and isolation become a global problem, but the causes of and coping mechanisms differ by age, gender, environment, and other factors. The spread of COVID-19 has dramatically changed our perception of infectious diseases and our way of living.

Countries around the world must continue to work together to search for measures to tackle and to co-exist with new infectious diseases that are expected to erupt on a global scale in the future.

Based on the understanding above, ICF has identified seven problems and issues in the area of wellness.

The societal problems and issues in this area are highly interrelated and directly impact each other. For example, the COVID-19 pandemic has increased the risk of loneliness and isolation, and loneliness and isolation in turn intensify the risk of lifestyle-related diseases.

Based on the understanding above, ICF has identified seven problems and issues in the area of wellness. Societal problems and issues in this area are highly interrelated. The illustrative examples of such are how: the pandemic increases the risk of loneliness and isolation; and loneliness and isolation intensify the risk of lifestyle-related diseases.

Behavior change is difficult because lifestyles are built on habits

Lifestyle-related diseases account for 60% of all deaths in Japan. These deaths are becoming more common as a result of the COVID-19 pandemic

(1) Lifestyle improvement for vulnerable groups like the elderly, etc.
(2) General behavior changes are vital to prevent serious illnesses in patients with lifestyle-related diseases

(1) Pre-identification and early detection of behavioral risks through various biomarkers
(2) Incentivization by insurance packages

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Rising medical costs due to lifestyle-related diseases

Lifestyle-related diseases account for almost 30% of all medical costs and 50% of all deaths in Japan.[1] As the general population continues to age, these medical costs will increase furtherThe voluntary stay-at-home and work-from-home during the COVID-19 pandemic have reduced society's level of physical activity and increased the risk of lifestyle-related diseases. In addition, obesity and some lifestyle-related diseases also increase the risk of increased severity in COVID-19 symptoms.[2]

Japan

Potential impact estimates

At the current rate, medical costs associated with lifestyle-related diseases are forecast to rise from JPY 10 trillion to JPY 14.6 trillion in 2025. (A)

Estimation Method

Estimate for the medical cost in 2025 caused by lifestylerelated diseases. Share of lifestyle-related diseases in total medical cost (in 2013)[3] × Total medical expenses[4] in 2025 = 34.4% × JPY 42.54 trillion = JPY 14.63 trillion.

If the global trend of increasing diabetes continues, associated economic costs will double (from $1.3 trillion in 2015 to $2.5 trillion in 2030).[5](A)

Issues

Improvements in technology and measures to detect early signs of disease and prevent severe illnesses

Key Points for Resolving Issues

People at Risk of Lifestyle-Related Diseases

[The key is sustaining lifestyle behavioral changes]

External incentives, such as evaluations from others, rewards and punishments, and coercion, are not helpful for sustaining lifestyle changes. For example, the effect of economic incentives varies widely from person to person (those who value loss and gain and those who are already health conscious are more likely to respond than those who most need to improve their lifestyle.)

The key to improving lifestyle habits is individual motivation. Spontaneous motivation often arises from collaboration with close peers and communities, a phenomenon MRI callsthe “mutual sphere”. For example, the Hirosaki University Center of Healthy Aging Innovation collects and analyzes prefectural residents' health checkup data. The data and analysis help develophealth care products and services through cooperation among industry, academia, and government.

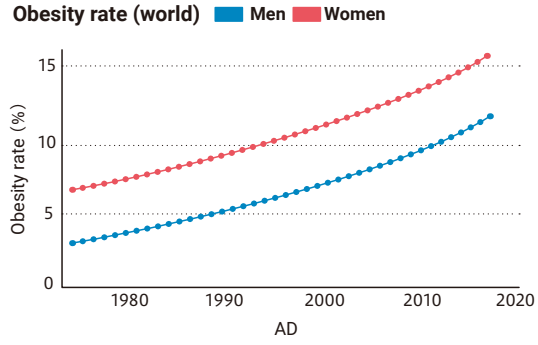
These efforts raise health awareness and promote behavior change through local communities, workplaces, and schools. In addition to visualization technologies such as wearable devices, new approaches to behavioral modification are expected that make use of psychology, neuroeconomics (an interdisciplinary approach that fuses brain science and behavioral economics), and cognitive behavioral therapy.

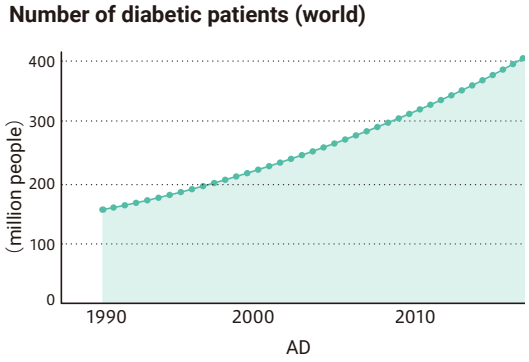
Key Points for Resolving Issues

Patients with Lifestyle-Related Diseases

[Promoting behavioral change to prevent diseases from worsening]

Lifestyle-related diseases have few easily perceptible symptoms, and in many cases become serious when patients repeatedly deviate from the doctor's instructions. Therefore, it is essential to educate patients on the serious implications of intensified symptoms, and to provide clear evidence through numerical data that emphasizes the importance of continuous daily efforts for health improvement. Currently, efforts are being made by local government officials to make individual calls to patients who are feared to be seriously ill, and by health insurance associations to provide specific health guidance, but these efforts have not been sufficiently effective so far.





Source: Japan Preventive Association of Life-style related Disease: What are Lifestyle-Related Diseases? Lifestyle-Related Diseases and Their Prevention, 2023 (in Japanese) https://seikatsusyukanbyo.com/prevention/about.php

Solutions

Clues to Solutions [Technological Trends]

1. People at Risk for Lifestyle-Related Diseases

Practical implementation period

Preliminary assessment of risk of developing lifestyle-related diseases

- It is now known that the bacterial composition in the intestines is related to control of blood glucose levels. Research on the improvement of gastrointestinal microbiota, or gut flora, is also ongoing — 2020-25
- Technology using AI-based analysis of health-checkup data was developed to predict the risks of lifestyle-related diseases.[6] — 2020-25

Case study

Sompo Holdings, Inc. and Toshiba Group have jointly developed an AI system that predicts the risk of three lifestyle-related diseases: type-2 diabetes, hypertension, and dyslipidemia.[7]

- Non-invasive blood glucose sensors are being developed for home use. They are expected to be effective for the prevention and detection of early stage diabetes.[8,9] — 2020-25
- In addition to conventional biomarkers such as blood pressure, blood glucose, neutral lipids, and cholesterol, new types of biomarkers (e.g. hormones such as adiponectin and leptin) are being studied to identify and prevent lifestyle-related diseases — 2025-35

Prevention of lifestyle-related diseases

- Insurance companies have developed programs that incorporate the results of exercising and physical examinations into insurance premiums. This incentive is expected to improve health awareness, physical activity, and quality of life — 2020-25

Case study

SUMITOMO LIFE INSURANCE COMPANY offers a program called Vitality that allows policyholders to earn reward points based on efforts made toward healthy living, such as the number of steps taken per day, visits to fitness centers, and participation in events. Based on the earned points, customers can receive premium discounts of up to 30%. If the policyholder does not participate in the health promotion program, however, premiums will be increased by up to 10%.[10]

- Sleep deprivation has been found to increase the risk of lifestyle-related diseases.[11] Efforts are being made to ensure that employees get enough sleep. — 2020-25

Case study

Some companies have introduced an employees' benefits package called Siesta Time, a program that allows employees to take a nap during working hours. Other companies have implemented a program called "A well-slept child is a well-kept child" that uses a smartphone app to measure daily sleep time and rewards employees who sleep an average of more than seven hours per day each month (SUNNY SIDE UP GROUP Inc., Japan).[12]

- Research is underway to suppress appetite by stimulating the central nervous system. — 2020-25

Case study

Modius is a device that reduces appetite by electrically stimulating the vestibular nerve behind the ear and subsequently the satiety and feeding centers in the hypothalamus (Neurovalens Ltd., U.K.).

- Early research is being conducted to reduce food intake by using augmented reality (AR) to make the food appear slightly larger.

2025-35

Case study

By utilizing the augmented satiety enabled by changing the apparent size of food, food intake can be increased or decreased by about 10% while maintaining a similar sense of satiety. (Hirose Tanikawa Narumi Lab., Graduate School of Information Science and Technology, the University of Tokyo)[13]

Behavior change based on behavioral economics and public health

- Studies are beginning to clarify the brain mechanisms that evaluate future risk against present profit-loss and empathy for others. There is hope for a nudge-based approach that unconsciously alters behavior.

2020-25

Case study

MHLW (Ministry of Health, Labour and Welfare) published a handbook called Start the Nudge Theory, Tomorrow. The book introduces ideas for increasing the rate of use of certainhealth checkup guides and for improving the rate of repeat colorectal cancer screening tests. (produced by Cancer Scan Co., Ltd.).[14]

In addition, some municipalities have succeeded in increasing the rate of vegetable consumption by expanding the variety of vegetable-centered dishes available at local restaurants and selling pre-cut vegetables at grocery stores. The key to success was found by creating an atmosphere where people's appetite will be spontaneously but naturally directed towards affordable vegetables. (Adachi Ward, Tokyo).[15]

2. Patients with Lifestyle-Related Diseases

Treatment of lifestyle-related diseases

- Monitoring technology using wearable devices is now seeing practical application. The availability of continuous blood glucose level data collection will increase the effectiveness of diet and exercise therapy.

2020-25

Case study

Abbott has commercialized a device called FreeStyle that can monitor blood glucose levels 24 hours a day for two consecutive weeks by attaching a sensor the size of a 500-yen coin (or a U.S. quarter) to the upper arm. [16]

- Insulin pump therapy, a standard anti-diabetic treatment, places a heavy burden on patients, requires machine maintenance, and has high operating costs. As a result, the development of an autonomous insulin pump that does not require a mechanical or electrical drive is underway to overcome these constraints.[17]

2020-25

Case study

Development of an artificial pancreas with a microneedle that detects blood glucose levels and automatically adjusts insulin supply is underway. Involved research groups, including Tokyo Medical and Dental University amd Kanagawa Institute of Industrial Science and Technology, successfully conducted demonstration experiments on diabetic laboratory mice.

- Seven gene clusters have been discovered that are related to the development of type 2 diabetes, which accounts for 90% of all diabetes cases. This discovery expands the potential of personalized medicine.[18] — 2025-35
- A newly developed method for creating insulin-producing cells from stem cells has led to significant progress towards curing type 1 diabetes by means other than conventional transplantation.[19] — 2035 and beyond

Support for patient lives

- Utilizing ICT, such as social media and informational websites, can improve patients' quality of life (QOL) by preventing isolation, providing job retention support, and fostering communities with other patients. — 2020-25

Early detection and treatment of cancer

- Efforts employing behavioral psychology are being made to promote the early detection of cancer (e.g. improving the cancer screening usage rate). Promotion to develop testing technologies and devices that do not require skilled examiners and are less burdensome for patients is also underway. — 2020-25
- A liquid biopsy is a method of diagnosing cancer by testing blood or urine samples. It examines either microRNA (miRNA) or circulating tumor DNA (ctDNA) — 2020-25
- miRNA is a short, single chain of nucleic acids that cancer cells release into the extracellular space early in their development with characteristics unique to different types of cancer. Since miRNAs are reported to circulate within the body via the blood, testing for the existence of miRNAs may lead to early cancer detection.[20] The miRNAs have been found not just in blood but also in urine. As a result, only small amounts of blood or urine will be necessary to diagnose cancer in the future. — 2020-25
- In the field of cancer treatment, efforts for precision medicine (i.e., personalized medicine) have seen encouraging progress. Recent attention has been given to new technologies in cancer immunotherapy, including CART-cell therapy and cancer vaccines. Furthermore, research has shown that intestinal bacteria can influence the effectiveness of cancer treatment.[21] — 2025-35

Solutions Clues to Solutions [Regulatory Trends]

- The Japanese government has amended several regulations to strengthen insurers' incentives for preventative medical care and health promotion. (1) The Japanese government also created a system to support the proactive efforts of insurers as part of the National Health Insurance program. The system provides subsidies based on the results of each municipality's measures for preventing intensification of diabetes symptoms. (2) The Japanese government revised the Latter-Stage Elderly Healthcare System in 2018 to base adjustment of subsidies given to corporate health unions and mutual aid associations on not just the implementation of designated health checkups and health insurance guidance, but also reflect cancer screening and efforts made to collaborate with employers in the same space.[22] Many health insurance institutions are faced with pressing financial situations in Japan. However, if practical solutions for lifestyle-related diseases were to be developed in the private sector, they are more likely to be utilized as a result.
- It has also been pointed out that the Pharmaceutical Affairs Law* hinders innovation in Japan.Although the Pharmaceuticals and Medical Devices Law* is an important law for improving health and hygiene, some argue that the law stifles innovation. The law strictly limits the method of advertising certain diseases, such as cancer, to the public who are not medical professionals. Even if data proving effectiveness in prevention and treatment was collected, the product must still be approved as a drug or medical device before it can be sold. Although MLHW has implemented an early approval system, it is still struggling to strike the right balance between earlier commercialization and the assurance of safety and effectiveness. * *Act on Securing Quality, Efficacy, and Safety of Products Including Pharmaceuticals and Medical Devices*

- With the revision of government-defined medical remuneration, preventive dental care became eligible for insurance coverage in April 2020.Oral care is said to reduce the risk of lifestyle-related diseases, so there are high expectations for preventive dentistry to gain popularity.[23]
- In 2020, the government of Japan approved health insurance coverage for CureAppSC, an app that helps smokers quit. This is the very first case in Japan that a software application, rather than conventional medication, has been covered by insurance. App-based healthcare may become a trend in the future.[24]
- The national government conducts cancer screening programs for five cancers to reduce the mortality rate. The targeted cancers are lung, stomach, colorectal, cervical, and breast cancer. The age, frequency of examinations, and recommended examination items are specified in the Guidelines for Priority Health Education for Cancer Prevention and Implementation of Cancer Screening (2008) for examinations conducted by municipalities. For examinations conducted at companies and workplaces, they are specified in Manual on Cancer Screening in the Workplace (2018).
- Some immune checkpoint inhibitors are already on the market, such as Opdivo (nivolumab) produced by ONO PHARMACEUTICAL CO., LTD. and Keytruda (pembrolizumab) by Merck & Co., Inc.
- The high price of Opdivo and its limited use were originally hindering its commercialization, but since its approval in 2014, the coverage of Opdivo has been gradually expanded and the drug price has been reduced to about 1/4 of the original price.
- The OncoGuideTM NCC Online Panel System, jointly developed by the National Cancer Center Japan and SYSMEX CORPORATION, and FoundationOne® CDx Cancer Genomic Profile by Chugai Pharmaceutical Co., Ltd., became covered by health insurance in 2019. Currently, testing is limited to patients who have completed the standard treatment for stage 4 or who are not eligible for any standard treatments.[25]
- In the U.K., a national campaign to reduce salt intake has significantly reduced the risk of hypertension and other conditions by reducing the nation's overall salt intake by 1.4g per day. In Japan, the 2020 revision of the Dietary Reference Intakes for Japanese lowered the target amount of sodium (salt equivalent) for adults by 0.5g.[26] (See p82 for more information on unhealthy diets)

Relevance to the SDGs

Problems

Rising medical costs due to lifestyle-related disease

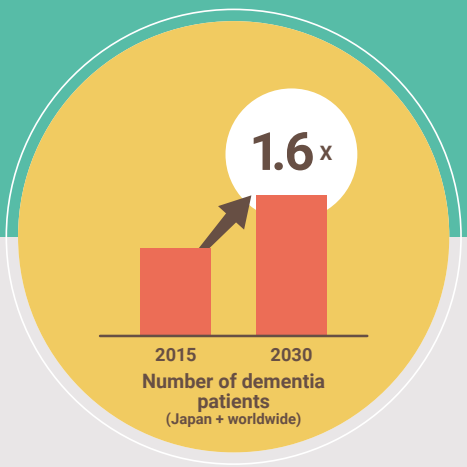
Societal Issues

Improvements in technology and measures to detect early signs of disease and prevent them from becoming severe

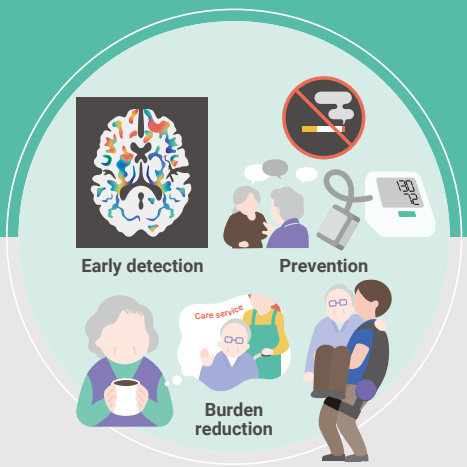
Relevance to the SDGs

3.4 By 2030, reduce youth mortality from non-communicable diseases by one-third through prevention and treatment, and promote mental health andPromote mental health and well-being

Making caregiving a longed-for profession



The number of dementia patients is increasing and will be 1.6x the number of 2015 patients by 2030 (8.3 million in Japan alone)



Early detection, prevention, and treatment of signs and symptoms, as well as reducing the burden on caregivers

Services that allow the elderly to maintain opportunities for social contact and mechanisms that provide incentives to improve the level of care provided

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Intensifying shortage of nursing care workers

In Japan, the percentage of seniors who can maintain independent living is about 80% for those in their mid-70s but drops sharply to 10%[27] for those in their late 80s.

The shortage of nursing care personnel is becoming an extremely prevalent issue as the number of people requiring nursing care increases. The COVID-19 pandemic changed people's behaviors, such as necessitating more hours spent at home. It has been pointed out that the decrease in physical activity and social interaction increases the risk of decline in physical and mental functions.

As the average life expectancy increases, the number of dementia patients grows. By 2030, dementia cases are expected to grow by 160% to 8.3 million[28] in Japan, and by 160% to 74.7 million[29] worldwide.

Japan
Potential impact estimates

In 2025, when all postwar baby boomer generation will be 75 or older and the "super-aged society" begins, national and local nursing care costs will increase to JPY 19.8 trillion (240% of JPY 8.4 trillion[30] in 2012). It is estimated that by 2025, there will be a shortage of 380,000 long-term nursing care workers. (A)

World
Potential impact estimates

The social cost of nursing, including both direct costs for medical and nursing care and the indirect opportunity cost lost by families, will total JPY 21.4 trillion in Japan in 2030 (compared to JPY 15.0 trillion in 2015,) and $2 trillion worldwide (compared to $818 billion in 2015.)[31](A)

Issues

Expansion of science-based nursing care to enhance productivity while ensuring quality

Key Points for Resolving Issues

Dementia Patients and People at Risk

[Early detection of symptoms and the development of effective countermeasures]

Alzheimer's disease is known to develop as a result of the aggregation of certain proteins (amyloid beta and tau proteins) over a period of around 20 years. Although medical drugs are being developed to treat Alzheimer's disease, the first step towards permanent solutions is early detection and prevention. According to the recommendations of the Lancet Committee (Lancet Commission on Dementia Prevention, Intervention and Care), 1/3 of dementia is preventable. The main risk factors for dementia are as follows[32]:

- Early life: Lack of education
- Midlife: High blood pressure, obesity, and hearing loss
- Later life: Depression, diabetes, physical inactivity, smoking, and limited social interaction

Key Points for Resolving Issues

Care Workers

[Ensuring autonomy and satisfaction, reducing physical and mental burdens of care workers]

The average monthly wage for nursing care workers in Japan is about JPY 230,000. In a survey conducted on care workers' concerns, anxieties, and dissatisfaction related to their working conditions, the most common response was insufficient staffing, followed by low compensation relative to the workload.[33] To secure the human resources in the long run, it is essential to recognize nursing care as a scientific and specialized profession, to provide appropriate compensation, and to ensure autonomy of the staff. In addition, it is important to utilize expert knowledge to develop an environment that can offer evidence-based scientific care and preventive.

Support for family members acting as caregivers is essential and should address a wide berth of affected aspects of life, including financial, work-life balance, and recovery.[34] Dementia symptoms and behaviors, such as wandering, delirium, violence, and verbal abuse, can vary greatly depending on the types of responses the patients receive during care. Appropriate control of these dementia symptoms can significantly reduce the physical and mental burden on caregivers. It is vital to select the most appropriate care and handling based on each patient's situations and individual characteristics.

The idea of simply making caregiving tasks more labor-saving and efficient is unlikely to lead to effective solutions. For example, even if there is an app that attaches a GPS to wandering patients and sends an alarm to the caregiver, it does not reduce the caregiver's workload. On the other hand, if measures are taken to lengthen the amount of time a person with dementia stays awake during the day, he or she might sleep more soundly at night, thereby reducing the patient's wandering and the burden placed on caregivers. The value of devices that can forecast bowel movements will be further enhanced if they are able to learn and be fine-tuned to individual differences.

Solutions

Clues to solution [Technological Trends]

1. Dementia Patients and People at Risk

Practical implementation period

Establishment of new means to promote and support the independence of the elderly

- Dementia may progress rapidly when physical inactivity occurs, such as when people have physical difficulty going outside or have limited contact with other people. For this reason, there is high demand for services that enable people to continue to have the same kind of interaction with others at home as they did when they were able to go out. — 2020-25

Case study

A U.K.-based company, Virtue Health Inc., offers a digital therapy platform called LookBack, which uses VR-based reminiscence activities to stabilize dementia conditions.[35]

- Efforts are also being made to emotionally support dementia patients by expressing solidarity, securing their place in society, and helping them make friends and find advocates to help them live with the disease. — 2020-25

Case study

Based on efforts in Scotland , Kyoto Prefecture has appointed workers to support dementia patients and their families. They work closely with those affected and their families, providing necessary support in cooperation with the initial-phase intensive support team for dementia. The workers provide emotional support and daily life assistance so that patients with dementia can live fulfilling lives within their community despite their affliction.

Prevention and treatment of dementia

- Expectations are growing for the early diagnosis (predictive signs) of dementia using MRI imaging. — 2020-25

Case study

A technology for the early diagnosis of Alzheimer's disease using AI analysis of MRI images has been commercialized. (Darmiyan, Inc., U.S.)[36]

- New services in this field, such as dementia prevention insurance and dementia prevention apps, are emerging.[37] — 2020-25
- Research institutions around the world are searching for biomarkers that would support the early detection of dementia. Research is currently focused in multiple areas, including the concentration levels of three types of proteins in the blood (apolipoprotein, transthyretin, and its complement) as well as the ratio of amyloid- β to its precursor, APP[38] — 2025-35
- Japan leads in amyloid-beta PET inspection technology, which visualizes amyloid- β accumulation. In addition, the mechanism (glymphatic) by which waste products such as amyloid- β are discharged from the brain continues to be better understood over time. The importance of sleep has been highlighted by this research as the waste discharge function is enhanced during sleep — 2025-35

- The possibility that intestinal bacteria produce inflammatory substances that affect the brain in some way has also emerged. It was found that people with 30% or more resident bacteria (Bacteroidales) in the intestine were 90% less likely to have dementia than others, raising interest in new research on the correlation between intestinal bacteria and dementia.[39] — 2025-35
- The Alzheimer's vaccine, which was developed out of competition by major pharmaceutical companies, widely disappointed as its effectiveness could not be proven in clinical trials. However, through progress in the basic research to further elucidate the mechanisms of amyloid production and degradation, is expected to lead to a drug that cures dementia in the long term — 2035 and beyond

Case study

Eisai Co., Ltd., and Biogen Inc., a U.S. pharmaceutical company, jointly developed a curative drug ADUHELM (aducanumab-avwa), which is the first of its kind and is expected to slow down the progression of Alzheimer's disease.[40]

Inhibition of aging

- It has been suggested that controlling telomeres (the ends of the chromosomes) may reduce the prevalence of many diseases caused by aging — 2035 and beyond

2. Caregivers

Ensuring autonomy and satisfaction of care workers

- Coordination between medical treatment and nursing care is key to achieving comprehensive community care. IT systems that support coordination and communication between the two functions are entering a period of widespread use. — 2020-25
- Tools are being developed to help care managers collect, analyze, and use data so that they can work to improve service users' quality of life based on scientific indicators.It is also essential to provide incentives to the care workers to improve the level of care required. — 2020-25
- Research and development are underway on a system using ICT and AI to aggregate and visualize regional resource information in order to find and propose appropriate long-term care services for users.[41] — 2020-25

Case study

An information database called MILMO net has been introduced in Yokohama and Fukuoka by WELMO INC. They are also researching and developing an AI Care Plan Assistant to help create care plans andreduce caregiver workload and stress by compensating for gaps in knowledge and experience (WELMO, INC.).[42]

Reducing the burden of nursing care

- The introduction of nursing robots is reducing the burden on caregivers. As low-price power-assisted suits become readily available, an increasing number of offices are introducing them to prevent job turnover due to back pain under the current labor shortage. — 2020-25

- Efforts are also being made to provide contactless care to ensure infection control across everyday caregiving operations. By combining sensors with AI-powered information analysis, the daily lives of elderly people can be remotely monitored, which reduces the burden on caregivers. — 2020-25
- Efforts are underway to introduce Humanitude®, a dementia care technique invented in France that uses ICT and AI — 2020-25

Case study

ExaWizards Inc. has introduced the dementia care technique Humanitude®.[43]By using image and voice recognition and AI technology to suggest optimal courses of action to caregivers, it is possible to improve the quality of care and reduce the burden placed on caregivers.

- Other services to further reduce the burden on caregivers through monitoring services and to propose rehabilitation programs have been developed. — 2020-25

Case study

A service that measures the heart rate, respiratory rate, and body movements during sleep to assess motor and cognitive functions is being developed to propose health improvement programs based on the results (Rehabilitation3.0, Inc.).[44]

- Robots require actuators for every moving joint, which makes it difficult to reduce manufacturing costs. When developing nursing robots, one shortcut involves reducing the number of moving joints and increasing the emphasis on ICT technologies such as sensors and AI. — 2025-35

Solutions

Clues to solution [Regulatory Trends]

- MHLW aims to realize a society where the wishes of dementia patients are respected, enabling them to live in a amiable environment in their familiar neighborhoods for as long as possible. MHLW and other relevant ministries and agencies have formulated the Comprehensive Strategies for Promoting Countermeasures for Dementia: Developing Communities Friendly to the Elderly with Dementia (also known as the New Orange Plan, released on January 27th, 2015).[45]
- The plan promotes comprehensive countermeasures that consist of the following seven pillars: dissemination and education, medical and nursing care, juvenile dementia, support for caretakers, creating dementia-friendly and elderly-friendly communities, research and development, and emphasis on the perspectives of dementia patients and their families
- MHLW has implemented a program to subsidize the cost of adopting nursing robots to encourage dissemination amongst nursing care providers. However, the subsidy has limitations; most local governments have set a limit of JPY 300,000 per robot. It has been suggested that more moderately priced robots should be developed to help spread the technology, rather than relying on high-function, high-priced products.
- In Japan, science-based nursing care using the new LIFE database started full-scale operation in 2021.[46] With the revision of the nursing care compensation rule, additional fees can be added to the CHASE database, resulting in combined operation with the VISIT database. The revisions made in FY 2024 and FY 2027 may make data provision and data utilization mandatory.
- As a result of the COVID-19 pandemic, the shortage of nursing care personnel has become a severe problem. In April 2021, MHLW launched an employment assistance loan program for those seeking employment as a caregiver in the nursing industry.
- The program will loan JPY 200,000 per person to those seeking a career change from other sectors to nursing care or disability welfare positions. The repayment of the loan is waived if the borrower works in the nursing care field or in welfare positions for two years.

Relevance to the SDGs

Problems

Intensifying shortage of care workers

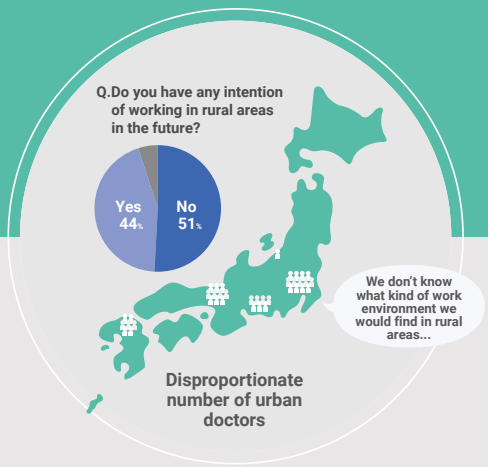
Societal Issues

Expanding science-based nursing care to enhance productivity while ensuring quality

Relevance to the SDGs

3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all

Medical resources are not scarce, but are unevenly distributed



Medical resources are unevenly distributed in certain cities and regions. Overworked physicians put further strain on the system

Digitalization of medical care to alleviate uneven distributions and reduce workloads of non-medical services

Promote online medical care, utilize AI, and share knowledge among physicians

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Inadequate access to medical and nursing services

Providing high quality medical and nursing services is becoming difficult in Japan for three major reasons: (1) a rapid rise in the number of seniors, (2) uneven geographic distribution of doctors and clinical nurses, and (3) a severe deterioration of working environments.

Globally, 5.6 million children under the age of five died in 2016. More than half of these deaths were due to causes that are preventable with simple care, treatment, and nutritional support (primarily premature births, diarrhea, pneumonia, and malaria). If all countries achieved a mortality rate as low as the average of high-income countries, 87% (about 5 million) of under-five deaths could have been avoided.

Japan
Potential impact estimates

The overwork of medical doctors has become a serious problem due to their uneven distribution across geographic regions.[47] One survey showed that more than 50% of all doctors have no intention of working in rural areas (i.e., places other than Tokyo's 23 wards, government-designated major cities, or prefectural capitals.) The most frequent reason cited is anxiety about the working environment.[48](B)

World
Potential impact estimates

Even considering the currently declining mortality rate, 60 million children under the age of five will die between 2017 and 2030. Half of these children will be newborns within the first month of life. The death rate needs to be lowered further.[49] (A)

Issues

Provide services and improve their quality regardless of patients' location or distance

Key Points for Resolving Issues

Developed Countries

[How to improve the efficiency of healthcare resource utilization]

In Japan, disparities in medical resources exist among certain branches of medicine and across geographic regions. In addition, doctors must deal with more outpatients and hospital admissions with chronic diseases due to the increase of the elderly population. In Japan, the number of outpatient visits is twice the OECD per capita average. Doctors are also heavily burdened with a large non-medical workload. This burden deprives doctors of the resources necessary to focus on the diagnosis and treatment of urgent care patients with acute illnesses.

There is a growing need for an environment in which medical and nursing care professionals can concentrate on their primary duties. This can be achieved by eliminating the uneven distribution of resources and promoting knowledge sharing through online medical care and digitalization of medical data. The COVID-19 pandemic revealed a significant shortage of hospital beds in Japan, making the efficient use of medical resources an urgent issue.

Key Points for Resolving Issues

Developing Countries

[How to prevent neonatal deaths]

The mortality rate of children under five is 76.5 per 1,000 live births in Africa, which is the highest in the world and about eight times higher than in Europe. The leading causes of death include premature birth, labor complications, and infectious diseases such as pneumonia, diarrhea, and malaria. Underlying this statistic is a weakened immune system due to malnutrition.

While heating and clean water are especially important in neonatal care, continuous care starting from pregnancy is also essential to prevent premature birth, complications, and infections. Efforts are also being made to reduce maternal and newborn mortality rates by using cell phones to ease the spread of inexpensive and convenient medical services.

Solutions

Clues to Solution [Technological Trends]

1.Developed Countries

Practical implementation period

2020-25

Online medical care is gaining popularity

- Services that allow patients to receive medical examinations online (including initial consultations) from the comfort of their own home, and that deliver medicines to their homes by sharing data with pharmacies, will become widespread.

Case study

Amazon offers Amazon Care, a medical service that combines online consultations with in-person visits.[50] In China, Ping An Good Doctor, a free app operated by an insurance company, offers online medical interview services, hospital searches and appointments, and the purchase of prescriptions drugs (Ping An Insurance (Group) Company of China, Ltd.).[51]

- As telemedicine becomes more widespread, the need for wearable devices that record vital data as well as portable testing kits for home and community use will grow. 2020-25

Case study

AI stethoscopes, recently subject to focused development, are gaining traction for their utility in online medical care. StethoMe sp. z o.o. and Sonavi Labs has introduced an AI-powered stethoscope, and AMI Kabushiki Kaisha has developed a new superstethoscope.[52]

Utilization of AI

- Many diagnostic imaging centers in Japan, which perform only diagnostic imaging, are located in front of railway stations. Japan has the advantage of having three times the number of MRI machines per capita relative to the OECD average, even as the division of labor in medical scanning work continues to increase 2020-25
- A system that uses AI to diagnose CT and MRI images is entering the practical application phase. Not only would such a system help doctors make decisions, but would also reduce the hours spent on evaluations. 2020-25

Case study

In October 2019, Lpixel Inc. became the first company to receive regulatory approval for a brain MRI device that uses deep learning to detect suspected aneurysms.

- A system that provides surgical navigation through machine learning has been developed. 2020-25

Case study

A system that applies AI-based machine learning to endoscope imaging to guide surgeries is being developed (Olympus Corporation, Oita University, and Fukuoka Institute of Technology).[53]

- It is difficult to continuously assign specialists to 24-hour intensive care units. Remote monitoring of ICUs (Tele-ICUs) is becoming more widespread.[54] 2020-25

Case study

Intensivists and intensive care nurses support the treatment and care of critically ill patients | Remote consultation system "Relieve" - Vitaars Inc.

Healthcare professionals working at ICUs nationwide are being supported by 24-hour remote monitoring. Remote support is available 24 hours a day for postoperative intensive care in hospitals without a resident intensivist (Vitaars Inc.).[55]

Knowledge sharing among physicians

- Online services that provide a forum for physician-based knowledge sharing and advice-giving are being used in areas where specialists are in short supply. 2020-25

Case study

exMedio Inc. provides Hippocra, a clinical mutual aid tool for physicians. With 300,000 registered users, the forum has become a community that provides consultation services in dermatology and ophthalmology, as well as mutual knowledge sharing on various topics from health insurance points to clinical drugs.

2. Developing Countries

Widespread provision of newborn care

- Neonatal care networks using ICT, such as cell phones, enable the timely delivery of necessary information. SMS (Short Message Service) can be used to provide pregnant women with information about their pregnancy, send reminders for prenatal checkups, and serve as a contact person in case of emergency. — 2020-25
- Since it is particularly difficult for premature infants to regulate their body temperatures on their own, it is vital to keep them warm immediately after birth. The development of inexpensive simplified incubators has been promoted as a solution. — 2020-25

Case study

The neonatal incubator Embrace is affordable and easy to use outside of the hospital (Embrace Innovations, India.)[56]

- Clean water, nutrition, and antibiotics are essential for neonatal care. Expectations are growing for technologies that can secure these resources inexpensively and reliably in developing countries. — 2020-25

Solutions

Clues to a Solution [Regulatory Trends]

- As a measure to eliminate the uneven distribution of medical resources, efforts are being made to realize what is called region-focused medical care. Japan aims to realign the roles of public medical institutions so that they will primarily focus on care services that only they can provide. The reorganization and consolidation of medical institutions will be based on an analysis of their medical treatment records and geographical conditions
- In April 2020, as part of the response to the spread of COVID-19, restrictions on telephone and online medical care, including pharmaceutical consultations, were removed as a temporary and exceptional measure.[57]However, online medical care is limited in their ability to make physical judgements since doctors cannot palpate or check patients' complexion online. Therefore, these consultations are allowed only in limited circumstances. While the Japanese government may expand the list of covered diseases and medical processes, they are operating carefully with regard to implementation.
- The MHLW, the Ministry of Economy, Trade and Industry (METI), and the Ministry of Internal Affairs and Communications (MIC) have jointly formulated the Basic Guidelines for the Management of Health and Other Personal Data by Private-sector PHR Business Operators for the use of Personal Health Record (PHR).[58] In the private sector, the PHR Service Business Association was established in 2023, and efforts to utilize health and medical data are currently underway.[59]
- Based on the revised Labor Standards Act, a penalizing maximum overtime work limit will apply to working physicians starting in April 2024.

Relevance to the SDGs

Problems

Inadequate access to medical and nursing services

Societal Issues

Provide services and improve their quality regardless of patients' location or distance

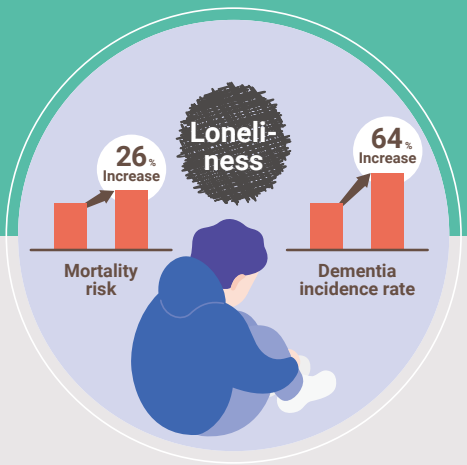
Relevance to the SDGs

3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births

3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births

3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being

Loneliness and isolation are bad for both mental and physical health



Physical and mental effects of loneliness increase risk of death by 26% and increase the probability of developing dementia by 64%

Implementation of measures to prevent loneliness and isolation and support affected individuals according to age, gender, environment, etc.

Provide consulting services via SNS for young people, support for creating connections for middle-aged people, and data-based monitoring for the elderly

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

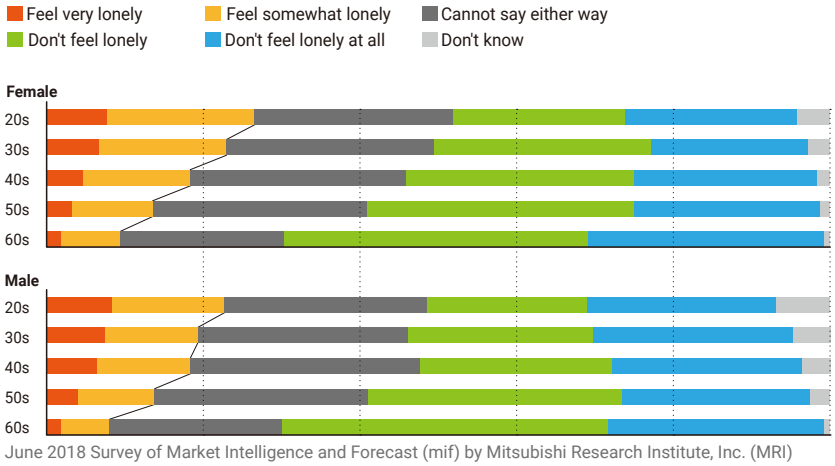
Solutions **Clues to Solutions**

Problems Worsening harm caused by loneliness and isolation

In 2020, the number of suicides in Japan increased for the first time in 11 years. The number of suicides in 2022 also increased compared to the previous year and remains high.[60] In addition, the number of suicides among elementary, middle, and high school studentsreached 514 in 2022, the highest number recorded in Japan.[61]

The adverse physical effects of loneliness and isolation are called syndemics, a new term combining synergy and epidemic, as they both exacerbate mental and physical health risks and become more pervasive as people become more affected.

Loneliness felt by age group



June 2018 Survey of Market Intelligence and Forecast (mif) by Mitsubishi Research Institute, Inc. (MRI)

World
Potential impact estimates

The physical and mental effects of loneliness increase the risk of death by 26%, the risk of developing dementia by 64% and coronary artery disease by 29%, and the risk of stroke by 32%.[62] (B)

The cost of loneliness is estimated to be £2.5 billion (JPY 450 billion) annually in the U.K. This is calculated as the sum of the costs arising from employee loneliness, including: absence from work due to depression or heart disease, receiving nursing care, declined productivity, and increased turnover. (B)

Issues

Early detection of high-risk groups, implementation of preventive measures, and reduction of adverse effects

Key Points for Resolving Issues

Early Detection of High-risk Groups and Implementation of Preventive Measures

[Support to prevent unwanted loneliness]

Loneliness is considered a subjective syndrome, while isolation is an objective phenomenon and is defined as having little or no contact with family or community. While having few social connections is not an issue in itself, unwanted loneliness is a problem when people cannot rely on or talk with others despite the desire to do so.

Causes and countermeasures against loneliness and isolation vary by age, gender, and environment. For example, mothers raising children, elderly people over 75 years old, and minorities are more prone to lonlinees and isolation. It is thus important to detect potential victims of loneliness early and implement effective prevention and support measures tailored to each type of target group.

Key Points for Resolving Issues

Mitigation of Harmful Effects

[Maintaining the physical and mental health of people in solitary conditions]

Loneliness is also a significant societal problem in the field of preventive medicine. It is necessary to establish a system that enables people that have few social connections (are isolated)to maintain their physical and mental health to avoid becoming seriously lonely.

Healthy lifestyle: Lifestyle plays a vital role in causing the illnesses of socially isolated people such as myocardial infarction, angina, and stroke. These can be avoided through improvements to lifestyle habits such as a non-smoking, a balanced diet, and moderate exercise.[63]

Maintaining mental health: Isolation sometimes leads to self-neglect and may require psychological health care. Effective measures include counseling services designed for people suffering from isolation and loneliness, living with pets, and engaging with communication robots.

Solutions

Clues to solution [Technological Trends]

1.Support to Avoid Unwanted Loneliness

Practical implementation period

Teenagers to those in their 20s: Expanding chat and social media consultation services

- Especially for younger generations, social media and chat services are considered more effective than telephone counseling. Online counseling and chat services by counselors are being implemented in many countries. — 2020-25

Case study

IbashoChat.org, a nonprofit organization, offers a 24/7 chat counseling service. About 80% of its users are teenagers or in their 20s.

30s to 50s: Supporting the creation of connections

- Encouraging casual conversation and communication at the workplace often leads to better connections among employees. — 2020-25

Case study

Bank of America implemented a simultaneous coffee break at its call center to encourage communication. It boosted the productivity of underperforming teams by 20% and the overall performance of the call center by 8%.

- The use of local currencies are expected to help create connections. For example, they can be used as compensation for those who provide services like preventive nursing care and childcare. — 2020-25

Case study

The state of Hawaii began issuing an Aloha Coin to revitalize local communities.[64] The initiative has at its core a mechanism that creates spontaneous connections led by the private sector.

60s and Beyond: Data-based monitoring and community support

- Efforts are underway to use data to identify people who are prone to loneliness and link them to support. In addition, while the need for sensor-based watch-over services is growing, it is also important to ensure that the elderly are not left behind in the digital age. — 2020-25

Case study

Using data such as marital status and health status, a heat map (visualization graph) of loneliness has been created. The map, which identifies vulnerable areas and people, is published publicly so that additional support can be obtained when and where it is needed (Age UK).[65]

Shumito Club is a social network service mainly for seniors where members participate in activities based on various hobbies.[66]In addition to encouraging the improvements to the local environment by installing benches in parks and improving bus stops, a group of seniors in London is also engages in twice-monthly activities such as walks with refreshments, exercise sessions, and film screenings.[67]

- Continuing care retirement communities (CCRCs) are housing facilities for seniors that provide continuous care starting from when residents are still healthy to when they need long-term nursing care.Widespread in the U.S., the CCRC model is attracting attention as an opportunity to foster social connections with peers because seniors move into these facilities while still healthy, and are thus capable of forming more active communities, hobbies, and values. 2020-25

Case study

Share Kanazawa is a leading example of the Japanese version of the CCRC model. The community consists of serviced housing for seniors , a childcare facility, university student housing, and a spa for locals. The resident seniors also operate the store within the community.[68]

People who have difficulty going out

- Remote operation of robots has realized a service that enables people who have difficulty going out or commuting to work. 2020-25

Case study

Employees with difficulty leaving their homes remotely operate avatar robots named OriHime and serve customers at a cafe (OryLab Inc.).[69]

2. Reduce the Harmful Effects of Loneliness

Maintaining physical and mental health of those in isolation

- Healthy lifestyle habits play an important role in preventing illnesses that are exacerbated by loneliness and isolation. Smoking, a poor diet, and a lack of exercise are to be avoided. There are high hopes for the utilization of technologies and services that support lifestyle improvement (See "Rising medical costs due to lifestyle-related diseases" on p. 16.) 2020-25
- Communication robots have proven effective in relieving the loneliness of people who have difficulty keeping pets. 2020-25

Case study

Yamaha Corporation has launched a robot named Charlie and is described by their slogan as “More than a pet but not quite a lover”. The miniature human-like robot responds when spoken to and can even sing.[70]

- Psychological findings and insights are also being used and developed to maintain healthy mental health. 2020-25

Case study

The U.K.’s National Health Service (NHS) is promoting the Gratitude Visit national movement, which calls for participants to write a thank you letter to their parents or anyone deserving of thanks, deliver it to them in person, and read it out loud in front of them. The recipient can even be someone who has passed away. The movement’s effectiveness has been acknowledged worldwide by the field of psychology.

Safety monitoring

- Services are provided to watch over users and reduce the risk of solitary and sudden death.

2020-25

Case study

In 2018, the nonprofit organization Enrich launched a new service using the LINE messaging app to protect the working-age generation from solitary death. The service sends out a safety notification at random intervals of one to three days. If the safety confirmation is not answered, the system resends it after 24 hours. If no word is received from the client within the following three hours, they are directly contacted via cell phone. If that also fails, the system informs the user's relatives.[71]

Solutions Clues to solution [Regulatory Trends]

- The U.K.'s Prime Minister appointed a Minister for Loneliness in 2018 and announced that £20 million (approximately JPY 2.87 billion) would be budgeted for measures that tackle loneliness. By 2023, "social prescriptions" (the concept of prescribing social connections rather than drugs) will be applied nationwide. Patients whom the physician deems to require a social prescription are referred to a community worker called a "link worker", who connects the patients with local resources and arranges participation in community activities.72
- In 2021, Japan's Prime Minister appointed a Minister of Loneliness and Isolation, modeled after the U.K. This appointment was made deal with the problem of loneliness and isolation, a phenomenon aggravated during the COVID-19 pandemic.
- In FY 2007, the MLHW launched the Community Support Center for Childcare Program, which aims to provide young families with opportunities to interact with other similar families in order to prevent loneliness during childcare.
- In Japan, the Act on Self-reliance Support for Needy Persons was implemented in 2015, enabling local governments to provide consultations to residents on social isolation and other issues. In addition, regional networks have been formed under the Hikikomori (seclusive syndrome) Support Promotion Program, including the establishment of nationwide Hikikomori Community Support Centers. The MLHW notified municipalities to work on the following items by the end of FY 2021:(1) Clarify and spread information on the consulting desk for hikikomori, those facing seclusive syndrome(2) Survey the situation and needs of the people who require support(3) Establish and operate municipal platforms.[73]
- The MLHW is promoting a comprehensive community care system to maintain the dignity and independent lifestyles of seniors. The care system offers seniors support in maintaining their lives in their current community until they require more intensive care.[74]
- In 2022, the Cabinet approved a comprehensive package of measures against suicide, including further promotion and strengthening of suicide prevention measures for children and young people, enhancement of support for women, intensifying efforts against suicide in communities, and promotion of measures based on the impact of the COVID-19 pandemic.[75] In addition, in 2023, an emergency strengthening plan preventing suicide among children was formulated.[76]

Relevance to the SDGs

Problems

Worsening harm caused by loneliness and isolation

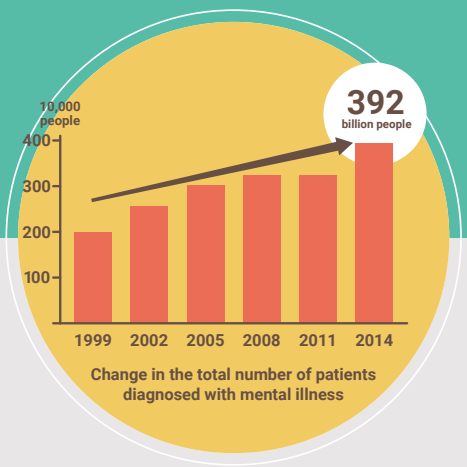
Societal Issues

Early detection of potential victims, implementation of preventive measures, and reduction of adverse effects

Relevance to the SDGs

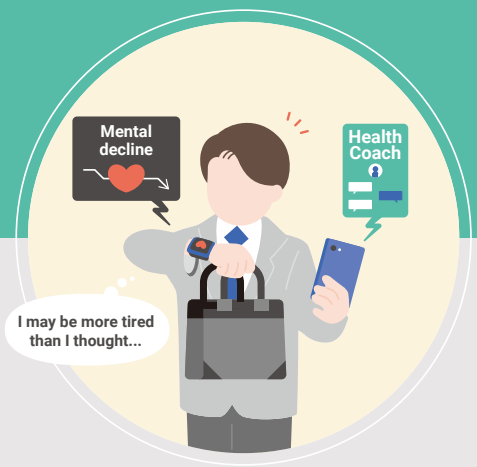
11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

Mental health care for everyone



The number of patients with mental disorders is increasing, totaling approximately 3.92 million in Japan alone

Prevention and detection of early signs and symptoms, as well as support for treatment and societal reintegration



Monitoring a variety of data, including physical data and daily activities, to understand the different forms of mental states

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Increase in the number of people suffering from mental illness

The number of patients seeking medical care due to mental illness has increased in recent years. Furthermore, new problems have emerged amid the COVID-19 pandemic, such as the growing number of people suffering from anxiety and stress. Suicide is also increasing among women and children, a tragic trend.[77]

It should be noted that presenteeism syndrome, a phenomenon where people will come to work even with health problems, is not a disease in the literal sense but will nevertheless decrease productivity. Symptoms among children and young people, as well as isolated seniors, are also issues that need attention. The losses caused by presenteeism account for 78% of companies' total health-related costs, including costs like medical care and sick leave.[78]

Mental health management is a vital issue in other countries as well, but characteristics differ from those in Japan, as they are more biased towards drug and alcohol addictions. Unlike Japan, where universal health insurance is available, individuals in the U.S. are responsible for their own healthcare. Americans are also generally more open about their own mental health issues than in Japan.

Japan

Potential impact estimates

Psychiatric disorders are affecting approximately 3.9 million patients.[79] The number of patients with depression is 500,000 men and 780,000 women, commonly found with men in their 40s to 50s and women in their 40s to 70s. About 20,000 dies by suicide every year.[80] The social cost of poor mental health is estimated at JPY 8.3 trillion, which includes the indirect cost of productivity decline caused by schizophrenia and depressive and anxiety disorders. The economic cost of lost workdays due to social anxiety disorder is estimated to be JPY 1.5 trillion.[81](B)

World
Potential impact estimates

It is estimated that one in three women and one in five men worldwide will experience depression in their lifetime.[82](B)

Issues

Support ranging from prevention to treatment and rehabilitation in society

Key Points for Resolving Issues

Mental Health Monitoring

[Everyday measures for prevention and early detection]

Mental health problems at workplaces can be prevented through the appropriate working hour management, anti-harassment measures, and promotion of active communication. In addition, the worsening of mental symptoms can be staved off through the early detection of warning signs and by providing appropriate support so that mental crises can be mollified. To make this possible, mental health monitoring must start when the patient is still healthy and to be able to issue appropriate alerts when concerning signs are identified. It is also important to build a mechanism that continuously motivates people to use these services.

Early signs detection methods include the use of pre-installed sensors in smartphones, the use of small devices, and insights from data of daily activities and self-assessments. It is also important to integrate monitoring into everyday life to acquire clean data during a person's healthy state, enabling comparative analysis against concerning data.

In addition to using big data and AI for analysis, it may be possible that more detailed sensing of brain waves and neurotransmission will become available in the future. Academic research into the functions of the brain and neurotransmitter systems is also underway. For example, research into brain functions includes the network responsible for consciousness and unconsciousness, the network that switches from one to the other, and the relationship between learning and the synaptic formation process.For accurate monitoring, it is important for these analyses to be combined with the latest knowledge on the central nervous system.

Key Points for Resolving Issues

Appropriate Intervention

[From preventing and treating mental deterioration to promoting inclusion and re-entry into society]

Based on the results of monitoring, there are two major types of interventions that can stabilize mental health. One approach is to support self-control for potential patients, and the second is to provide support from others to patients already affected by mental illness.

Examples of supporting self-control include periodic checkups, taking actions based on alerts from monitors, and monitoring at specific timing such as during sleep. While the appropriate support for the latter approach is to see a medical institution, efforts are underway in the U.S. to utilize online medical services to diagnose and even issue prescriptions. Online counseling services are also becoming popular in Japan. As for post-treatment support, it is crucial to address the possibility of relapse and to provide inclusive support and assistance for patients rejoining society. This type of support should aim to maintain continuous social participation after recovery by helping patients secure a proper work environment and find a job that best meets the goals of all involved.

Solutions

Clues to Solution [Technological Trends]

Practical implementation period

Mental Monitoring

- By sensing and analyzing a variety of data, including physical data and daily activity data, it has become possible to accurately assess the status of mental health (healthy, in mental decline, or with signs of relapse). — 2020-25

Case study

PST Inc. offers MIMOSYS, an app that analyzes the state of mind based on fluctuations in voice frequency, focusing on the involuntary movement of vocal cords.[83] Research is also making progress on the diagnosis of depression by measuring blood PEA levels.

- Devices for sensing are becoming smaller and smaller, and by utilizing widely available smartphones and other devices, sufficient data is being obtained with a lighter physical and psychological burden on users. — 2020-25

Case study

Israeli startup Binah.ai offers a service to measure heart rate and mental stress levels from a camera-captured video of users' faces.[84] In Japan, Binah.ai is collaborating with Sompo Himawari Life Insurance Inc..[85] Their iPhone healthcare app records users' activity, sleep, mindfulness, nutrition, and provides analysis and recommendations based on the data.[86]

Appropriate Intervention

- Services are provided in a wide range of fields from mindfulness and sleep to mental illness. Services include advice on psychological self-control, consultation with psychiatrists and other specialists, and drug prescription. — 2020-25

Case study

Calm, a U.S. unicorn company, offers various voice programs to help users manage anxiety, depression, and insomnia.[87] The annual plan is priced at $5/month. Ginger.io, an MIT startup, uses AI to analyze smartphone usage and provides a system for video conferencing with therapists and psychiatrists when necessary.[88] In addition, Lyra Health, Inc. uses AI to connect patients and compatible counselors to improve counseling effectiveness.[89] A study found that 73% of recipients showed significant improvement with a blended care practice of therapist-led video-based cognitive behavioral therapy and Internet intervention.[90]

Stimulation and functional expansion of cranial nerves

- Understanding of the mechanisms and functions of the brain and neurotransmission is being developed in academia. Based on academic findings, services to stimulate changes by applying magnetism and electricity to cranial nerve function have also been developed — 2020-25

Case study

Hacosco Inc., a neuroscience-based service provider, has partnered with the streaming music company Spotify to offer Brain Music, an app that allows users to create music playlists for different purposes, such as improving concentration or relieving anxiety and frustration.[91]

- Research is also being conducted to improve mental capacity and enhance individual well-being by expanding neurological functions.

2035 and beyond

Support for working environment

2020-25

- Working environments must respond to different types of needs to mitigate issues arising from mental health issues, including physical difficulty in commuting to offices despite the desire to continue working and difficulty with work that requires face-to-face interaction.

Robot-provided care

2025-35

- Robotic services are provided in which robots communicate and make physical contact with people to provide mental support and boost motivation. As a result of positioning robots as family members, robots are expected to and have already been seen to improve the mental health of family members.

Case study

LOVOT by GROOVE X, Ltd. became an honoree product at the CES 2020 Innovation Awards. It is a family-type robot that moves on wheels and acts as a family member by integrating itself into people's lives by learning, reacting, and observing.[92] Qoobo by YUKAI Engineering Inc. is a cushion-type therapy robot that wags its tail when stroked. An on-site experiment at a care facility for seniors revealed that the interaction with the robot provided an opportunity to encourage participation in activities with others.[93]

A demonstration experiment using Qoobo, a robot that moves seniors' hearts, was conducted at a senior care facility. The positive response has also persisted for a long time. Press release of YUKAI Engineering Inc. (prtimes.jp).

Solutions

Clues to solution [Regulatory Trends]

- The 2014 revision of the Industrial Safety and Health Act made stress checksand response measures for employees mandatory for all establishments where 50 or more workers are regularly employed. Employers must conduct the stress check once a year and report results to the Labor Standards Offices
- The MLHW is promoting a collaborative health concept and has released the Collaborative Health Guidelines for Promoting Data-Based Health and Health Conscious Managements (2017). In health management, the idea is for health insurers and companies to cooperate and promote the health t of employees and their families. The guideline presents a quantitative evaluation of the health-related costs of presenteeism and absenteeism, describing the current health management processes occurring through cooperation between insurers and businesses. Presenteeism is a state in which employees are at work, but with reduced productivity , while absenteeism is a state in which employees are absent from work entirely.
- Transformative technologies are helping the pursuit of well-being by utilizing academic accomplishments in fields such as neuroscience, but have not yet been reflected in specific regulation. The commercialization of related services will require discussions on various issues, such as the regulation and social acceptability of external access and stimulation of the brain, as well as the ethics of the technology for developers.
- In 2019, the U.S. Food and Drug Administration (FDA) approved the first new drug for postpartum depression. FDA also approved a fast-acting oral medicine for depression in 2022 that presents effects within one week.[94]

Relevance to the SDGs

Problems

Increase in the number of people suffering from mental illness

Societal Issues

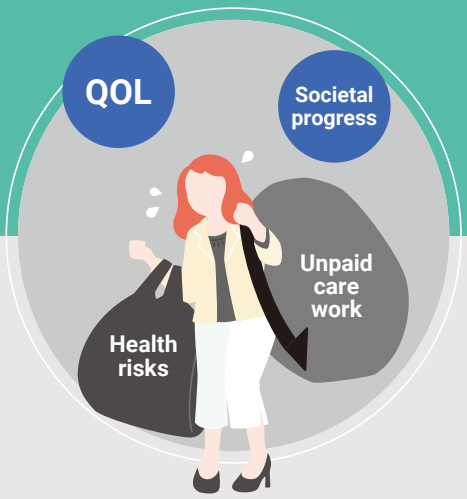
Support ranging from prevention to treatment and rehabilitation in society

Relevance to the SDGs

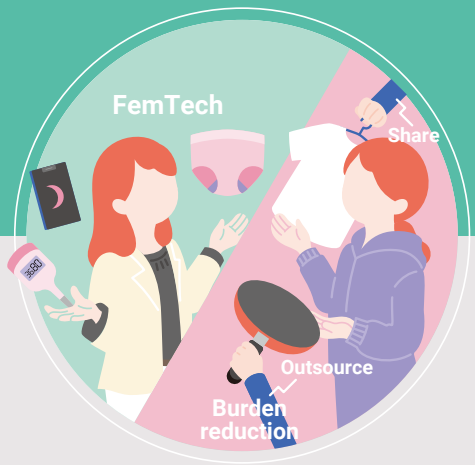
3.4 By 2030, reduce youth mortality from non-communicable diseases by one-third through prevention and treatment, and promote mental health andPromote mental health and well-being

3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol

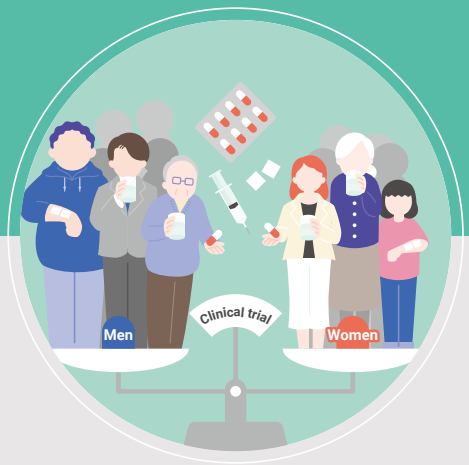
Many women want to be active but are unable



Health risks specific to women (menstruation, PMS, menopausal symptoms, etc.) and uneven care workload are major societal issues



(1)Product development that takes women's specific health issues into account
(2)Reduce care-work burden by developing products that take women into consideration



Bridging the gender gap through new product and drug development tailored to diverse body types and constitutions

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Increased health risks for women

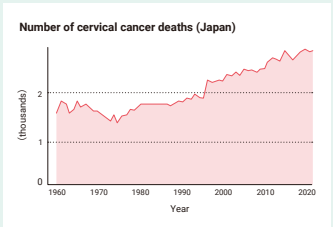
The percentage of women in the total labor force is on the rise, reaching 44.4% in 2019, compared to 39.7% in 1985.[95] The increasing empowerment of women in society has been accompanied by increasing health risks , especially for working women, in terms of both impact and the number of cases. There are concerns not only about the potential impact on women's quality of life and healthy life expectancy, but also about the negative impact on corporate productivity and women's further advancement in society. A survey found that 52% of female employees have experienced issues due to health challenges including menstruation, PMS (premenstrual syndrome), and menopause[96]

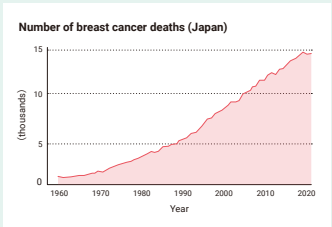
Globally, women are responsible for 75% of unpaid care work, including housework, childcare, and nursing care. This burden of this work affects women's physical and mental health. [97] Even when limits are set on the number of hours of paid work, including the hours of unpaid work will in effect result in total working hours longer than a standard full-time job. Data has shown that Japanese women have the shortest average sleep hours in the world.[98]

Additionally, the development of medication often overlooks women-specific side effects, which results in a lack of effective options for women.

Japan
Potential impact estimates

Totals amount to JPY 6.37 trillion per year for medical expenditure and productivity loss from working women facing gynecological diseases. The breakdown of estimated expenditure is JPY 1.42 trillion and productivity loss is JPY 4.95 trillion.[99](B)





Source: OECD (https://www.oecd.org/gender/data/)

Issues

Giving attention to women's health both in developed products and participatory social systems

Key Points for Resolving Issues

Medical Perspective

[Product development that considers health issues unique to women]

Women's quality of life and labor productivity are significantly affected by various gynecological illnesses including menstrual symptoms, breast cancer, cervical cancer, and endometriosis. In addition, infertility treatments, postpartum depression, and menopausal disorders are also factors that limit women uniquely. It is thus important that women themselves have the necessary knowledge and visit gynecologists and other specialists sufficiently often. At the same time, men should acquire knowledge of preventing and treating women's diseases including pregnancy and childbirth.

Femtech is increasingly gaining attention as a subset of technology that directly solves women-specific health problems. Other products that have been recently developed include new sanitary products, pelvic floor muscle care items, and health management apps

Key Points for Resolving Issues

The Perspective of Equality

[Reducing the burden of caregiving work and developing products that consider gender differences]

It is necessary to reduce the burden of uncompensated work, which tends to be borne by women. This workload can be reduced through visualization of the care workload, fair assessment and sharing of the workload, and the use of ICT technology to improve efficiency and substitute services. In addition to pharmaceuticals, the injury rate among women is relatively higher because the sizes and weights of various equipment such as automobile seat belts, farm machinery, construction equipment, and protective clothing are (in many cases) designed for standard male workers. Many speech recognition systems alsohave difficulty in recognizing women's voices. During the research and development of such products, it is crucial to employ the so-called Gendered Innovations approach, which analyzes gender differences and applies the results to product design. It has also been pointed out that speech recognition systems have difficulty in recognizing women's voices. In the research and development of such products, it is crucial to employ the so called gendered innovations approach, which analyzes gender differences and applies the results to product design

Solutions

Clues to Solution [Technological Trends]

1. Products with Women-specific Health Issues in Mind

Practical implementation period

2020-25

Providing health and medical information

- A service has been launched that provide women with necessary information according to their life stages, such as pregnancy, childbirth, childcare, menopause transition, and postmenopause

Case study

FamiOne, Inc. provides chat services to support expecting and nursing mothers. It also provides companies with informational seminars for not just the female workers going through fertility treatment but also managers and young employees.[100]

TRULY provides information on vaginal care and menopause caused by changes in female sex hormones, a service that allows women to self-check the severity of their menopausal, and an online consultation service with female physicians.[101]

- A wearable device and app have been developed to track morning sickness cycles during pregnancy and provide personalized advice to alleviate the symptoms. 2020-25
- Services are being developed to provide gender-specific medicine (medical care based on gender difference) using AI 2020-25

Case study

An AI diagnosis navigation system WaiSE provides diagnostic support for diseases of menopausal women that are often overlooked by asking female patients about age, symptoms, and more detailed AI-generated questions (Katai Laboratory, The National Graduate Institute for Policy Studies).[102]

Reducing the burden of checkups

- Patients tend to hesitate to undergo gynecological checkups due to embarrassment, pain, and fear. To alleviate this, examination technologies and devices are being developed to ease the patient burden. 2020-25

Case study

Imaging equipment has been developed utilizing ultrasound for breast cancer screening. It is painless and can capture highly reproducible three-dimensional images of the entire breast, regardless of the skill of the examiner's(Lily MedTech Inc.).

- Breast cancer testing by liquid biopsy (diagnosing cancer from blood and other bodily fluids) is also seeing practical application.[103] 2020-25

Case study

Research is being conducted to detect breast cancer and determine the risk of recurrence by measuring exosomes in tears collected at home (TearExo Co., Ltd.).[104]

2. Reducing the Burden of Care Work

Housework and Childcare Burden

- Women's career advancement is often hindered by a shortage housework providers in dual-income households. Focusing on this fact, services that support the sharing and outsourcing of housework are becoming widespread. 2020-25

Case study

DAIWA HOUSE INDUSTRY CO., LTD. has proposed a Household Chore Share House concept in which the household members share chores naturally.[105]In addition, TASKAJI Inc. outsources cleaning, cooking, and childcare services on behalf of clients.[106]

3. Gendered Innovations

Products tailored to women's physiques

- New products tailored to women's physiques are becoming popular in the market and include: a 7/8-sized keyboard for pianists with smaller hands[107]; a smartphone that women can operate with one hand; and a VR headset tailored to the average size of a women's head. Similarly, protective equipment such as life jackets, safety shoes, and seat belts should also be made with women's bodies in mind 2020-25

Case study

The Galaxy Z Flip foldable phone series is attracting attention for its compact size that fits well in women's hands and its ability to fold vertically. [108]

Increasing participation of women in clinical trials

2025-35

- The promotion of virtual clinical trials conducted at participants' homes or nearby medical institutions could facilitate the participation of women who have been unable to participate in clinical trials in the past due to time constraints.[109] *Virtual clinical trial (VCT) is not an established industry term. It has various names, such as decentralized clinical trial (DCT) and remote clinical trial.

Solutions

Clues to solution [Regulatory Trends]

- In Japan, fertility treatment has been covered by health insurance since April 2022. The insurance coverage has reduced the financial and psychological burden of treatment but has also encouraged its standardization.
- The Maternal and Child Health Act encourages expecting mother to receive regular health checkups. In 2017, the Health Checkup Program for Expecting and Nursing Mothers was established to prevent postpartum depression and abuse of newborns. The program provides every pre- and postnatal woman with a subsidy for two maternity health checkups.In addition, municipalities are responsible for implementing the initiative as well as prenatal and postnatal support programs.[110]Because the revised Maternal and Child Health Act, which went into effect in April 2021, stipulates that the implementation of postpartum care is an obligation of local, the number of municipalities providing postpartum care is increasing.
- In 2016, the Maternal and Child Health Act was revised, enabling the nationwide expansion of Maternal and Child Health Comprehensive Support Centers. The objective is to provide seamless support from pregnancy through the child-rearing period. In the U.S., in an effort to address the gender gap in drug development, it is illegal to exclude women from government-funded clinical trials; Australia has similar rules. The EU goes further by requiring that experiments conducted on animals in the preclinical phases must also be done on both sexes; the U.S. followed suit, passing the same requirement in 2016
- In the U.S., crash test dummies based on female physiques have been used in car crash safety tests since 2011. There have been calls to mandate the use of pregnant women's dummies, as motor vehicle crashes are the leading cause of stillbirths due to maternal trauma.

Relevance to the SDGs

Problems

Increasing health risks for women

Societal Issues

Giving attention to women's health both in developed products and participatory social systems

Relevance to the SDGs

3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births

5.1 End all forms of discrimination against all women and girls everywhere

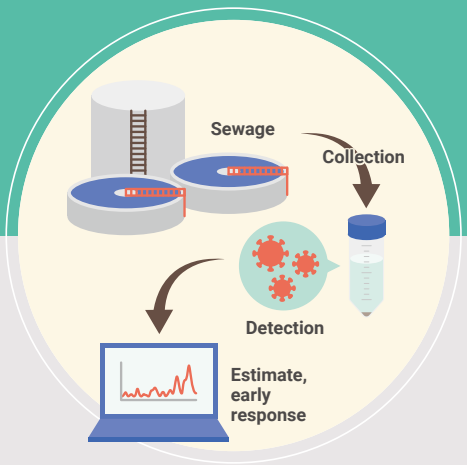
5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life

8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value

Severe infectious diseases threaten society and economies

Infectious diseases such as COVID-19, malaria, tuberculosis, and HIV, remain a substantial threat worldwide

Detection of outbreaks of infections early, prevention of spread, and the protection of economic activity



Detection and early response to infectious diseases using everyday infrastructure like sewage systems

Frequent and severe pandemics

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Frequent and severe pandemics

The infectious disease COVID-19 quickly became a pandemic, causing tremendous damage worldwide, and is still prevalent today. Countermeasures like lockdowns have caused enormous health hazards and social and economic damage, changing the face of society.

There is still a high risk of new types of infectious diseases being transmitted through contact with nature via human activities, or mutations of already-known bacteria and viruses. Preparation for the next pandemic is an urgent requirement for society. The increase of antimicrobial resistance (AMR) in bacteria has also become a worldwide concern

Other infectious diseases also pose a threat, with about half of the world's population at risk of malaria, especially in Africa, where the number of infected people reached 247 million in 2021.[111] In addition to malaria, conventional infectious diseases such as tuberculosis and HIV remain a threat in many countries.

World
Potential impact estimates

As of March 2023, more than 676.57 million people worldwide have contracted COVID-19, and more than 6.88 million have died as a result.[112] In the event of a moderate to a severe pandemic, predicted global mortality is projected to be between 14 and 71 million.[113] The annual global economic losses that would occur is estimated to be $570 billion.[114](B)

Malaria was estimated to have caused 619,000 deaths in 2021. The disease is estimated to slow economic growth in African countries by 1.3% per year, resulting in an annual loss of$12 billion in GDP.[115](A)

Issues

Preventative measures to improve resilience against infectious diseases and reduce their spread

Key Points for Resolving Issues

Developed Countries

[Information-based prevention and control of outbreaks; balancing medical resources and economic activities]

It is essential to quickly acquire information on global infectious disease outbreaks and epidemics to speed up initial responses and prevent their spread. It is also important to take public health measures, including social distancing, to avoid infection clusters and prevent the collapse of medical infrastructure .

At the same time, it is important to implement measures to maintain economic activity, disseminate appropriate information, and implement support policies to prevent widespread confusion.

Key Points for Resolving Issues

Developing Countries

[Improving sanitation in developing countries, where pandemics are likely to be more severe]

In the event of a pandemic, developing countries with poor sanitary conditions are more likely to be hit more severely. As a result, developed countries have taken the initiative in developing vaccines and testing equipment and have offered them to developing countries. It is also important to improve sanitary conditions at the grassroots level. Solutions using familiar technologies that can be integrated into daily lifestyles are needed. inspection equipment and have offered these to developing countries. Grassroots efforts in improving sanitation is also important. Solutions using familiar technologies that suit people's lifestyles are required

Summary of the Expert Meeting on COVID-19 Infection Control

		Main Response Policies
a	Clarify the roles of each involved party in times of infectious disease outbreaks and practical training for actual crises.	In ordinary times, each region should make efforts to differentiate medical functions and clarify the roles of each party in times of infectious disease outbreak.
b	Ensure a medical care provision system for home and overnight care patients and positive facility residents.	Each region also needs to differentiate the roles of primary medical institutions during times of infectious disease outbreaks from their roles during ordinary times.
c	Share costs of outpatient medical care	A new system of publicly funded medical care that assumes home and overnight care patients will receive medical care.
d	Secure medical personnel during outbreaks	In addition to demonstrating the expertise of each profession and reforming working styles even in ordinary times, developing task shifting and sharing with regard to infection outbreaks.
e	Coordinate hospitalization within regions	Facilitate communication and information sharing among prefectures with cities that have health centers and special sections, and establish a system to coordinate hospitalization within each region in case of emergency.
f	Coordinate hospitalization over wide areas	Clarify the division of roles between the national government and prefectures in cases where coordination of hospitalization is necessary across prefectural areas.
g	Promotion of medical DX	Enable the rapid collection of information on the status of infection and the implementation of measures to build a healthcare delivery system through digitization.

Source: the Expert Meeting on Novel Coronavirus Disease Control, Medium- and Long-Term Issues for the Next Infectious Disease Outbreak Based on Previous Efforts against COVID-19,June 15, 2022.

Solutions

Clues to Solution [Technological Trends]

1. Developed Countries

Practical implementation period

Detection and prediction of the spread of infection

- There are high expectations for a surveillance system to detect outbreaks of new infectious diseases in normal times, a system to utilize biosensors[116] and share data, and a system that uses AI to predict new infectious diseases based on hospital visitor travel history and symptoms. — 2020-25
- After an epidemic, a system that can anonymously confirm whether or not a person has been in close contact with an infected person, a translation tool to appropriately respond to foreigners who are unwell, and an AI to analyze medical questionnaires would be greatly useful. — 2020-25

Case study

In response to the COVID-19 outbreak, Kanagawa Prefecture created and provides a COVID-19 Notification System via the LINE messaging app. By scanning a QR-style bar code with their smart phones, users can receive notification from the system if there was a risk or suspicion of close contact with infected persons. An alert function has also been added to inform users to leave restaurants after a pre-determined amount of time, usually 90 minutes.

Collecting and sharing information

- Systems are needed to appropriately collect and disclose relevant information, including data on transmission routes, recovery, recurrence, death, the status of medical resources, and availability of healthcare professionals. — 2020-25
- Research and development activities are also being carried out to collect information from infrastructure that is routinely used for other purposes, such as sewerage. Work is underway to detect COVID-19 in sewage.[117] — 2020-25

Case study

Code for Japan, a nonprofit organization based in Tokyo, launched a website dedicated to COVID-19.[118] The site, which was developed in a short period of time using open source, has code available on GitHub, which was used to quickly launch similar sites by municipalities across Japan.

Online medical care

- When there is a suspicion of infection, a system in which patients can receive a medical examination and have medicine sent to them without contact would be effective in preventing infection and the spread of the disease. However, compared to face-to-face diagnosis, physical findings are inherently more limited, so the scope of its application and usage of the system should be appropriately defined through policy. — 2020-25

Development of new rapid test kits, pharmaceutical drugs, and vaccines

- Rapid test kits that can screen infections quickly are effective in promoting preventive actions and preventing the transmission of disease and are expected to become widespread once costs are lowered. — 2020-25

- Existing drugs may also be effective as treatments for new types of infections. Studies are underway to use AI to identify candidate drugs from existing drugs without actually administering the drugs to patients. — 2020-25
- Vaccine development is also important to prevent further transmission and future pandemics. mRNA saw practical use in a vaccine for the first time due to its role in battling the COVID-19 pandemic. — 2020-25

Case study

A silkworm research team at Kyushu University, in collaboration with KAICO LTD., discovered a silkworm species that can produce a large amount of protein as a source for vaccines and developed it as a COVID-19 vaccine candidate.[119]

- Research for the prediction and early detection of worsening infectious diseases using AI analytics is also in progress. — 2025-35

Case study

AI can detect signals that lead to worsening pneumonia from breathing sounds, which automates auscultation and saves labor. A system using this AI has enabled physicians to manage the risk of worsening symptoms remotely (Murata Manufacturing Co., Ltd., Kyoto Prefectural University of Medicine).[120]

2. Developing Countries

Addressing public health issues

- Insect-proof nets, soaps that can be used without water, water purification tablets, and fecal decomposition agents have been developed. — 2020-25

Case study

Countermeasures against mosquitos that carry infectious diseases have been developed, such as Olyset® Net, an insecticide-treated mosquito net (Sumitomo Chemical Company, Limited, Japan),[121] and Photonic Fence, a laser that selectively kills female mosquitoes (Intellectual Ventures Management LLC, U.S.).[122]

- Inexpensive and safe sewage and sanitation facilities are in high demand. — 2020-25

Case study

SATO toilets are designed for developing countries, which require only a small amount of water to flush(LIXIL Group Corporation, Japan.)[123]

- ICT can be used to collect the latest information on infectious disease risks and to raise immediate awareness when needed. — 2020-25

Case study

Google Flu Trends allowed users to see how the flu epidemic was trending in real-time via search terms (now discontinued).

- The pandemic sparked the development and commercialization of an autonomous disinfectant robot. 2020-25

Case study

PATORO, an unmanned security and disinfectant robot developed by ZMP INC., is equipped with a disinfectant spraying function using an electric sprayer. It can perform unmanned indoor and outdoor patrols for disinfection, sterilizing surfaces as it goes.[124]

Storage and transportation of vaccines at room temperature

- Rice-based oral vaccines for cholera and other viral enteric diarrhea can be stored at room temperature, making transportation in developing countries much easier than conventional vaccines. 2020-25
- Vaccines can even be transported to remote islands by drones. If all vaccines could be stored at room temperature, as in the case with rice-based vaccines, the use of drones for delivery would be further promoted. 2020-25
- Research and development for new vaccines (transdermal, rice-based, DNA vaccines, etc.) are progressing. Transdermal vaccines (also known as skin patch vaccines) can be stored at room temperature and are expected to enable immunization in the absence of medical personnel. 2020-25

Solutions

Clues to solution [Regulatory Trends]

- In April 2020, as a result of the spread of COVID-19, restrictions for online and telephone medical care and drug consultations (including initial consultations) were removed as part of a temporary and exception-based response by the Japanese government. (See "Inadequate access to medical and nursing services" on p. 28.)
- In response to the COVID-19 pandemic, some countries and regions implemented lockdown measures, which restricted citizens' activities. In some countries, these lockdown measures completely prohibited people from leaving home except for essential grocery shopping—commuting was otherwise prohibited, even for work. In Japan, the government requested that its citizens refrained from leaving home and, despite lacking any penalties or enforcement, these measures saw a certain degree of effect. There is still debate as to whether Japan should implement stricter enforcement when responding to future infection outbreaks.
- In the U.S. and major European countries, vaccinations are covered by health insurance. In Japan, only certain publicly funded immunizations, designated by national and local governments, are covered by health insurance, and the cost of the others is borne entirely by individuals. For example, the vaccination for mumps, which is part of vaccine recommendations in most countries around the world, is not eligible for coverage, reducing the vaccination rate and leading to preventable effects like hearing loss and meningitis. Routine vaccination for influenza is limited only to the elderly, and other generations must pay out of pocket. The delay in immunization systems compared to major overseas countries has been heavily criticized as a dangerous "vaccine gap". There is also a need to shift to routine vaccinations that are principally covered by government funds. The introduction of new vaccines is also keenly needed.
- Japan's goal of eradicating rubella by 2020 was not achieved, and the MHLW is now offering free rubella tests and vaccinations to men of eligible ages. The free vaccination period, which was originally scheduled to end in FY 2021, has been extended to FY 2024.[125]
- To prevent the rise of drug-resistant bacteria, the World Health Organization (WHO) recommends a ban on adding antibiotics to animal feed. However, Japan, the U.S., and China have continued to add antibiotics to feed.[126]
- CARB-X, the world's largest nonprofit organization, was established in 2016 to respond to antimicrobial resistances (AMR). It aims to promote antimicrobial research and is funded by the U.S. government.[127]Japan established the Agency for Medical Research and Development (AMED) in 2015 to support the creation of drug-resistant medication discovery. Many have commented domestically, however, that its budget and scale need to be expanded.
- In June 2021, Japan approved a national strategy to strengthen its system for vaccine development and production. In July, the Strategic Center of Biomedical Advanced Research and Development for Preparedness and Response (SCARDA) was established within AMED. The center will support the research and development of vaccines in normal times and work quickly to produce effective and rapidly distributable vaccines during emergencies.
- Drones in Japan are regulated by the Civil Aeronautics Act and the Act on Prohibition of Flight of Small-sized Aircraft, etc. However, the regulations on drone use are much less strict in developing countries, so the use of drones in the vaccine transportation may become more widespread with time.

Relevance to the SDGs

Problems

Frequent and severe pandemics

Societal Issues

Preventative measures to improve resilience against infectious diseases and reduce their spread

Relevance to the SDGs

3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases

6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations

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02

A Society Where All People Have Access To safe And Secure Water And Food

Water And Food

Humans require food and water to survive, but these resources are heavily affected by changes in the climate and natural environment. Drought and starvation have threatened the safety and lives of many people, but the day when technological innovation can resolve these problems is steadily approaching.

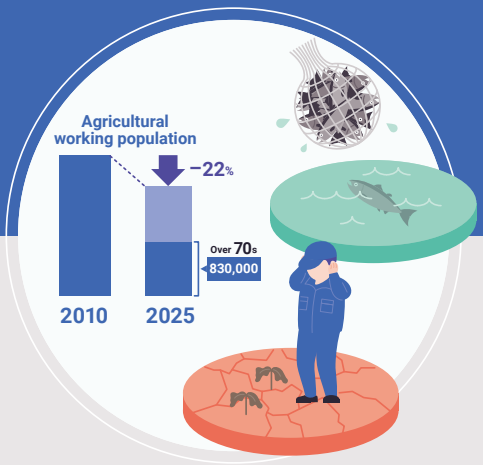
In order to ensure a stable supply of water and food in sufficient quantities for all people, the efficiency of water circulation and the production, supply, and consumption of food as a whole must be improved. In particular, making the agriculture and fisheries industries more attractive through labor-saving and productivity improvement will lead to the securing of workers and products.

It is essential to secure and maintain not only a sufficient amount of food but also improve access to healthy food and meals. While the quest for better tasting and healthier food continues, low-income groups in many countries tend to consume cheaper processed foods, leading to higher obesity rates—another societal issue. In addition, there is an increasing demand for food diversity based on ideology, religion, age, and physical constitution. Diversity and personalization are becoming important keywords in the discussion of food.

The taste and enjoyment of food play an important role in human happiness. Food can also play a substantial role in promoting communication not just at the dinner table but during the farm work and cooking processes.

ICF aspires to create a society where everyone has access to clean water and safe, nourishing food regardless of where they live or their economic situation. In the water and food area, problems and issues have been organized into the following seven categories:

Our ability to produce food is being threatened



In Japan, young people are rapidly leaving agriculture and fishing industries. Worldwide, water resources are being heavily overfished and soil quality is being degraded

Increase productivity of primary industries by increasing the number of farmers, supporting agriculture innovations, and promoting farmland preservation

Sustainable and efficient production management using bio-mechanical and ICT technologies

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Decline in food supply capacity

Worldwide, economic growth and urbanization have caused the conversion or abandonment of agricultural land and the depletion of fishery resources. As a result, the amount of available agricultural land has decreased and the quality of the soil has deteriorated. The Food and Agriculture Organization of the United Nations (FAO) has called for a halt to the rapid degradation of the world's soil caused by population growth, industrialization, and climate change.

A growing percentage of the world's population faces food insecurity due to regional conflicts, economic stagnation caused by the spread of infectious diseases, and disasters and famines caused by extreme weather events.

The global COVID-19 pandemic, followed by Russia's invasion of Ukraine, which broke out in February 2022, has had a major impact on the food sector. Prices of grain and other commodities are at risk of rising sharply in the short term due to soaring energy and resource prices. Supply chains have also been disrupted, such as those affected by the blockade of the Black Sea. In Japan, the so-called 2024 problem of a severe shortage of truck drivers due to the enforcement of the Work Style Reform Bills is expected to have a significant impact on the distribution of agricultural commodities.(For more details on the 2024 problem in logistics, see p. 150.)

Productivity in agriculture and fishing tends to be lower compared to other industries worldwide. They are not attractive career options for young people, which results in a shortage of labor that raises concern about whether agriculture and fisheries are sustainable in the long-term future. Japan is also facing a continued aging and severe shortage of its workforce. The problem is particularly apparent among part-time farming fa The environmental impact of food production is significant and has yet to be reduced. To achieve sustainable food procurement while increasing food production that matches population growth, it is necessary to properly understand the environmental impact of food production and take measures to address it.

Japan

Potential impact estimates

The number of people working in agriculture continues to decline.The average age of agriculture workers reached 68.4 years[1] in 2022. If the current trend continues, the number of agricultural workers in 2025 will be 22% lower than in2010, falling to 1.7 million.[2] Of this population, the number of workers who are 70 and above is expected to reach 830,000. (A)

As contents of cargo, agricultural and fishery products make up the highestpercentage[3] of goods with the following conditions for transportation drivers: more than 16 working hours per trip, trips with less than 8 hours of rest, and trips with more than 4 hours of continuous driving. As a result, these products are the most affected by the shortage of transport capacity caused by to the 2024 problem. To maintain current transportation capacity, about 35,000 extra drivers are needed for the agricultural and fishery products sector alone.[4]

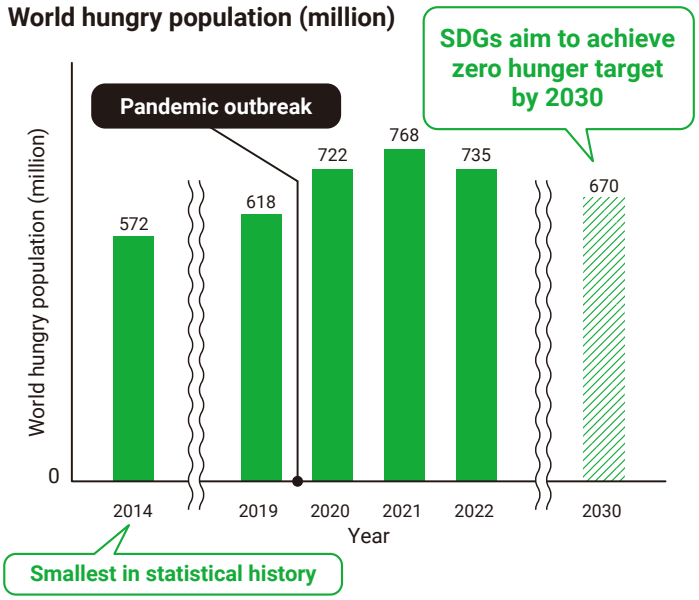
World

Potential impact estimates

33% of the world's land has deteriorated to a "moderate to severe" level of pollution as a result of erosion, salinization, consolidation, acidification, and chemical contamination.[5]

As of 2022, it is estimated that around 700 million people are facing starvation, an increase of about 122 million people from before the COVID-19 pandemic.[6] Although the Sustainable Development Goals (SDGs) aim to eliminate hunger by 2030, current estimates suggest that 670 million people will still be suffering from hunger (see figure below).(A)

Agricultural production accounted for 13% of the world's total greenhouse gas (GHG) emissions in 2019, and 31% if extended to include the entire food system.[7]



Source: The State of Food Security and Nutrition in the World (SOFI) 2023 - UNICEF DATA

Issues

Strengthening the industrialization of food production by improving productivity

Key Points for Resolving Issues

Elderly Farmers and Fishers

[Becoming more mechanized, larger-scale, and higher value-added industries]

Many farmers are leaving the industry due to their age. This phenomenon is particularly impactful in the rice-growing regions where part-time farming is prevalent. In order to secure this workforce, it is crucial to improve productivity through labor-saving practices, total automation of certain processes, and the pursuit of large-scale and high value-added industry advantages. Wealthy farmers with more than 50 hectares of arable land and annual incomes of more than JPY 20 million are more likely to secure successors. In fisheries, value is now being added through diversification, such as tapping into new fishery resources, improving fishing equipment and techniques, and creating new consumer needs for a wider variety of local fish.

Key Points for Resolving Issues

Prospective New Farmers

[Industrialization, expansion of farming opportunities, and smooth successions]

Large-scale farming operations by corporations will improve productivity and industrialization in agriculture. This change will provide potential new farmers with more opportunities to participate. For a prospective farmer, rather than starting farming from scratch, acquiring land and expertise from existing farmers will reduce costs and risks.

People who wish to change jobs and start farming need better access to industry information and services that can match farmers with regions and crops to specialize in. New farmers need support so that they can achieve high levels of productivity, especially in areas such as inheriting land, the transfer of expertise, labor-saving, and adding value to their farms.

Key Points for Resolving Issues

Climate Change Countermeasures, Farmland Conservation, and Prevention of Overfishing

Efforts are needed to develop new types of crops that are resistant to climate change, to conserve farmland, and to prevent overfishing. For example, the Norwegian Fishermen's Association lists the total catch quota and the catch to date for each vessel in real time on its website. Through this operation, the association works to manage the catch rate to prevent overfishing and increase profits.[8] Technology must also be developed to quickly reduce the number of pest insects, such as grasshoppers, so that crops will not be devoured when they temporarily increase in number.

Key Points for Resolving Issues

Establishment of Sustainable Food Procurement and Security Systems

About 70% of GHG emissions in agriculture, forestry, and fisheries are methane and N_2O, which originate from the gastrointestinal fermentation of livestock and agricultural soils. In addition to reducing energy-derived emissions, curbing methane and N_2O emissions specific to agriculture, such as through the improvement of feed and soil ameliorants, is important.

It is necessary to establish a food production system domestically and maintain agricultural productivity to ensure a sustainable food supply in times of emergency, and to build cooperative relationships with other countries through technical assistance. Especially in Japan, exporting GHG-reduction technologies and providing technical assistance to Asian countries are essential for food security.

Clues to Solutions [Technological Trends]

1. Elder Workers in Agriculture and Fishery

Practical implementation period

Strengthening the industrialization of food production by improving productivity

- If non-destructive inspection equipment can be miniaturized, it will be possible to harvest only individual products that have ripened to a specified value or higher at harvest time. — 2020-25
- Improvements in agriculture have been achieved through a Farm Machine Relay program. Farming machinery and personnel are shared between regions with different farm work periods in a relay system, which contributes to an increased machinery operating rate and reduction of costs. — 2020-25

Case study

A new type of business venture in Japan by JA MITSUI LEASING, LTD. and ZEN-NOH involves the shared leasing of farm machinery, where large combine harvesters are shared among rice and wheat farmers (National Federation of Agricultural Cooperative Associations).

- Power-assisted suits and robots can be used to support strenuous work or reduce physical workloads, easing the burden on farmers. — 2020-25
- Autonomous combine harvesters and rice transplanters that are combined with advanced technologies, including GPS, sensors, and AI cameras, have begun to see practical use. In addition, drones used for crop dusting and smartphone-linked water volume controllers using the Internet of Things (IoT) are emerging to save labor in agriculture. However, problems still remain, such as the lack of surroundings safety checks and emergency stop operations, so complete unmanned agricultural work has not yet been realized. In addition, the high cost of introducing IoT makes it difficult for Japanese farmers with small-scale operations to recoup their investment, so the use of IoT is not widespread. — 2020-25

Case study

Kubota Corporation plans to launch the world's first uncrewed combine harvester capable of harvesting rice and barley through autonomous driving and operation in January 2024. All three major machinery, tractors, rice-transplanters, and combine harvesters, will have autonomous driving models.[9]

Improving efficiency at the production stage and effectively utilizing surplus food resources

- Production adjustment systems that respond to market demand, food production that is in areas closer to consumption (including vegetable factories and land-based aquaculture) , and super water-saving agriculture (precision agriculture) are expected to be developed in the near future. — 2025-35
- There is a need to develop technologies to prevent the deterioration of food quality, such as precut vegetables that are cheaper and easier to preserve , and frozen vegetables that maintain their nutrients. — 2020-25

- Diversification has demonstrated the potential to enhance high value-added fisheries. In the future, measures are expected to include conservation of the marine environment, and the impact on the ecosystem, through the identification and utilization of microorganisms and plants that absorb pollutants. — 2020-25

Case study

Benners Co., Ltd. is developing Fishelle!, a subscription service that sells unused fish in pre-processed meal packs. Unused fish that would normally be discarded can be transformed into a stable income for fishermen, and the value of unused fish is also likely to increase. The company also operates Marinity, a platform that connects fish sellers and buyers.[10]

2. Prospective New Farmers

Matching human resources and the transfer of expertise

- Initial efforts are being made to dispatch personnel from different industries to rice producers during busy seasons such as planting and harvesting. Future efforts must include an increase in the scale and efficiency of matching services with other various industries. — 2020-25
- Expectations are high for services that match farmers seeking successors with new candidates as well as that provide support services for those new farmers. — 2020-25

Case study

Noumers is a matching app that connects farmers with people who are interested in trying to farm. This aim is to lower the barriers for beginners who are interested in agriculture, but do not know how to start (Mynavi Corporation).[11]

- A new service has emerged that formalizes cultivation expertise and provides instruction on cultivation methods based on soil analysis and weather data. — 2020-25

Case study

Sagri[12] is an agricultural management app that analyzes farmland and relays the appropriate amount of required pesticide and fertilizer (developed and operated by Sagri Co., Ltd.). The cultivation optimization support system AI-RICH gives instructions on for better growth based on environmental information of crops obtained from sensors. (Plant Life Systems Co., Ltd.).[13]

3. Global

Technological development for secruing a stable food supply

- Progress is being made toward the development of crops that are resistant to climate change and pests. Research and development efforts have also set their sights on increasing seed germination rates. — 2020-25
- Advancements have been made in the practical application of biofortification, which develops new varieties of crops enriched by micronutrients such as vitamins and minerals. — 2020-25

Case study

HarvestPlus, a pioneer in biofortification research, has released more than 340 fortified varieties of crops in more than 40 countries between 2004 and 2018 Their goal is to provide fortified crops to one billion people by 2030.[14]

- In developing countries, another challenge is the lack of cultivation techniques and knowledge of local farmers. There are high expectations for the sharing of cultivation knowledge through ICT and for automated cultivation systems using sensors other new technologies. 2025-35
- The development of desalinating crops with high salt absorption capacity may help to remove salt from heavily chlorinated agricultural land, as well as irrigation in dry soil with accumulated salt.[15] 2025-35

Case study

Brassica, sunflower, cotton, and tomato are typical salt-tolerant plants that are now being used to additionally absorb salt. In addition, research and development of plants with higher salt absorption performance, such as common ice plants and alfalfas, is also currently underway.

- Industrial production of chemical fertilizers and pesticides significantly burdens the environment, and the excessive use of fertilizers leads to soil and water pollution. A shift toward a sustainable food system, which is achieved by tailoring the mixture of fertilizers to soil characteristics and switching to organic fertilizers that can maintain prices and yields is becoming more necessary. 2025-35

Case study

TOWING Co., Ltd. sells an artificially generated soil called High-performance Soil that is produced by adding microorganisms to biochar and mixing it with organic fertilizers. In addition to its carbon fixation effect on farmland, the soil is also expected to have an economic benefit, as the microorganisms shorten the process of creating high-quality soil, which normally takes three to five years, to one month.[16]

- Of the three elements that make up fertilizer (nitrogen, phosphorus, and potassium), phosphate rock is produced only in certain countries, including China and Russia. As a result, it is easily affected by world affairs and politics, so the importance of its recycling is being re-evaluated. For example, efforts to recover phosphorus by separating it from sewage sludge have begun[17], and Fukuoka City has begun selling fertilizers made from recycled phosphorus.[18] 2020-25
- As overfishing continues to increase as a problem, catch management is being promoted particularly in Europe and the U.S. The current mainstream management method is the Total Allowable Catch (TAC) system which sets maximum fishing limits for each species of fish. Fishing specific species using sensors and the introduction of a catch adjustment system according to the ecosystem of certain sea areas are expected. 2020-25

Case study

Tokyo University of Marine Science and Technology and HORIEI Co., Ltd. have jointly developed a fixed net to reduce unintentional tuna catches by releasing bluefin tuna in shallow depths.[19]

Kunimi Maru Inc. provides a fully on-demand fishing service, Fish to Order. The company only catches fish when they are ordered, rather than catching more fish than necessary to create a supply surplus. Although the amount of fish caught has been reduced by about 1/3, the company is able to maintain its income by trading directly with consumers instead of through wholesalers.[20]

- Research and development to control the generation of CH_4 and N_2O is also in progress. 2020-25

Case study

To reduce GHG emissions from livestock, it is effective to inhibit gastrointestinal fermentation by improving cattle feed. If dairy cows are fed a formula using liquid extracted from cashew nut shells, it may reduce methane emissions by 20-40%.[21]

For rice cultivation, methane emissions from rice paddies can be effectively suppressed through proper water management. A one-week extension of the mid-drying period to dry out the soil can reduce methane generation by about 30%.[22]

- If the contribution to GHG reduction can be linked to carbon credit transactions, it could provide a new income source for farmers and livestock breeders. The number of agricultural registrations in the J-credit Scheme has been increasing in recent times. However, there are many barriers in the farming sector, where many small and medium-sized enterprises (SMEs) are located, such as calculating the amount of reductions and document preparation that require specialized knowledge. A simplified application procedure for the J-credit is sorely needed. 2020-25

Solutions Clues to Solutions [Regulatory Trends]

- Productive Green Zones: In 2022, 80% of the Productive Green Zone designated farmland was given exemption from farming. . However, due to the establishment of the Specified Productive Green Zone System and other institutional reforms in 2022, approximately 90% of the exempted land was shifted to the Specified Productive Green Zone.[23]
- The Main Crop Seeds Act: The Act was repealed in 2018, allowing private companies to begin developing and supplying seeds.
- The Plant Variety Protection and Seed Act: In 2020, Japan's legislature amended the act to apply criminal charges and fines for damages against smuggling out superior breeds from Japan. This amendment is expected to prevent the cross-border outflow of high-quality varieties.[24]
- The Cropland Act: With the revision of the Cropland Act, the minimum area requirement for farmland acquisition was abolished in April 2023. In addition, there is a movement to conditionally allow general corporations to acquire farmland outside the National Strategic Special Zones, thus lowering the hurdle for companies entering the agricultural industry.[25]
- As a countermeasure against price spikes, the Japanese government provided partial support for fertilizer costs to farmers who made efforts to reduce chemical fertilizers for one year from June 2022.[26]
- Agricultural drones have been used mainly for spraying pesticides, but there remain many operational restrictions due to regulations such as the Civil Aeronautics Law, the Agricultural Chemicals Regulation Law, and the Radio Law. However, the Japanese government is in the process of deregulating drone use, positioning them as part of an aerial industrial revolution. The use of agricultural drones is currently limited to rice paddies, soybeans, and wheat grains. It will be expanded to include use in field growth surveys and in transporting harvested crops.Fishery resource management is essential to prevent the decline of fisheries due to overfishing. Fishing countries such as New Zealand, Iceland, and Norway have introduced fishing quotas since the 1980s, and Japan, too, adopted catch quotas when the Fisheries Law was revised in December 2018.
- In 2018, Japan developed the Catch and Landing Data Platform (CALDAP) to record and provide information on catches and landings of marine products, which is used to provide data and issue certificates necessary for export.[27] The system still requires standardization of its specifications and an expansion of the rules covering different fish species.
- In January 2018, the United States implemented the Seafood Import Monitoring Program (SIMP). The program requires importers to provide data on the catch and landing of fishery products made with specific fish species.[28]
- There is currently no international standard on the minerals and vitamins used for biofortification., but one with a built-in certification system is expected to be developed in the future. Discussion is already taking place at the United Nations based on empirical research by the WHO and the International Food Policy Research Institute (IFPRI).[29,30]

- In 2020, the EU announced its Farm to Fork Strategy, which represents a major policy direction for future food administration. It mentioned the need for a sustainable food system and a safe and stable food supply for emergencies. The goal is to halve the use of chemical pesticides and the sale of antibiotics for livestock and aquaculture by 2030.[31]
- In Japan, the Strategy for Sustainable Food Systems,(MIDORI was formulated in 2021, which outlines a policy to achieve both productivity improvement and sustainability of food, agriculture, forestry, and fishery industries through innovation.[32] It sets numerical targets such as zero CO_2 emission in agriculture, forestry, and fisheries and an increase in the percentage of organic agricultural area up to 25% of total arable land from the current 0.5% by 2050.[33]
- The Cross-ministerial Strategic Innovation Promotion Program (SIP) set forth by the Cabinet Office also targets the creation of a sustainable yet healthy food chain as one its policy goals. The project includes a roadmap for increasing the production of protein derived from soybeans and fishery products and building a domestic fertilizer recycling system. It also fosters startups and businesses that will play a role in creating domestic food chains.[34]
- In Japan, the Basic Law on Food, Agriculture, and Rural Areas, which has been enacted for more than 20 years and is considered the constitution on agricultural policy, will soon be reviewed. The law will strengthen food security against the backdrop of the changes in the supply chain such as imports and exports, the declining number of farmers and farmland, climate change ando the ever-changing global situation, including the Ukraine crisis.[35]

Relevance to the SDGs

Problems

Decline in food supply capacity

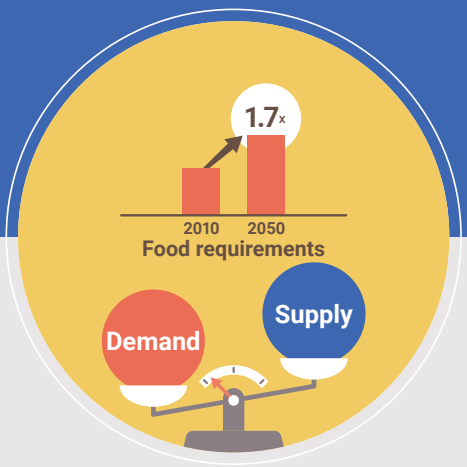
Societal Issues

Improve productivity through industrialization of food production and securing manpower

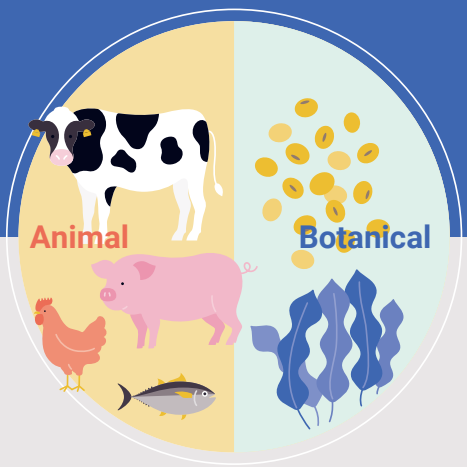
Relevance to the SDGs

2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries

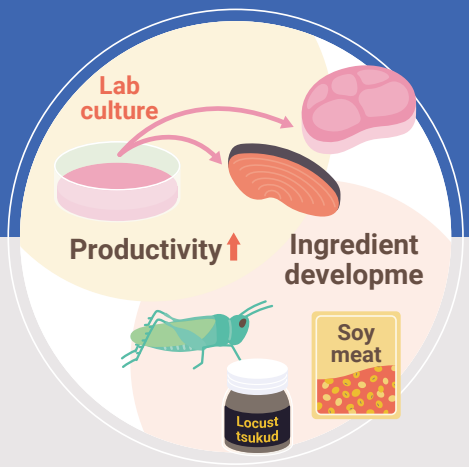
The number of hungry people is increasing



Around 2030, there will be a "protein crisis" once demand outpaces supply



Secure new protein resources that remain abundant yet sustainable



Improved productivity through the development of lab-grown meat and aquaculture technologies, and the development of new types of food ingredients like insects and soybeans

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

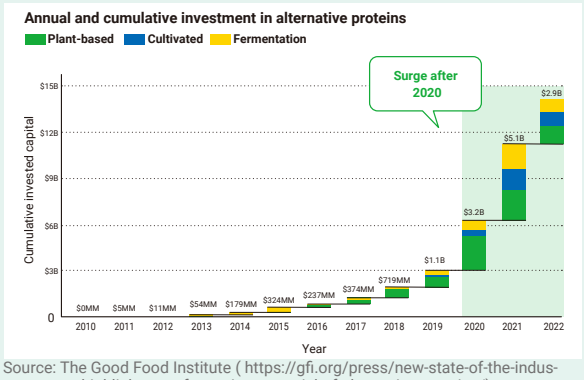
Problems Difficulties in food procurement due to population growth

Demand for protein is expected to exceed supply around 2030, resulting in a protein crisis that has been recognized as a global issue. The stable procurement of animal and plant protein sources may become difficult in the future.

The explosive growth of the population, particularly in developing countries, coupled with the increasing demand for biofuels, has raised concerns about the availability of food to feed all people in the future.

World
Potential impact estimates

Global consumption of alternative proteins is projected to increase from approximately 13 million metric tons in 2020 to 97 million metric tons in 2035, with a market size forecasted to be around USD 290 billion. Investment in the alternative protein market has also increased rapidly since around 2020 (see figure below). The share of alternative proteins in the animal protein market is expected to increase from 2% to 11% over the same period.[36] (C)



Source: The Good Food Institute (https://gfi.org/press/new-state-of-the-industry-reports-highlight-transformative-potential-of-alternative-proteins/)

World
Potential impact estimates

As of 2019, the Ministry of Agriculture, Forestry and Fisheries (MAFF) has estimated that the world population will reach 8.6 billion by 2050. To secure enough food for this population, production of staple crops such as grains must increase by 70%[37] compared to 2010.(B)

The current world population is growing faster than the above estimate, however, and a 2022 report by the United Nations predicts that it could exceed 8.6 billion as soon as 2032.[38]

Issues

Securing an ample food supply to meet increasing global demand

Key Points for Resolving Issues

Protein

[Improving food production productivity and securing new protein resources]

There are two approaches for resolving food shortages: improving food production productivity and the development of new food sources. In terms of productivity improvement, there has been progress in developing and improving technologies to increase efficiency and productivity, including plant factories, feeding systems, aquaculture production, cultured meat, and livestock production using genome editing.

In terms of new food sources, there are especially high expectations for the development of new proteins. Because animal proteins depend on plant proteins, plant proteins have an inherent advantage over animal proteins in terms of production efficiency. Development of meat substitutes that allow animal proteins to be replaced by plant proteins, or plant proteins that produce protein more efficiently than traditional meat, such as algae, is underway.

Key Points for Resolving Issues

Grain

[Stable supply of food]

Developing countries are particularly vulnerable to food shortages caused by unseasonable weather or natural disasters, and as such as especially susceptible to price increases in the grain market. There is a need to develop crops that are resilient to climate change and improve grain self-sufficiency, as well as to strengthen regulations on grain trade.

Solutions

Clues to solution [Technological Trends]

1.Protein

Practical implementation period

Efficient aquaculture production of marine proteins

- In Japan, aquaculture accounts for only about 20% of total fish catches, but the utilization of coastal areas is becoming saturated. In recent years, energy-saving aquaculture technologies have been developed and improved, such as the utilization of waste heat from aquaculture facilities and the establishment of fish tanks in caves with constant water temperatures, resulting in cost reductions. In offshore aquaculture, where the heavy burden of transporting food has hampered development, ICT is also expected to improve the efficiency of feeding systems. — 2020-25

Case study

A research center is developing hatchling production and other aquaculture techniques for red sea bream, flounder, abalone, and tiger prawn using warm wastewater from power plants (Shizuoka Prefectural Research Center for Warm Water Utilization, Japan).[39]

NIPPON STEEL ENGINEERING CO., LTD. has aimed to automate offshore aquaculture by providing automated feeding and production control systems enabled by AI and underwater cameras in 2023. The system is expected to decrease working hours for feeding to less than one-quarter and all but eliminate the labor at sea.[40]

- Cultured fish meat technology, which produces fish meat by culturing fish cells, is attracting attention. — 2020-25

Case study

Finless Foods, Inc., a U.S. biotechnology firm, is developing plant-based tuna as well as cell-cultured tuna.[41] Avant Meats Limited, a Hong Kong-based startup, aims to commercialize cultivated fish products.[42]

- Productivity can be improved at fisheries through high-density aquaculture (using highly oxygenated water), where a much larger number of fish are raised in a single fish tank. Output can reach 30 times that of conventional aquaculture depending on the species of fish. — 2025-35

Efficient meat production methods

- Progress has been made towards the practical application of efficient livestock production through genome-editing technology (e.g. increasing the amount of meat yielded and making the animals less susceptible to disease).[43] — 2025-35
- Cultured meat, in which livestock stem cells are cultured to produce edible meat, is attracting attention. In addition to improvements in culture technology and product quality, mass production has reduced costs and is gaining acceptance in the market. — 2025-35

Development of new protein resources and cooking ingredients

- Insects are currently being converted into feed for livestock and foodstuffs for humans. Current remaining issues include achieving efficient production systems optimized to insect habitats and appropriate quality control methods. Insects have the potential to be served as healthy food or nutritional supplements by controlling what they are fed. 2020-25

Case study

Ryohin Keikaku Co., Ltd., which runs the Mujirushi Ryohin (MUJI) brand, released cricket crackers on their e-commerce (EC) site in May 2020.[44] Major companies such as NICHIREI CORPORATION, Calbee, Inc., and NIPPON TELEGRAPH AND TELEPHONE EAST CORPORATION (NTT EAST) have entered the market subsequently.

- Plant-based meat substitutes made from soybeans and other ingredients have also seen practical application. In addition to improving production efficiency, the remaining future challenges include replicating the flavor and texture of real meat and ensuring safety. 2020-25

Case study

The Impossible Burger is a type of substitute meat made from soybeans that uses leghemoglobin to give it the same taste as real meat (developed by Impossible Foods Inc., U.S.).

2. Grain

Development of mechanisms for securing a stable food supply

- Interest is growing in systems that support meat and school lunches in developing countries.[45] 2020-25

Case study

Ajinomoto is running the School Meal Project in Vietnam to improve the nutritional balance of school lunches. The project also provides Ajinomoto with an opportunity to expand their product offerings in Vietnam (AJINOMOTO VIETNAM CO., LTD.).

(For more information on the development of technologies for securing stable food supplies in developing countries, see Societal Problem (1) Decline in Food Supply Capacity on p. 60.)

Solutions

Clues to solution [Regulatory Trends]

- In January 2018, regulations on novel foods were implemented throughout the E.U., liberalizing trade in edible insects and their processed foods. In 2017, Switzerland legalized the sale of three designated insects as food: mealworms, crickets, and grasshoppers.
- Europe requires that biofuels are produced solely from non-edible parts of food so that biofuel production will not induce food shortages and increases in food prices. On the other side of the Atlantic, the U.S. both encourages the production of biofuel and allows edible parts of food to be used.[46]
- Whether it is acceptable to label alternative meat products with the word "meat" has become a matter of intense debate both in Japan and around the world. For example, in the U.S., beef producer groups have demanded laws and regulations on the labeling of meat, arguing that an explicit distinction should be made between alternative meat and conventional meat products. As a result, bills are being considered and implemented at the state level. The State of Missouri passed a law in 2018 that allowed plant-based meat alternatives to continue using the term "meat" as part of their labeling, as long as the words "plant-based" are also clearly stated. The State of Texas banned the term "meat" entirely from labels for alternative meats in 2021. In Japan, suppliers are required to avoid labeling that may mislead consumers, so they are required to label the products separately from the name, with sublabels like "Produced with soybeans" or "A non-meat product".[47]
- In 2019, the E.U. officially ruled that insects currently being sold in the market as edible will remain legal, but all further attempts at commericializing edible insects would require in-depth safety assessments. In the U.S., concerns about allergic reactions toe insect-derived food additives such as carmine and cochineal extract led to FDA-mandated warning labels on the products.[48] In Japan, food allergy labeling on edible insects is not currently required because insects are not listed in the Specified Raw Materials that are subject to current food allergy labeling regulations.
- In 2020, Singapore became the first country to approve the sale of cultivated chicken meat, followed by the U.S. in 2022. Singapore's national strategy for food security involves using technology to generate 30% of its national nutritional needs by 2030 (30 by 30 target), and is focusing on cellular agriculture (a production method that uses cell culture technology to produce food and other resources).[49]
- Japan has not made sufficient progress in developing rules and regulations for the manufacturing and marketing of alternative meats. However, the Strategy for Sustainable Food Systems, MIDORI formulated by MAFF in May 2021 explicitly stated that Japan would promote the development of food technologies, such as the research and development of alternative meat and insect food.[50] In December 2022, the Japan Association for Cellular Agriculture (JACA) was established[51] to discuss issues and measures related to the advancement of the cellular agriculture industry. Furthermore, in February 2023, Prime Minister Fumio Kishida expressed his intention to develop the cellular agriculture industry. It is expected that environmental improvements, including the establishment of safety standards, will be made.[52]

Relevance to the SDGs

Problems

Difficulties in food procurement due to population growth

Societal Issues

Secure ample food supply to meet the rise in global demand

Relevance to the SDGs

2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

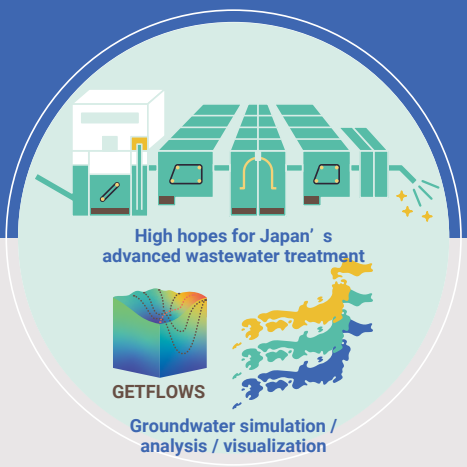
2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

2.c Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility

Obtaining access to clean water for everyone

The expansion of basic infrastructure has not kept up with the growing demand for water

Development of methods and technologies that can recover, purify, and distribute unbalanced water resources according to demand



In addition to building inexpensive and streamlined infrastructure, ICT and AI can be used to manage facilities

Problems **Societal Problems: What is wrong?**

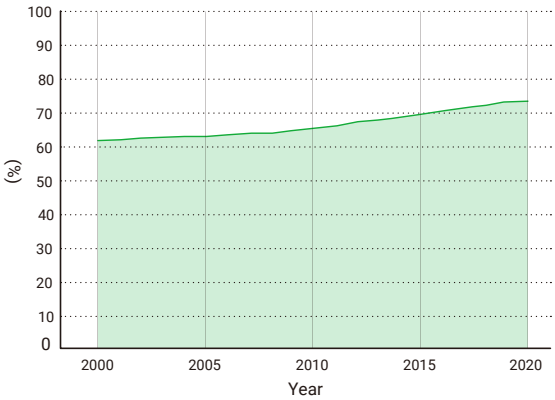
Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Insufficient usable water resources

While global demand for water continues to increase, many areas are not keeping up with developing fundamental water infrastructure, including seawater desalination plants. Even today, 1/4 of the world's population does not have access to safely managed water (see figure below). In addition, rainfall variability associated with global warming, such as droughts and floods, has resulted in a shortage of water resources that can be used for drinking and agricultural production.

Percentage of population with access to safely managed drinking water (Global)



Source: The WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP)

World
Potential impact estimates

By 2025, 5.5 billion out of the world's 8.2 billion people will face water stress, and 1.8 billion will fall into absolute water scarcity.[53](A)

* Yearly water demand for agriculture, manufacturing, energy, and the environment is estimated at 1,700 m^3 per capita. Water stress is defined as a condition in which the annual usable water volume per capita is less than 1,700 m^3, and absolute water scarcity as less than 500 m^3.

The global expenditure on desalination was USD 2.72 billion in 2015. It has been estimated to have increased to USD 4.99 billion in 2020.[54](A)

*Desalination technologies can be broadly classified into two categories: Those that use thermal methods to distill seawater and those that use membranes to physically filter out saline matter using reverse osmosis. Use of the membrane desalination is growing due to its lower energy consumption, with expenditures in 2020expected to be USD 600 million for thermal desalination and USD 4.4 billion for membrane desalination.

Japan
Potential impact estimates

Japan imports about 80 billion m^3 of virtual water*, most of which is attributed to food.[55]

* Virtual water: An estimate of how much water would be needed to produce the products that a country imports.

Issues

Securing and improving water infrastructure and functionalities

Key Points for Resolving Issues

Countries and regions that lack clean water

[Securing the absolute quantity of water needed and improving the quality of water]

The amount of water in a river basin is defined as the residue of precipitation minus the run-offs. The run-offs can be rainwater flowing into rivers, soaking into ground, or evaporation. In areas with low rainfall, it is imperative (and achievable) to secure water through wastewater recycling and seawater desalination. Some areas have enough water resources but cannot secure sufficient clean water due to environmental pollution caused by garbage, a lack of flushing toilets, and pollution. To solve these problems, water quality must be improved. Most cities are located in areas where a certain amount of rainfall can be expected. However, due to the effects of global warming and other factors, wild swings between the extremes of heavy rainfall and total drought is becoming more and more common. The localization, concentration, and intensity of rainfall are also making it difficult to store efficiently. Efficient recovery systems and storage technologies for water resources are urgently needed.

Key Points for Resolving Issues

Water Infrastructure Operators

[How to manage in accordance with demand]

Even in countries and regions where absolute water demand is met, the efficient operation of water infrastructure is a societal issue. In addition to ensuring the profitability of existing water infrastructure facilities, through measures like privatization and the integrated management of water and wastewater, it is also important to design an efficient layout for new infrastructure construction and renewal that can meet the fluctuating demand for water resources. To achieve sustainable water resource in each basin, the following 3 activities must be conducted:

1. **Identification of available water resources**
   Need for visualization of the total water resources, including surface water and groundwater.
2. **Estimation of demand for water resources**
   AI and ICT are important tools, especially for developing countries that need build their infrastructure from scratch. By designing small-scale reservoirs to meet the real-time demand forecast, efficient management becomes possible.
3. **Flexibly supply water to meet fluctuating demand**
   Installing dispersed, small-scale water storage devices and wastewater treatment within individual areas would be an effective step towards flexible supply.

Solutions

Clues to Solution [Technological Trends]

1. Countries and Regions Lacking Clean Water

Practical implementation period

Technological development for water supply, conservation, drainage, and recycling

- For regions where constructing water facilities is difficult due to the geography and environment, inexpensive and simple alternative technologies are required. Water supply projects in developing countries face problems caused by inadequate management, such as water leakage, water theft, and malfunctioning meters, most of which are expected to be solved by technology. — 2020-25

Case study

India has begun to make use of automatic and sound-based leak detection devices to detect water leaks in supply and distribution pipes.[56] Hippo Rollers and Waterwheels are devices capable of transporting water by rolling water tanks along the ground, allowing for cheaper, easier, and efficient water transportation. Water flow sensors built in northern Kenya using IoT networks have enabled early detection of leaks and theft (Kenya Resilient Arid Lands Partnership for Integrated Development (RAPID) program, IBM).[57]

- Development of water-related products that can save and recycle water is progressing. — 2020-25

Case study

A spray that coats the surface of toilet bowls so that no water is needed to keep them clean has been developed and put to practical use. The technology is said to cut the amount of water consumed by toilet flushing worldwide in half. (the Liquid-Entrenched Smooth Surface (LESS) coating, The Pennsylvania State University).[58] LIXIL Corporation and the Bill & Melinda Gates Foundation are developing fully circulating toilet systems for off-grid areas without tap water and sewage systems (New Off-grid Toilet Systems, LIXIL Corporation).[59]

WOTA CORP. provides the WOTA BOX that can reuse 98% of the water in a portable tank without requiring water pipes. It uses unique water treatment IoT sensors and AI to measure water quality in real-time and purify water through optimized means. Since no current large-scale water infrastructure is required, it is easy to recoupinvestments.[60] (For more information on the need to renovate infrastructure, see p. 176)

- If real-time monitoring of pollution in rivers in real time and easily, it will clarify where the responsibility for wastewater treatment lies and what measures should be taken. Expectations are high for wastewater treatment technologies of Japanese firms, which are some of the most advanced in the world. — 2025-35
- Possible technological developments to recover water resources include filtration and desalination of seawater, reclaiming wastewater, and rainwater storagetanks. — 2020-25

Case study

The Warka Tower, a large water tower developed by Warka Water, Inc., collects moisture in the air without using electricity (Warka Water Inc., U.S.).[61] Implementation is underway of an underground plastic rainwater storage system to solve the water shortage problem in India (JICA, Totetsu Mfg. Co., Ltd., and myclimate Japan Co. Ltd., Japan).[62]

evelopment of water-saving technologies

- Efforts in precision agriculture are making progress. Systems with sensors to monitor weather conditions and growth in detail, as well as systems to efficiently apply fertilizer and water are being put into practical use and spreading. The widespread use of precision agriculture will drastically reduce the amount of water needed for agriculture. — 2020-25

2. Operators of Water Infrastructure

Strengthening the operational base of water infrastructure businesses

- Through the utilization of ICT and AI, it will be possible to maintain asset records for the facilities that make up the infrastructure system, to properly assess the status of pipelines, and to improve operational efficiency through demand forecasting. — 2025-35
- By visualizing the potential water resources in the basin, the system may also produce new water or recycle drainage water based on the available resources and demand. The groundwater can also be simulated, for example through surface water monitoring by satellites.[63] — 2025-35

Case study

GETFLOWS is a simulation system that analyzes the terrestrial hydrological cycle, including the mutual exchange of surface water and groundwater. The system can be applied not only to the evaluation of basin resources but also to floods, tsunamis, and groundwater pollution (developed by Geosphere Environmental Technology Corporation, Japan). The National Institute for Land and Infrastructure Management (NILIM) has used the simulation system to analyze the hydrological cycle of Ono Basin, Fukui Prefecture, raising expectations for further applications.

Building efficient water infrastructure

- Promoting dispersed water use utilizing decentralized equipment for drainage treatment will be especially helpful in communities with low population density. — 2020-25

Solutions

Clues to a Solution [Regulatory Trends]

- Regulations are being promoted in developing countries concerning the pollution of rivers. The Ministry of the Environment (MOE) is supporting the implementation of effective wastewater regulations to improve the quality of the Chitarum River in Indonesia.[64]
- In Japan, the Basic Act on the Hydrological Cycle was enacted in 2014 to comprehensively promote measures related to the water cycle. The Water Supply Act was revised in 2018 to enable the private sector to operate water supply facilities (effective October 2019).
- As the number of groundwater use-only water systems increases, issues such as decreasing water supplies revenues for water utilities have become apparent. It is possible that related legislation will be developed to address this issue. Kyoto City established the Water Facility Maintenance Fee System, which requires groundwater users who meet certain conditions to bear a part of the water system maintenance.[65]

Relevance to the SDGs

Problems

Insufficient usable water resources

Societal Issues

Securing and improving water infrastructure and functionalities

Relevance to the SDGs

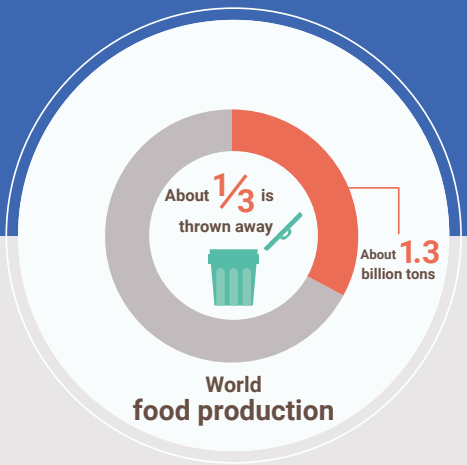
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all

6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity

6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate

1/3 of all food is being thrown away, what can we do about it?



Large amounts of food waste occur at each stage of production, distribution, and consumption

The establishment of a logistics system to transport appropriate quantities of foodstuffs according to demand under effective management and to convert waste into usable resources

Demand forecasting based on weather data that can be used to adjust purchasing volume and logistics

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

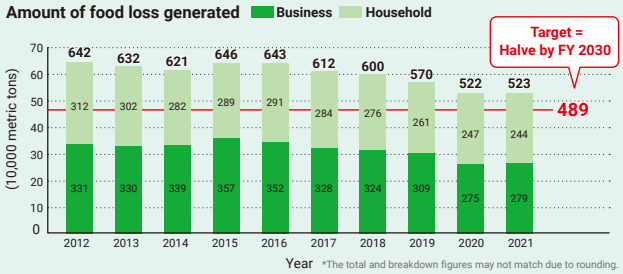
Problems Adverse effects of increasing food loss and waste

Today, large amounts of food waste occur throughout all stages of the food cycle, from production to distribution to consumption. In developed countries, food loss is observed more in the retail and consumption stages, while in developing countries, waste occurs more often post-harvest during transportation, treatment, storage and processing.

Japan

Potential impact estimates

Disposal of the edible parts of foodstuffs, usually called food loss and waste, amounts to 5.23 million metric tons per year, which is equivalent to 1.2 times the amount of global food aid of 4.4 million metric tons.[66] About half of this waste originates directly from households (see figure below).[67] (B)



- Detailed estimation of food loss started in FY2012.
- In FY2021, approximately 5.23 million tons, the same level as the previous year.
- Food loss from businesses increased by about 40,000 metric tons (about 1.5%), and food loss from households decreased by about 30,000 metric tons (about 1.2%.).
- Close monitoring of medium- to long-term trends is essential to achieve the FY 2023 halving target.

Source: The Ministry of the Environment (https://www.env.go.jp/content/000138776.pdf in Japanese)

World
Potential impact estimates

Approximately 1/3 of all food produced, or 11.3 billion metric tons, is thrown away worldwide.

Food waste causes economic losses equivalent to USD 680 billion in developed countries and USD 310 billion in developing countries.[68](B)

Issues

Streamlining the food supply chain from production to supply to consumption; reducing food waste

Key Points for Resolving Issues

Production and Distribution Stages

[Improvement of post-harvest processing, storage technologies, and logistics]

Damage to fish, including cuts and bruising, results in the dumping of 9 -15 % of marine catches in developed countries and 6-8% of marine catches in developing countries.[69] Harvesting techniques can help to solve this problem (e.g. catch equipment that does not damage fish). In years when crops are especially abundant, market prices are often maintained by disposing of part of the harvest. When attempting to reduce food loss at this point, transportation costs pose a major barrier between the surplus (producers) and the shortage (consumers, including food banks). Producers and distributors must collaborate with each other to reduce transportation costs to find ways to provide surplus food to consumers and food banks. Distributors can help, for example, by loading surplus food onto part of their regular distribution route. In developing countries, food is often damaged during transportation due to weak distribution infrastructure. In addition to the development of temperature-controlled transportation technologies, it is also necessary to improve awareness and education on hygiene and sanitation.

Key Points for Resolving Issues

Retail and Consumption Stages

[Demand-driven procurement and manufacturing]

One of the major causes of food loss is excessive overstocking by restaurants and retail stores. Excessive overstocking in fear of losing sales leads to food returns and food waste. Procurement based on scientific forecast of demand using measures like weather information and ICT would lead to reduction of food loss. Another countermeasure for food loss involves improving consumer understanding and tolerance out-of-stock or near-expired products. In Japan, most convenience stores do not conventionally mark down prices for unsold stock. It is also common for food manufacturers to deliver products to stores within the first one-third of the period from the manufacturing date to the best-by date. As a result, food products are on store shelves for a shorter period of time than in Europe and the U.S., resulting in higher domestic food loss. In this respect, there are growing expectations for the use of ICT as a tool to enhance communication among producers, distributors, and consumers. To reduce food loss at the retail stage, it is important to upgrade the food supply chain, including demand-responsive manufacturing. In developed countries, high levels of household waste are also characteristic of the food industry. In addition to edible parts of foods going unused during cooking or as leftovers, spoiled products left in the refrigerator are often thrown away. Smart home appliances that help consumers avoid over-purchasing groceries, use them efficiently in cooking, and finish plates entirely are being developed and are gaining popularity.

Solutions

Clues to solution [Technological Trends]

1. Production and Processing Stages

Loss reduction in production and harvest

- In addition to fishing equipment that does not damage fish, researchers have also developed technology to restore external injuries of fish damaged by objects like nets. Fish that cannot be distributed can be utilized by manufacturers as processed food or as feed. — 2020-25

Case study

Low-salinity treatment technology is being developed to prevent wounds from deteriorating and reduce the time to it takes to repair them (Fisheries and Marine Technology Center, Hiroshima Prefectural Technology Research Institute, Japan).

Food loss reduction during processing and distribution

- Improved logistics systems and infrastructure are essential to reduce food loss. Efficient distribution can be achieved by building inexpensive cold chains and through monitoring with sensors. — 2020-25
- Distribution time and costs can also be saved by building agricultural and aquaculture systems, including vegetable factories, in the vicinity of consumption areas. — 2020-25
- Efforts are also underway to reduce overstocking and food loss by utilizing demand forecasts based on meteorological data. — 2020-25

Case study

A service called Feels Like Temperature was designed to reduce food loss by using meteorological and SNS data to forecast demand based on consumer perceptions and covers not just physical but also psychological factors (Japan Weather Association, eco+logi Project).[70]

- Deregulation is also being explored, including the ease of processing standards by manufacturers, utilization of substandard products, review of delivery deadlines, and generalization of best-before dates to year and month only. — 2020-25

Case study

Morinaga & Co., Ltd. is using substandard products, which have defects generated in the manufacturing process, as feed. They have also started selling them as imperfect products on their EC website.[71]

2. Retail and Consumption Stages

Waste reduction at the retail stage and recycling of waste food into usable resources

- Food that would otherwise be thrown away can be utilized for purposes other than consumption including animal feed, fertilizer, and energy generation via methane conversion. **2020-25**

Case study

A liquid fermented feed has been manufactured by sterilizing and fermenting food waste. High value-added pork can be produced while reducing feed costs by 50% (JAPAN FOOD ECOLOGY CENTER, INC.).[72]

Developing "edible cement" with ground and heat-pressed food waste is underway and is being considered for use as emergency food in times of disaster. One version derived from Chinese cabbage has four times the flexural strength of concrete (fabula Inc.).[73]

- The advancement of the food supply chain will enable safe and secure food distribution and storage. Future progress in rectifying food loss and waste will likely be fueled by initiatives including the quantification of recipes, optimization of procurement based on actual sales, the matching of supply and demand, and the creation a common platform for food bank operations. **2025-35**

Case study

U.S. company Afresh Technologies, Inc. provides inventory and supply chain management software using AI. According to the company, stores that have implemented the software have cut food loss by about 1/4compared to non-adopters.[74]

Reduction of food waste at the consumption stage

- Several food-sharing apps have been developed to offer safe, edible, unsold food items to users at a fixed monthly rate and prevent food disposal.[75] **2020-25**

Case study

VALUE Drivers Inc. operates an EC website, tabeloop, where farmers and businesses list products that are substandard or close to their expiration date and consumers can buy them at a steep discount.[76]

- Smart home appliances are expected to help reduce waste from the household. They can be used in a variety of situations, including alert functions for food products nearing expiration dates, providing methods for first-in, first-out (FIFO)food storage, advising on menu development, automatically replenishing food stocks, and managing optimum storage temperature. If food preparation and disposal (including composting) could be automated in the future, food losses would be greatly reduced. **2025-35**

Case study

Stock Manager is a service that helps consumers plan and conduct their shopping better. The service makes use of a smartphone connected to a weight measuring plate in the refrigerator to monitor the speed and quantity of user consumption as well as inventory best-by dates (Stock Manager, Panasonic Corporation).[77]

Solutions

Clues to solution [Regulatory Trends]

- The Ministry of Agriculture, Forestry and Fisheries (MAFF) has been encouraging food-related businesses to reduce waste by setting targets for the reduction of food waste. The ministry is also considering expanding the targets for industries that were previously exempt from the system. The costs of donations to food banks are tax-deductible, and tax benefits are available for donations.
- Other countries are also making an effort to reduce food loss and waste. In France, in order to reduce food waste, the labeling of best-by dates has been replaced by a single labeling of expiration dates. In place of the original system in which food donations to charitable organizations receive a sales tax refund for the donation, a law prohibiting food waste was enacted, and fines are imposed for food waste.
- There is no regulation in Japan on the expiration dates of food products with long shelf lives. It is expected that the introduction of rules will promote market distribution.[78]
- In the U.S., the Good Samaritan Law applies when a person donates food to a charity or food bank in good faith. The donor will not be held accountable in case of accidents so long as they made their donation in good faith and without compensation. The State of California passed a food donation law in 2017 that grants similar protections to individual food donations.[79] In fact, there has never been successful litigation involving donated food. In Europe, Italy is the only country with a similar law that protects food donors. In France, some have argued that its quality inspection requirements are excessively burdensome on donors.
- The MAFF is developing human rights guidelines to promote respect for human rights in food industry supply chains.[80] Some point out that the food industry is dominated by small- and medium-sized companies (SMEs) and as a result has not made sufficient progress in tackling the risk of human rights violations.

Relevance to the SDGs

Problems

Adverse effects of increasing food loss and waste

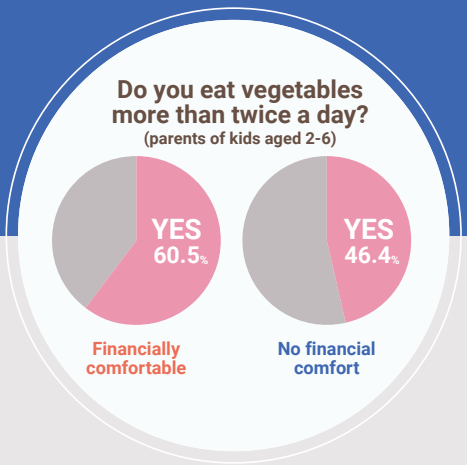
Societal Issues

Streamlining food supply chain across all stages from production to supply and consumption; reducing food waste

Relevance to the SDGs

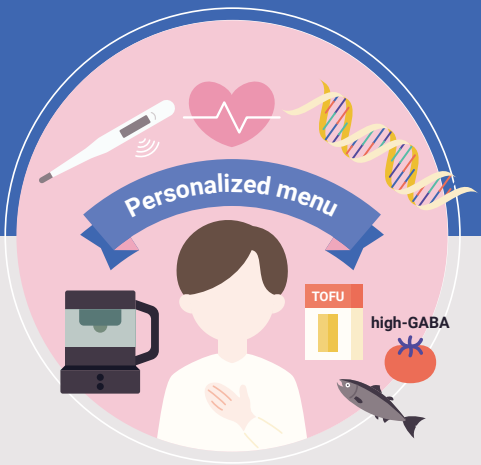
12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses

People remain unhealthy even in an age of excess



Both adults and children tend to eat more processed foods, especially in the poorest areas of the country

Create an environment where people can naturally choose healthy food that fits their individual needs through accurate information and expansion of available food forms



Providing information on healthy eating and developing accessible functional and complete meals, including personalization using IoT

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Unhealthy food remaining widespread in prosperous societies

The diet of low-income families tends to be dominated by inexpensive processed foods, making it difficult for them to have a healthy diet. Regions that face this phenomenon are referred to as food deserts and have become a major societal problem worldwide.

Overnutrition is also considered to be a type of malnutrition. The simultaneous dual burden of malnutrition, in which undernutrition and overnutrition coexist, has become an international problem. For example, within the same country or even household, undernutrition (underweight, stunting, anemia, micronutrient deficiencies, etc.) and overnutrition (overweight, obesity, and diet-related noncommunicable diseases such as type 2 diabetes and cardiovascular disease) may occur simultaneously. It is more common to see overnutrition in prime and middle ages and undernutrition due to frailty over time.[81]

According to Japan's National Nutrition Survey on Preschool Children, financially secure families eat significantly more fish, soybeans and soybean products, vegetables, and fruits. In financially insecure families, however, people have a higher tendency to eat foods like instant noodles and sweets, including pastries.

World
Potential impact estimates

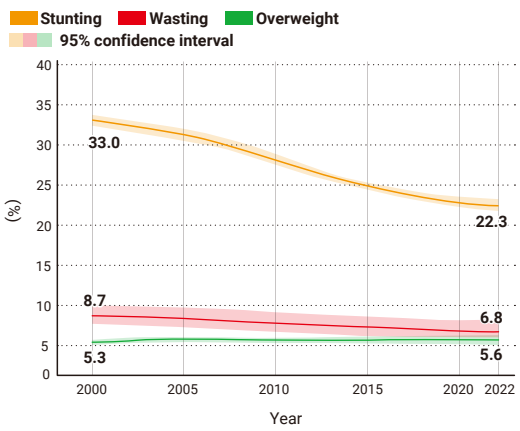
An estimated 18.8 million residents in the U.S., representing 6.1% of the population, live in low-income communities with poor access to healthy food. These communities are often distant from supermarkets, which is defined as being more than one mile away in urban areas or more than ten miles away in rural areas.[82] In the U.S., the adult obesity rate has reached 40%, and the federal government spends USD260 billion per year on health care for obese patients.[83]

World

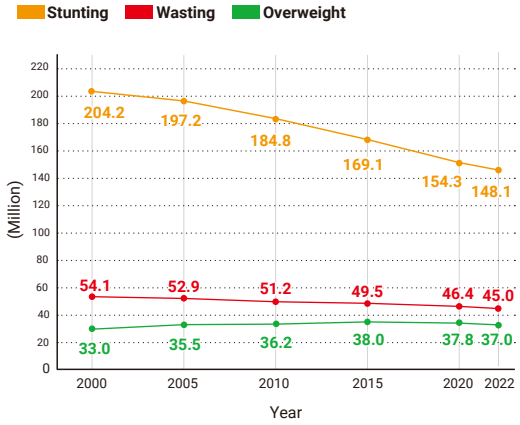
Potential impact estimates

Of the world's children under age 5, 149.2 million (about 22%) are stunted due to undernutrition, while 38.9 million (about 5.7%) are obese (see figure below).[84] Both hunger and obesity are more prevalent in poor countries, partly due to poor metabolic function caused by malnutrition during infancy and partly due to food deprivation based on insecurity of food supply.[85]

Percentage of children under 5 affected by stunting, wasting, and overweight (Global/2000~2022)



Number of children under 5 affected by stunting, wasting, and overweight (global/2000~2022)



Stunting has been steadily declining since 2000, but faster progress is needed to achieve the 2030 target.
Overweight incidences remains at alarming rates, and requires a course correction to achieve the 2030 target.

Source: UNICEF Data website (https://data.unicef.org/wp-content/uploads/2023/05/JME-2023-Levels-and-trends-in-child-malnutrition.pdf)

Japan

Potential impact estimates

According to a survey of parents with children aged 2-6, 60.5% of financially secure families consume vegetables at least twice a day, compared to 46.4% in financially insecure families.[86]

Issues

Providing and improving access to healthy meals

Key Points for Resolving Issues

Identifying a Healthy Diet

[Providing science-based information on food and health]

Food and health are closely related. It is vital to provide science-based food and health information using reliable data. Various reliable studies report that healthy foods include fish, vegetables and fruits, unrefined carbohydrates, olive oil, and nuts.[87] Notably, even foods that are considered healthy can be harmful if eaten in severe excess. Research on dietary methods such as carbohydrate restriction and fasting is also underway.

In addition, the suitability of a diet depends on the individual's physical constitution, lifestyle (e.g., amount of exercise), age, and other factors. It is essential for consumers to seek advice and make decisions based on personalized information with regard to the optimal diet for their health.

Key Points for Resolving Issues

Improved Access to Healthy Diets

[Delivering healthy meals to many people]

Though most people know that vegetables and fruits are good for their health, many cannot access healthy meals because they are not sold close by or are too expensive. The solution is to create an environment where healthy foods can be easily ordered and purchased on a regional basis. Healthy meals can be provided to children through school lunches. Systems that take sub-standard fruits and either donates them or distributes them as processed products are beginning to become popular.

Development for functional foods that provide necessary nutrients and enable easy intake of well-balance meals is also progressing. Rare sugars, which are being researched and developed in Japan, are being looked at to help prevent obesity and lifestyle-related diseases.[88]

Solutions

Clues to Solution [Technological Trends]

1. Defining Healthy Meals

Practical implementation period

Providing information on food and health

- There is a service to provide information on healthy foods on a regular basis. — 2020-25

Case study

snaQme is a subscription service that delivers personalized snacks on a regular basis. It also delivers a physical informational booklet on healthy and environmentally-friendly confectioneries. (snaq.me, Inc.)[89]

Personalization

- IoT is being used to provide food tailored to individual physical constitutions. — 2020-25

Case study

A teapot that automatically brews the most suitable tea for the user has been on the market since 2020. Sensors are equipped to measure heartbeat and body temperature to analyze the user's mood and physical condition (LOAD & ROAD INC.).[90]

- Efforts are also being made to support optimal food selection based on DNA analysis. — 2020-25

Case study

DnaNudge performs DNA analysis on saliva at supermarket entrances for its customers. The company then nudges customers to select healthier foods based on the test results. When a customer scans the barcode on a food item, the system uses the customer's DNA data to determine whether the food is appropriate or not before sending a green or red signal to the customer's wrist band. (DNANudge, U.K.)[91]

2. Improved Access to Healthy Meals

Functional foods

- Genome editing has led to the development of food that helps maintain and improve health. — 2020-25

Case study

Eating one to two pieces of high-GABA tomatoes a day is believed to help prevent high blood pressure (Sicilian Rouge High GABA by Sanatech Seed Co., Ltd.).[92]

- Efforts are also underway to provide healthy foods in a form that makes them easier to eat. — 2020-25

Case study

TOFU BAR, a condensed, portable form of tofu, is sold in convenience stores as a functional food and emphasizes its health benefits (Asahico Corporation).[93]

Complete meals

2020-25

- Food products have been developed that can provide balanced nutrients for daily requirements, and further improvements are being to improve taste and lower prices.

Case study

BASE BREAD is a bread with nearly complete nutrients, such as protein, dietary fiber, vitamins, and minerals, and is being marketed to people who are too busy to cook for themselves (BASE FOOD, Inc.).[94]

Utilization of school lunch system

2020-25

- Japan's school lunch system is internationally renowned for its reasonable cost, balanced nutrition, and quality taste, as well as for serving warm homemade meals. The School Lunch Program Act enables allocating a nutrition instructor system and putting cooking and delivery systems in place. This system can be effectively applied to schools in developing countries.[95]

Case study

AJINOMOTO VIETNAM CO., LTD. has launched a school lunch project in Vietnam by applying Japan's school lunch system. The company has developed and released software that enables staff with limited knowledge and experience to create nutritionally balanced menus and has introduced the software to schools throughout Vietnam.[96]

PECOFREE Inc. (Japan) provides a mobile ordering service for high school students to order school lunches through their smartphones. Students can choose daily from a large, healthy menu and from a special allergy-friendly menu designed by registered dietitians.[97]

Solutions Clues to solution [Regulatory Trends]

- In 2015, the Foods with Function Claims System came into effect, requiring businesses to label the functionality of their products based on scientific evidence. Unlike Food for Specified Health Uses (FOSHU), it does not require governmental approval for each product, but requires notifying the Consumer Affairs Agency (CAA) 60 days prior to the release of the product.
- In the U.S., the Healthy, Hunger-Free Kids Act (P.L. 111-296) was enacted in 2010. It requires that vegetables and fruits be included daily in school lunches and mandates the use of whole grains. Universal free school lunches were implemented in 2020 in response to the COVID-19 pandemic were extended through 2022. The 2022 federal budget also includes subsidies to improve nutrition in school lunches.[98,99]
- In 2021, the Tokyo Compact on Global Nutrition for Growth was issued at the Tokyo Nutrition for Growth (N4G) Summit. There, Japan pledged to contribute to Universal Health Coverage (UHC) that ensures access to adequate health promotion, prevention, treatment, and restoration services for all people at an affordable cost by providing more than JPY 300 billion for nutritional assistance to various countries and regions over the next three years. The Compact also indicated that it would recognize initiatives that promote the disclosure of corporate actions on nutrition for mobilizing new investments in nutrition-based financing.[100]
- The EU's Farm to Fork Strategy moved toward the legislation of a nutrient profiling system by 2022. For example, nutritional labeling may now require a scale ranking from 1 to 5. If similar systems becomes mandatory, countries outside the EU that export food may be required to comply.[101]
- In 2023, leading food manufacturers, distributors, retailers, and others established the Japan Association for Optimized Nutritional Food to define and certify food with sufficient amounts of major daily nutrients as Optimized Nutritional Food.[102]

Relevance to the SDGs

Problems

Unhealthy food that remains in prosperous societies

Societal Issues

Providing and improving access to healthy meals

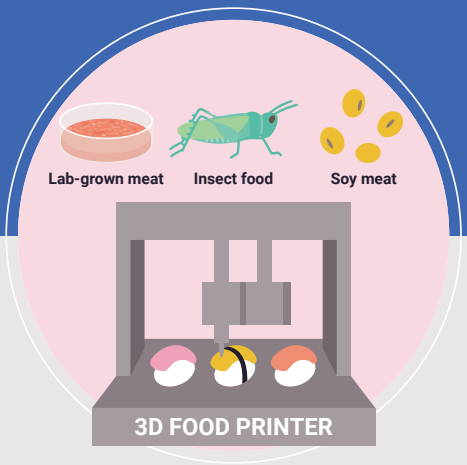
Relevance to the SDGs

2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

Finding food for all dietary restrictions and requirements

More and more people are seeking diversity in their food options and styles that accommodate differences in dietary preference and restriction based on values, ideology, and constitution

Ensure that food diversity and quality can match individual circumstances without substantial burdens such as cost, etc.



Development of new food ingredients and cooking methods that match values, religion, age, and constitution, using new technologies like 3D printing

Problems **Societal Problems: What is wrong?**

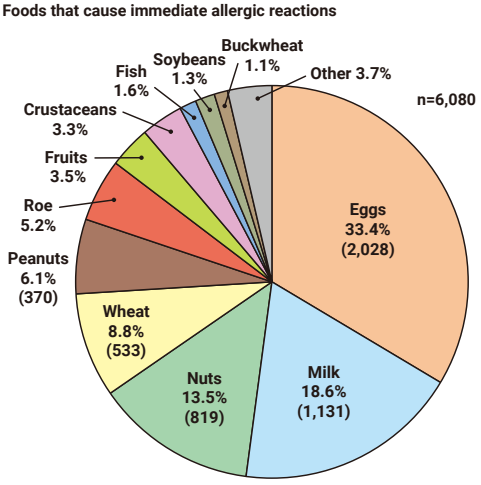
Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems The shift toward greater respect for food diversity

There is a growing movement to provide culinary diversity that is tailored to individual values, ideas, and beliefs. A notable example is the expansion of the halal market in response to the continuing population growth of Muslim countries.

In Japan, among the people suffering from food allergies, infants make up the highest proportion (34% at age 0). This decreases with age, but 5% of the population over 18 still suffer from some kind of allergy. Eggs, milk, and wheat account for a large proportion of the foods causing allergies, but other common allergens include seafood, fruits, soybeans, and peanuts (See figure below).[103]



Source: The Consumer Affairs Agency (CAA), The FY 2021 Report on Food Labeling Related to Food Allergy (in Japanese) (https://www.caa.go.jp/notice/entry/029032/)

World
Potential impact estimates

Expenditures of Muslim people is on the rise and is projected to reach USD 1.38 trillion in 2024.[104] The percentage of Muslims in the world population is also on the rise, predicted to reach 26.4% in 2030.[105] (C)

The prevalence of food allergies is also increasing worldwide. Approximately 10% of preschoolers in developed countries have some sort of food allergy.[106]

Issues

Improving the diversity and quality of food to conform to the needs of individuals

Key Points for Resolving Issues

Improving Food Quality by Accommodating Various Beliefs and Religions

[Development of new ingredients and cooking methods]

There is an increasing demand for dietary diversity for a variety of reasons, including a growing trend toward vegetarianism and veganism in addition to the dietary prohibitions related to religion. Alternative meats may enable various people, including those who are restricted from eating normal meat, to sit around the same table and share the same culinary experiences. While promoting new foodstuffs and protein sources, such as insects and alternative meat, requires that they taste good, provide well-balanced nutrition, and safety, it also requires measures to reduce the negative inclinations of people that feel aversion to the products or outright reject the concept.

Key Points for Resolving Issues

Food Tailored to Age and Constitution

[Visualization of necessary elements and burden lightening]

The factors of diversity in food experience are widespread, including allergies, tooth decay, and age. The caloric and nutritional requirements are significantly different between those who are on a diet and those who are athletes building muscle. Some seniors and dementia patients often experience a declining sense of taste and smell.[107] It takes substantial effort and time to prepare a variety of meals for each member of the family. One survey found that33.5% of the guardians of children aged 0-2 years and younger responded that preparing baby food is difficult and burdensome.[108] It is necessary to reduce these burdens.

Solutions

Clues to Solution [Technological Trends]

Practical implementation period

1. Improving Food Quality by Accommodating Various Beliefs and Religions

Development of new ingredients and cooking methods

- Cultured meat has the potential to produce quality and high nutrition meat, in addition to reducing environmental impact and protecting animals. It is also expected to diversify the quality of meat by flexibly controlling the balance between lean meat and fat. — 2025-35

Case study

IntegriCulture Inc. (Japan) is developing a technology to combine fat cells and collagen fibers to adjust the amount of fat in cultured meat. They aim to produce meat suitable for various purposes, such as marbled meat for epicureans and other types for athletes and dieters.[109]

- New recipes are being developed with big data and AI, while new cooking methods are being developed using 3D printers. 3D food printers can also be used in areas affected by disasters or poverty. — 2025-35

Case study

SPACE FOODSPHERE Association (Japan) is conducting a three-way collaborative project among industry, the government, and academia. The project is developing food production technologies, such as ultra-efficient plant factories, bio-food reactors, and augmented ecosystems. They also provide solutions for improving the quality of life in food, including automated kitchens, communication experiences through food, and meal replacements.[110]

- The potential of edible insects is gaining attention. For example, formic acid, found in ants, has a strong and unique fragrance. Thus, the acid has potential as an ingredient in condiments that would result in unique flavors that cannot be replicated by other ingredients.[111] — 2020-25

Case study

Ellie Inc. (Japan) is working on edible insects as an alternative protein source, focusing on silkworms, since cultivation technology has already been established through sericulture. Because silkworms are known to be richer and sweeter than other insects, the company provides silkworm-augmented foods, such as minestrone soup, snacks, and hamburgers. Some products are heavily based on silkworms, such as the hamburgers that contain 50% silkworm.[112]

In 2018, Aspire Food Group, a U.S. company, became the world's first company to produce insect food eligible for halal and kosher designation. Kosher foods are prepared according to the rules of Jewish law, while halal foods adhere to Islamic law.

2. Food Tailored to Individual Ages and Constitutions

Cooking Appliances

- A cooking appliance that can soften ingredients without damaging their appearance or taste for people with weakened chewing and swallowing abilities has been developed. — 2020-25

A cooking appliance called DeliSofter entered the marketplace in 2020. Just by pressing a button, it softens ingredients or cooks food so that users can mash them with just their gums or tongue (GIFMO Co., Ltd., a spin-out venture company from Panasonic Corporation, Japan).[113]

- Expectations are high for cooking appliances that not only soften foods but also easily remove certain allergens or reduce calories. 2035 and beyond
- Cross-modal sensory interaction changes the perception of the five senses by applying multiple sensory information simultaneously. This function has the potential to provide food that meets individual consumer preferences even if they have dietary restrictions due to disease, allergies, or other reasons. 2035 and beyond

Case study

By using headsets and air pumps to manipulate the five senses such as sight and smell, plain-flavored cookies can be made to taste like strawberry-flavored ones (Cyber Interface Lab, The University of Tokyo).[114]

Solutions

Clues to solution [Regulatory Trends]

- In Japan, the Third Basic Plan for the Promotion of Shokuiku is being promoted based on the Basic Act on Shokuiku. The plan lays out five priority issues for promoting education through food, (called Shokuiku): (1) focusing on youth, (2) adapting to diverse lifestyles, (3) extending healthy life expectancy, (4) developing awareness of food circulation and the environment, and (5) passing on Japanese food culture to subsequent generations.115
- In January 2018, regulations on novel foods were implemented in the EU, liberalizing trade in edible insects and processed foods. In 2017, Switzerland legalized the sale of three designated insects as food: mealworms, crickets, and grasshoppers.
- There is no universal international standard for halal foods, and each country or accreditation institute issues a halal certification based on its own standards. Globally, the Codex Alimentarius Commission (CAC) has established standards for the use of the "halal food". On the other hand, a committee within the Standards & Metrology Institute for Islamic Countries (SMIIC) is discussing how to harmonize the different definitions and standards of "halal" among Muslim countries.

Relevance to the SDGs

Problems

The shift toward greater respect for food diversity

Societal Issues

Improving the diversity and quality of food to conform to the needs of individuals

Relevance to the SDGs

10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status

Living a rich life through food and its cultures

Solitary eating (the act of eating alone) and individual eating (the act of eating different foods at the same table, even next to others) are increasing

Creating an environment that improves the well-being of everyone through opportunities through communication about, over, and through food

Research on the healing effects of farming, development of kitchen spaces that bring people together (shared kitchens), online dining tables using VR, etc.

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Encouraging communication through food

An increasing number of people eat alone. Additionally, more families are eating different meals even when gathered at the same table. About 15% of people eat all their meals alone for more than half of the days of the week, and this percentage is on the rise.[116] Solitary eating is a problem that has been shown to lead to unbalanced or insufficient nutritional intake. Solitary eating in childhood is also connected to negative impacts on physical and psychological growth.

A wider variety of communication using food is expected to become more common in the post-pandemic society. Food plays a significant role in realizing an affluent society, ranging from the need for quality food during disasters as well as the need to provide delicious food to children and seniors during normal times.

Japan

Potential impact estimates

As many as 26.0% of women in their 70s and 25.4% of men in their 20s eat all three of their meals alone almost every day. Even more concerningly, these percentages are on the rise.[117]

In fact, not only do 93% of the seniors living by themselves eat alone but so do 20% of those living with their families. . Some have suggested that this solitary eating is a major contributor to the low BMI and overall malnutrition of seniors in Japan.[118]

Issues

Promoting communication through all aspects of food from farming and cooking to the dinner table

Communication Through Food

The most influential variable that explains human happiness is identified as satisfaction in the communication among family members, and within this family communication satisfaction, the satisfaction with and over meals contributes the most.[119] The act of eating is not just about obtaining the nutrition needed to live and satisfying physiological needs. Communication with people at the table is nearly equally as important as it satisfies the inherent human need for love and companionship. Furthermore, eating serves as an opportunity to feel a connection with food producers and distributors and serves as education of the seasonal and local culinary culture of a region. During the COVID-19 pandemic, conversation was restricted during meals to prevent infection. It is necessary to recapture communication over food, such as by overcoming the disadvantage of sparsely populated areas by utilizing VR.

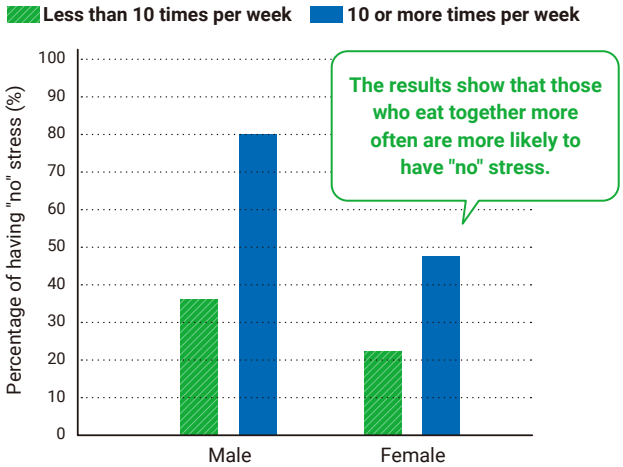
Key Points for Resolving Issues

Promoting Communication Using Food

[The process of making and cooking]

In addition to conversations during meals, opportunities for communication can be found in the process of growing crops and cooking food. Attention is also being paid to the effects of promoting communication among parents, children, and family members through activities such as farming, fishing, and cooking in the kitchen. For example, a kitchen that is designed for all the family members, from children to seniors, to easily take part in the cooking process together will facilitate active communication within the family.

Relationship between number of meals shared with family and stress (20s, 30s)



Source: The Ministry of Agriculture, Forestry and Fisheries' website (in Japanese) (https://www.maff.go.jp/j/syokuiku/evidence/attach/pdf/index-27.pdf)

Solutions

Clues to Solution [Technological Trends]

1. Promoting Communication over Food

Practical implementation period

Communication in the production process

- Agro-healing, in which stress is reduced through farm work, is attracting attention. — 2020-25

Case study

Juntendo University and NTT Communications Corporation conducted a practical experiment to measure stress levels to see the effectiveness of agro-healing activities. They visualized stress reduction with data obtained through wearable biosensors.[120]

- Preparing homemade food items is being used as an opportunity to build bonds within communities. — 2020-25

Case study

Panasonic Corporation and Marukome Co., Ltd. jointly operate a service, Ferment 2.0, to make homemade miso without using preservatives or additives. The service enables consumers to make their favorite miso using sensor sticks. A community-focused version, Miso BALL CLUB, is also being planned.[121]

Communication in the cooking process

- The concept of shared dining, which aims to expand connections and improve health and quality of life through the communication generated by cooking, eating, and drinking together by utilizing information learned about one another, is being proposed as part of the movement to promote food-based communication. — 2020-25

Case study

AEON Co., Ltd. has conducted a social experiment called Onikatsu (based on the Japanese words for “rice ball” and “lifestyle”) to create an association based on the joy of food as multiple people select ingredients, cook, and eat rice balls together, which in turn will lead to the improvement of health and quality of life. In addition, Long Cutlery, tools with extra-long handles, are designed to spark communication by intentionally creating situations where it is difficult to eat and cook alone (KUSAKA Nahoko Laboratory, Doshisha Women's College of Liberal Arts).[122]

- When considering kitchens as places for communication, the design of a kitchen that is easy to use and encourages the participation of children and the elderly to gather as been proposed. — 2020-25

Case study

The Four Generation Kitchen is a kitchen concept where four generations, from children to seniors, can safely enjoy cooking together. It particularly focuses on the ability of seniors to continue participate in cooking.[123]

- Collaborative cooking is emerging as a service for employee training and team building. 2020-25

Case study

ABC Cooking Studio Co. is offering the cooking class Cooking to Build a Team as part of employee training program, aiming to encourage communication through collaborative work (ABC Cooking Studio Co., Ltd.).[124]

Communication in the eating process + new experiences

- The trend toward "local production for local consumption" is narrowing the distance between the two areas, and has evolved to the point that production and consumption can sometimes even be found in the same building. Condos that utilize this concept, for example where agriculture, livestock production, and fisheries are all entirely conducted within one building, have been proposed. 2025-35

Case study

CAFÉ Stylo at Ginza Itoya serves salads and other dishes made with vegetables produced in the plant factory one floor below the restaurant.[125]

- Virtual reality is also being used to share dining tables over the internet. 2020-25

Case study

Minami-Awaji City is trying to solve the solitary-eating problem by providing a virtual eat-together experience through VR (Awaji Koku VR Verchan Reality).[126]

Solutions Clues to solution [Regulatory Trends]

- In 2013, UNESCO listed 和食 (pronounced: Washoku), the traditional culinary culture of the Japanese people, as an Intangible Cultural Heritage. The Ministry of Agriculture, Forestry and Fisheries (MAFF) is actively promoting and disseminating information in order to pass this culinary culture to future generations. For example, MAFF supports workshops for families with children and activities on culinary education to deepen children's understanding of Japanese culinary cultures, such as food for festivities and local regional cuisine.[127]
- In FY 2020, the Ministry of Health, Labour and Welfare (MHLW) implemented the Project for Strengthening the Care-giving of Aid-Requiring Children. Through the project, MHLW subsidizes the private entities that operate Kodomo Shokudo, which are cafeterias or home-delivery meal services for children in need.[128]

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03

A Society Where All Can Enjoy Sustainable And Clean Energy, Resources And Environment

Energy And Environment

The effects of global warming are beginning to be felt around the world. In Japan, especially, issues like flood damage caused by torrential rains have seen dramatic recent increases. Countries around the world are taking initiatives to help reduce the risks and impacts of global warming. At the 26th Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC) held in November 2021, it was stipulated explicitly that efforts should be made to limit the global temperature increase to within 1.5 °C above pre-industrial levels. More than 120 countries and regions, including Japan, have declared their intention to achieve carbon neutrality by 2050. Private companies are also expected to make efforts as part of ESG management. In addition to policies and regulations, solutions regarding energy through innovation in both the supply and demand sides may also bring new business opportunities.

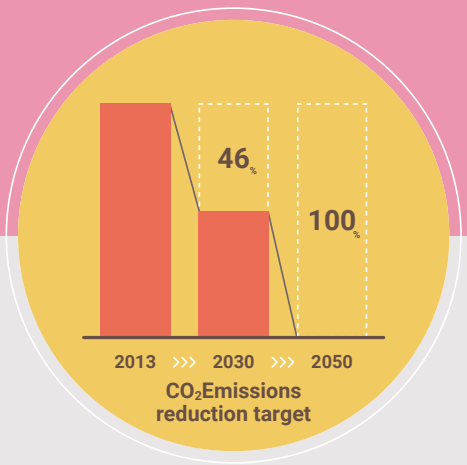
In order to achieve carbon neutrality, many countries around the world are shifting to renewable energy supplies at a significantly accelerating pace. Substantial progress has also been made in power generation costs and stable supply sources, which have traditionally been considered major issues of renewable energy. In terms of energy demand, within the buildings (residential and services) and transportation sectors, there remains significant room for improvement and dissemination of energy-saving products and energy management. Another challenge is emerging, however: the increase in power consumption by the digital society.

In terms of resources, the fundamental underlying goal is to effectively secure and utilize limited natural resources and to promote the realization of a recycling-oriented society. The finite nature of quantity must be overcome by promoting the efficient use and recycling of minerals, metals, petroleum, soil, and forests, using a variety of perspectives including urban mining.

As economic and living standards continue to improve worldwide, preventing pollution and the destruction of the environment, as well as the loss of biodiversity, are becoming more urgent issues. To ensure the sustainability of society and the planet, it is essential to achieve nature-positive outcomes by putting biodiversity on a path to recovery while also cleaning up pollution.

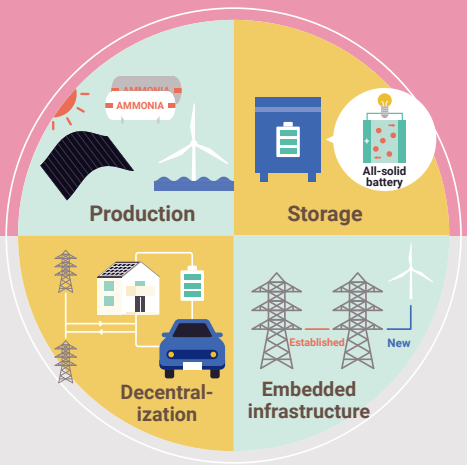
Using the above framework, ICF has classified the problems and issues in the Energy and Environmental area into five categories. Although installing new solar power plants can contribute to decarbonization, it may cause other environmental damages. The five problems and issues listed below have a trade-off relationship with each other and will thus require a balanced perspective for solutions.

Halving CO2 emissions by 2030



At the current rate of renewable energy introduction, halving CO2 emissions by 2030 will be not be completed

Develop and disseminate energy supply technologies that enable decarbonization



Development of technologies for energy production, storage, and decentralization, as well as their integration into and replacement of existing infrastructure

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Need to accelerate decarbonization in the supply side of energy

Japan's 6th Basic Energy Plan states that the country intends to reduce greenhouse gas emission by 46% from the level of FY 2013 by FY 2030. The supply side must further strive for the introduction and expansion of renewable energies to accelerate decarbonization.

Japan

Potential impact estimates

By designating areas for promoting renewable energy and actively introducing solar power generation, restarting nuclear power generation, and discontinuing thermal power generation, CO_2 emissions from the energy supply sector are expected to decrease by about 50% from 103 million t-CO_2 in FY 2013 to 56 million t-CO_2 in FY 2030. [1,2](A)

Issues

Promote comprehensive decarbonization measures

Key Points for Resolving Issues

Development of Energy Production and Conversion Technologies

[Expanding renewable energies and power generation using hydrogen and ammonia]

In order to achieve carbon neutrality by 2050, it is necessary to promote various initiatives, including the development of next-generation solar batteries, floating offshore wind turbines, carbon-neutral liquid fuels, and other technologies, as well as research into nuclear fusion power generation.

Research is underway to replace coal with hydrogen and ammonia in thermal power plants, which is expected to become an important source of decarbonized energy in the future. The core challenge for global implementation is in developing a method to produce hydrogen and ammonia without generating CO_2

Key Points for Resolving Issues

Development of Energy Storage and Transportation Technologies

[Improving the performance, safety, and affordability of storage batteries]

The primary weakness of solar and wind power generation is their unstable output as a result of their dependence on natural and seasonal conditions. The solution to this problem is to improve the performance, safety, and affordability of storage batteries. Solid-state electrolyte technology is attracting attention as the next-generation battery that will bring about dramatic improvement in both safety and reliability. Practical use of the technology is expected by the second half of the 2020s.

In some countries, the cost of generating electricity from renewable energy sources has already begun to fall below the price parity of fossil fuels—a phenomenon called grid parity. Furthermore, as a result of further declines in the cost of storage batteries, storage parity,, where the total cost of power generation, including storage, is lower than fossil fuels, is expected to be achieved within 10 years.

Key Points for Resolving Issues

Development of New Decentralized Energy Systems

[Virtual power plants and microgrids]

While an increasing number of businesses are entering the renewable energy generation sector, there is a growing need on the demand side to use locally generated renewables, especially from the perspective of the ESGs. Given this, virtual power plants (VPPs) and microgrids, which integrate small-scale renewable energy generation facilities, electric vehicle storage batteries, and other power resources to function like power plants, are attracting attention as a means of locally producing and consuming energy.

Although some proof-of-concept projects have started in Japan, their application is still limited due to the high cost of building private power lines. Additionally, there is currently no precedent of a power company allowing its electric power lines to be shared, and thus the system has not yet been streamlined.

Solutions

Clues to Solutions [Technological Trends]

Development of energy production and conversion technologies

Practical implementation period

- Development of energy production and conversion technologies Solar power generation, which has long been used as a renewable energy source, is making progress in the development of next-generation models. The Perovskite solar cell in particular is expected to reduce the cost of energy production. Unlike existing silicon-based solar cells, they can be easily manufactured through simply a coating, and are characterized by their light weight and flexibility. — 2025-35
- Offshore wind power generation has the advantage of more stable wind conditions, such as the way the wind blows at a particular location, and higher facility utilization rates than onshore wind power generation. Offshore wind power plants are currently being developed on a larger scale, especially throughout Europe. Japan plans to install 10 GW of offshore wind power generation by 2030 and 90 GW by 2050, 20% of the total projected demand.[3] In preparation for the installation of a large number of offshore wind turbines, human resource development is also required for research, design, manufacturing, assembly, and installation.[4] — 2020-25

Case study

In the U.K., the world's largest producer of offshore wind power, the proportion of offshore wind power to its annual power generation has increased to 27% in 2022. The Crown Estate and Crown Estate Scotland are actively attracting new entrants to new offshore wind power development, including auctioning new seabed lands in 2019.

- Floating nuclear power plants that operate offshore are also attracting new attention. Floating nuclear power plants can be installed anywhere at sea, are inexpensive to build, and have the advantage of being able to withstand tsunamis and other disasters. — 2025-35
- Progress is being made in the development of technologies to utilize otherwise unused heat and new energy resources like algae and methane hydrate. There is also a growing need for carbon-neutral liquid fuels; aviation biofuel produced from biomass feedstock is beginning to see use in commercial aircraft. — 2020-25
- Hydrogen and ammonia are growing in importance as future energy sources. Research is underway on power generation using hydrogen and ammonia to promote the decarbonization of thermal power plants.[5] The goal is to reduce the use of coal by firing plants with an ammonia-coal mix. — 2025-35
- Research on nuclear fusion using deuterium and tritium is also underway. While there are many issues that need to be addressed before it can be put into practical application, substantial progress has been made in recent years. — 2035 and beyond

Case study

There are two major nuclear fusion systems: magnetic confinement and laser fusion. The International Thermonuclear Experimental Reactor (ITER), a magnetic confinement system being developed through international collaboration, is scheduled to start operation in 2025. Also, in December 2022, a team from the Lawrence Livermore National Laboratory achieved a world's first by implementing a laser-based fusion system that generates more energy than what is put into the fuel, creating a "net gain". Other methods are also being studied, and in May 2023 Helion Energy announced that it had signed a contract to be the first company in the world to commercialize fusion power generation by 2028 and to supply power to Microsoft by 2030.[6]

Development of energy storage and transportation technologies

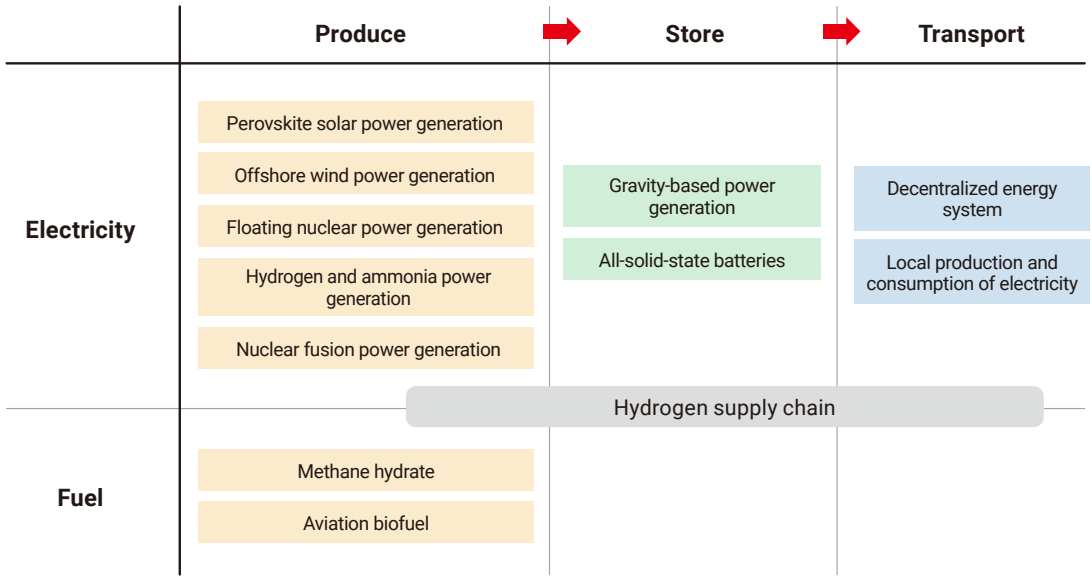
- In order to utilize renewable energy as a stable source of power, it is imperative to combine it with power storage technologies. Technologies for storage include batteries, thermal storage, and hydrogen conversion storage. In the future, batteries are expected to be smaller in size, shorter in charging time, lower in cost, and safe and easy to recycle. Moves toward the commercialization of all-solid-state batteries, which hold great promise for improving safety and increasing storage capacity, are accelerating. — 2025-35
- Gravity power generation, which utilizes the same principles as conventional pumped-storage power generation by using the gravitational energy of concrete blocks instead of water, is attracting attention as an inexpensive energy storage system. By raising and lowering the blocks, the concrete blocks are capable of both storing and generating electricity. — 2020-25

Case study

Energy Vault Holdings, Inc. has built warehouse-type gravity-based power generation systems in the U.S. and China. The company has also begun commercialization of its technology.[7]

- In order to make effective use of hydrogen for decarbonization, it is imperative that the hydrogen supply chain is designed manually from start to finish, including hydrogen production, storage, transportation, and utilization. Demonstrations of the local production for the local consumption hydrogen supply chain have been conducted throughout Japan. The experiments target the generation of hydrogen from local resources and then consuming it solely within the region it was produced in.[8] — 2025-35

Trends of New Decarbonization Technology in Energy Supply



Practical applications for new distributed energy systems

- As part of society's trend of shifting from a centralized to a distributed model, local power production and consumption is expected to become more important than ever before. — 2025-35
- Distributed energy systems that utilize demand-side assets, such as connecting electric vehicles (EVs) to the power grid, have entered the proof-of-concept stage and are close to commercialization. In the future, it is hoped that storage batteries will be used to realize an off-grid self-sufficient world in which electricity is primarily generated locally from solar, wind, and other natural energy sources without relying on electric power companies. — 2020-25

Case study

A system has been developed for efficient energy supply by predicting next-day wind power generation (Google LLC, U.S. and DeepMind Technologies Limited, U.S.).[9]

In addition, Powerpeers, a service provided in the Netherlands by Vattenfall AB, a major Swedish power company, operates a P2P power trading marketplace as a commercialized business in which individuals and corporations that own distributed energy resources, such as solar power and storage batteries, supply power to other consumers.[10]

Solutions

Clues to Solutions [Regulatory Trends]

- In Japan, the Basic Policy on Green Transformation (formally, Act for Promoting a Smooth Transition to a Decarbonized Growth-Oriented Industrial Structure; translations tentative) was enacted in May 2023. The government intends to issue JPY 20 trillion in GX Economic Transition Bonds over the next ten years to support the creation of new technologies and services for decarbonization. At the same time, as a growth-oriented form of carbon pricing, the government plans to start imposing fossil fuel levies in FY 2028 and then auctioning carbon-emission allowances to power generators in 2033. By putting a price on carbon emissions, the project aims to increase the added value of GX-related products and businesses.[11]
- In 2017, Japan formulated the world's first national hydrogen strategy, the Basic Hydrogen Strategy. By 2022, a total of 26 countries and regions had formulated hydrogen strategies . In June 2023, the Japanese government revised its Basic Hydrogen Strategy for the first time in six years, setting a new target to increase the amount of hydrogen produced domestically or imported to 12 million metric tons per year by 2040, and announced a JPY 15 trillion investment by a combined government and private sector effort.[12]
- The U.K. expects to provide more than 30% of its electricity from clean and environmentally friendly offshore wind turbines by 2030.[13] In Japan, the Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities, enacted in December 2018, promotes the development of rules for the use of general sea areas for offshore wind power plants
- Feed-in tariffs (FITs) are being reviewed worldwide, with Germany in particular taking the lead in transitioning to a feed-in premium (FIP) scheme. Japan has introduced competition for renewable energy through a post-FIT scheme. A market-linked feed-in premium (FIP) has been introduced in fields including large-scale solar and wind power generation for commercial use since FY 2022. Unlike under an FIT, an FIP does not purchase electricity at a fixed price, but rather adds certain premiums (via a subsidy) to the price point at which the electricity is sold on the general market. This makes it easier for renewable energy power generation companies to secure profitability and will incentivize business entry. Additionally, since the market determines the price of power based on the supply and demand of electricity—and supply will become more efficient under this system—the price at which electricity is sold will be lower than under the FIT. [14]

- Many countries operate using the non-fossil fuel energy certificate system which certifies the value of electricity derived from non-fossil energy sources such as renewable energy. The certificates are traded through electric power companies, and the electric retailers that purchase them can reduce the actual amount of their CO_2 emissions by the value of the certificate. In the U.S., as well as in major countries in Europe and Asia, systems have been put in place to track certificates by attaching attribute information, such as the location of the power generation facilities, to the certificates. Certificates are also tracked in Japan.[15]
- Stadtwerke, a municipally owned utility company in Germany, maintains and operates public infrastructure including electricity, gas, water, and transportation. Over the next ten years, Stadtwerke plans to invest aggressively in upgrading electricity distribution networks, IT, renewable energy, and distributed power resources. Stadtwerke will play a major role in the energy conversion being promoted by the federal government.[16]

Relevance to the SDGs

Problems

Need to accelerate decarbonization in the supply side of energy

Societal Issues

Promote comprehensive decarbonization measures

Relevance to the SDGs

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services

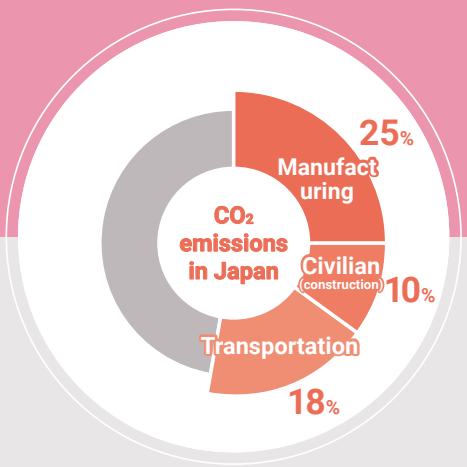
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix

7.3 By 2030, double the global rate of improvement in energy efficiency

7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology

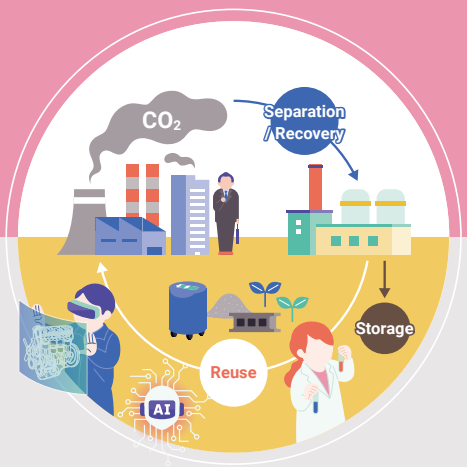
7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of supportable Consumption and Production, with developed countries taking the lead

Half of Japan's decarbonization is the responsibility of the demand-side



3 major sectors (manufacturing, construction, and transportation) contribute to about 50% of all CO2 emissions in Japan

Decarbonize, capture, and recycle CO2 under the assumption that factories, buildings, and cars cannot be rapidly replaced



Innovations in energy-saving technologies produce sustainable, high-quality power, as well as the development of low-cost, low-energy carbon recycling technologies

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Large room for energy conservation and decarbonization on the demand side

On the energy demand side, there are three sectors—industry, buildings, and transportation, which account for 25%, 10%, and 18% of Japan's CO_2 emissions in2018, respectively. Further conservation and decarbonization on the demand side of energy are imperative in order to truly realize carbon neutrality.

Japan's industrial sector, including the steel industry, has made huge progress by global standards in introducing energy-saving technologies. However, there is little room for energy conservation and decarbonization if the future relies on conventional technologies. Innovate technologies need to be developed to tap into further opportunities for conservation.

Energy-saving products have been introduced to the market and range energy-saving houses and buildings in residential and service uses to electric vehicles in the transportation sector. However, such products have yet to see widespread use. It is necessary to reduce CO_2 emissions not only at the product usage stage but also throughout the entire product life cycle, including manufacturing, usage, recycling, and disposal.

The increase in power consumption resulting from the exponential growth in AI usage in digital fields has become a global problem.

Japan
Potential impact estimates

If no energy conservation measures are taken, total electricity demand for the business and household sectors is expected to increase by 13% from 607.3 billion kWh in FY 2013 to 687 billion kWh in FY 2030. If conservation measures are taken, the demand in FY 2030 is estimated to be 511 billion kWh. Promoting energy conservation measures as targeted will reduce consumption by 176 billion kWh and electricity costs by JPY 3.4 trillion.

*Comprehensive unit price for electricity (business sector) = JPY 17.61 /kWh. Comprehensive unit price for electricity (household sector) = JPY 22.0 /kWh. * Source: Energy Data and Modelling Center, Institute of Energy Economics, Japan, "EDMC Handbook of Japan's & World Energy & Economic Statistics FY 2016," 2016. (A)

Issues

Promote decarbonization in the industrial, household, and transportation sectors

Key Points for Resolving Issues

Industrial Sector

[Technological innovations for decarbonizing manufacturing processes and capturing and recycling CO_2]

In the industrial sector, decarbonization must be promoted through technological innovation in manufacturing processes. In the steel industry working on research and development of hydrogen-based ironmaking, which uses hydrogen to extract iron from ore instead of burning coke.

A process called Carbon Capture, Utilization and Storage (CCUS), in which CO_2 generated in the manufacturing process is separated and captured after the fact and stored or used, has also seen encouraging results. Because the industrial sector emits a certain amount of CO_2 from relatively few locations, it is easier to capture CO_2 than in the consumer and transportation sectors.

There have been attempts to use the captured CO_2 as a carbon resource instead of just storing it underground. Technological development is underway to use CO_2 in the following three ways:

1. As a raw material for cement
2. As part of the trigeneration process in plant factories
   Note: Trigeneration is an energy supply system that utilizes heat, electricity, and CO_2 from thermal sources
3. As a material for fuel cells by extracting and converting CO_2 into formic acid

Key Points for Resolving Issues

Buildings (Residential and Services) Sector

[Popularization of energy-saving houses and buildings, as well as energy technology innovation using IoT]

The government's policy goal of the Strategic Energy Plan includes the promotion of Net Zero Energy Houses (ZEH) and Net Zero Energy Buildings (ZEB).[17] To this end, it is necessary to raise consumer awareness of these standards and provide focused education to small- and medium-sized construction firms that lack proficiency in energy conservation standards.

It is also important to encourage innovation in energy-related technologies utilizing IoT and digitization. Using data obtained through networks of wireless terminals with multiple sensors enables structures to ensure both comfortable amounts of space while still optimizing energy production and consumption.

Key Points for Resolving Issues

Transportation Sector

[Development of technologies in automotive batteries and FCVs, as well as improvement of utilization rates through shared and joint transportation]

The transportation sector also needs to promote energy conservation and decarbonization products. Efforts in the automotive sector, which accounts for 85% of direct CO_2 emissions, are especially important.

To popularize EVs for personal use, it is also imperative to advance automotive batteries, especially for driving range and safety. As vehicles emit CO_2 throughout their entire lifecycle, notably not just while being driven, decarbonization must be pursued at each stage of production, from acquiring the components to manufacturing and disposal. Car sharing also improves the effective utilization of resources by encouraging the utilization of idle private cars.

In the freight trucking industry, the current loading rate is as low as approximately 40%. Cooperation among logistics trucking companies and automotive manufacturers must take place in order to raise the rate to an optimal level. In public transportation, share-ride taxis and on-demand bus services are possible measures to improve the number of passengers per vehicle and the overall operation ratio. For freight trucks, it can be effective to promote the development of fuel cell vehicles (FCV), which offer significant advantages in driving range, loading capacity, and refueling time.18

Since CO_2 is emitted not just during the time a car is driving, but also during the acquisition of component materials, manufacturing of products, and disposal of the vehicles, it is necessary to enhance the decarbonization efforts throughout its entire life cycle.

Solutions

Clues to solution [Technological Trends]

1. Industrial Sector

Practical implementation period

Technological innovation in the manufacturing process

- Steel production using electric furnaces is attracting significant attention as a step towards a recycling-oriented society, as the new process produces only one fourth of the CO_2 emissions from blast furnaces, and the involved scrap iron is efficiently recycled. Production of high-grade steel by electric furnaces has been difficult in the past due to impurities such as copper and nitrogen mixed in with the iron scrap, but technological development is making progress to alleviate these impurities.[19] — 2020-25
- Quicklime, the primary raw material for cement, generates CO_2 during the current manufacturing methods that depend on the decarboxylation reaction of limestone. Technology is currently being developed to recycle the CO_2 from the cement manufacturing process and reuse it as a resource for cement and construction materials. Proof-of-concept projects are already underway toward the practical application of these technologies. [20] — 2025-35
- Production processes are the subject of recent innovation exploration because of the large amounts of energy required to produce materials in chemical manufacturing. A catalyst is a substance that accelerates certain chemical reactions, and by using AI to discover catalysts, there is a strong potential to find manufacturing processes that are dramatically more energy efficient in a short period of time. — 2025-35

Case study

The Interdisciplinary Research Center for Catalytic Chemistry at the National Institute of Advanced Industrial Science and Technology (AIST) has developed a technology that uses AI to predict catalytic reactions.[21] AIST has been advocating strongly for Catalyst Informatics, which combines catalytic science and informatics and is expected to significantly shorten the development time of catalysts.

Carbon recycling technology

- Technologies are being developed to separate and capture CO_2 at its origins, such as in exhaust from power plants and factories. Currently available methods include chemical absorption, physical absorption, solid absorption, and membrane separation. The next challenge will be to reduce cost and the energy required for these processes. — 2025-35
- Direct Air Capture (DAC technology), which directly absorbs and separates CO_2 from the atmosphere, has been used in specific fields like the International Space Station and in submarines. Development of an experimental plant and its commercialization are also progressing to help work towards global carbon neutrality — 2025-35

Case study

Climeworks AG, a Swiss university startup, is the first company to commercialize a CO_2 DAC plant. The recovered CO_2 is used for carbonated water sold by The Coca-Cola Company. Climeworks also completed a plant in Iceland in 2021 that is capable of recovering 4,000 metric tons of CO_2 annually. The plant uses renewable energy from a nearby geothermal power station and stores the recovered CO_2 deep underground.[22]

2. BuildingsConsumer (Residential and Services) Sector

Energy-saving houses and buildings

- Passive houses are being built to reduce energy consumption while providing comfortable living by incorporating passive solar power, which brings in natural light and sunlight while minimizing the usage of traditional equipment or power.[23] — 2020-25

Energy management

- The use of IoT-based energy management services (HEMS/BEMS/FEMS, etc.) is expanding in homes, buildings, and factories. — 2020-25
- A new process called energy harvesting is also attracting attention. The process converts the low-density heat and vibration energy captured from close surroundings into electric energy. Incorporating the technology into sensors also makes it possible to construct a flexible network of sensors that does not incur any power costs. This process has already seen use in elevators, vending machines, and construction machinery, but could also be applied in monitoring the deterioration of infrastructure like tunnels and bridges.[24] — 2020-25

Case study

An IoT sensor mat has been commercialized that uses self-generated power to transmit two types of wireless IDs when the mat is stepped on and when the user leaves the mat, allowing movement activity to be tracked including time spent at certain locations. (Global Energy Harvest Co., Japan)[25]

Energy conservation in data centers

- Data centers can significantly reduce power consumption by selecting locations that take into account climatic and environmental conditions, such as those in cold climates. — 2020-25

Case study

New cooling concepts that do not introduce outside air directly into the room are being adopted, and technologies are being developed to both save energy and stabilize the air environment, such as humidity control and dust removal, inside server rooms. (KAJIMA CORPORATION, Japan)[26]

There are also examples of efforts to develop data centers that do not need cooling at all. (Microsoft Corp., the U.S.)[27]

Providing information and incentives to change behavior

- The private sector is taking the lead in visualizing and providing information on the environmental impact of corporate activities

2020-25

Case study

CDP, an international NGO, is encouraging companies to disclose information on their greenhouse gas emissions and lists companies that have demonstrated outstanding strategies and responses to climate change on their Climate Change A-List.[28] The list is one of the major evaluation guidelines for ESG investment and continues to attract greater attention year after year.

- Household energy consumption and CO_2 emissions vary according to family composition, residential area, and other factors. There are efforts to increase incentives for households to save energy and reduce CO_2 emissions by comparing neighboring homes with similar family structures.

2020-25

Case study

TEPCO runs a website service called Daily Life with TEPCO Web. TEPCO users, by providing their profile, can compare their electricity usage with other households that have similar family composition.[29]

An experimental project also encourages households to save energy by using nudges through conservation advice to reduce electricity bills.[30]

Community Solar

- Community solar initiatives are starting to sprout in which residents who lack a roof of their and are thus unable install solar panels can receive power from community solar systems. This is expected to increase the number of residents who can and will use renewable energy.

2020-25

Case study

Nexamp, Inc., a U.S. company, provides community solar services for individuals and businesses, mainly in the state of Massachusetts. The company offers the benefit of 10-20%lower electricity bills for households.[31]

Behavior change services to help consumers become carbon neutral

2020-25

- The Japanese government has launched services to help consumers to visualize, and take action to reduce, the GHG emissions of their own lives. These services currently target individuals and the employees of companies.

Case study

NTT DOCOMO, INC. provides a service called Caboneu Record to make it easier and more fun for consumers to continue taking actions that contribute to carbon neutrality. The service automatically calculates the amount of CO_2 reduction and the degree of contribution to carbon neutrality by using information on transportation modes estimated from location data and the purchase history of environmentally friendly products. The service incorporating game elements to provide users with additional motivation to continue activities that contribute to carbon neutrality.[32]

COOL CHOICE, a national campaign promoted by the Ministry of the Environment (MOE), is calling for individual lifestyle changes to realize a decarbonized society. MOE has organized information on the actions for decarbonization and posted a guideline called Zero Carbon Action 30 (as the figure below.)[33]

Zero Carbon Action 30, COOL CHOICE, MOE (Translation Tentative)

Source: The Ministry of the Environment's website.

3. Transportation Sector

Innovation in battery technology

2025-35

- Liquid lithium-ion batteries, which are currently the mainstream choice for automotive use, have many technical issues including safety, economy, charging time, weight, and dependence on scarce resources. Usage is expected to transition towards all-solid-state batteries by around 2030. By about 2035, innovative products such as fluoride-ion and zinc anode batteries are expected to become widely available.

Case study

Toyota Motor Corporation has announced that it will introduce all-solid-state batteries, which solve almost all of the issues of liquid lithium batteries, into EVs as early as 2027.[34]

NEDO has initiated research and development on fluoride ion batteries and zinc anode batteries by forming an industrial, governmental, and academic alliance. These innovative batteries achieve high energy density as well as increased safety while using inexpensive materials that are not in scarcity.[35]

Wireless power supply for electric vehicles

2035 and beyond

- Wireless power transmission technology is being developed to supply power to running vehicles via roadside inductor coil. This technology will reduce the size and weight of vehicle batteries as well as energy consumption throughout their lifecycle of driving, manufacturing, and disposal. With this technology, a vehicle can run indefinitely without worrying about charging, which improves its overall operation rate.[36]

Recycled carbon fuel (Synthetic fuel/e-fuel, SAF)

2025-35

- In terms of mileage and other factors, commercial vehicles benefit more from utilizing conventional internal combustion engines that emit less CO_2, rather than simply being electrified. The manufacturing cost of synthetic fuels is a problem, however, so research and development for cost reductions are being carried out around the world. For aircraft, sustainable aviation fuel (SAF) is being developed using biomass, waste cooking oil, and exhaust gas as raw materials.[37]

Case study

An increasing number of global airlines have signed the 2030 Ambition Statement, which aims to increase the share of SAF in aircraft fuel to 10% by 2030.[38]

4. Common to All Sectors

Visualization of GHG emissions and GHG reduction planning through carbon accounting platforms

2020-25

- Carbon accounting services that track greenhouse gas emissions by companies, their supply chains, loans, and investments have emerged and are beginning to spread globally. Global standards for measurement include the GHG Protocol, which calculates companies' greenhouse gas emissions, and the PCAF, which allows financial institutions to calculate the GHG emissions of the companies in which they invest and finance.

Solutions

Clues to solution [Regulatory Trends]

- Japan's Fifth Strategic Energy Plan, issued in 2018, mandates a policy target for more than half of custom-built homes in 2020 and the average of all newly built homes in 2030 to comply to ZEH. Three ministries, the Ministry of Economy, Trade and Industry (METI), the Ministry of Environment (MOE), and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), provide subsidies to promote ZEH
- In the automotive industry, there is excitement surrounding the introduction of the Life Cycle Assessment (LCA), which evaluates environmental impacts not only at the use stage, or tank-to-wheel, but also throughout the entire life cycle, from raw material extraction to manufacturing, use, and disposal. The EU plans to introduce an LCA regulation mandate on batteries in 2024. In addition, the CO_2 emission assessment may be changed from a Tank-to-Wheel to a LCA basis.
- Medium-term passenger car electrification policies are being adopted in multiple countries. The UK., for example, will ban sales of gasoline cars in 2030 and hybrid vehicles in 2035. Japan plans to electrify 100% of new car sales by 2035.[39]
- The Task Force on Climate-related Financial Disclosures (TCFD) released its final report in June 2017, recommending that companies disclose their climate-related risks and opportunities. Due to changes in the Corporate Governance Code, the Tokyo Stock Exchange required companies listed on its Prime Market to disclose information based on the TCFD starting from April 2022.[40]
- In addition to TCFD, an increasing number of Japanese companies are participating in international initiatives related to climate change and decarbonization. As of June 2023, 1,389 organizations out of 4,638 worldwide have joined the TCFD, 515 organizations out of 2,698 worldwide have joined the SBT, which sets greenhouse gas reduction targets, and 81 organizations out of 412 worldwide have joined RE100, which aims for 100% renewable energy for electricity used in business activities. The number of Japanese members is ranked first or second in each initiative.[41]
- In February 2022, the Industrial Science, Technology and Environment Policy Bureau of the Ministry of Economy, Trade and Industry (METI) announced the GX League Basic Concept. Since the driving force for the green transformation (GX) in Japan is regarded as crucial, the GX League was established as a forum for a group of companies actively engaged in green-transformation work together to discuss ways to reform the entire economic and social system, as well as practice creating new markets.[42] As of June 2023, companies accounting for more than 40% of Japan's GHG emissions have participated as members.[43]
- In FY 2013, Japan launched the J-Credit Scheme, issuing carbon credits to companies engaged in projects that reduce greenhouse gas emissions or increase carbon sinks. The amount of J-credits used in FY 2020 amounted to only about 600 thousand metric tons (for reference, Japan's total greenhouse gas emissions in FY 2021 were 1.12 billion metric tons).[44]
- In February 2023, the State of California introduced the Carbon Dioxide Removal Market Development Act (SB 308), requiring that companies with high carbon emissions, such as electric power companies and cement manufacturers, compensate for their emissions by purchasing negative emissions credits starting in 2027. The compensation obligation is only 1% of emissions in 2027, but by 2045, the state would seek 100% compensation.[45]
- Although the European Union (EU) said it would ban the sale of new gas-powered engine cars in 2035, it made a major change to its policy in March 2023, allowing cars with engines that use environmentally-friendly synthetic fuels.[46]

Relevance to the SDGs

Problems

Large room for energy conservation and decarbonization on the demand side

Societal Issues

Promote decarbonization in the industrial, household, and transportation sectors

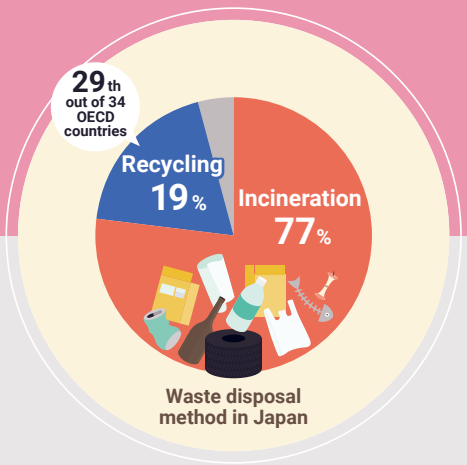
Relevance to the SDGs

7.2 By 2030, increase substantially the share of renewable energy in the global energy mix

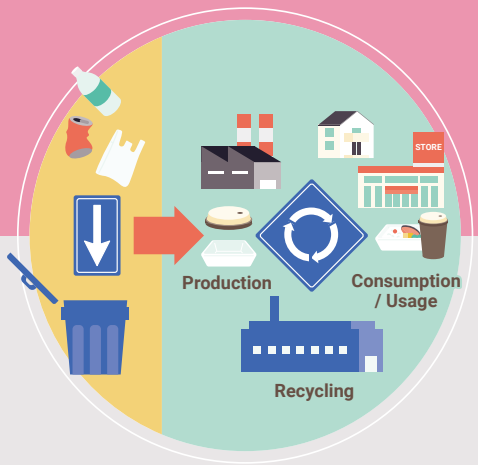
7.3 By 2030, double the global rate of improvement in energy efficiency

13.2 Integrate climate change measures into national policies, strategies and planning

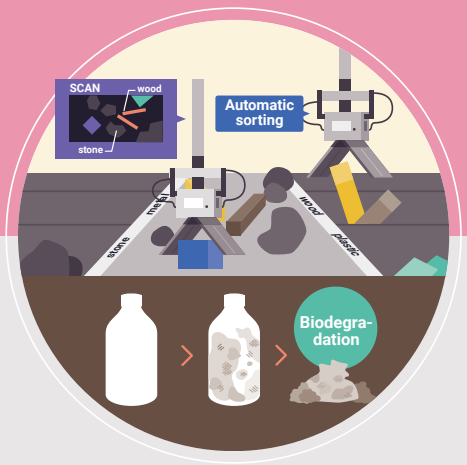
Is Japan now behind in recycling?



The majority of waste disposal in Japan is by incineration. Resources are not recycled.



Transition to a recycling-oriented society that maximizes the effective use of resources



Development and promotion of more efficient and automated recycling and the development of plastics that break down naturally and quickly

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Insufficient recycling and ineffective use of resources

Incineration (garbage burning) accounts for 77% of Japan's waste disposal, the highest percentage among OECD member countries. At the same time, only 19% of materials are recycled into usable resources, placing Japan at 29th among OECD countries. Incineration without energy recovery is also higher than in other countries and is not fully utilized effectively. [47]

Certain precious metals, such as iridium and lithium, are indispensable for next-generation vehicles and ICT equipment. These metals accumulate in what are now being called “urban mines” but are not yet sufficiently recovered or recycled. Japan’s urban mine reserves are equivalent to 15% of the world’s natural reserves of indium, which are used in smartphone screens, 10% of tantalum reserves, which are used in capacitors, and 4% of lithium reserves, which are used in lithium-ion batteries.[48] This large accumulation reflects the low utilization rate of urban mines in Japan, since recycling is not considered economically feasible. The cost of recovering, separating, and refining the metals is ultimately higher than the cost of simply procuring the resources on the global market, further reducing the incentive to recycle.

The utilization rate of domestically available forest resources and organic biomass is also insufficient. The annual growth of forests in Japan amounts to about 70 million m3, of which only 31 million m3 (about 44%) is utilized.[49]

Japan

Potential impact estimates

Urban mines in Japan have accumulated enormous amounts of metal resources. Gold reserves amount to 6,800 tons (equivalent to 16% of the world's existing reserves) and silver reserves amount to 60,000 tons (22% of the world's existing reserves). 6,800 tons of gold, converted to yen at a rate of 7,000 yen/g, amounts to about JPY 50 trillion. (C)

Japan
Potential impact estimates

Japan's forests are strewn with approximately 20 million m3 of unutilized fallen branches and timber from forest thinning.[50] If used for biomass power generation, these neglected resources would total the equivalent of JPY 160 billion per year, and would reduce CO2 emissions by 4.3 million metric tons per year, or 0.4% of Japan's total emissions, rendering an additional equivalent of JPY 2.8 billion per year in carbon credits. (C)

Estimation Method

Estimations have been derived from the economic value of using the timber from forest thinning in biomass power generation and the value of the possible reduction of CO2 emission.

Total fuel value = (Unused thinned timber[51] × Fuel unit price of thinned timber[52])

CO2 credits = (Unused thinned timber ÷ Use of biomass power plant of 5,000 kW scale[53] × Annual generated electric energy of 5,000 kW scale power plant[54] × Actual emission factor[55] × CO2 unit price[56])

Issues

Create a recycling-oriented society that makes effective use of all resources

Key Points for Resolving Issues

Enhancing Resource Utilization throughout Product Life Cycles
[Recycle, reuse, and easy recyclable/reusable design]

The 3Rs of sustainability (reduce, reuse, and recycle) are essential parts of building a recycling-oriented society. For example, manufacturers are expected to adopt recyclable materials and design products that are easy to disassemble and repair. In terms of production, using raw materials efficiently (for example, by reducing the amount of material in containers and packaging) remains a vital aspect of sustainable manufacturing. Consumers should use goods for longer by prioritizing long-life products and by curbing their use of private goods by utilizing shared services.

Key Points for Resolving Issues

Advanced Recycling
[Horizontal recycling that maintains quality levels]

It is important to promote "horizontal recycling", in which products are recycled into materials of the same type and quality, rather than "vertical recycling", in which products are recycled into objects that are different from the original products and are of relatively lower quality.

The efficient separation of recyclable resources by sensors, robots, etc., and the development of materials and product design that facilitate horizontal recycling will enable expansion of horizontal recycling at low cost. The key to advancing recycling is establishing businesses that can be monetized, but it is challenging to make recycled products more competitive than new ones. Although the creation of trading markets for recycled products is expected, the developing trading information remains an issue.

Key Points for Resolving Issues

Improving Utilization of Biomass Resources

[Technological development, cost reduction, and development of trading markets]

Biomass resources are roughly classified into three categories:

1. Waste (domestic drainage water, food waste, etc.)
2. Unused materials (wood from tree thinning, crop residues, etc.)
3. Agricultural production (grazing grass, algae, etc.)

Their uses are diverse, including feed, fertilizer, and construction materials, as well as a source of renewable energy. Biojet fuel is also expected to be a renewable energy source. As waste is required to be disposed of appropriately, converting it to energy is an effective method to cut its associated costs.[57] (Reference: The annual cost for local governments and municipalities to dispose of domestic waste is approximately JPY 2 trillion per year) In order to utilize biomass resources effectively, it is necessary to develop technologies corresponding to their type and source.

Expertise on enhancing wood-biomass power generation is being shared, revealing techniques that enable more efficient drying of raw wood and utilization of low-quality materials. Wood-biomass is derived from leftover lumber resulting from tree thinning activities, at sawmills, and in construction projects. Therefore, to secure a stable supply over the long term, it is necessary to increase the demand for domestic lumber through improved productivity and price competitiveness. Japan's self-sufficiency rate is only one third of its current annual timber demand of about 70 million m3. Developing trading platforms is also an effective effort to support the stable procurement of wood-biomass.

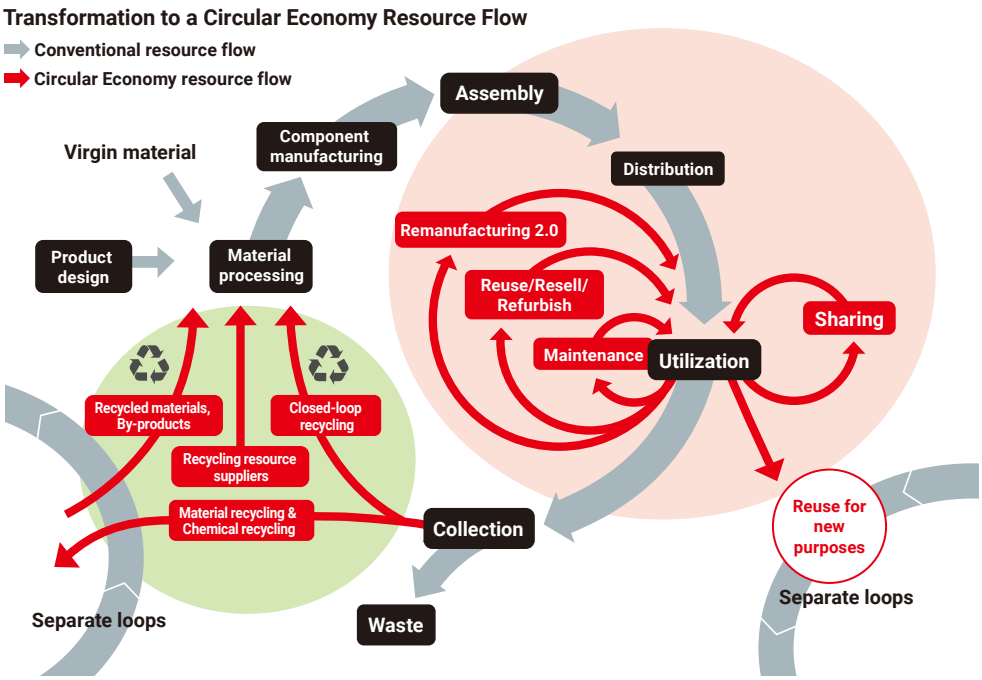
Regarding biomass resources, it is expected not only to be used for energy but also to be developed as an alternative to naphtha, a raw material of petroleum products.

Key Points for Resolving Issues

Achieving a Circular Economy

[Transforming the resource circulation flow]

Reform of resource circulation flow is achieved by enhancement of resource utilization throughout the product life cycle, advancing recycling, and improving the utilization of biomass resources (see the figure below).



Source: The Ministry of Economy, Trade and Industry, "Growth-Oriented, Resource-Autonomous Circular Economy Strategy" (March 2023)

Clues to Solution [Technological Trends]

Practical implementation period

Enhancing resource utilization throughout the product life cycle

- Biodegradable materials, cellulose nanofibers, and biomass-derived plastics, which are alternative materials to plastics, are being developed to create products that do not use depleting resources. — 2020-25
- Projects and businesses for the effective use of resources are emerging through local residential communities and recycling-oriented systems that emphasize durability and design. — 2020-25

Case study

A real estate company has developed a service that serves as an intermediary for condominium residents to borrow, lend, buy, and sell unused materials among one another (sharecome by NIPPON STEEL KOWA REAL ESTATE CO., LTD., Japan).[58]

E-commerce operators, manufacturers, and retailers have collaborated to launch a recycling business that makes direct use of reusable, durable, and finely designed containers that are made of glass and stainless steel. (LOOP Global Holdings LLC, U.S.).[59]

- Research is being conducted in storage batteries to reduce recycling costs by incorporating design and manufacturing processes that facilitate disassembly after use.[60] — 2025-35

Advanced recycling

- Product sorting with sensors and robots has improved efficiency in recycling — 2020-25

Case study

The world's first waste-sorting robotic system has been developed (ZenRobotics Oy, Finland).[61] Operating 24 hours a day, the combination of industrial robots and machine learning technology has enabled both high-purity recycling as well as cutting down the cost of disposal.

In Japan, by utilizing AI and robotics, an automatic picking system has been developed that sorts waste fed into conveyors (UENOTEX Co., Ltd., Japan).[62]

- There is also anticipation for technologies that identify discarded electronic devices using image recognition and automatically recycle the nonferrous and rare metals they contain at low cost. — 2025-35

Case study

Development of a technology to automatically extract rare earth metals from small home appliances, such as smartphones, is expected by 2022 (CEDEST at AIST, Japan, established in 2018).[63]

- Efforts to recycle waste and unnecessary materials using microorganisms as catalysts have also begun. — 2020-25

Case study

Using microorganisms as a catalyst, a proof-of-concept experiment began in April 2022 to test new technologies to convert garbage that would otherwise be incinerated, including domestic food waste, into ethanol. It aims to sell ethanol made from combustible garbage by FY 2025. (The project was jointly developed by SEKISUI CHEMICAL CO., LTD., INCJ Ltd., Japan, and a U.S. entrepreneur, LanzaTech)[64]

- Chemical recycling has led to the development of recycling technologies that break down plastic bottles and clothing to the molecular level before recycling them back into plastic bottles and fibers. 2020-25

Case study

PET bottles are generally considered to be of low quality for recycling, because they may be contaminated in the collection box with substances from labels, caps, garbage, and leftover drinks, making it difficult to realize bottle-to-bottle recycling. However, JEPLAN, INC., has succeeded in the horizontal recycling of PET bottles through chemical recycling.[65]

Similarly, a recycling business is also being developed that collects clothing at retail stores, breaks apart the polyester into smaller substances, or BHET, and then reprocesses the BHET back into polyester.[66]

Enhancing utilization of biomass resources

- Cost reduction is desired through the development of technologies that can use sewage sludge, organic waste, and livestock excrement through batch treatment. In particular, sewage sludge is considered to play a central role in a recycling society, and is being utilized as energy, fertilizer for green spaces and agricultural land, and raw material for construction. There is also a movement to compost food scraps for various uses by local communities. 2020-25

Case study

4Nature is carrying out a project to convert domestic food waste into compost. Community members gather and discuss in search of the most effective way to use the compost (1.2-mile community compost by 4Nature, Inc., Japan).[67]

- A zero-waste biomass recycling process using houseflies and soldier flies is being developed.[68] 2020-25

Case study

Technology has been developed to produce larvae of American Soldier Flies using food residue (unused biomass resources) as feed for farmed fish and livestock (Research Institute of Environment, Agriculture and Fisheries, Osaka Prefecture, Japan, etc.).

A company has also developed a biomass recycling system that uses houseflies to recycle 100% of input biomass into feed and organic matter (MUSCA Inc., Japan).

- Efficient forest management methods are being developed to collect and analyze forest data using drones, satellites, and aerial surveying technologies.[69] 2020-25
- Some issues are already being overcome through the sharing of expertise in wood drying, the introduction of dryers for low-quality wood, and inital diagnostic tools for wood-based biomass power. 2020-25
- Developing sound and competitive wood-biomass trading platforms is also important for the stable procurement of biomass products such as wood chips and pellets. 2025-35

Case study

Following the introduction of a biomass trading platform in 2012, Lithuania saw a significant increase in new entrants to the market and its biomass supply business greatly expanded. The share of wood-biomass fuels for supplying heat to regions is expected to reach approximately 80% in 2020 from less than 30% in 2012. As a result, the price of wood-biomass fell by up to 40% in some regions compared to 2012, as did the price of heat supply by district.[70]

- Biomass-derived plastics are being developed and marketed.

2020-25

Case study

The Mitsui Chemicals Group produces bio-based raw materials such as ethylene, propylene, C4 fraction, and benzene by feeding biomass naphtha produced from vegetable oil waste and residue oils produced at its plant in Osaka. As of November 2022, approximately 30 kinds of products have been converted into biomass using the mass balance method.[71]

Solutions

Clues to a Solution [Regulatory Trends]

- The Ministry of the Environment (MOE) is advocating the creation of a Regional Recycling Symbiosis Zone as a way for each region to achieve self-reliance and decentralization while still remaining complementary. MOE provides various projects in support of the realization of its proposed plan. The Plastic Resource Circulation Strategy was published in 2019, mandating the reduction of cumulative emissions of disposable plastics by 25% by 2030. Various recycling laws and regulations now require recycling and waste measures for each field.
- In April 2022, the Act on Promotion of Resource Circulation for Plastics came into effect in Japan. The act encourages all stakeholders at every stage of the plastic life cycle, from product design to waste disposal, to promote resource circulation.[72]
- The EU adopted the Regulation on Batteries and Waste Batteries in June 2023. The regulation aims to gradually escalate the recovery targets for all batteries sold in the EU, including automotive, industrial, and portable batteries, with recovery targets for lithium of 50% by the end of 2027 and 80% by the end of 2031.[73]
- The introduction of the feed-in tariff (FIT) system for renewable energy in 2012 has encouraged wood-biomass power plants to be fueled by forest residues and wood from forest thinning. The Forest Management Act, enacted in May 2018, established a system of "forest banks" through which municipalities consolidate and manage forests that private owners cannot manage themselves. According to the Act on Forest Environment Tax and Subsidy, enacted in March 2019, JPY 1,000 per person every year will be collected as a national tax starting FY 2024. The tax revenue will be used as a financial resource for local governments to use for forest thinning operation and administration, forest maintenance, and utilization of the collected wood.

Relevance to the SDGs

Problems

Insufficient recycling and ineffective use of resources

Societal Issues

Create a recycling-oriented society that makes effective use of all resources

Relevance to the SDGs

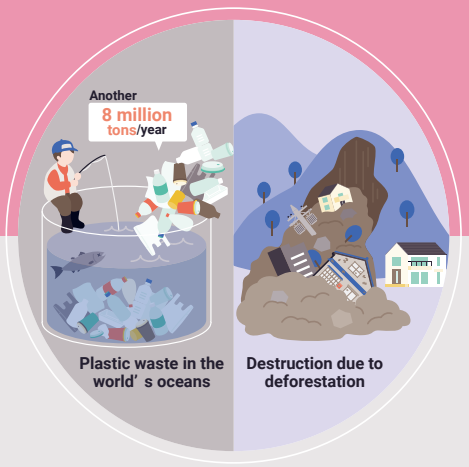
8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead

9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities

12.2 By 2030, achieve the sustainable management and efficient use of natural resources

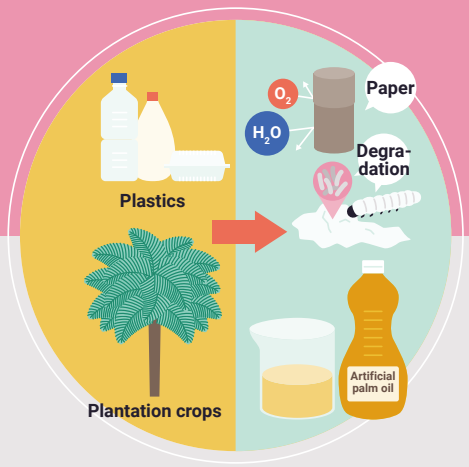
12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse

Environmental pollution is becoming increasingly invisible



Water pollution and deforestation cause adverse ecological effects and natural disasters even in places far away from the original damage

Prevention of new pollution and the restoration of currently contaminated environments



Promoting the development of alternative materials and degradation technologies for plastics, and developing technologies to prevent illegal harvesting of plantation crops

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Intensifying environmental pollution and deterioration

90% of the world's population lives under polluted air. Air pollution is caused mainly by factories, automobile gas emission, and coal and charcoal burning. Air pollution is causing maladies including stroke, heart attack, and lung cancer.[74,75]

Chronic water pollution occurs mainly from drainage systems in factories and households, as well as the inflow of pesticides and plastics. Temporary marine pollution such as waste dumping and oil spills caused by maritime accidents are also causing severe problems.

There has been rapid deforestation, mainly in tropical forests, in recent years. The amount of natural forest has been shrinking, with the quality of the forest lands that do remain severely deteriorating. This has resulted in devastating conditions, including the loss of many wildlife species and severe negative impacts on the lives of those who depend on the forests for their livelihoods. In addition, large-scale flooding and forest fires are occurring with increasing frequency due to the aggravation of global warming.[76]

World
Potential impact estimates

More than 7 million people around the world have died prematurely due to air pollution. This results in an estimated economic loss of about JPY 530 trillion per year.[77](B)

Plastic litter in the world's oceans totals 150 million tons, to which 8 million metric tons are added every year. Annual economic losses in the Asia-Pacific region are estimated at USD 620 million for tourism and USD 360 million for fisheries and aquaculture. In 2050, the total weight of plastic waste accumulated in the ocean is projected to exceed that of fish.[78](A)

World
Potential impact estimates

In the past 40 years, one billion hectares of tropical rainforest have disappeared. This area is equivalent to the size of the European continent. If the destruction continues at this pace, remaining rainforests are expected to disappear completely within 100 years.[79](A)

Issues

Take immediate action to assess the current situation, analyze underlying factors, and implement countermeasures

Key Points for Resolving Issues

Measures to Control Pollution

[Preventing new and clearing existing contamination]

To prevent air, water, and soil pollution, it is essential to create (1) a system to monitor current pollution conditions and (2) effective regulations. In terms of preventive technologies, it is imperative to use renewable energy to develop lower-polluting automobiles and alternatives to plastic materials. At the same time, for water and soil that is already contaminated, bioremediation technologies that use microorganisms and plants to clear pollution are actively attracting attention. Technology to recover maritime plastic waste is also being developed.

Key Points for Resolving Issues

Combating Deforestation

[Enhancing region-based measures s and coordinating global effort]

The leading direct cause of deforestation is the expansion of commercial agriculture and plantations, but infrastructure development and extraction of natural resources are also becoming significant contributing factors. Indirect factors such as population growth, national policies, and market demand are also playing a role. It is difficult to improve this situation in a short period of time. Nonetheless, it is imperative to implement specific initiatives on a regional basis, such as removing contributing factors through technological development, conserving and restoring forests, and reviewing business models. There is also a need for a mechanism to link efforts to address environmental issues on a global basis, led by the United Nations, involving various stakeholders, such as enterprises and individuals.[80]

Solutions

Clues to solution [Technological Trends]

Practical implementation period

Air pollution countermeasures

- As a countermeasure against air pollution in large cities caused by automobiles and factories (including power plants), the development of cleaner vehicles and the use of electric energy generated from renewable energy is progressing. Proof-of-concept research is also being conducted on a service that encourages charging EVs and PHVs with renewable electricity and provides local community "coupons" as incentives. The service promotes measures against global warming while reducing the economic burden of adaption.[81] — 2020-25
- For households in developing countries that depend on wood or charcoal for cooking and heating, inexpensive alternative devices that do not emit smoke are in great need. — 2020-25

Case study

To solve the air pollution problem caused by coal-burning for heating and cooking in Ulaanbaatar, the capital of Mongolia, a Japanese company has developed a technology that produces smoke-free coal. (MEIWA CO., LTD., Japan)[82]

Soil and water pollution control

- New restoration technologies, such as bioremediation and phytoremediation derived from microorganisms and plants, are needed to combat pollution in soil and water. Future challenges include securing safety without affecting ecosystems, and discovering and applying microorganisms and plants that can decontaminate pollutants. — 2025-35

Prevention of plastic runoff into the ocean

- Causal countermeasures: The most effective way to prevent plastics from flowing into oceans is to reduce the amount of plastic used overall. In order to reduce the amount of plastic used, efforts are being made to develop alternative materials to plastics (e.g., biodegradable materials). In many cases, biomass materials such as starch and paper are being used, and products using corn and cassava have been developed. — 2020-25

Case study

SHIELDPLUS is a barrier material and is used as an alternative to plastic. It is structurally comparable to paper, but does not let oxygen and smells penetrate (Nippon Paper Industries Co., Ltd.).[83]

- Follow-up measures: The reuse of plastics instead of discarding them is being promoted. Development of plastics that are easy to reuse (material, color, form, etc.) and promotion of the use of recycled plastics are desired. — 2025-35

Case study

A company is aiming to completely recycle PET bottles by creating a version made from a combination of recycled PET resin and plant-derived materials, by 2030 (Suntory Holdings Limited, Japan).[84]

- Follow-up measures: Technology to break down plastics is also being developed. A moth with enzymes that decompose plastics can digest plastic products in three days to six weeks. It has also been confirmed that caterpillars (larvae of wax moths, Galleria mellonella) can eat polyethylene. A study is underway to extract and produce PETase, a plastic degradative enzyme, from PET-eating bacteria (ideonella sakaiensis).[85] 2025-35
- Follow-up measures: Efforts are being made to use waste plastics not only for incineration or landfill disposal, but also as a recyclable material in society. 2025-35

Case study

LIXIL Corporation has developed a recyclable material, revia, by fusing various types of waste plastics, including composite plastics, which are considered difficult to recycle, and waste wood from demolition and repair of buildings. It began sales in January 2023.[86]

Measures against plastic in the ocean

- Causal countermeasures: The development of biodegradable plastics is advancing. Such plastics will decompose into inorganic substances by the work of microorganisms. 2025-35

Case study

A biodegradable polymer (PHBH) developed by Kaneka is 100% plant-derived and can be decomposed into inorganic substances by microorganisms in seawater. PHBH can be processed into drinking straws and plastic bags, making it a promising alternative to plastic(KANEKA CORPORATION, Japan).[87]

- Follow-up measures: Technological development for monitoring, collecting, and reusing plastic waste in the ocean is progressing. However, technology to collect microplastics has yet to be fully realized. 2025-35

Case study

The Ocean Cleanup, an organization based in the Netherlands is developing a system to collect marine plastic using tidal currents (The Ocean Cleanup, the Netherlands).[88]

- Follow-up measures: Efforts are being made to collect plastics that have flowed into the ocean and upcycle them in a way that adds value. 2020-25

Case study

REMARE Co., Ltd. sells artwork made with marine and discarded plastics collected by cleaning beaches and purchasing used fishing gear from fishers.[89]

Removal of deforestation factors

- To contain the destruction of tropical rainforests by plantation agriculture, there are high expectations for the development of alternative products to substitute agricultural crops. 2025-35

Case study

A U.S. company is developing a synthetic palm oil that can be used as an alternative to the palm oil produced from palm trees in tropical rainforests (C16 Biosciences, the U.S.).[90]

- The use of IoT, AI, and drones to promote the integration of the agricultural and livestock industry could help contribute to mitigate deforestation. 2020-25

Forest conservation technologies

- Technology is being developed to quickly detect environmental changes or damages such as deforestation, wildfires, and floods.

2025-35

Case study

Huawei, together with Rainforest Connection, a U.S. non-profit organization, is conducting a project to prevent illegal logging and poaching in Southeast Asia by utilizing voice monitoring systems and AI. (Huawei Technologies, Co. Ltd.)[91]

Exci, Inc., an Australian company, has developed a system that uses AI to analyze image data taken by satellites and ground cameras to detect wildfires within minutes of their occurrence.[92]

Reforestation technologies

- A public-private partnership is operating a proof-of-concept experiment and developing technologies in depleted areas in developing countries where tree planting is difficult. Its technology database is publicly available.

2025-35

Case study

The Japan International Forestry Promotion and Cooperation Center (JIFPRO) is implementing a project to export reforestation technologies to developing countries. In FY 2020, technology demonstrations were conducted in dry forest areas, coastal zones, and low nutrient lands. These technologies are available on the web in English and Japanese as Technical Note for Tree Planting Practices.[93]

Business models for forest protection

- A business model plan has been published that contributes to sustainable forest management and improvement of those living in forest areas.

2025-35

Case study

Japan International Forestry Promotion and Cooperation Center (JIFPRO) released the Forest Business Database of Developing Countries (BFPRO) online. The database promotes new business models that make use of forest resources such as African blackwood, cacao beans, and beeswax.[94]

Solutions Clues to solution [Regulatory Trends]

- In China, where air pollution control had not been adequately addressed, there have been moves to strengthen measures. Amendments to the Environmental Protection Law (2014) has tightened penalties for violators,[95] and significant progress was made during the 13th Five-Year Plan (2016–2020 in establishing emission standards for pollutants.
- China is also pursuing regulations on waste imports. In 2017, the Chinese government announced that the import of foreign wastes, such as waste plastics, waste papers (excluding newspapers), magazines, cardboards, and cartons would be gradually phased out. In response to these regulations, Japan began providing emergency subsidies for waste plastic sophistication facilities in 2017, but also enacted amendments to the Waste Management and Public Cleansing Act in 2018, and the Act on Control of Export, Import and Others of Specified Hazardous Wastes and Other Wastes (Basel Law) in 2018[96]

- International regulations on marine debris are being tightened. At the G7 Summit held in June 2018, the Ocean Plastics Charter was proposed, and the E.U. is tightening regulations on single-use plastics. Following the publication of the EU Plastics Strategy in January 2018, the Council of the E.U. approved a new directive in May 2019 banning single-use plastic tableware and polystyrene foam containers. In Japan, the Act on Promoting the Treatment of Marine Debris was revised in 2018 to add controlling measures against microplastics. In the future, fish and shellfish containing microplastics could be subject to export regulations like food additives.[97]
- In June 2019, the Osaka Blue Ocean Vision was shared at the G20 Ministerial Meeting on Energy Transitions and Global Environment for Sustainable Growth. The Vision calls for zero tolerance on new pollution from marine plastic waste by 2050.
- Subsequently, at the G7 Hiroshima Summit in May 2023, the goal of achieving zero plastic pollution was accelerated to 2040.[98]
- In March 2022, the United Nations Environment Assembly (UNEA) adopted a resolution to establish an intergovernmental negotiating committee to develop a legally binding international instrument to promote effective measures against marine plastic waste. Their intent is to begin negotiations in the second half of 2022, complete work by the end of 2024, and adopt a treaty in 2025.[99]
- In recent years, the increase in the clearing of forests to construct solar power plants has aroused opposition from residents requiring disaster prevention and environmental protection. The Forestry Agency has turned to strengthening regulations and in 2019 established detailed operating rules in the Forest Land Development Permit Standards for solar power plants. An increasing number of local governments are establishing their own ordinances to regulate forest clearing for solar power development.[100]
- The EU established a regulation in May 2023 to ensure that products distributed in or exported from the region do not contribute to deforestation or forest degradation. The regulation will require any operator or trader to be able to prove that the products, including their raw materials, do not originate from recently deforested land or contribute to forest degradation throughout the production process starting in December 2024. Seven items are designated to be reported: soy, beef, palm oil, wood, cocoa, coffee, and rubber.[101]

Relevance to the SDGs

Problems

Intensifying environmental deterioration and pollution

Societal Issues

Take immediate action to assess the current situation, analyze underlying factors, and implement countermeasures

Relevance to the SDGs

3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination

11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment

14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

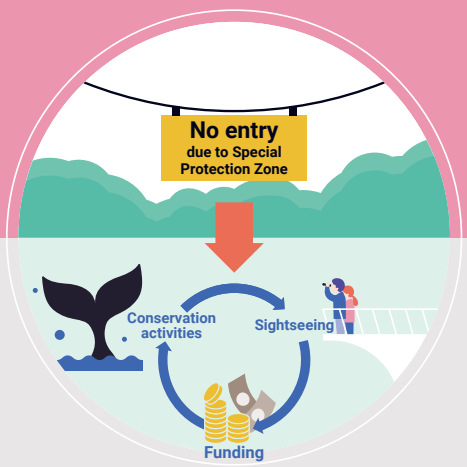
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels

15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally

15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world

Biodiversity loss creates unintended consequences

Loss of biodiversity can cause a variety of problems, including global warming, food shortages, and increased infectious diseases



Create tourism resources in areas inhabited by rare species and secure funds for conservation

Developing educational tools and business models that lead to the conservation of rare species

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Loss of biodiversity

In recent years, biodiversity has been severely damaged by deforestation and invasion by non-native species. "Biodiversity" refers to the wide variety of organisms and ecosystems on Earth that play an essential role in maintaining lives and natural systems. The International Union for Conservation of Nature (IUCN) has published a list of endangered species called the Red List, stating that more than 44,000 of the 2.13 million species known to exist on the planet are in danger of extinction. There are concerns that the loss of biodiversity could lead to a negative cycle of global warming, food shortages, and an increase in risk of infectious diseases.[102]

However, recent efforts intended to conserve and protect the environment have instead at times resulted in adverse effects on general biodiversity.[103]

The installation and operation of renewable energy-related facilities have reduced the habitat area of organisms in the ocean and forest, resulting in changes to the reproduction and behavior of certain ecosystems.

Experts are concerned that the practice of regularly administering substantial amounts of antibiotics to livestock could lead to life-threatening infections for both the animals and for humans. Not only can antibiotics from livestock can contaminate soil and water, but new bacteria that are antibiotic-resistant can also be produced as a result.

World
Potential impact estimates

Diverse ecosystems provide four important functions:
(1) Provisioning services (food and water supply)
(2) Regulating services (purification of air and water; disaster prevention)
(3) Cultural services (cultures that enrich human life)
(4) Supporting services (foundations for green plant photosynthesis and soil formation)

The economic value these functions provide to the earth and humanity is estimated to be USD 33 trillion per year.[104](C)

Issues

Maintain sustainable coexistence between humans and other living creatures

Key Points for Resolving Issues

Visualization

[Understanding the actual condition of ecosystems and their segregation]

Although living creatures and organisms on earth have coexisted for a long time, it has become clear that human activities have often led to the loss of biodiversity and to environmental destruction. This has resulted in many loud and clear calls for conservation. Ecosystems, however, cannot be conserved if humans simply stopped interacting with nature. For example, significant deterioration has been observed in farming villages and other rural areas that has been caused mainly by the aging and declining population. These population changes result in an imbalance in biodiversity, where certain organisms face extinction while others increase to excess. Therefore, it is important to analyze the diverse organisms that originally inhabited the area and their interdependence in order to create an environment in which humans and organisms can live in harmony. At the individual level, it is possible to indirectly contribute to the preservation of ecosystems by accessing and learning about the real-world status of the planet. There are high expectations for a mechanism to increase awareness of ecosystems through the use of advanced technology.

Key Points for Resolving Issues

Commercialization

[Securing conservation funds through the utilization of ecosystems]

In the past, conservation efforts were limited to protective initiatives, such as banning entry to areas inhabited by rare organisms. In recent years, proactive efforts have become more common, like inviting tourists to the destination to increase awareness of the rare organisms, as well as channeling the tourism revenue into conservation activities. Establishing a system to secure conservation funds acquired through utilizing biodiversity will enable sustainable coexistence between humans and other organisms.

Solutions

Clues to solution [Technological Trends]

Visualization

Practical implementation period

- State-of-the-art techniques for surveying and monitoring are being used to visualize ecosystems, including invasive non-native species, and to research ways to mitigate their impacts — 2025-35

Case study

In the area around Nishinoshima Island in the Ogasawara Island region, research is being conducted to reveal the primitive ecosystems of terrestrial and marine organisms by utilizing drones and unmanned underwater vehicles, such as AUVs and ROVs.[105]

The University of Georgia in the U.S. is providing the Early Detection and Distribution Mapping System, or EDDMapS. The system collects an enormous amount of data on non-native species and pest insects that are observed by individuals and volunteers. This information is compiled into a distribution map as a platform. This map is available to the public.[106]

A Japanese company, Biome, has developed an app, also named "Biome", to help collect data on living creatures. The company collects and compiles posted images, locations, and time on the app to visualize data on the distribution and impact of each organism. (Biome Inc., Japan)[107] In Japan, Biome is the sole source of integrated biological information from multiple sources, and user contributions within Biome have led to the discovery of an invasive species of Yolinus albopustulatus.[108]

- Opportunities to learn about biodiversity are becoming more accessible through exhibitions and art with advanced technologies. — 2020-25

Case study

Mori Building Co., Ltd. and teamLab Inc. opened a digital art museum MORI Building DIGITAL ART MUSEUM: teamLab Borderless. A device to learn about endangered species and ecosystems has also been installed in Graffiti Nature - High Mountains and Deep Valleys, Red List.[109]

- More tools are becoming available for children to both enjoy and learn about biodiversity. — 2020-25

Case study

The smartphone app LINNÉ LENS instantly identifies creatures in aquariums and zoos when users hold up their smartphone. Users can have fun learning about the species through the collected and categorized data.[110]

Innoqua Inc. possesses the technology to realize coral spawning in an artificial tank. Using this technology, the company has developed a hands-on environmental edutainment program called the Coral Reef Lab for elementary school students to learn about essential themes, such as the fun and possibilities of the ocean and its creatures, environmental issues through coral (an iconic symbol of the marine ecosystems), and the symbiosis between humans and nature.[111]

- Guidance and evaluation tools for measuring biodiversity are being developed. — 2020-25

Case study

ThinkNature Inc. provides TN LEAD, a service that enables companies to quantitatively evaluate and analyze their impact on nature to help them disclose information on the environment in accordance with the guidance of Taskforce on Nature-related Financial Disclosures (TNFD).[112]

Commercialization

- Business models are being developed to conserve and utilize rare organisms, mainly in the tourism and agriculture sectors. — 2025-35

Case study

Honeybees play an essential role in developing pharmaceuticals and in the growth of vegetables and fruits. Efforts to cultivate and conserve honeybees on the rooftops of urban buildings are gaining popularity in many cities nationwide. This initiative is helpful not only for urban greening and ecosystem conservation but also for the creation of local communities dietary and environmental education for children. Companies are also experimenting in attempts to create a viable business model by selling honey from beekeeping.[113]

Toyooka City is promoting an initiative named "Stork-nurturing Agriculture." This rice farming method minimizes the use of pesticides in order to increase the number of living creatures in rice fields. In addition to preserving the storks, this farming method has also provided economic benefits through increased farmer income and eco-tourism.[114]

Nestlé S.A. is focusing on regenerative agriculture aimed at conserving and restoring farmland and its ecosystems. They aim to raise the share of key raw materials sourced from regenerative agriculture to 20% by 2025 and 50% by 2030.[115]

- Efforts to offset biodiversity impacts by companies, mainly overseas, are progressing. — 2020-25

Case study

In 2005, Walmart Inc., in coordination with the National Fish and Wildlife Foundation (NFWF), began implementing a new initiative. Every time a new store is opened, Walmart will pledge to provide funds to help preserve the ecosystem of the land larger than the size of the floor space of the new store.

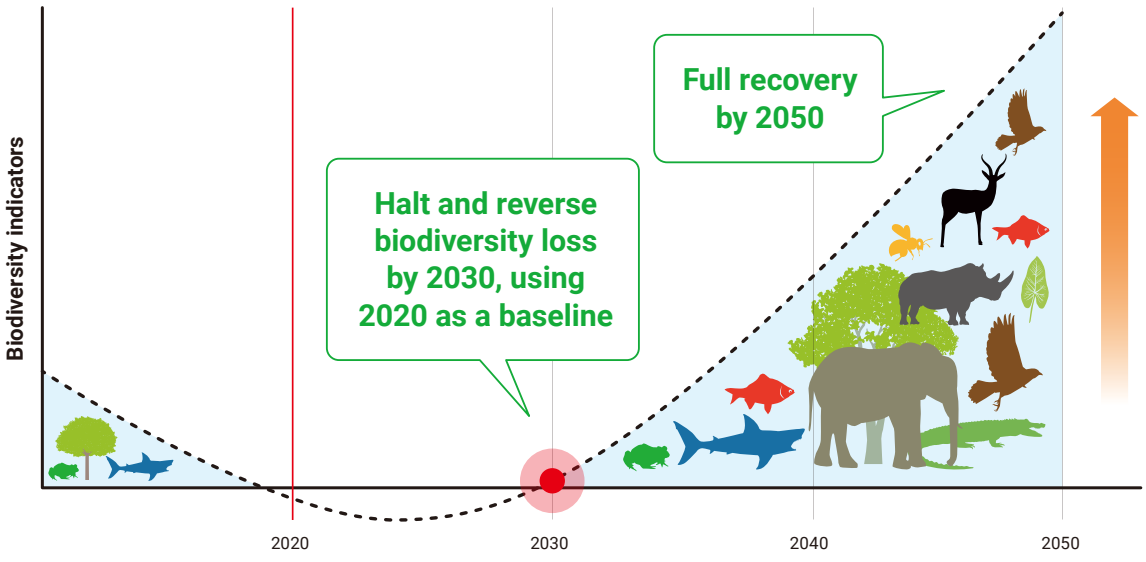
Solutions

Clues to solution [Regulatory Trends]

- Green infrastructure is being developed and is expected to create sustainable and attractive communities by utilizing the diverse functions of the natural environment, such as by providing habitats for living organisms, forming desirable landscapes, and controlling rising temperature. It will also contribute to ecosystem conservation, as well as disaster prevention and mitigation. Additionally, these changes will increase the attractiveness of urban and living environments. Currently, implementation is progressing through a public-private partnership platform formed across various ministries and agencies[116]
- The Ministry of the Environment (MOE) released two publications with the intent to enhance biodiversity conservation as a business of the private sector so that loans and investments will become available more easily available to innovators. Current publications include the Casebook on Biodiversity Engagements by Private Sector and the Good Practices in Corporate Disclosure Related to Biodiversity and Natural Capital.[117]
- The Ministry of the Environment (MOE) is also promoting the National Park Enjoyment Project. By enhancing the brand value of domestic national parks and increasing the number of foreign visitors to Japan, the project aims not only to promote regional development but also to raise awareness of ecosystem conservation.[118]
- The second session of the 15th Conference of the Parties (COP15) to the Convention on Biological Diversity (CBD), which was ratified by about 200 countries, was held in Montreal, Canada from December 7 to 19, 2022(the first session was held in Kunming, China, from October 11 to 15, 2021). The Kunming-Montreal Global Biodiversity Framework was adopted as the successor to the Aichi Biodiversity Targets, which were set in 2010 but were ultimately not met. The following four directions were determined:

  1. Targets for conservation (30 by 30 target),
  2. Targets for business and mainstreaming,
  3. Targets for nature-based solutions, and
  4. Review mechanisms (national strategy revisions by COP16 and monitoring framework including review by COP17).[119]

- At COP15, a new global goal of "halt[ing] and revers[ing] biodiversity loss and set[ting] it back on the path of recovery by 2030" as well as general "nature positivity" was explicitly codified (see figure below.)The World Economic Forum (WEF) report The Future of Nature and Business (2020) argues that the transition to a nature-positive economy will create USD10 trillion/year in business opportunities and approximately 400 million jobs by 2030.[120]



Source: World Wide Fund For Nature (WWF) Japan website

- At the G7 Summit in the U.K. in June 2021, the G7 countries pledged themselves to the "30 by 30 target", which seeks to conserve more than 30% of land and sea as healthy ecosystems by 2030. However, Japan has fewer conservation areas, such as national parks, than the G7 target. To meet this goal, land that has been protected and promoted traditionally by local communities, companies, and organizations, such as "satochi-satoyama," corporate forests, and shrine and temple forests are registered as OECMs (Other Effective area-based Conservation Measures) in an international database to promote their conservation.[121]
- There is a growing trend toward financial institution-led information disclosure in order to better understand the impacts of biodiversity on society and businesses. In September 2023, The Task Force on Nature-related Financial Disclosures (TNFD) published a framework for companies and organizations to report and act on nature-related risks. In the future, it will become mandatory to disclose the impacts of business activities on nature.[122]

Relevance to the SDGs

Problems

Loss of biodiversity

Societal Issues

Maintain sustainable coexistence between humans and other living creatures

Relevance to the SDGs

6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism

14.b Provide access for small-scale artisanal fishers to marine resources and markets

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04

A Society Where All People Can Meet Their Mobility Needs In A Free, Safe, And Clean Manner

Mobility

The advancement of transportation systems and resources, including cars and railroads, has enabled consumers to expand their range and means of traveling. While developments in the mobility sector have enriched people's lives, they have also caused environmental problems and economic losses due to traffic congestion and accidents. Since most populations are concentrated in urban areas, the operation of buses, railways, and other public transportation has been reduced or even eliminated in more rural areas, especially areas with declining population, forcing suburban residents to increasingly rely on private automobiles. In addition, changes in public transportation, logistics services, and the social environment have highlighted the need for business reform. In the logistics industry, addressing the shortage of truck drivers created by the implementation of the Work Style Reform Bills has also become an urgent task.

New technologies and services must be developed to resolve these problems. Automobile manufacturers are introducing new technologies to improve safety and transition towards electric vehicles. The energy industry is developing new forms of energy aiming to create CO_2 emission-free cars and aircraft Public transportation companies are using AI to improve the convenience of demand-responsive transport (DRT) and streamline bus operations through autonomous driving. In response to the shortage of truck drivers, logistics companies are providing services to improve loading efficiency by matching the load capacity of trucks with the shipment size and volume. There has also been significant progress on automating warehouse operations and improving last-mile efficiency. In suburban areas, drones are also being used to fulfill last-mile operations.

At the same time, digitization and the shift to online operations have expanded the possibilities for new activities and communication. In addition to transportation for just commuting to work, going shopping, and transporting goods, new mobility-based value is being created that brings enjoyment and affluence to consumers. These new services include personal transportation based on individual users' tastes and feelings, virtual travel experiences using remote-controlled robots, a sharing service for compact EVs in tourist sites and electric scooters in cities, and an in-car entertainment concept that utilizes autonomous driving. The development of services to make better use of travel time can additionally lead to new business opportunities.

Utilizing the perspectives above, ICF has organized the problems and issues in the mobility field into the following four categories:

The popularization of car-centric infrastructure consistently creates societal issues

The spread of automobiles has caused many world-wide issues, including traffic congestion, accidents, and environmental pollution

Optimization of traffic volume, bolstering functions to avoid or mitigate serious accidents, and reducing cars' overall environmental impact

Development of technologies for path control and safety functions using quantum computers, and promotion of decarbonization through low-impact production

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Adverse effects of vehicle-centric transportation systems

Traffic congestion is frequently seen within and between cities worldwide and is the cause of enormous economic losses. Thanks to the measures taken both in hardware and software, congestion is declining. Even in developed countries where populations are decreasing and cities are becoming more compact, however, congestion continues to cause substantial economic losses.

Given the popularity of automobiles, cars were often prioritized in construction of roads and in urban planning. Unregulated urban expansion in the suburbs (called urban sprawl) was also based on the assumption that most people use cars. In recent years, fatal traffic accidents been occurring more frequently where the elderly are either victims or perpetrators.

Automobiles are a major cause of environmental problems, such as NO_X from exhaust gases that cause air pollution, CO_2 emissions that accelerate global warming, and noise that is a nuisance to surrounding communities.

World
Potential impact estimates

The COVID-19 pandemic reduced traffic congestion in 2021. Nonetheless, the financial losses from congestion are estimated to be around JPY 21.4 trillion in the U.S., JPY 6.2 trillion in the U.K., and JPY 4.0 trillion in Germany. (B)

Estimation Method

Overall economic loss = Economic loss per driver in a country[1]/year multiplied by the population of the country (2020)[2]

Electric vehicles and renewable-energy power generation systems have the potential to fully replace fossil fuel vehicles. If this happens, an estimate has suggested that it could reduce CO_2 emissions by approximately 20% compared to a scenario where no policy initiatives are implemented.[3](C)

Japan
Potential impact estimates

Though the number of traffic fatalities decreased by 42% in 2022 compared to 2012, fatalities of seniors aged 65 and over only decreased by 35%.[4] Similarly, the number of total accidents decreased by 56% in 2021 compared to 2011, but accidents caused by elderly drivers were decreased by only36%.[5](B)

Issues

Optimizing traffic flow and promoting the use of safe and comfortable mobility services

Key Points for Resolving Issues

Optimization

[Solutions that promote the leveling of traffic volume and congestion time]

Demand-side management, through advancing technology and control mechanisms, that equalizes traffic demand and disperses traffic where and when it is concentrated is part of an effective solution for dealing with urban traffic congestion. For example, newly advanced functions of car navigation systems can guide drivers to uncongested roads, while sophisticated traffic prediction systems that utilize private sector data from via telematics like drive data coupled with AI can forecast ideal travel times. It is also important to build mechanisms to encourage demand-side behavior modifications, such as promoting staggered commuting and telework to reduce traffic congestion during morning and evening rush hours.

Key Points for Resolving Issues

Accident Prevention

[Enhancing safety support functions in vehicles and on roads]

Many new vehicles sold in Japan are already equipped with systems to support safe driving. New technologies are being developed to prevent accidents caused by unsafe turning at intersections, as well as to manage drivers' physical health and prevent accidentally stepping on the accelerator during braking.

On the other hand, the emergence of electric scooters as a new means of transportation has raised concerns about new forms of traffic accidents, necessitating the expansion of safety measures.

Key Points for Resolving Issues

Reducing Environmental Impact

[Promoting the spread and use of transportation with low environmental impact]

In order to reduce the environmental impact of the mobility sector, including cars, it is particularly effective to replace them with clean energy vehicles (CEVs). Improving fuel efficiency and developing fuels with lower environmental impact are also important steps.

In addition, it is essential to introduce services that support eco-friendly mobility, such as shared rides to improve operational efficiency, and encourage city-wide switches to bicycles and electric scooters that have less impact on the environment.

Solutions

Clues to Solutions [Technological Trends]

1. Optimization

Practical implementation period

Route control and adjustment synchronization

- New technologies that utilize AI analysis and digital twins are enabling successfull traffic flow smoothing and clearing, which are in turn making highly accurate route guidance possible. For example, digital twins can replicate a world within cyberspace based on high-definition geospatial and sensor information. Researchers can conduct social experiments, which could be difficult to organize in the real world, and reproduce traffic flow through simulations.

2025-35

Case study

TOYOTA CENTRAL R&D LABS., INC. and the University of Tokyo (JAPAN) have developed a method using quantum computing to adaptively control urban traffic lights to operate in sync with traffic conditions.[6]

NTT Human Informatics Laboratories is studying the use of digital twins to optimize traffic flow that does not cause congestion. By using traffic-demand data with fine temporal and spatial granularity they are working to reproduce real traffic flow on the digital twin world and to predict future traffic flow.[7]

- The development of systems that use highly accurate GPS satellite location information to generate lane-by-lane traffic congestion information and provide efficient route guidance that avoids congested lanes, as well as systems that charge vehicles with tolls for entering cities during busy hours, is underway.[8,9]

2020-25

Behavioral modification on the demand side

- Systems that encourage drivers to avoid traffic jams by providing traffic congestion forecasts using big data are becoming more widespread.

2025-35

Case study

NTT DOCOMO Inc., Hitotsubashi University, and Ritsumeikan University, in collaboration with the Gotemba Premium Outlets' operator MITSUBISHI ESTATE SIMON Co., Ltd., Central Nippon Expressway Co., Ltd., and the Gotemba City Tourism Association, have embarked on a proof-of-concept experiment in 2021 to reduce congestion and traffic jams by using nudges. This initiative aims to reduce CO_2 emissions by distributing tourist information.[10]

In July 2022, the Vehicle Information and Communication System Center (VICS Center) announced that it would expand nationwide the additional VICS information provision using probe information gathered independently by private institutions, such as Toyota Motor Corporation, Nissan Motor Co., Ltd., Honda Motor Co., Ltd., and Pioneer Corporation. Based on a demonstration experiment that has been conducted since April 2020, the center concluded that the probe information contributes to avoiding congestion and achieving smoother traffic flow.[11]

2. Avoiding Accidents

Safe driving technologies

- Technology has been developed to utilize facial image analysis and vital sign monitoring sensors to constantly monitor drivers' health conditions. System development is also underway to switch to autonomous driving when the system detects an abnormality, such as drowsy driving or when the driver's poor health condition becomes debilitating, and to move to a safe location, stop, and make an emergency call.[12] — 2025-35
- An accident-avoidance technology using road-to-vehicle and vehicle-to-vehicle communication has been developed to prevent collisions in intersections between vehicles making a turn and going straight. In addition, to prevent accidents that occur at blind turns, a blind spot information system that uses AI cameras to detect cyclists and pedestrians to warn drivers has been launched. — 2020-25

Case study

SoftBank Corp. and SUZUKI MOTOR CORPORATION have jointly tested and confirmed the utility of a system that uses vehicle-station and vehicle-vehicle communication to warn drivers of both oncoming and turning vehicles when there is a risk of a collision in an intersection.[13]

In November 2022, INBYTE Co., Ltd. launched i7, an AI camera system for preventing entanglement accidents. It is an optional blind spot information system that detects cyclists approaching the rear blind spot of large trucks and will subsequently warn drivers.[14]

Ensuring pedestrian safety

- Technology has been developed to automatically display a crosswalk across the road when a pedestrian is about to cross. — 2025-35

Case study

Umbrellium Ltd., a U.K. company, has developed and is conducting a pilot run of a road sign control system that dynamically displays crosswalks over roads. The system displays crosswalks and stop lines on pavement in response to the presence and movements of pedestrians and bicycles.[15]

- Safe and secure traffic spaces where people are prioritized are being developed. — 2025-35

Case study

In an effort to promote the development of safe and secure community roads that prioritize people, Zone 30 Plus was established in August 2021 in Japan. Police and road administrators are coordinating on the installation and expansion of the zone nationwide to improve traffic safety through an appropriate combination of speed limit regulations (capped currently at 30jm/hr) and physical devices.[16]

Efforts to build comfortable and walkable cities are underway around the world.[17] Walkable city initiatives limit automobiles entering designated areas, and instead introduce one-person personal mobility vehicles and mobile shops, where the stores themselves move around to provide services.[18]

3. Reduction of Environmental Impact

Reducing environmental impact of vehicles

- There is a movement towards decarbonizing automobile and aircraft fuels, including the production processes and their materials.

2025-35

Case study

ENEOS Corporation is working to drastically reduce CO_2 emissions and to achieve carbon neutrality in the transportation sector, such as automobiles and aircraft, by developing technologies for the production of synthetic fuels made with CO_2 and hydrogen, which can replace existing petroleum products (gasoline, jet fuel, diesel, etc.).[19]

Sustainable aviation fuel (SAF) is a jet fuel made from renewable or waste materials that meets sustainability criteria. The JAL Group has set a goal of replacing 10% of all fuel loads with SAF by 2030.[20]

- Ridesharing using private cars owned by individuals is expected to reduce the total volume of traffic through carpooling among multiple people heading in the same direction. The advantage of ridesharing is that private car owners can provide services in their spare time, and users can use the service at a discount. Since anyone can become a service provider, however, there are concerns about the quality of the drivers, problems between drivers and users, and responses to accidents.

2020-25

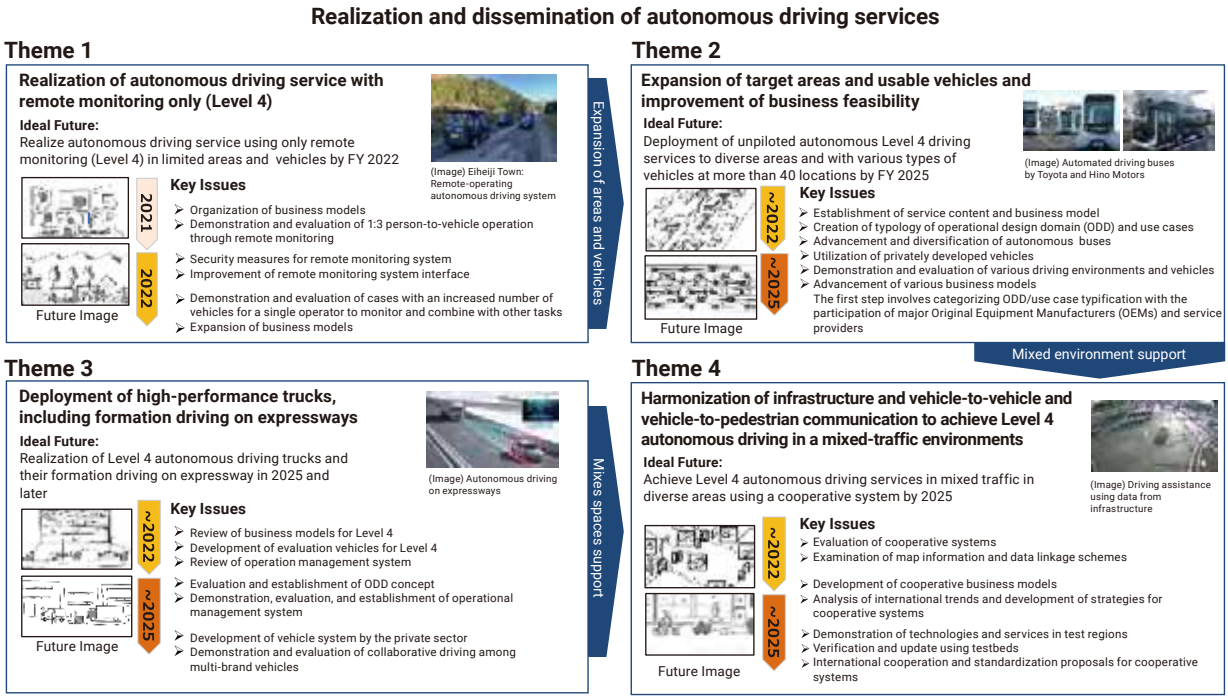
Case study

NearMe Inc. and Mitsubishi Estate Co., Ltd. conducted a demonstration experiment of an urban MaaS for the Mitsubishi Estate Residence Club members from November 16, 2020, to February 15, 2021. The service is called "nearMe.Town," a door-to-door mobility service in the space between homes and workplaces or shops. "near Me.Town" is an on-demand shuttle ride-sharing service that uses AI to allow users to reserve desired arrival and departure points in operating areas. It features lower prices than taxis because AI chooses the most efficient route for transporting multiple people.[21]

Solutions Clues to Solutions [Regulatory Trends]

- The Ministry of the Environment, Japan (MOE) and the Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) are working jointly to promote Green Slow Mobility, which also attempts to address various regional transportation challenges. The project supports demonstrations of experimental projects, the promotion of major decarbonization efforts in regional transportation, the fulfillment of the last one mile, the promotion of tourism, and the revitalization of central urban areas.[22]
- The MLIT and the Ministry of Economy, Trade and Industry, Japan (METI) began temporary tax reduction measures in 2019 to promote the purchase of eco-friendly cars.[23]
- The MLIT established the Walkable Downtown Promotion Project in FY 2020 to provide focused and integrated support for restoring and utilizing existing infrastructure such as streets, parks, and plazas for the construction of walkable cities.[24]
- The MLIT has introduced Japan's first dynamic road pricing system to reduce traffic congestion on the Metropolitan Expressway by adding or discounting tolls depending on the time of day during the 2022 Tokyo Olympic and Paralympic Games.
- In November 2021, the MLIT mandated the installation of automatic brakes in all new passenger vehicles produced in Japan. Automakers are also encouraged to further develop such technology.

- Emission regulations in Japan are being tightened every year. Other countries around the world are also beginning to restrict the sale of gasoline and diesel vehicles to control emissions. . For example, the British government has announced a plan to completely ban new gas and diesel vehicles by 2035.[25]
- In March 2023, the Council of the European Union formally adopted a bill to revise carbon dioxide (CO_2) emission standards for cars and commercial vansas part of the Fit for 55 Packge, a comprehensive in the European Green Deal bill proposed by the European Commission (EC) in July 2021. It states that all new cars and vans sold in the EU after 2035 must produce zero CO_2 emissions. However, as an exemption, the sales of new vehicles equipped with a dedicated internal combustion engine using synthetic fuel (e-fuel) or hydrogen will be permitted after 2035.[26]
- The METI and the MLIT have jointly launched the Project on Research, Development, Demonstration and Deployment of Automated Driving toward the Level 4 and its Enhanced Mobility Services (RoAD to the L4). The project aims to realize and disseminate advanced mobility services such as Level 4 autonomous driving through consistent efforts ranging from research and development to demonstration experiments and societal implementation.[27]



Source: RoAD to the L4 (Project on Research, Development, Demonstration and Deployment of Automated Driving toward the Level 4 and its Enhanced Mobility Services) (Japanese only) https://www.road-to-the-l4.go.jp/

Relevance to the SDGs

Problems

Adverse effects of vehicle-centric transportation systems

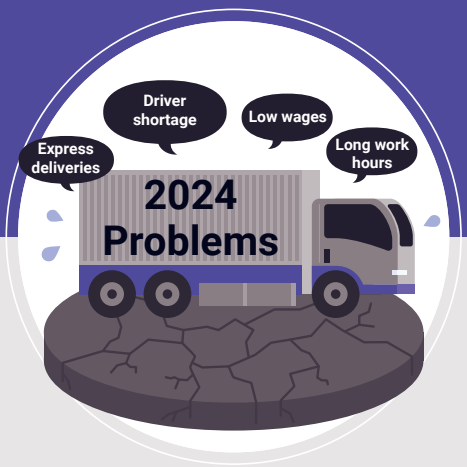
Societal Issues

Optimizing traffic flow and promoting the use of safe and comfortable mobility services

Relevance to the SDGs

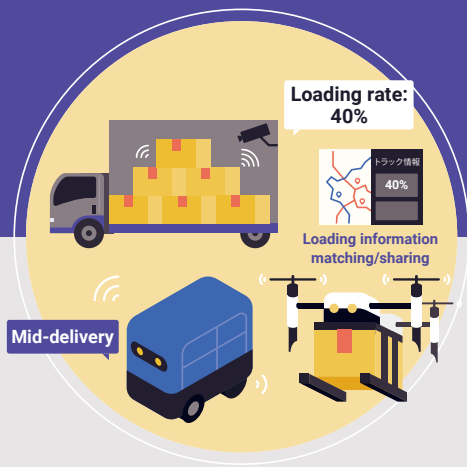
3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents

Logistics and distribution systems can no longer withstand the increased demand



The ability of Japan's logistics services to deliver goods quickly and reliably is in jeopardy due to the increasing frequency of small-lot, high-frequency deliveries, as well as a shortage of drivers.

Optimize the entire supply chain and develop driver-independent transportation and delivery methods



Improved efficiency of deliveries through coordination and through data monitoring, as well as the labor-saving and automation of deliveries through automated driving and drones

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Insufficient logistics processing capacity for increased demand

Although domestic freight traffic has been on a long-term downward trend, it is becoming smaller-lot and more frequent, mainly due to the rapid increase in home delivery services. As a result, truck loading rates are declining and delivery efficiency is deteriorating.[28]

The trucking industry faces a shortage of drivers mainly due to its harsh labor environment, including low wages and long working hours.

Under these circumstances, the Standards for Improvement of Working Hours for Vehicle Drivers will be applied in April 2024 to revise the maximum working hours and ensure rest periods for truck drivers. These revisions, however, raise concerns about a further shortage of transportation capacity due to the more limited working hours of each driver.

Japan

Potential impact estimates

The Committee on Sustainable Logistics estimates that if nothing is done to address the so-called "2024 problem," the transportation capacity of commercial trucks could fall by 14.2% in 2024 and another 34.1% in 2030.[29]

Issues

Building a sustainable logistics network

Key Points for Resolving Issues

Improving Delivery Efficiency

[Improving loading rates, coordinating supply chains, and determining optimal routes]

To improve operational efficiency, it is necessary to improve the utilization of existing resources by increasing truck loading rates and reducing waiting times.

To increase the load-to-truck ratio of trucks, it is important for the logistics industry to collaborate on transportation throughout the supply chain, including manufacturers, wholesalers, and retailers. It would also be effective to use sensors and cameras to monitor loading conditions and to match freight transportation demand with truck loading information.

In addition, it is necessary to minimize driving distance and time by configuring optimal routes. A service that detects the absence of recipients and provides drivers with optimal routes to avoid redelivery is being developed.

Key Points for Resolving Issues

Labor Saving and Automation

[Autonomous driving, utilization of delivery robots and drones]

Autonomous truck driving can be an efficient solution to compensate for the shortage of drivers in an environment where demand continues to increase. Semi-autonomous truck platooning technology, where multiple trucks are wirelessly connected and a crewed lead truck "tows" the remaining uncrewed vehicles, is one technology that is being developed. Demonstration of Level 4 autonomous driving trucks in dedicated lanes is also underway.

Delivery robots and drones are also being put to practical use to enable automatic delivery operations.

Key Points for Resolving Issues

New Delivery Services

[Decentralized personal delivery and mixed-freight consolidation]

Creating non-conventional delivery mechanisms may be the solution to cope with the increase in smaller-lot but higher-frequency type of domestic demand.

Some companies are offering delivery services in which fresh foods or daily necessities are delivered by personal delivery staff using bicycles.

Some transportation service providers have begun making better use of their buses and taxis by utilizing them for cargo delivery or mixed-loading with passengers.

Solutions

Clues to solution [Technological Trends]

1. Improving Delivery Efficiency

Practical implementation period

Coordinating supply chains

- Efforts to realize efficient logistics have started to take place not just among logistics providers but across the entire supply chain. R&D is also underway to build and utilize a database that collects, centrally manages, and visualizes the distribution information and commercial flow of the entire supply chain.[30]

2020-25

Case study

NEXT Logistics Japan Co., Ltd. is promoting the transportation of mixed-freight loads using double-trailer trucks. The company aims to carry more cargo per driver while increasing the loading ratio by consolidating cargo across different industries and businesses. At the same time, by utilizing a system called NeLOSS, which is linked to a quantum computer, the company aims to improve management and the accuracy of transportation forecasts, and to further increase the loading capacity of cargo rooms by optimizing personnel positions based on specific skills.[31]

Photographs: Courtesy of NEXT Logistics Japan Co., Ltd.

- Dynamic pricing is being introduced in the logistics industry as a mechanism for leveling the volume of deliveries and efficiently utilizing delivery resources.

2020-25

Case study

Seino Information Services, Co., Ltd. (Japan) has developed a system to level delivery volumes. The system uses AI to predict demand and apply discounted rates for early delivery reservations.

Matching shippers and trucks

- Research and development is underway for technologies that utilize sensors and cameras to monitor truck loading status. Through this, services are being implemented to match shippers' transportation demand with truck loading information to reduce driving with low loading rates.

2020-25

Case study

a-xross corp. (Japan) operates "Trakuru Go", a delivery matching service that connects shippers and carriers. Shippers can compare fares of multiple carriers and simplify the work involved in making arrangements. The carriers can search across Japan for shipments that match load availability.

Four Japanese companies, Nippon Express Company, Ltd., SoftBank Corp., Sharp Corporation, and Wireless City Planning Inc., conducted a proof-of-concept experiment of an automatic matching system for trucks with pickup and delivery demands. The experiment also verified a load monitoring technology that acquires trucks' location, weight data, and 3D images of the luggage area and transmits them to the controlling personnel via a 5G wireless network.[32]

Optimizing routes

- Technology has been developed to determine optimal routes for efficient transportation derived from truck driving records and in-car sensors. — 2020-25

Case study

Groovenauts, Inc. (Japan) has begun offering a service to optimize logistics and distribution operations using quantum computers. The service automatically calculates and indicates optimal delivery routes with the shortest driving distance and time based on various information, including truck loading and operating status, driver skills and working conditions, destination and designated delivery time, and customer-specific requirements.[33]

Avoiding redelivery

- Aiming to reduce redelivery and optimize delivery routes, research and development is underway for a system that detects the absence of recipients based on data from household electricity smart meters and uses AI to suggest delivery routes. — 2020-25

Case study

Japan Data Science Consortium Co. Ltd., SAGAWA EXPRESS CO., LTD., The University of Tokyo, Yokosuka City, and Grid Data Bank Lab. LLP (Japan) conducted a proof-of-concept experiment of a system that detects absences based on power consumption data obtained from smart meters to propose AI-calculated optimal delivery routes. In a field trial in Yokosuka City from October to December 2020, redelivery caused by recipients not being home was reduced by about 20%.[34,35]

2. Labor-saving and Automation

Autonomous driving

- Uncrewed truck platooning technology is being developed to cope with the shortage of truck drivers and to improve operational efficiency. Development is also underway for technologies that that maintain a safe distance between vehicles through automatic control as well as for semi-autonomous truck towing technology that enables platoons to be led by a crewed towing truck.[36] — 2020-25
- The Japanese government (the MLIT and the METI) plans to install dedicated lanes for autonomous driving vehicles on the Shin Tomei Expressway and begin demonstration experiments of Level 4 autonomous driving trucks in FY 2024. — 2025-35

Case study

Japan's Ministry of Economy, Trade and Industry (METI) and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) promoted the development of the semi-autonomous truck platooning to realize uncrewed vehicle formations on highways by the end of FY 2020. In February 2021, the two ministries commissioned Toyota Tsusho Corporation to experiment in which three large trucks traveled at 80 km/hour in formation with a nine-meter distance between each vehicle.[37]

In April 2023, T2 Inc. conducted a proof-of-concept experiment of Level 4 autonomous driving, which does not require a driver given certain conditions, such as route or speed, using large trucks on an expressway in Chiba Prefecture.[38]

Home delivery robots and drones

2020-25

- Proof-of-concept experiments of an uncrewed delivery service are being conducted using micro-mobility, drones, and vertical takeoff and landing aircraft (VTOL). In particular, efforts to put drones to practical use is being pursued for small-lot delivery to sparsely populated areas and on remote islands.[39,40]

Case study

In October 2021, Kawasaki Heavy Industries, Ltd. conducted two proof-of-concept experiments of an uncrewed VTOL for delivery to a mountainous area in Ina City, Nagano Prefecture. In November of the same year, a coordinated delivery test of complete uncrewed transportation was conducted by linking a VTOL and a delivery robot. The experiment involved the following steps: (1) the delivery robot loaded with parcels boards the uncrewed VTOL unassisted, (2) the VTOL takes off flies, and lands autonomously, and (3) the delivery robot autonomously disembarks from the VTOL and delivers the parcels.[41]

In March 2023, JAPAN POST Co., Ltd. carried out a Level 4 flight experiment in Okutama Town, Tokyo in which a drone was flown outside the pilot's sight range. In the test, packages were delivered to a house in a mountainous area about two kilometers from the Okutama Post Office. The drone flew over residential and mountainous areas for about five minutes on a predetermined route.[42]

3. New Delivery Service

Decentralized personal deliveries

2020-25

- A new business that handles small-lot deliveries has begun matching shippers with individual delivery workers, who then undertake direct home deliveries by bicycle or motorbike.

Case study

SAROUTE Co., Ltd. (Japan), a motorcycle courier company, operates a cloud service that matches shippers with individual drivers. The app enables every part of the process in one place, from orders to payments. The drivers then deliver goods by bicycles or motorcycles in their free time.[43] SAROUTE, in collaboration with certain pharmacies, began a pilot service for prescription drug delivery in 2022.[44]

Mixed-freight loading of cargo and passengers

2020-25

- Transportation service providers are now offering mixed-loading transportation in which they carry both cargo and passengers simultaneously on an on-demand vehicle.

Case study

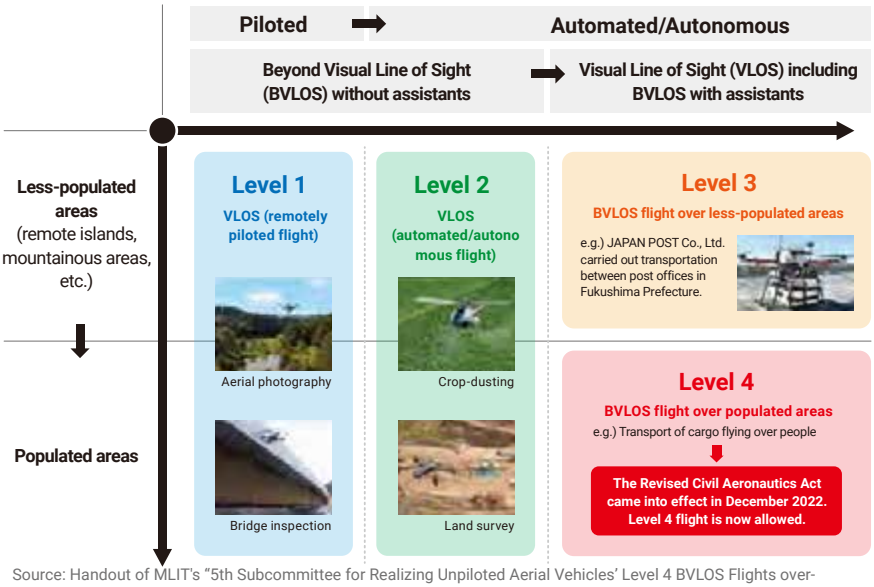
Mirai Share Co., Ltd. (Japan) uses shared taxis to provide on-demand transportation that combines the transportation of passengers and the delivery of goods and groceries purchased from affiliated stores.[45]

Solutions

Clues to solution [Regulatory Trends]

- The Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) has implemented measures to support initiatives to improve the efficiency of distribution operations through the Act on Advancement of Integration and Streamlining of Distribution Business. The measures support efforts to reduce stress on the environment and contribute to labor-saving through collaboration of two or more companies.[46]
- The MLIT has allowed paid deliveries by private vehicles only during designated busy seasons such as year-end, new year holidays and summertime. The approved carriers are required to provide safety guidance on operation and labor management.[47]
- In 2020, the National Police Agency (NPA) defined procedures for proof-of-concept experiments for autonomous delivery robots on public roads. The NPA requires business operators to accompany the robot in person throughout the experiment to monitor and operate the robot. In 2021, the agency established the Road Use Permits Standard to simplify the procedure when specific requirements are met, such as when an automated delivery robot has a driving record of 240 hours or more.[48,49]
- Since 2020, the MLIT has been studying ways to improve the regulatory environment surrounding remotely controlled UAVs and drones in inhabited areas. As a countermeasure against frequent accidents and unauthorized flights, registration of UAVs will become mandatory after June 2022, and flights of unregistered aerial vehicles will be prohibited.[50,51]
- Truck drivers work 20% longer hours per year than the average for all industries and have the highest number of workers' compensation claims and approvals. Since April 2024, a cap on overtime work (960 hours per year excluding holidays), will be established for truck drivers under the Work Style Reform Bills. In line with this cap, working and rest hours were also reviewed in the Standards for Improvement of Working Hours for Vehicle Drivers under the jurisdiction of the MLIT.[52]
- METI and MLIT have been promoting the "RoAD to the L4" project to achieve their goal of launching autonomous driving mobility services with remote monitoring in abandoned railway sites in FY 2022, which was outlined in the Grand Design and Action Plan for a New Form of Capitalism and Follow-up (June 2022). Under these circumstances, technologies and services for autonomous driving systems with remote monitoring were approved as part of an Level 4 automated system for the first time in Japan in March 2023. Later, in April 2023, the Fukui Prefectural Public Safety Commission approved an application for specified automated driving operation based on the Road Traffic Act for the first time in Japan.[53]
- To realize a more convenient and comfortable society, the MLIT launched a new system for UAVs in December 2022. The system includes model-based certification, pilot certification, and flight operation rules. In addition to the current levels from 1-3, level 4, which is defined by out-of-sight autonomous flights over inhabited areas, is now allowed.[54]

UAV Flight Operations Levels



Source: Handout of MLIT's "5th Subcommittee for Realizing Unpiloted Aerial Vehicles' Level 4 BVLOS Flights over-Populated Areas"

Aged and depopulated areas are becoming inaccessible isolated islands

The number of areas where the public transportation network cannot be maintained is expanding, and the elderly living there are becoming more isolated

Introduce a new MaaS that incorporates transportation services with goods sales and medical services

Complementing the inconvenience of transportation by providing goods sales services with pick-up and drop-off services in collaboration with transportation operators and commercial facilities, as well as mobile sales and door-to-door medical services.

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Difficulty in providing mobility services where transportation is inconvenient

In depopulated areas and suburbs, the business of operating transportation networks is deteriorating due to the decline in the number of users. Although the national and local governments subsidize operating and vehicle expenses to help maintain local transportation, they are unable to fully cover all costs, resulting in reduced or completely discontinued services. Consequently, the benefits of local residents are being harmed, and depopulation has accelerated.

As the number of areas increases where public transportation services are reduced or terminated, senior citizens and people with disabilities who cannot drive will lose their means of mobility.

Japan

Potential impact estimates

In the Tokyo Metropolitan area, the senior population living outside of a 50 km radius from Tokyo and without access to convenient transportation* is expected to increase from 540,000 in 2010 to 1.09 million in 2040.55(A)

*Population of people aged 65 years and over, living in an area that is more than 1 km away from a train station and does not have a bus stop with at least one departure or arrival per hour.

Nationwide, it is estimated that the population of people aged 65 or older who have difficulty shopping for food will increase from 3.82 million in 2010 to 5.98 million in 2025 (difficulty shopping for food is defined as living 500 meters or more from the nearest grocery store and without a car).56(A)

Issues

Providing mobility services to maintain quality of life

Key Points for Resolving Issues

Providing Transportation to Fill Gaps

[On-demand and last-mile transportation]

As public transportation services continue to be reduced or eliminated, inexpensive and convenient transportation services are necessary to maintain the quality of life of local residents.

On-demand transportation is available in some areas as an alternative to public transportation. The challenge is to eliminate the hassle of calling and making reservations that would otherwise reduce the convenience of these services. There is great demand for operators to provide services that are easy for everyone to use, with special consideration for those who do not use computers or smartphones.

For seniors and people who have difficulty walking, it is also vital to provide last-one-mile transportation between statio

Key Points for Resolving Issues

Purpose-driven Transportation Services

[Collaboration and integration of transportation with goods and services]

In order to meet the needs of people living in areas where convenient transportation is not accessible, transportation operators are not the only providers capable of filling the demand gap. Commercial, medical, and tourism vendors could provide transportation as part of their services. Collaboration between transportation operators and these additional service providers is becoming increasingly popular at certain destinations to provide transportation to and from stores as well as home deliveries.

Conversely, another effective way to eliminate inconveniences is for the service providers to move within the proximity of user residences, such as through mobile retail sales and house-call medical services.

Key Points for Resolving Issues

Small-scale Services to Meet Diverse Needs

[Improving operational and network efficiency]

In areas where the demand for transportation is expected to decrease due to declining birthrates, it is important to move from a centralized transportation system to a small-scale, decentralized system to meet diverse mobility needs.

Improving the operational efficiency of existing networks can be achieved with AI-assisted demand forecasting, efficient operation through autonomous driving, and mixed-loading transportation of cargo and passengers.

Solutions

Clues to Solution [Technological Trends]

1. Providing Transportation to Fill Gaps

Practical implementation period

On-demand transportation

2020-25

- On-Demand transportation systems, which operate based on demand without timetables or fixed routes, have already seen significant practical application. However, the inconvenience of making reservations remains a large obstacle in expanding their use. In response, user-friendly apps and reservation kiosks are being developed for users who do not use smartphones or personal computers.

Case study

Dai Nippon Printing Co., Ltd. and Mirai Share Co., Ltd. (Japan) conducted a proof-of-concept experiment in Odai Town, Mie Prefecture, in which an AI-assisted system optimized vehicle dispatching based on on-demand reservations and the locations of active taxis and buses. Reservation kiosks were also placed at roadside stations and local clinics so that seniors without smartphones could easily access the service. The kiosks use digital signage and a touch screen, heavily simplifying the process needed to book transportation home.[57]

Providing last-one-mile transportation

2020-25

- Personal mobility and micro-mobility are attracting attention as means to provide smooth transportation from train stations and bus stops to users' final destinations. Autonomous driving experiments are also being conducted in sparsely populated areas and in tourist spots.

Case study

Tsukuba City and KDDI CORPORATION (Japan) conducted a proof-of-concept experiment linking an autonomous vehicle and an electric wheelchair in efforts to test the efficiency of low-speed personal mobility devices. By using a remote-control device, these autonomous wheelchairs support traditional transportation from residences to hospitals, as well as provide mobility within the hospital facility itself.[58]

Toyota Transportation Research Institute (Japan) conducted an public road test of Toyota's self-balancing two-wheeled personal mobility vehicles. The test was designed to support seniors who have difficulty walking long distances. Because users stand on the vehicle and move slowly, it is possible to travel alongside ordinary pedestrians while conversing with them.[59]

Joint management of multiple transportation operators

2020-25

- In order to support struggling transportation operators in regional cities where centralized management is difficult, there is a movement to allow joint management of these providers and increase the number of users by improving convenience.

Case study

In March 2021, the MLIT granted the first approval for joint management of route bus operators based on the Joint Management Plan for Route Bus Businesses in Kumamoto Area (1st Edition) under the Antimonopoly Act. Five bus operators now work together to improve the efficiency of overlapping routes and equalize waiting times to ensure a standardized level of convenience while maintaining sustainable transportation services in the Kumamoto area.[60]

2. Providing Purpose-driven Transportation Services

Cooperation between transportation operators and service providers

- Recently, transportation operators and destination service providers, such as commercial and merchandise facilities, have begun to collaborate to provide highly convenient services that include activities for consumers at their destinations.

2020-25

Case study

MONET Technologies Inc. and IZUMI Co., Ltd., a shopping center operator, are conducting a proof-of-concept experiment of MaaS for retail businesses by linking mobile services with retail stores. MONET Technologies provides an on-demand bus to pick up and drop off customers at supermarkets. The company also provides a shopping support service that allows customers to order products by phone in advance and pick them up at the store. In addition, the buses are operated as a mixed freight/passenger service in which the on-demand buses simultaneously pick up and drop off supermarket customers and deliver products to their homes.[61]

Mobile retailers and services

- Automakers and retailers such as supermarkets and convenience stores are collaborating to develop uncrewed mobile retail stores using autonomous driving technology. The technology is expected to help resolve problems not just in urban areas but also in more depopulated or rural areas where shopping is difficult.

2020-25

Case study

A U.S. supermarket chain, Stop & Shop Supermarket Company, has partnered with Robomart, Inc. (U.S.) to launch a mobile fresh food grocery sales service of using autonomous driving vehicles, Robomarts, in 2019.[62]

- Vehicles equipped to provide nursing and medical care, as well as administrative services, are being tested on whether they can deliver these services to homes of people who have difficulty traveling or using online services.

2020-25

Case study

care. The multi-purpose medical vehicle visits users and provides online medical care via a certified doctor from a remote location. The service aims to resolve the shortage of physicians in rural areas and simultaneously improve the health of residents with mobility difficulties. A nurse rides on the vehicle equipped with medical equipment to support patients and doctors. In FY 2022, the city plans to provide mobile administrative service by utilizing local community buses during their idle daytime hours.[63] These initiatives are also being implemented in Odai Town, Mie Prefecture[64], and Tokuji District, Yamaguchi Prefecture.[65]

3. Meeting Small-scale Diverse Needs

Improving operational efficiency

- AI enables demand forecasting, traffic congestion prediction, and the ability to search for real-time optimal routes. Practical application of AI-based on-demand transportation services is seeing great success.

2020-25

Case study

Nissan Motor Co., Ltd., and NTT DOCOMO, INC. have conducted a proof-of-concept experiment in Yokohama City of an autonomous driving service that uses AI to optimize vehicle dispatching and routiung based on real-time passenger boarding requests.[66]

- Autonomous buses are seeing practical application on public roads to reduce the number of areas where transportation is no longer accessible due to bus service downsizing or termination. — 2020-25

Improving the efficiency of existing networks

- Mixed freight/passenger loading styles for trains, bus, taxi and on-demand transportation is becoming popular as a way to both maintain regional transportation and improve logistics efficiency. — 2020-25
- On-Demand transportation and home delivery services are being used in areas with low population density to improve user convenience, operator utilization rate, and transportation efficiency. — 2020-25

Case study

Nissan Motor Co., Ltd., and Toppan Inc., together with the Network of Multisectoral Actors Laboratory (NoMA Lab) in Fukushima Prefecture, conducted a proof-of-concept experiment of a home delivery service using on-demand transportation in Namie Town, Fukushima Prefecture. The service provided a new shopping experience using a VR-enabled shopping support service for users who cannot visit stores by themselves. At the same time, it improves delivery efficiency by utilizing on-demand transportation.[67]

Revitalizing communities through new mobility services

- In Japan, micro-mobility, such as electric scooters, emerged around 2000 and is gaining societal recognition. Because this personal mobility is environmentally friendly and more easily accessible than bicycles, it is already being widely used in tourist spots and urban areas. — 2020-25

Case study

BRJ Inc. signed the Cooperative Agreement on Tourism and Community Development Using Electric Scooters with Nagareyama City and began a proof-of-concept experiment of the shared electric scooters service in August 2022. The company has installed seven ports within the city, raising expectations for this new mode of transportation.[68]

Photograph: Courtesy of BRJ Inc.

Solutions Clues to a Solution [Regulatory Trends]

- To maintain transportation and logistics services in sparsely populated areas, the Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) partially lifted the ban on mixed freight/passenger transportation in 2017. This form of mixed transportation is currently permitted nationwide for scheduled passenger buses and permitted in sparsely populated areas for chartered buses, taxis, and trucks.[69]
- The government is looking into revising transportation regulations to enable the safe use of new technologies, such as personal mobility and electric scooters, and to take advantage of their potential performance and notable convenience. In 2020, the National Police Agency, Japan (NPA) established the Expert Review Panel on Transportation Regulations for Various Traffic Entities to examine new transportation regulations and vehicle classifications under the Road Traffic Act.[70]
- The MLIT simplified the fare notification process in 2020 to promote flexible fare arrangements among multiple transportation operators and collaboration among stakeholders at destinations. A special provision was established to require only one representative entity to submit fare applications.[71]
- Paid ride-sharing services using private cars are common in the U.S. and Southeast Asia, but are strictly regulated in Japan by the Road Traffic Act. In 2020, the government lifted the ban on a limited basis in response to the COVID-19 pandemic. Today, municipalities and NPOs can operate the service for residents and tourists and for welfare-related deliveries in areas without public transportation.[72,73]
- In November 2021, the MLIT partially lifted the ban on ride-sharing taxi services nationwide. The taxi operators are now allowed to match passengers with similar destinations through an app and provide shared rides.[74]
- In February 2023, the MLIT proposed a re-design of regional public transportation in the interim report of the Council of Transportation Policy and the Panel on Infrastructure Development.[75] The intent of the re-design is to strengthen the effectiveness of regional councils and plans, and to utilize new technologies to improve profitability and convenience, and to reframe transportation as part of regional management. In June 2023, the final report presented the basic ideas and structure for a new institutional framework for re-designing regional public transportation.[76]
- In July 2023, the National Police Agency began enforcing provisions on traffic methods for specified small motorized bicycles (such as electric scooters) in the Act Partially Amending the Road Traffic Act (Act No. 32 of 2022). As a result, electric scooters that meet specific requirements, such as having a maximum speed comparable to bicycles, are subject to new traffic rules, including permission for the scooters to travel on the same roads as bicycles.[77]

Relevance to the SDGs

Problems

Difficulty in providing mobility services where transportation is inconvenient

Societal Issues

Providing mobility services to maintain quality of life

Relevance to the SDGs

11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons

Technology has enabled the transfer of experience, not just people and objects

The COVID-19 pandemic revealed that remote work was not only feasible, but popular

While avoiding accidents and maintaining personal space have become normal expectations, the desire for entertaining transportation is growing

Unprecedented [Mobility x ____] ideas and digital technology will change the concept of tourism

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Rapid changes in mobility opportunities due todigital technologies

Remarkable progress in the digitization and proliferation of online services is expanding the possibilities for new activities and communication. New technologies are being explored as a means to create diverse opportunities for human activity, especially through better mobility services that suit the new normal.

At the same time, especially in the post-pandemic era, people are reaffirming that these exciting activities, including traveling, leisure, dining in person with friends and acquaintances, and eating out, are mentally and spiritually enriching, so such activities will also need to be promoted.

Japan

Potential impact estimates

The popularity of teleworking will encourage people to move from the Tokyo Metropolitan Area to more rural provincial areas. According to some estimates, approximately 230,000 people will be able to move, including the telework candidates and their families, as well as potentially 150,000 people from supporting industries (including retail and restaurant). By one estimate, the positive impact in the local area on consumption is JPY 500 billion per year.[78](C)

Issues

Providing a wider variety of customer consumer experiences in response to changes in transportation configuration

Key Points for Resolving Issues

Diversifying Work Styles

[Improving efficiency in work and creating a better work-life balance]

Teleworking has spread rapidly in light of the COVID-19 pandemic. Coupled with the trend toward work-life balance reform, the digitalization of office work is expected to accelerate even further. At the same time, urban offices are expected to relocate to rural areas and employees to rural areas.

Online services that can effectively use the spare time created by streamlining business operations will contribute to improving the quality of life. It will also supplement activities, mainly in residential areas, that can only be performed in person, such as shopping, dining out, and playing sports, as well as sponsoring health promotion services.

Key Points for Resolving Issues

New lifestyles

[Creating spiritually fulfilling mobility]

Based on the idea that mobility can be mentally enriching, it is important to create new behavioral opportunities and improve the value of transportation according to each individual's values, with special consideration to the modern living environment in the post-pandemic world.

Key Points for Resolving Issues

Next-generation Mobility

[New types of mobility and associated services]

The nature of mobility is changing. The expansion of ride-sharing, mobility as an entertainment venue, and the spread of remote-controlled robots have begun to reduce the need for any physical movement.

The COVID-19 pandemic has increased the need for interaction and travel free from direct contact with others.

The advancement of autonomous driving technology has prompted discussions about how people spend their travel time. The development of services to utilize this travel time, which is likely to grow in the future, represents a significant business opportunity.

Key Points for Resolving Issues

Urban Digital Transformation (DX)

[Creating open innovation]

3D city models have been developed as platform data for urban activities and use cases have already begun to be developed in various fields using these models. Open innovation is expected to be created by allowing anyone to freely access urban data.

Solutions

Clues to solution [Technological Trends]

1. Diversifying Work Styles

Improving the office environment

- In the wake of the COVID-19 pandemic, hotels have experienced a drastic decrease in demand. Some hotels are considering remodeling into office spaces. 2020-25

Case study

The Osaka City Shinkin Bank has started operating its Yodoyabash Office in BizMiix Yodoyabashi, a rental office that was remodeled from a bankrupt hotel. The bank intends to utilize the office as a consultation service and seminar development center for its tenants.[79]

Integrating office and home in rural areas

- The prevalence of teleworking has shifted people's housing needs, and interest in relocation to rural areas is growing. As a result, the need for satellite offices in rural areas is expected to increase. 2020-25
- In addition, attention has been drawn to efforts to utilize teleworking to create a better work-life balance and to enjoy personal travelling after business trips.[80] 2020-25

Case study

MRI is promoting the idea of a temporary work-from-home system in rural areas for office workers in large cities. To simultaneously realize work style reform and contribute to regional revitalization, MRI has implemented the program in cooperation with a large number of local municipalities.

Using spare time

- Various skill-sharing services that offer and share knowledge and experience online are gaining popularity as ways to utilize spare time and improve quality of life. 2020-25

2. New lifestyles

Mobility as means of regional revitalization

- The unique value of the real world is being re-evaluated, especially the parts that cannot be satisfied directly by online experiences. There is a growing movement to utilize renovated antique traditional Japanese homes or vacant houses not only as places to stay, but also as places where people can gain experiences unique to the area.[81] 2020-25

Case study

NOTE, Inc. (Japan) aims to support regional revitalization by creating a renaissance of historic buildings that have been forgotten in the region and by developing sustainable tourism resources. Its brand, NIPPONIA, is a coined name combing Nippon (the Japanese word for Japan) and the Italian city of Bologna, where the idea is derived from.[82]

East Japan Railway Company (JR East) and SATOYUME CO., LTD. have established a joint venture company, Ensen Marugoto Co., Ltd. (Japan). The company renovates and utilizes antique traditional houses along the villages of the railroad lines as guest rooms and utilizes station buildings and railroad facilities as the hotel's reception area. The company is working to build the concept of a full-fledged hotel along the railway lineby collaborating with local residents to provide customer service and management.[83]

- Attention is being focused on new ways for tourists to not just temporarily visit local areas, but enjoy new forms of tourist experiences by participating directly in resolving local problems and having sincere interactions with local residents.

2020-25

Case study

OTETSUTABI (JAPAN) runs an online platform that matches farmers, local inns, and other business operators facing short-term and seasonal labor shortages with young people interested in the region. Participants, while enjoying the trip, can reduce their travel expenses and interact with local businesses by helping farmers and inns.[84]

- Since mobility, such as driving and traveling, is thought to enrich the mind, attention is being paid not only to providing information on optimal travel methods and routes, but also to creating mechanisms to change attitudes and behavior toward going out and searching for preferred destinations.

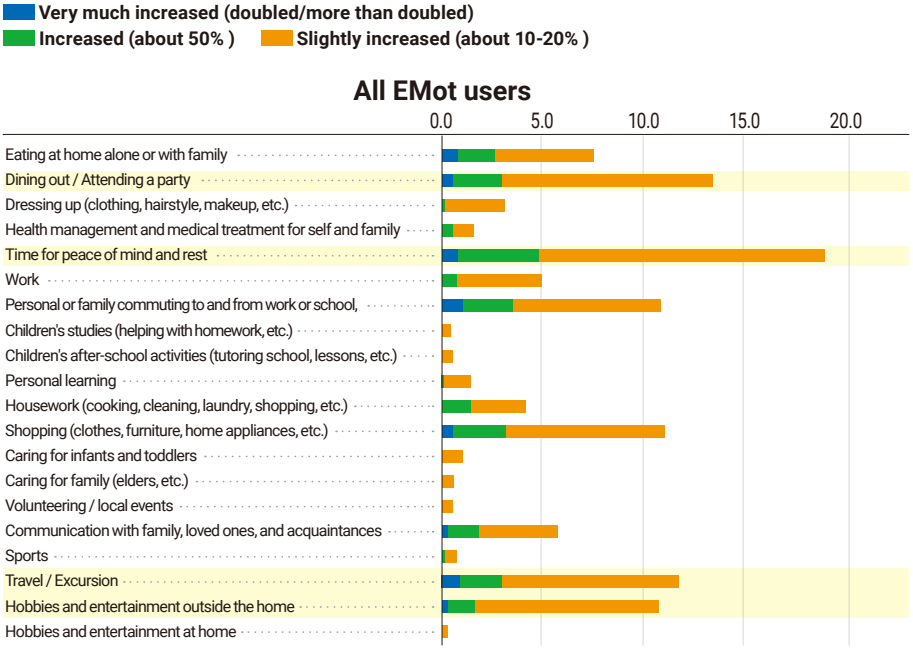
2020-25

Case study

Mitsubishi Research Institute, Inc. has structured the value creation process for "actfulness" that brings value to residents, businesses, and communities by realizing actions that enrich the mind and soul. Aiming to enable nationwide “actfulness,” MRI has conducted joint research with Odakyu Electric Railway Co., Ltd to estimate the effects of increased behavioral opportunities and confirmed an improvement in residents' life satisfaction and economic impacts from the empirical data.[85]

Effects of promoting behavior changes through the use of services aimed at improving transportation convenience

(Joint research with Odakyu Electric Railway Co., Ltd.)



Source: Questionnaire survey by joint research of Mitsubishi Research Institute, Inc. and Odakyu Electric Railway Co., Ltd.
(Participants were EMoT users. N=677, conducted in July 2022)

3. Next-generation Mobility

Shared mobility

- Sharing services for the temporary use of electric scooters and electric bikes as a means of last-one-mile transportation are expanding.[86] — 2020-25
- Matching apps for shared taxis are being developed and proof-of-concept experiments are taking place in various locations. This service can be used for short-distance travel and to solve the taxi driver shortage problem. — 2025-35

Remotely operated robots

- A service that intends to provide a travel experience comparable to in-person tourism by combining avatars and remote-controlled robots is rapidly growing. — 2020-25

Case study

avatarin, Inc. (Japan), a startup launched from ANA HOLDINGS, has developed "avatarin," which allows users to be instantly transported to any place where an avatar or remote-controlled robot is located.[87]

- New technologies, such as telexistence and haptics, are being put into practical use. They enable users to operate remote robots with human-like senses and physical functions. — 2025-35

Entertainment in transportation

- The prevalence of autonomous driving has prompted the creation of services offering new mobility experiences. — 2025-35

Case study

Sony Corporation has unveiled a concept car, Vision-S, and established Sony Mobility Inc. in April2022. The company aims to provide a new version of mobility that includes entertainment using novel technologies.[88]

Gekidaniino, G.K., a member company of the Kansai Electric Power Group, has developed "iino," a transportation device that runs autonomously at a low speed of 5 km/hour. It can travel side-by-side with walking pedestrians and provide an enjoyable mobility experience.[89]

4. Urban DX

Diversifying digitalization

- Metaverse tourism, which enables tourists to visit cities in a virtual space, is becoming popular as an alternative to in-person traveling. The virtual cities are recreations of an actual cities using location-based information technology such as GPS and GIS.[90] — 2020-25
- Metaverse tourism is also expected to contribute to regional revitalization by visualizing the multifaceted attractions of each region and by providing opportunities to enjoy new values of the area. — 2020-25

Case study

Tourist destinations in Sumida Ward tend to be concentrated around the Tokyo Skytree. The ward is attempting to decentralize this concentration by creating a metaverse tourism map to visualize its diverse cultural resources and attractions. The ward is also developing human resources for its metaverse tourism.[91]

Project PLATEAU is a project led by the MLIT to create 3D models of cities throughout Japan. Its three main themes are:1) Improving the efficiency and sophistication of data management, 2) developing advanced use cases, and 3) expanding data coverage. Efforts are underway to develop and utilize these 3D city models and create an open data ecosystem.

In addition, to promote the development of 3D city models across the country, a subcommittee has been established under the Public-private Platform for Smart City, aiming to realize Society 5.0, where cyber and physical spaces are highly integrated.[92]

Solutions

Clues to solution [Regulatory Trends]

- The Cabinet Office, Government of Japan (CAO) is promoting work-from-home efforts that contribute to regional revitalization. Subsidies are provided to support projects that will create a flow of people to rural areas through the construction and operation of satellite offices.[93]
- In cooperation with other ministries and agencies, the CAO is also attempting to create and expand the number of non-residents that connect, contribute, and interact with regional communities by disseminating information through its portal site and allocating local tax grants for model projects.[94,95]
- The Japan Tourism Agency (JTA) has launched the “Project to Discover My Second Hometown” to promote relationships with new people and revitalize local economies.[96]
- Given the increased popularity of electric scooters, the National Police Agency (NPA decided to relax regulations for electric bikes in March 2022. Current regulation requires scooter users to obtain a driver's license, drive on vehicle lanes, and wear helmets.

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Resolving Societal Issues and DX

Co-creation activities through open innovation can effectively further promote the resolution of societal issues through digital transformation (DX).

DX Accelerates the Resolution of Societal Issues

Digital Transformation (DX) is an initiative to transform business processes and customer experiences using digital technologies. In resolving societal issues, DX plays an important role in a wide range of issues, from identifying problems to analyzing problems and developing new solutions.

DX encompasses a wide range of fields, from Big Data analysis to AI and machine learning, IoT sensors, and cloud services.

Big Data analysis enables the analysis and visualization of vast amounts of data, offering an effective approach to identifying societal problems to be addressed and exploring approaches by analyzing what really happened. For example, in order to alleviate traffic congestion, activities such as analyzing traffic flow data and exploring potential solutions are being conducted.

AI and machine learning can identify, predict, and optimize patterns, which can help us provide solutions to new societal issues by reducing costs and providing personalized services. For example, when promoting 'locally produced and locally consumed' renewable energy, such as solar power, for decarbonization, we use AI-based tools to make detailed forecasts of energy supply and electricity demand by time zones and regions.

The cloud services provide solutions to societal issues by enabling various services online. The popularity of online meetings and educational platforms after the COVID-19 pandemic is fresh in our minds.

What's more remarkable about recent developments is Generative AI that can create text, music, images, and more based on AI systems. ChatGPT, an interactive AI released in December 2022, is a type of generative AI that has come into the spotlight for its ability to generate texts that sound human-like.

In addition to expanding the range of solutions to societal issues, generative AI will also be an important tool for those who take action to resolve them. With generative AI, for example, we can expect an accelerated process, from problem configuration to solution building, by further exploration of societal issues, ideation of solutions, and the rapid creation of mock-ups for service validation.

Viewpoints from Societal Issues and DX are Both Important

So, what is necessary to utilize DX technology, which is showing further progress, to resolve societal issues in a broader scope? When considering the application of DX to societal issues, it is crucial to combine two perspectives: one that considers leveraging DX technology as a starting point to explore potential applications (seed-centric), and another that focuses on utilizing DX for solving specific issues (need-centric). However, in reality, there are only a few individuals and organizations that are capable of effectively combining and applying both perspectives.

Therefore, by gathering talents from diverse backgrounds, including those involved in DX, and deepening discussions on resolutions to societal problems, we can gather various ideas from perspectives of both 'seeds' and 'needs.' Such kind of co-creation activities through open innovation can be considered highly effective in delineating the direction of DX-based resolutions to societal issues.

05

A Resilient Society Where The Safety And Security Of All Is Assured

Disaster Prevention And Infrastructure

The year 2023 is a milestone that marks 100 years since the Great Kanto Earthquake. In these 100 years, the Japanese population has become even more concentrated in Tokyo, and there are concerns about the damage a direct seismic hit to the capital region may cause. The national government estimates that a megathrust on the Nankai Trough would cause more than 320 thousand deaths and economic damage of JPY 220 trillion in the worst-case scenario.

Earthquakes are not the only hazard enveloping the nation. Over the past 100 years, the average temperature has risen by 0.74 °C for the world and 1.3 °C in Japan. Also, storms, floods, and droughts have increased significantly. Many of the UN's SDGs include items on resilience and disaster, and it has become a common global issue. However, a long journey still remains before arriving at a resilient future where everyone can live safely and securely. Japan should lead disaster prevention as a nation prone to natural hazards. To do so, Japan too must bolster its education for disaster prevention in ordinary times, advanced techniques for prediction and mitigation, means for transportation of relief supplies after disasters, and countermeasures against the long-term dysfunction of infrastructure.

Aging urban and regional infrastructure pose additional issues, including the increasing financial burden of maintenance and management. The rising number of vacant houses constitutes a significant problem. It is insufficient to maintain and manage existing infrastructure efficiently using AI analysis technology; existing regional infrastructure must be readdressed, integrating and retiring facilities as needed to ensure the focused and efficient use of limited resources. Also, infrastructure-use must tap into the private sector's technical and managerial expertise.

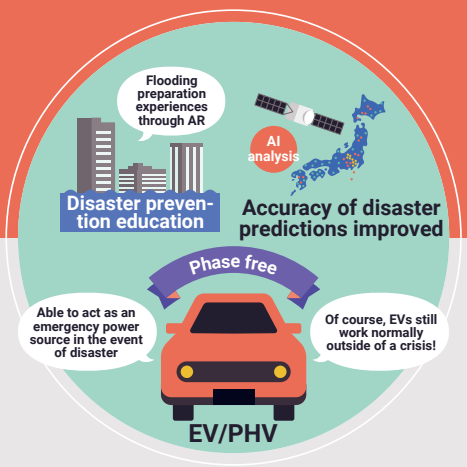
While great gains in convenience can be found in connecting social and economic activities via network technologies, it brings an aggravated risk of cyberattack on critical infrastructure such as electricity and oil pipelines. In the area of disaster prevention and infrastructure, including cybersecurity measures, it is necessary to build a sustainable foundation that ensures the safety and security of all.

From the viewpoints above, ICF has identified the following four problems and issues in the disaster prevention and infrastructure fields.

Becoming prepared for disasters on a daily basis

Japan is a disaster-prone country, but lacks preparedness for natural disasters like torrential rains, floods, and earthquakes

Increase confidence in disaster forecasts and disaster information, and routinely plan post-disaster evacuation actions as a personal matter



Promoting disaster prevention education and improving the accuracy of disaster forecasting, as well as utilizing long-term infrastructure

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

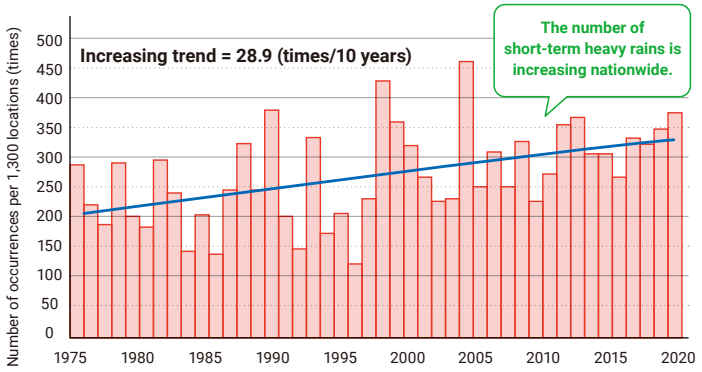
Problems Insufficient preparation and response to natural disasters

Natural disasters have increased both in frequency and severity due to climate change leading to large losses in human life and severe damage to infrastructure. As a result, more time is required for the recovery and reconstruction of infrastructure.Floods have particularly grown in frequency and severity in recent years, and damage has grown too (see the figure below).

Systematic, proactive, and scientific measures are all insufficient in preparation for natural disasters, emergency response in the event of a disaster, and recovery and reconstruction following a disaster. As a result, unforeseen damage, including secondary disasters, continue to occur due to the regionally limited, passive responses to large-scale disasters.

Transportation efficiency is subpar for relief supplies and personnel following a disaster; this prevents a minimum standard to be ensured for living conditions, especially drinking water, sewerage, and toilets.

Annual occurrence of hourly precipitations of 50 mm or more nationwide by AMeDAS



Source: Section 1 "Environmental Changes Surrounding Japan," White Paper on Land, Infrastructure, Transport and Tourism in Japan, 2020.

Japan
Potential impact estimates

According to the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the total amount of flood damages nationwide in 2019 was JPY 2.18 trillion. This amount is the largest in one year excluding tsunami damages since the statistics began in 1961. Of this, JPY 1.88 trillion was caused by Typhoon, Hagibis (mid-October, 2019).[1](B)

In the case of a mega-earthquake centered beneath the Tokyo Metropolis, the number of evacuees is expected to reach 7.2 million by two weeks post-incident. Government emergency supplies will be insufficient at their current levels. In the first week after the earthquake, shortages are expected to reach as high as 34 million meals worth of food and 17 million liters of drinking water.[2](A)

Issues

Strengthening of disaster response capabilities through innovative technologies and societal infrastructure

Key Points for Resolving Issues

Normal Times and During Disasters

[Prediction and assessment of disasters via public-private sharing of information establishing an operating framework]

Floods take some lead time from the beginning of the downpour to the occurrence of the disaster. It is often possible to take more proactive measures than earthquakes, which strike without warning. Flood control measures have been implemented individually for each facility, including dams, embankments, subways, roads, forest conservation, and water and sewer systems. However, comprehensive measures are more effective. While difficult from a technical standpoint until recently, these measures are now possible thanks to the practical use of technology such as IoT, AI, and quantum computers.

Disaster countermeasures can benefit by utilizing and combining information held by the private sector. For example, the following information helps response teams assess damage and take emergency actions:

- Vehicle probe information
- Information of retail premises of distribution and transportation companies
- Information from mobile phones
- Infrastructure related information, such as electricity, gas, and water

An overall picture of the disaster can be quickly perceived if the public and private sectors share various information over a common channel. A mechanism like this will lead to substantial improvements in such emergency response measures as evacuation, rescue, prevention of secondary disasters, transportation of relief supplies, and restoration of infrastructure.

In the early stages of a disaster, local governments often fail to conduct agile responses or smooth cooperation with other organizations. These problems can be overcome with the appropriate structure and an operational framework for disaster times; establishing an emergency command center is one example.

Disaster prevention must be considered an issue that is personal for each and every resident, so as to inspire proactive and self-directed preparedness. More than ten years have passed since the Great East Japan Earthquake, and people are less conscious of the importance of self-initiated preparation.[3] In a 2022 survey, about 40% of the respondents said they had never discussed measures against natural disasters with their family or people close to them, and about 60% of them said it was because they did not have a chance to talk.[4] Efforts to pass on the lessons learned from the disaster, and apply them to the future too, are important, but new opportunities need to be created to take measures against potential disasters.

Key Points for Resolving Issues

Emergency Response
[Assisted and un-assisted evacuation of local residents]

Residents can be motivated to evacuate in the face of a disaster if provided with the proper information and if their individual circumstances, such as lifestyles and health conditions, can be addressed. Examples include translation of information to non-Japanese speakers, effective use of hazard maps, and personal evacuation guidance through digital technology, and assistance to arrive safely at the shelter, or other final destination.

The information offered must directly lead to action, and potential content could include warnings on the imminence of risk and evacuation routes. Education in normal times is just as essential and provides residents with an increased sensitivity to potential risks. Preparedness for vulnerable people should also be considered so that they may avoid crises unassisted.

Key Points for Resolving Issues

Emergency Response and Post-Disaster Restoration & Reconstruction
[Responding to needs during disaster]

In the event of disaster, governments assist in supplying daily necessities and fuel to evacuation centers, dispatching personnel to medical institutions, and providing medical supplies. However, public assistance alone does not cover all needs. Support can be bolstered and expedited by supplementing this deficiency with private funds and ideas from various organizations. Private companies can enjoy expanded business opportunities as a result.

In the event of disaster, it is also important to prepare for power outage and disruption of communications infrastructure. Hardware needs to be overhauled in advance, making full use of edge devices and portable routers.

Smooth and prompt treatment of disaster waste is required for recovery. Affected municipalities are in charge of disposing of disaster waste. Each municipality needs to make arrangements systematically, such as estimating the amount of waste and securing temporary storage sites before a disaster occurs, then transporting the waste smoothly to each disposal station based on the arrangements when a disaster occurs.[5]

Solutions

Clues to Solutions [Technological Trends]

1. Normal Times

Disaster prediction

Practical implementation period

- National Research Institute for Earth Science and Disaster Resilience (NIED) operates MOWLAS, a system that integrates land and ocean datasets to predict earthquakes and tsunamis. The data obtained by MOWLAS contributes to research and development, such as early detection, assessment of the situation, information provision, and long-term evaluation. It can also be utilized by the private sector for disaster prevention.[6] — 2020-25
- As a measure against linear precipitation zones, development is underway of a system that can forecast and plan evacuation half a day before a disaster. The system utilizes the latest technologies such as water vapor lidar (Light Detection and Ranging) and water vapor observation equipment via digital terrestrial broadcasting.[7] — 2020-25
- A new system is being developed that forecasts river water levels, storm tides, storm surge, and tracks the path of a super typhoon on a real-time basis. The system also integrates dams and floodgates and has a centralized control function.[8] — 2020-25
- A variety of systems have been developed for real-time flood and submerged land forecasting. These systems utilize big data concerning water levels and rainfall as well as AI and sensing technologies.[9] — 2020-25

- Development is underway of a platform that supports decision-making regarding disaster risks. The platform utilizes AI through a probability model, evaluates disaster risks, and provides visualizations. — 2025-35

Case study

One Concern, a disaster resilience startup in the Silicon Valley, is working on hyperlocal real-time damage assessment. They use AI to analyze weather and building data to assess damages in the region before, during, and after disasters such as floods and earthquakes.[10]

Strengthening infrastructural resilience

- In areas at risk of flood and water damage, measures must be taken in coordination with community planning. In Japan, green infrastructure is being implemented to help build greener urban environments, for larger environmental conservation efforts in normal times, and to retain rainwater during a disaster. For example, in recent years, the national government has been promoting the River Basin Disaster Resilience and Sustainability by ALL Project, which utilizes green infrastructure and the existing flood control measures against frequent natural disasters. Not only administrators but all relevant stakeholders, including the national and local governments, businesses, and residents, are working on flood control across the entire basin from the catchment area to the flood-prone areas.[11] They contribute to the greening of the town and environmental conservation in normal times and are developing an infrastructure to reduce stormwater runoff in the event of a disaster.[12] — 2020-25

Case study

The Netherlands has historically been highly conscious of flood risks. The government office responsible for flood control conducts safety assessments and reinforces levees using a long-term scenario to the year 2100. The Netherlands announced in her its national plan continued efforts to make the country a safe and attractive place through innovation in the private sector and industrialization of water management technology. The plan is updated annually and not only covers a long-term flood risk of rivers and water management but expands its horizon to space above the water.[13]

- Projects are being promoted to prevent water disasters, in which sensor technology, drones, and image analysis technology for surveillance cameras are used in rivers.[14] — 2020-25
- Seismic isolation technology has been developed to protect buildings from sinking by soil liquefaction after an earthquake.[15] — 2025-35
- To promote the stable supply of electric power, Japan is converting utility poles to underground cables, but there are issues in construction, including high costs and large amounts of the required time.[16] — 2025-35

Collaboration to make no distinctions between daily life and disaster

- In Japan, ministries, agencies, municipalities, and companies are all working to share and utilize information digitally. For example, the Digital Agency is working to set up a system using the nation's individual number cards in which the information submitted to public authorities once does not need to be submitted again thanks to data linkage. The aim is to use data for welfare services in normal times and provide personal support to residents during disasters.[17] — 2020-25

- The phase-free concept is gaining momentum for its application to a wide range of daily activities. The concept calls for products and services to be made so that they are useful in both normal times and disaster situations. One example is plug-in hybrid vehicles (PHV) equipped with storage batteries as emergency power sources during power outages. Another is organizing volunteer groups during normal times to enhance resilience capabilities against disaster. — 2020-25

Disaster prevention education

- To prevent delays in evacuation and raise awareness of dangers, VR and AR technologies are being used during normal times to visualize the damage caused by tsunamis and river flooding. — 2020-25

Case study

Weathernews Inc. released an app that runs information on user location through MLIT's data on flood hazard areas and provides presumed damage on screen.[18]

The Digicel Foundation, funded by the IDB (Inter-American Development Bank), has developed a free VR game to help people with disabilities simulate potential hazards in a disaster.[19]

- Solutions are under development that integrate disaster risk information into hazard maps to convey disaster risk information to residents in an easy-to- understand manner. To make visual recognition through 3D images easier, improvements are being made that include a hyper-local flooding simulation search system called Flood Navigation.[20] — 2020-25
- The nudge concept from behavioral economics is being implemented in various fields to modify people's behavior into a predictable form and eliminate bias in decision making. Such efforts are becoming more and more critical for evacuation activities during disaster. — 2020-25
- In schools, efforts are being made to create opportunities for students to think about disaster prevention within the regular curriculum. Disaster prevention is being incorporated into various class subjects. For example, in math classes, students are tasked with calculating speed, time, and journey length in a tsunami evacuation, using simultaneous equations. — 2020-25

Formulation of more specific evacuation plans in normal times

- In the event of a disaster, it is necessary not only to provide supplies, but also to take into consideration individual conditions such as appropriate meals for people with allergies, proper food for infants according to their age in months, and maintenance of hygiene and privacy in shelters. — 2025-35

Case study

In Gosen City, Niigata Prefecture, staff members of the disaster prevention division and registered dietitians are working to examine the nutritional value of stockpiled foods. They use the simple simulator for estimating the amount of well-balanced food stocks for large-scale disasters developed by the MHLW in 2020.[21]

2. Emergency Response

Rapid assessment and unified management during disaster

- More UAVs have been introduced to disaster management headquarters in recent years because of their agility and low operating costs. About 60% of fire departments nationwide have adopted them.[22] Lithium-ion batteries are the most common power source for the present UAVs, and one of their challenges is the short flight time. However, when the development of a hybrid micro gas turbine system moves ahead, the flight time will be extended, and the load capacity will be increased.[23] Local governments are also conducting proof-of-concept experiments on the transportation of goods. — 2020-25

- It can also be beneficial to use a network of monitoring cameras on the ground is also essential. The number of victims can be reduced by using AI to automatically detect disasters and provide immediate alerts. In addition, unified management of the monitoring information will lead to a rapid assessment of the disaster situation. In the event of a disaster, satellites are used to observe and analyze damages within two hours after the occurrence. Such a system will enable immediate initial response.[24] 2020-25
- A high error rate was prevalent among conventional methods for detecting mudslides. A system was developed that detects actual mudslides by combining vibration sensors and AI-assisted analysis. As for landslides, a 3D terrain model (CIM Model) is being used as a virtual site model to remotely identify the hyper local situation accurately and provide prompt and efficient technical support.[25] 2020-25
- New technologies will enable the immediate implementation of initial and emergency responses, and include those that utilize digital twin and chatbot technologies.[26] The system captures changing disaster dynamics. The transmission of content directly to residents' smart phones has potential to promote optimal personal action and thus a higher level of self-supporting behavior during disaster. 2025-35
- Also, national and local governments and private sectors need to unify the collected information after fact-checking to understand the damage and establish a relief system quickly. Advanecd tools are beginning to surface for collecting and fact-checking information from social media through AI. In Japan, the Information Support Team (ISUT) has been in full operation since 2019, and they collect information promptly when a disaster occurs.[27] 2020-25

Case study

Spectee Inc. uses AI to collect reliable crisis management information from SNS and weather data in real-time after the outbreak of a crisis, such as a disaster, and to visualize and predict the damage situation.[28]

- Local-Alert is a common infrastructure in Japan to quickly and efficiently transmit disaster-related information to residents and has been in place for some time. 2020-25
- Research is being conducted using quantum computing to quickly identify appropriate evacuation routes.[29] 2025-35

Support for safety confirmation and search for missing residents

- A new monitoring service has been developed as a means of confirming the safety of seniors in normal times. AI detects the safety of seniors out of their ordinary movements by analyzing data obtained via smart utility meters. Discussion is underway for the use of this service in the event of a disaster.[30] 2020-25
- Search and rescue is a recent subject of development where GPS information is combined with data from mobile phones and drones.[31] 2020-25

Urgently securing critical infrastructure

- New types of toilets can cope in circumstances where the water supply is insufficient. One type can dispose of waste using only a small amount of water. Another is an assembling type toilet that wraps up waste without using water. A shower package has been developed that does not require drainage work at the time of disaster. 2020-25
- As an effort to restore the information and communications infrastructure in the face of an emergency, new developments are being made that include ICT units and portable high-speed data communication facilities. There are also expectations for the creation of a next-generation communication tool for disaster prevention that shares information between related parties.[32] 2020-25

- To prevent secondary health hazards caused by lack of water, development is underway of a three-dimensional numerical model for water flow to analyze the amount of available groundwater.[33] 2025-35

3. Restoration and Reconstruction

Transporting necessary relief goods

- For the stable and efficient transportation of relief supplies, development is underway of a delivery route system utilizing AI. The transportation system applies drones when the transportation network is cut off. 2020-25

Case study

Hacobu has developed a dynamics management service, MOVO Fleet, that can locate freight vehicle positions in real-time, even during a disaster. The company aims to build a logistics information platform that integrates IoT and cloud systems by incorporating other products.[34]

- During disasters, social media and chatbots are used as a means of providing real-time information regarding the necessity of rescue and relief supplies. However, there are problems related to the accuracy of the information. 2020-25

Case study

Weathernews Inc. conducted an on-site proof of concept experiment of an interactive information platform in 2019 with Ibaraki Prefecture. The platform utilizes social media and provides information regarding disasters through its Disaster Prevention Chatbot.[35]

Amazon's Wish List is used for supplying relief goods to shelters during disasters and connecting victims with supporters.

Measures against lengthy failures of infrastructure

- A decision-making system is being developed to minimize the secondary economic damage caused by infrastructure failures. The system forecasts the negative impact on the economy and prioritizes road sections for reconstruction by combining geographic information system (GIS) data with big data collected from economic activities and real-time information of infrastructure damages.[36] 2020-25
- In the case of a disaster, inexpensive temporary housing will be secured through the development of 3D printed housing along with a program of pooling unoccupied houses. There is also a need for operational measures such as building communities so that local residents will not be isolated. 2025-35

Case study

ICON Technology, Inc., a U.S. startup, has produced low-cost, 3D-printed homes and is providing them to people, including the homeless.[37]

Solutions Clues to Solutions [Regulatory Trends]

- The new Fundamental Plan for National Resilience[38] and National Spatial Plan[39], approved by the Cabinet in July 2023, clearly stated the use of new technologies, such as digital technology and the further enhancement of regional disaster prevention capabilities. The government will strengthen regional disaster prevention capabilities to ensure that no one is left behind, advance the openness of data, and promoting risk analysis and assessment by the private sector—all to achieve the safety and security of citizens effectively.

- The Japan Society of Civil Engineers (JSCE) launched a joint project on infrastructure resilience with the American Society of Civil Engineers (ASCE). The project aims to ensure the sustainability of the societal infrastructure, which is an integrated and massive system. They have started by systematizing technology and providing a framework for evaluation and management of performance and governance of the parties involved.[40]
- In disaster forecast utilizing meteorological information, the development of IoT has enabled the accumulation of data from multiple organizations other than JMA (Japan Meteorological Agency). However, data utilization is limited by the Meteorological Service Act.[41]
- MLIT revised the Real Estate Brokerage Act in July 2020 to mandate real estate brokers to inform buyers of flood risk information as part of the important information required for transactions. This revision was made in light of the frequent large-scale floods and water damages in recent years.[42]
- In 2021, the Cabinet Office (CAO) revised its guidelines to prevent delays in evacuating residents in disaster-stricken areas. They abolished the Recommending Evacuation warning status, and now residents are required to leave in the face of a Mandatory Evacuation warning status.[43]
- The Ministry of Economy, Trade and Industry (METI) revised the Electricity Business Act in 2020 to enable electric utility companies to promptly provide information to public authorities without the consent of individual customers, with the intention of using such information in the event of disaster.[44]
- An exemption to the Civil Aeronautics Act was enacted to promptly enable drones to fly over no-fly zones such as populated housing areas when requested by local government in emergencies. The exemption was applied during the Kumamoto Earthquakes to help identify the damage in a short period of time.
- The Building Standards Act is a significant barrier to the introduction of 3D-printed housing in Japan.
- Based on the damage caused by Typhoon Hagibis in 2019, the Basic Act on Disaster Management was partially amended in 2021. The amendment aims to ensure smooth and swift evacuation in a disasters, and municipalities have five years to prepare individual evacuation plans for those who have difficulty evacuating independently and need assistance. The local allocation tax will cover the costs of preparing these individual evacuation plans.[45]
- Operation of the Disaster Waste Treatment Support Staff Program (Human Resource Pooling Program), which consists of local government employees who have experienced disaster waste disposal, began in 2021.[46] In the face of frequent damage that exceeds the capacity of local governments to cope with, registered staff support reconstruction with their knowledge gained from experience.
- In 2022, the Tokyo Metropolitan Government (TMG) revised its expected damage scenarios for an earthquake centered beneath the metropolis for the first time in ten years; a new scenario was added. The documents show a timeline of catastrophes that may occur in the wake of an earthquake. TMG aims for the materials to act as a tool for residents to better imagine the possible damage immediately after a disaster and from a longer-term perspective, as well as to motivate preparedness in advance.[47]
- In 2022, the MLIT amended the Act on the Regulation of Housing Land Development, in light of the mudslide disaster caused by the fall of embankments in Atami City in 2021. Under the amendment, embankment-regulated areas were designated, and an approval system was introduced for embankments in the designated areas. Also, it requires the clarification of responsibility and strengthening of penal provisions.[48]

Relevance to the SDGs

Problems

Insufficient preparation and response to natural disasters

Societal Issues

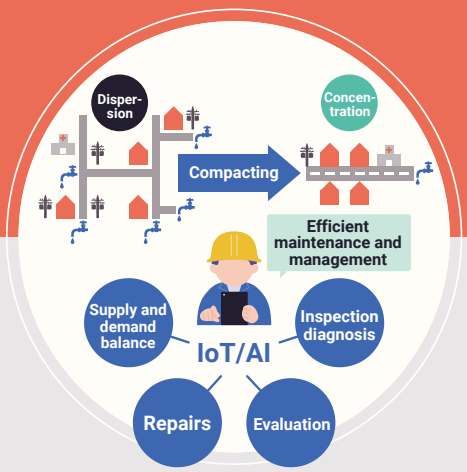
Strengthening of disaster response capabilities through innovative technologies and societal infrastructure

Relevance to the SDGs

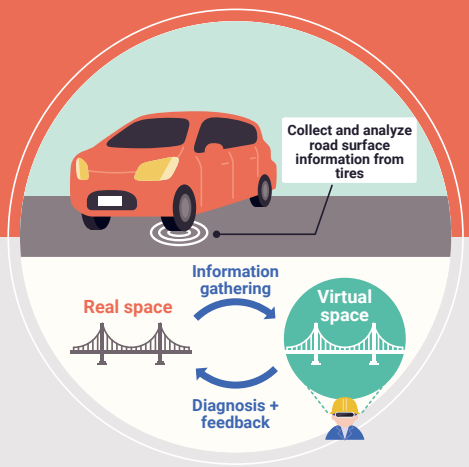
1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters

Creating societal infrastructure that supports everybody

A great deal of infrastructure is requiring renewal at the same time, which will cost a great deal of money



Assess the urgency and importance of infrastructure renewal projects while promoting compactness of the city



Advancing inspection techniques, as well as promoting accurate diagnosis using virtual spaces and updating databases based on testing

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Poor management of societal infrastructure

The societal infrastructure that was built intensively during the period of high economic growth will soon begin to deteriorate and needs to be renewed en masse. Costs pose a significant problem for national and local governments that must maintain and manage facilities.

This is particularly prevalent in rural areas facing population decline: local governments, and their budgets, are strained from maintaining infrastructure inappropriate for the current population size. In the future, regional disparities are expected to widen in the quantity and quality of infrastructure services.[49] Therefore, it is necessary to devise measures to efficiently update and rebuild infrastructure.

The construction industry faces serious problems too: an older workforce and a lack of personnel. Labor shortages are set to become more acute due to limits for overtime work set to start in 2024, a result of the Work Style Reform Bills. On the client side too, specialists are in noticeable shortage, including among public servants. As of May 2022, 56% of villages were without a single civil engineer involved in bridge management.[50]

The societal infrastructure is the basis of economic activity and its low profitability has become an accepted norm; these facilities are seen as existing for the public good and as indispensable for people's safety, security, productivity, and quality of life. Some infrastructural facilities do not charge fees for their services. Infrastructure that sees little use often goes overlooked by planners.

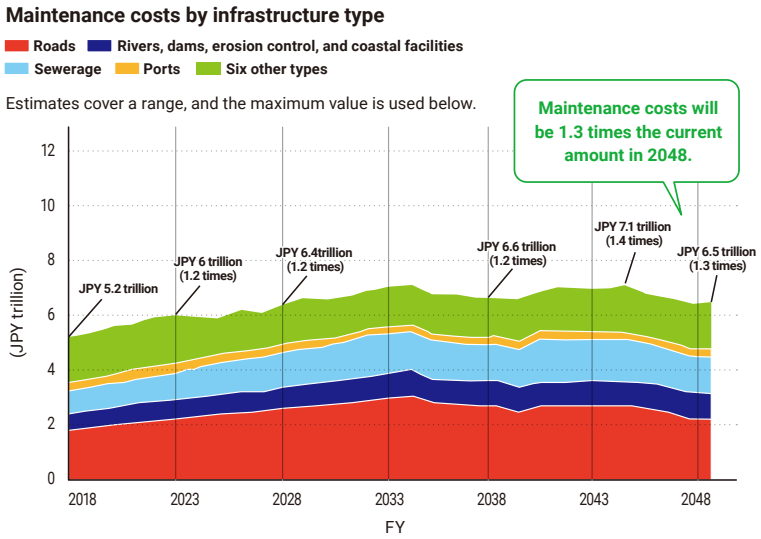
Societal infrastructure for lifeline services has been managed on a regional or functional basis, and this has interfered with achieving joint operation and diversified usage.

Japan

Potential impact estimates

Maintenance and renewal costs for domestic infrastructure in FY 2048 are forecast to reach 1.3 times their FY 2018 levels (see the figure below). In addition, estimates for cumulative costs over the next 30 years from FY 2018 to FY 2048 are in the range of JPY 176.5 trillion to 194.6 trillion. [51](A)

It would cost taxpayers on average JPY 1.4 trillion per year to replace all waterworks if facility lifespans were adhered to.[52](B)



Source: The Ministry of Land, Infrastructure, Transport and Tourism, *Information portal site for measures against aging social infrastructure, infrastructure maintenance information (in Japanese)*https://www.mlit.go.jp/sogoseisaku/maintenance/_pdf/research01_02_pdf02.pdf

Issues

Improvements to efficient management of infrastructure through better utilization and aggregated, centralized control

Key Points for Resolving Issues

Improving the Efficiency of Infrastructure Management

[Labor-saving and automation for efficient operation and maintenance]

For long-term maintenance of infrastructure under a declining population, it is crucial to consider how to: (1) reduce cost and increase efficiency in maintenance, (2) prioritize and determine the necessity of repair and reconstruction, and (3) upgrade infrastructure by utilizing new technologies. It is essential to build, sustain, and develop a maintenance cycle based on effective preventive maintenance that uses IoT. The cycle consists of inspection and diagnosis, evaluation, and repair or reconstruction phases. For infrastructure that needs updating, reconstruction must be conducted using the latest forms of next-generation infrastructure technology, which enable safe and resilient preparation for disasters.

Key Points for Resolving Issues

Consolidating Infrastructure

[Compact cities and concentrated, efficient infrastructure use over a wide area]

Many municipalities are become low-density with their residents spread out across a wide area—an important consideration when reviewing less frequently used infrastructure. For sustainable urban management, it is essential to form cities and societies that use limited resources intensively and efficiently. Infrastructure must be pared down as well, consolidating, resources rather than spreading them thin over wide areas in an attempt to maintain existing infrastructure.

Virtual power plants use IoT to manage and control multiple power sources dispersed throughout an area as if operating a de facto single plant. The sources include solar power, wind power, electric vehicles, and storage batteries. Demand will grow for a centralized system that controls a region's infrastructure function.

The downsizing, consolidating, and abolishing of infrastructure are expected to free up land and assets, it will be important to find effective ways to use these.

Key Points for Resolving Issues

Utilization of Infrastructure

[Multifaceted perspectives for effective use]

The following three measures will boost operational efficiency and effective utilization of infrastructure:(1) Introducing public-private partnerships (PPP) to improve profitability through private business (2) Adjusting the balance between supply and demand by using technologies such as IoT to identify periods of maximal and minimal demand in power (3) Promoting multi-purpose and advanced use of infrastructure; this achieves the advantages from multifaceted perspectives such as profitability, energy efficiency, societal needs, and improvements to quality of life.

(1) PPP

Private companies can participate in public services and expand their business domains. By becoming an agent in infrastructure management, companies can accumulate technical knowledge and develop new business models. Building a win-win relationship between the public and private sectors will contribute to the sustainability of infrastructure and local communities.

(2) Supply-demand balancing

Dynamic pricing according to demand is expected to become popular in light of improvements in AI.

(3) Multi-purpose and advanced use of infrastructure

This makes it possible to secure a variety of revenue sources. In Japan, for example, optical fibers installed in sewer pipes for sensing and other management purposes are already open to private companies to provide broadband network services.53 In addition, such uses of infrastructure will serve to fulfill society's needs and enrich the lives of residents. Potential new facilities that residents could use include farming spaces, fab labs, and drone depots.

Solutions

Clues to solution [Technological Trends]

1. Improving the Efficiency of Infrastructure Management

Practical implementation period

Efficient monitoring and inspection

- Digital twin technology, which has been made possible through advanced sensors, can help make the maintenance of infrastructure more efficient. It enables the forecasting of degradation due to aging and the immediate identification of damage to bridges during disasters. — 2020-25
- Technology is under development to assess road surface conditions via vehicle tires. Tires are used as sensors, which makes the gathering of data more efficient. — 2020-25

Case study

In 2015, Bridgestone Corporation became the first company in the world to succeed in practical application of a sensing technology, CAIS™, that analyzes road surface information from data collected via sensors installed in tires.[54]

- In inspection and diagnosis, aerial photography using drones, improvements in sensing technology, and advancement in AI analysis have led to inexpensive and real-time identification of degradation and damage to bridges, tunnels, and pavement. These advancements enable repair and reconstruction at appropriate times. Eliminating the need for conventional inspection vehicles leads to cost reduction; road and lane closure also become unnecessary. These new technologies should also help solve labor shortages, reduce inspection workload, and improve the safety of worker while in elevated positions. — 2020-25

Case study

UrbanX Technologies, Inc. has developed Road Inspection AI, enabling real-time quantitative road inspections to detect road damage using smartphones with AI.[55]

- Advanced technologies for deterioration prediction drive the development of techniques to clarify the priority of maintenance work. Better sensing technologies will make it possible to develop measures for understanding long-term changes in structures due to earthquakes and temperature fluctuations. High-precision analysis will also come to use a vast array of environmental variables assisted by AI.[56] — 2020-25

Case study

Fracta Inc., a Silicon Valley-based startup, uses its own AI-powered online pipe diagnostic tool to predict the deterioration of water pipes. The company says it can save about 40% of conventional costs by optimizing the timing of renewals.[57]

Efficient infrastructure construction, maintenance and management by utilizing new technologies

- Innovation in materials for structural objects is seen in the development of particular pavement technologies, such as concrete and asphalt, that can self-restore to their original state. Furthermore, materials are under development that can enhance strength when put under stress. Such materials are expected to feature long service life and bolster the integrity of points bearing heavy loads.[58] — 2025-35

- New construction methods, such as 3D printing and panel methods, are expected to shorten the construction period and reduce the burden on craftspeople. 2020-25

Case study

Polyuse Inc. utilizes 3D printers in concrete construction. Eliminating the need for concrete molds allows for more flexible modeling and reduces waste.[59]

Another company has developed large panels that expedite the house construction process down to a single day. The panels, which comprise everything from the columns, beams, and windows, are manufactured at a factory and need only be assembled at construction sites. (WOOD STATION CORPORATION)[60]

Design for future change

- Urban planning has turned to city digital twins. Since 2020, MLIT has run Project PLATEAU, a project to create 3D models of cities across Japan, and promotes the digital transformation of urban planning. The 3D city models are accessible to the public as open data and approved for commercial use.[61] 2020-25

Case study

Panasonic Corporation has combined PLATEAU with virtual reality to recreate the Shin-Osaka Station in virtual space. They add another layer of data consisting of pedestrian movement over the map to assess the flow of station users. Panasonic aims to identify spatial design issues in 3D and use the tool in discussions for area management.[62]

- Design without rework is a new concept starting to take hold that espouses step-by-step modifications to deal with greater external forces in the future induced by climate change. 2020-25

Case study

The U.K.'s Thames Estuary TE 2100 plan delineates ways to respond to high tide water and flooding caused by long-term climate change. The solution aims to reduce economic and environmental costs by flexibly changing plans in accordance with risk conditions.

2. Consolidating Infrastructure

- The Compact City + Network concept calls for the rationalization of the maintenance and management of infrastructure and to improve the efficiency of administrative services in urban development. The concept gradually guides the construction of residential areas along public transportation routes and close to everyday activities. 2020-25

3. Utilization of Infrastructure

Privatization: Formation of public-private partnership (PPP)

- There are expectations for the empirical technological development for each type of infrastructure and the accumulation of management expertise from expressway networks where concession contracts are underway. 2020-25

Case study

Aichi Road Concession Co., Ltd. operates toll roads that were formerly run by Aichi Prefecture. The company provides a verification field free of charge for new technologies called Aichi Accelerate Field®.[63]

Supply-demand adjustment: demand side management

- Dynamic pricing is being taken up around the world as a way to optimize the rate at which infrastructure is used. Dynamic pricing is expected to become popular in Japan as well as an analytical tool using big data and AI. — 2025-35

Case study

The Kansai Electric Power Company, Idemitsu Kosan, and Sumitomo Electric Industries started an on-site proof of concept experiment of dynamic pricing in May 2020. The hourly rate system correlates with wholesale electricity prices to shift the peak hours of charging electric vehicles.[64]

Multi-purpose utilization of infrastructure

- Solar power installations are making their way to large-scale public facilities like ports, airports, and roads. The solar panels themselves are being redesigned to fit in the new types of location.[65] — 2020-25

Case study

NIPPO CORPORATION and MIRAI-LABO are developing a photovoltaic pavement called Solar Mobiway.[66]

- Green infrastructure initiatives are expected to improve societal infrastructure, provide good landscapes, and prevent and reduce damage from disasters, such as flooding and global warming.[67] — 2020-25
- With the aim of creating a bustling community, a movement is growing to utilize road space for events such as open cafes and other activities. There is the prospect of imminent technological development and urban design to accommodate the flexible use of roads.[68] — 2025-35

Case study

The Flowell system developed by Colas, U.K., embeds LED light signals in roads to flexibly change driving lanes and shared spaces in town.[69]

- A growing number of deteriorating, idle public facilities have been renovated by the private sector and are seeing use in business for purposes other than their original value proposition. — 2020-25

Case study

R.project Inc. is developing a business that revitalizes local communities by transforming underutilized public and private facilities into training camps for sports and other activities.

Nagoya City constructed and now operates the multipurpose sports field, Terraspo Tsurumai, in Tsurumai Park. In the overhaul project, a private-sector company proposed a plan that required no financial assistance from the city to renovate the aged athletics stadium into a multipurpose field. Maintenance and operation are carried out on a stand-alone basis.

Upgrading Individual Infrastructure

- Biomass stations are starting to consume unused organic materials sourced from local sewage treatment plants including food waste and excrement.[70] Sewage is also being used to research infectious diseases. — 2025-35

Solutions

Clues to solution [Regulatory Trends]

- The Periodic Inspection Procedures for infrastructure were established based on the law to improve the efficiency of maintenance after the collapse of the Sasago Tunnel ceiling panels. To further enhance inspection efficiency, the 2020 revision acknowledged the use of new technologies to complement, substitute, and enhance the existing standard of close-range visual inspection. However, since inspection frequency is fixed at once every five years, it is impossible to adjust the frequency in accordance with risk. Furthermore, there is no incentive for infrastructure managers to introduce new technologies. A catalog of available technologies is one way in discussion to promote the use of new technologies and achieve greater flexibility and frequency in inspection.[71,72]
- Japan has been promoting infrastructure development based on the concept of a civil minimum, the smallest amount of infrastructure possible to maintain the quality of life of citizens. Asset□management is another concept that still has yet to take hold, and infrastructure services must be provided in a way that maximizes the satisfaction of residents while using only limited financial resources.[73,74]
- MLIT has worked to make simple and flexible legal regulations such as road occupancy permits to promote multifaceted road uses. However, as an emergency measure to cope with COVID-19, in 2020 MLIT relaxed the Road Occupancy Permit Standards and is expected to accelerate its plan together with the Pedestrian Access Enhancement Road System scheduled to be implemented in the same year.[75,76]
- MLIT is also prioritizing subsidies to projects that utilize new technologies to reduce costs and human resources.[77] In addition, they started issuing special grant tax measures for local governments to cover the cost of introducing ICT database systems and drones since FY 2019.
- The Digital Agency has been reforming the mandated paper-based procedures to effectively utilize digital technologies for business activities. They plan to review all 10,000 provisions of laws and regulations concerning the analog mandatory by June 2024.[78]
- Singapore[79] and Finland[80] are working to create country-level digital twins.(See p.161 for the Japanese Project PLATEAU)

Relevance to the SDGs

Problems

Poor management of societal infrastructure

Societal Issues

Improvements to efficient management of infrastructure through, better utilization and aggregated, centralized control

Relevance to the SDGs

1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters

9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all

9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020

11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries

11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations

11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning

11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels

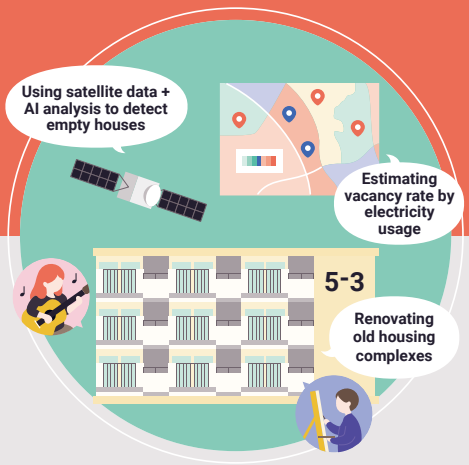
12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products

13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries

The increase in vacant and abandoned homes

The increase in vacant houses is also present in urban areas, degrading the living environment and reducing the effectiveness of social services

Efficiently evaluate the status of vacant housing and renovate abandoned structures with inexpensive technology to revitalize the local economy



Increasing the value of vacant homes and their effective reuse while promoting more sophisticated analysis of vacant homes

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Urban decay caused by an increasing number of vacant houses

The number of vacant houses reached a record high of 8,489,000 in 2018, accounting for 13.6% of the country's total number of houses.[81] Vacancy is due to declining population and birthrate, aging population, and changes in social needs. Unmanaged vacant houses cause societal problems and negatively affect the living environment including related to disaster prevention, sanitation, and landscape.

The vacancy problem is on the rise in both depopulated regions and urban areas. In the latter case, small plots of land become vacant in a sporadic manner—the result a cityscape Japan alludes to a sponge, porous in nature. This phenomenon is the cause of urban decay, which brings with it a deteriorated social environment and truncated resident services.[82]

Approximately 4.78 million units, which account for more than half of the vacant houses, are apartment complexes such as condominiums or rentals. More vacancy in older condominiums leads to decreased management fees, insufficient repair funds, and stalling of necessary renovation. Such real estate typical continues to go unsold in a negative cycle. On the other hand, more than 70,000 newly built condominiums were sold in 2022[83], and the average price is still rising. As a result, the number of houses has been steadily increasing, with the problem of vacant houses unsolved.

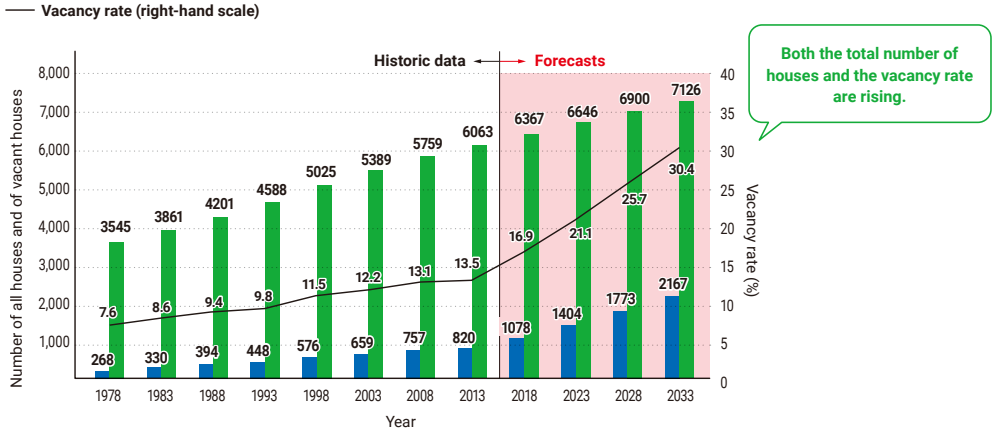
Japan

Potential impact estimates

The national rate of vacancy will reach 30.4% in 2033.84 (See the figure below.)

Foreign tourists visiting Japan display an interest in traditional, antique houses. Vacant old houses, through their revival and utilization have potential to satisfy this demand. Estimates based on the number of foreign visitors who intend to use these antique houses call for 7,390 houses to meet this demand. The foreign visitors' consumption may result in an economic effect of about JPY 38 billion in the regions of those antique houses. This estimate is based on presumed spending per person per night.85(C)

Historic data and forecast for total number of houses, vacant houses, and vacancy rate



Source: Data on existing housing distribution in 2030 estimated by Nomura Research Institute (Nomura Research Institute's news release, "Number of existing housing distribution is predicted to increase to 340,000 units in 2030 - Vacant houses are to increase to over 20 million units in 2033" (in Japanese))

Issues

Revitalization of local communities by making use of vacant houses

Key Points for Resolving Issues

The Situation

[Innovation in Methods to Research and Assess the Market]

Under current regulations, local governments are responsible for checking the current status of vacant houses, promoting countermeasures, and creating databases. However, the process of identifying vacant houses is labor-intensive, time-consuming, and expensive as it is conducted visually on each house.[86] In addition to improving the efficiency of surveys, making the current state of vacant houses visible to the market will expand the possibility of utilization by private businesses.

Key Points for Resolving Issues

Promotion of Effective Use and Repurposing
[Remodeling and renovation]

Some vacant houses are worth remodeling or renovating to promote effective use. Quality houses in the suburbs, such as housing complexes, can be used as accommodation for families with small children.

Vacant houses can also be repurposed for uses other than living, such as working spaces and hotels, depending on the local conditions or user needs. The development of inexpensive renovation technologies will give incentive to individual owners and private businesses to use vacant houses—the result, the revitalization of the local economy.

Solutions

Clues to Solution [Technological Trends]

1. Confirm the Current Situation

Practical implementation period

Use of advanced technologies

- Changes can be detected in vacant houses and land through the development of AI-assisted analysis of spatial data observed via satellites.[87] — 2020-25
- Studies have confirmed the possibility of utilizing data from smart utility meters to identify the distribution of vacant houses. The data enables new analysis such as vacancy duration and future vacant houses that were difficult to obtain with conventional methods.[88] — 2020-25

Information platform

- Local governments have started to coordinate with organizations that are likely to possess information on vacant housing, such as post offices and real estate companies. The information is integrated into a platform and used to encourage owners to utilize the houses or work with real estate agencies.[89] — 2020-25
- The government integrated locally managed vacant house databases into the National Vacant House and Land Bank. This has enabled users to easily search and compare property information. Furthermore, additional information on the neighborhood and hazard maps have been upgraded. — 2020-25
- As a disaster countermeasure, a nationwide system must be constructed that can enable daily management such as dismantling, repair, and maintenance, as well as quick matching and contracting when the necessity arises due to a disaster. — 2020-25

2. Make Effective Use of Stock

Use of advanced technologies

- MR (mixed reality) technology is used to remotely control construction work. The technology ensures smooth communication between parties, such as architects and site supervisors, regarding the current state of vacant houses for each project. The technology will also improve the quality of construction work and reduce the time supervisors spend traveling between sites.[90] — 2020-25

Utilization of regional expertise

- By establishing a coordination system with local craftspeople and holding workshops on DIY and self-renovation, efforts are being made to resolve funding issues for renovation and to popularize renovation techniques.[91] — 2020-25

Effective utilization after value enhancement

- Renovation is gaining popularity as a means to make better use of vacant houses. Furthermore, once renovated, the vacant houses are then leased out to third party entities. 2020-25

Case study

Address Co., Ltd. established a system to renovate vacant houses and vacation homes as needed and then lease them from property owners for renting out. They resolve the vacant house problem by renting out properties to those who wish to move to rural areas. At the same time, Address Co., Ltd. proposes a new lifestyle facilitated by a fixed charge system enabling customers to live in multiple locations for a flat fee.[92]

- Vacant houses and rooms have also started to see use as disaster prevention centers and evacuation sites. 2020-25

Case study

Solar Crew Co., Ltd. is working with local residents to renovate vacant houses by DIY and transform them into disaster prevention centers with earthquake-resistant shelters and solar power generation facilities. In normal times, they are used as a community platform for event spaces and shared offices.[93]

3. Promotion of Recycling

Increasing sales opportunities by owners

- A system is gaining popularity that uses big data and AI to quickly assess the value of vacant properties online. It is expected to increase opportunities for owners to sell their unused properties.[94,95] 2020-25
- VR and 3D cameras are being introduced to make it easier to preview vacant houses in remote areas. 2020-25

Case study

GA technologies Co., Ltd. has partnered with PropTech, Beike, a Chinese company, to launch a 3D walk-through preview service.[96]

Solutions

Clues to a Solution [Regulatory Trends]

- Various local governments have enacted ordinances to promote the use of vacant houses. For example, Kobe City started three programs in September 2018: Consultations on the Utilization of Vacant Land; Banks for the Use of Vacant Houses and Lands; and the Housing Environment Improvement Support System. Measures include tax breaks for property owners who provide their land free of charge and subsidies for demolition costs.[97]
- MLIT is revising the Act on Special Measures concerning Urban Reconstruction to prevent the aforementioned sponge problem in cities and to develop compact and prosperous cities under the Compact City + Network concept. The government, in 2020, added the perspective of developing safe towns in response to natural disasters.
- MLIT revised the Real Estate Brokerage Act in July 2020, given the severe damage caused by frequent large-scale floods and water disasters in recent years. It mandates real estate brokers to explain flood risks as an essential item in real estate transactions.[98]
- The Cabinet approved the Basic Land Policy based on the Basic Land Act in May 2021. Individual measures deployed based on the policy include better treatment of unclaimed and mismanaged land. The policy measures also include the revision of the real estate registration system and the establishment of a system to transfer the property rights to the national treasury (i.e. the national escheatment program for inherited real estate).[99,100]
- In April 2022, the MLIT revised the Act on Advancement of Proper Condominium Management and launched the certification system for condominium management plans. Under the system, local governments certify plans that meet specific standards. The program is intended to launch preferential interest rates, improve property values, and promote the distribution of pre-owned condominiums.[101]
- MLIT revised the Vacant Houses Special Measures Act. Previous to revision, owners are entitled to preferential property tax treatment while they have their house, and this renders a large number of owners unwilling to demolish their vacant houses. Under the revised Act, poorly managed properties will be designated as unmanaged vacant houses, and the preferential property tax treatment will be lifted to promote the management and utilization of vacant houses.[102]
- It is said that there are more than 4.1 million hectares of unclaimed land in Japan, which exceeds the total area of the Kyushu region. To solve this problem, the Act Partially Amending the Civil Code and Other Acts and the Act on the Vesting of Land Ownership Acquired Through Inheritance in the National Treasury were approved in 2021. Inheritance registration will become mandatory in 2024. Inheritance in the past is also subject to the obligation.[103]

Relevance to the SDGs

Problems

Urban decay caused by an increasing number of vacant houses

Societal Issues

Revitalization of local communities by making use of vacant houses

Relevance to the SDGs

11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries

11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

Common targets include manufacturing and administration sectors

As IoT becomes more ubiquitous, all devices will become more sophisticated and utilize more complex information, which puts control systems at greater risk of cyber-attacks.

Visualize locations of high cyber attack risk and implement respective and custom security measures, as well as encourage personal cyber hygiene

Developing technologies for detection, intrusion prevention, and rewriting prevention, as well as development of a mechanism to guarantee the safety of digital products

Problems **Societal Problems: What is wrong?**

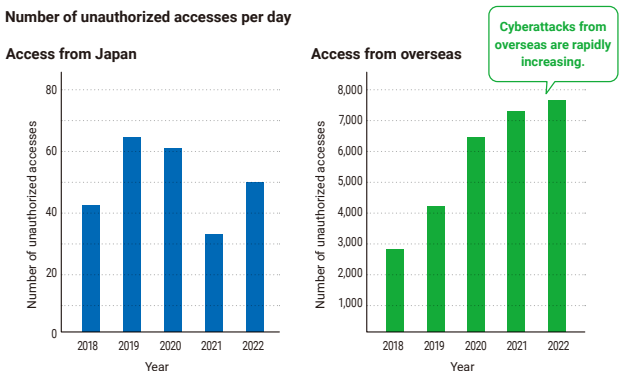
Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Larger number and harsher types of cyberattacks

Cyberattacks on control systems of critical infrastructure are increasingly threatening the sustainability of continuous provision of services. Targeted facilities include the manufacturing production lines of power companies, oil pipelines, and automotive companies. In Japan, the number of cyberattacks from overseas is increasing rapidly (see the figure below). Cyberspace has already become a battleground between nations. The Russian invasion of Ukraine targeted power plants and telecommunications facilities. There is an urgent need to strengthen cyber defenses.

Cyberattacks are on the rise that target network-connected IoT devices such as cars, surveillance cameras, and robots. The risk of vehicle and drone hijacking is becoming a reality with potential to put human lives in danger. In recent years, generative AI has entered the market. Concerns about cyberattack programs that are out of human control and creating new viruses exist. Confirmation of the impact of AI and discussion on regulations have just begun.



Source: The chart is created by MRI from the Metropolitan Police Department's public information material, *Report on Cyberspace Threats in 2022* (in Japanese)

World
Potential impact estimates

In 2020, cybercrime was responsible for more than USD 1 trillion in economic losses, equivalent to more than 1% of the global GDP. It is also over 1.5 times the 2018 level. The losses include theft of intellectual properties and financial assets, and damages to the operational efficiency of companies.[104] (B)

The global drone market was worth about JPY 1.6 trillion in 2018 and is expected to grow at a compound annual growth rate (CAGR) of 8.3% between 2020 and 2025. Military demand is expected to dominate the market.[105] (A)

Issues

Security measures based on a Society 5.0 world

Key Points for Resolving Issues

Control System

[Establishing Security in the Cyber and Physical Realms]

The risk of cyberattacks is increasing as more control systems are equipped with operating systems and protocols of a standardized form. Control systems also see an increased risk of attack when they are connected to other systems via the internet. However, updates to security equipment are often delayed as their continuous 24/7 operation can hinder maintenance. Countermeasures must be incorporated into early steps of design and address attack from both the cyber and physical spheres. There will be an increasing need for solutions that can enhance the security of systems in operation by replacing or upgrading afterwards.

Key Points for Resolving Issues

Automated Equipment

[Visualization of Potential Risks and Domestic Production of Key Technologies]

Next generation automated devices, such as autonomous vehicles, drones, and robots, are built with a complex mix of components. At the time of operation, there is a vast amount of communication via IoT devices. For this reason, it is difficult to perceive the location and timing of cyberattack risk, and there is a growing demand for the visualization of these risks. Furthermore, security measures must cover the entire supply chain in addition to an individual company itself. As concerns increase over the risk of confidential information leaking overseas, expectations will also increase for the development of cybersecurity technologies and services by domestic companies.

Key Points for Resolving Issues

Web Access

[Comprehensive Security Environment under the Zero Trust Concept]

Conventionally, networks have been perceived as a dichotomy: the internal side and the external side. Measures were taken at the border line dividing the two sides, assuming the internal side to be safe and external side risky. However, the Zero Trust concept has spread with the popularity of cloud services. The idea employs security measures for each individual instance of communication; all communication access is inspected taking nothing for granted. It is vital to build a comprehensive security environment that requires improvement of cybersecurity literacy and development of human resources.

Security measures are also being considered to protect personal information flooding social media. Policymakers are also considering regulations over deepfake media that abuses AI technology.

Solutions

Clues to solution [Technological Trends]

1. Control System

Technology to reinforce system security

- Solution services that do not compromise the availability of control systems are becoming pervasive and include security risk assessment, cyberattack exercise, and penetration testing. — 2020-25
- METI encourages the creation of a Software Bill of Materials (SBOM)[106], which lists software components. — 2020-25

Technologies to reinforce network security

- Cyber security risks have been identified at industrial IoT gateways, and demand is growing for the development of secure devices and countermeasures. Industrial IoT gateways link external information networks, including control systems, with on-premise industrial networks.[107] — 2025-35

2. Automated Equipment

Technology to enhance the security of equipment

- Growing interest has surfaced around security measures for controlling systems. Such security measures, otherwise known as a Building Automation System (BAS), automatically control various equipment such as air conditioning equipment in a building. — 2020-25

Case study

Panasonic Corporation and Mori Building Co., Ltd. started a proof of concept experiment from the end of January 2019 to develop security technology for building automation systems. The technology uses AI to enable the detection of abnormalities on premise.[108]

- There is an increasing need for technical solutions that prevent the remote-control hacking of autonomous vehicles. — 2025-35

Case study

SafeRide Technologies Ltd has developed vSentry, a service that combines AI and abnormality detection technologies. It assesses the risk of cyberattacks on automobiles and detects cyberattacks on a real time basis.[109]

- Cyberattacks on AI are expected to increase, resulting in AI making wrong decisions or rewriting the learning data. Research is underway to enhance the security of AI systems. — 2020-25

Case study

Robust Intelligence, Inc., a San Francisco-based startup, is building an AI security platform and has already begun providing them to companies including NTT Data Corporation.[110]

- GNSS, or Global Positioning Navigation Satellite System, identifies the positions of automated equipment. In Japan, antenna and signal authentication technology are in the early stages of being developed as countermeasure against hacking on GNSS in Japan.[111] — 2025-35

Technologies to enhance supply chain security

- ISO/SAE 21434 is the international standard for measures against cyberattack on automobiles. Following the standard, various solution services are taking hold: the establishment of basic rules and a framework for cybersecurity; vulnerability diagnosis in each manufacturing process; and continuous security evaluation. — 2025-35

3. Access to Web Sites

Technology to prevent damages from fraudulent access

- With the expansion of money transfer services using smartphones, further improvements in security technologies are required to detect unauthorized access and to prevent fraudulent purchases. — 2020-25
- The improved performance of quantum computers may enable decrypting of the existing ciphers used in internet communications and virtual currencies. Research is making progress on quantum cryptography as a means to prevent decryption.[112] — 2020-25
- There is progress in the development of tools to check the authenticity of news and images posted on the internet. Expectation is high for prevention of fraud such as fake news and for the use of social media information during disasters. — 2020-25

Case study

A San Diego-based startup, Truepic Inc., has created a smartphone app that accurately maps the date, time, and location data of the photographic images.[113]

Technology to prevent damages from fraudulent access

- New social networks have emerged that offer more secure interaction with others, including by invitation-only membership, voice communication, and anonymity. — 2020-25

Case study

Under the COVID-19 pandemic, a social network named Clubhouse has rapidly gained popularity. Clubhouse enrollment is limited to an invitation basis and only voice is used for communication.

Dtto, launched in April 2021, is a social network dedicated to university students. It allows users to be anonymous and implements numerous security measures to curb crimes related to social media. Measures include identity verification, AI-assisted message monitoring, and prohibition of exchanging direct messages.[114]

- There is a need for online elections. The challenge is how to ensure identity verification and at the same time to secure anonymity. — 2025-35

Solutions

Clues to solution [Regulatory Trends]

- Japan's National Police Agency has decided to set up a cyber bureau in FY 2022 to deal with increasingly serious cyberattacks.
- In 2020, the government established the Information System Security Management and Assessment Program or ISMAP. It assesses and registers cloud services that meet the high-security requirements of the government, aiming at a smooth implementation of the systems.[115]
- METI formulated the Cyber/Physical Security Framework (CPSF), which summarizes the overall picture of the security measures required for industries.[116]
- A movement is spreading in the U.S., China, and other countries worldwide, to develop regulation for prevention of deepfake media used in impersonation and pornography. In Japan, there is debate over the necessity to regulate deepfakes under the Public Offices Election Act.[117]
- In March 2022, the Ministry of Defense (MOD) established the Cyber Defense Command of the Self-Defense Forces (SDF). MOD plans to hire the first civilian SDF personnel in the cyber field in 2024.[118]
- The Japanese government revised three security-related documents, including the National Security Strategy, in December 2022. The documents newly stipulate the introduction of Active Cyber Defense[119] to take preemptive countermeasures against cyberattacks that could significantly impact the country and essential infrastructure. Also, they indicate that Japan would expand its cyber defense workforce to 20,000 personnel. In January 2023, the Cabinet Secretariat established the Preparatory Office for the Development of a Cyber Security System and began studying the legislation.
- The Economic Security Promotion Act, promulgated in May 2023, introduced a system in which the government conducts a prior screening before installing critical equipment to companies responsible for essential infrastructure, including outsourcing companies.[120] More cyber security measures are required for infrastructure companies.
- Japan, the United States, Australia, and India are trying to create a system for government cyber departments to immediately share information in response to cyberattacks targeting critical infrastructure.[121] This information-sharing system will include private infrastructure companies.

Relevance to the SDGs

Problems

Larger number and harsher types of cyberattacks

Societal Issues

Security measures based on a Society 5.0 world

Relevance to the SDGs

9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all

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Special Column
3

Water Resources are a Double-Edged Sword

Water touches every aspect of our lives, from drinking water to transporting goods, sometimes causing disasters.
Now is the time for Japan to take the lead around the world and in addressing water-related challenges.

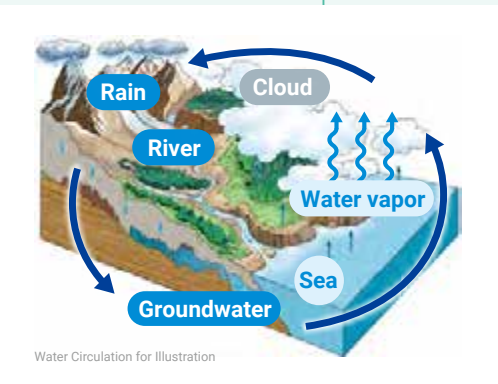
Consideration of Water from "Water Utilization" and "Water Control"

Earth is a planet of water. Two thirds of the Earth's surface, 60% of our human bodies, and 80% of newborn babies are made up of water.

Water utilization involves drawing water for drinking, agricultural, and industrial uses from rivers and lakes. One of the societal problems discussed in this book is the lack of available water resources, which is generally related to water utilization.

Water control is essential to water utilization. Water control aims to control the risks water poses while attempting to receiving its benefits.In recent years, Japan has been promoting 'Water Basin Disaster Resilience and Sustainability by All' as a new approach to flood control. The word 'basin' here includes drainage basins and river areas as well as flood-prone areas. All stakeholders related to water basins, including private companies and residents, are working together to promote sustainable flood control measures. However, the aging infrastructure related to flood control has become a growing concern in recent years, as discussed in this book within the context of disaster prevention and infrastructure.

In addition, for the purpose of transportation, water can generate a large impact, both positive and negative. For example, sediment transport is essential for the formation of landforms, but water does not carry only what is visible. On the one hand, in recent years, there has been progress in research and testing of "sewage surveillance," which involves testing and monitoring viruses in wastewater and understanding the infection status in a region. This is expected to contribute to the field of wellness. On the other hand, the transportation purpose of water can cause new societal problems, such as sedimentation in dams that reduces their capacity and microplastics that leads to marine pollution.



Water Circulation for Illustration

Japan's Abundant Water Resources and Various Water Problems

Moreover, water sometimes causes direct harm to us. Floods, high tides, and intensive rainfall, which have occurred frequently in Japan in recent years, are referred to as water disasters. Due to climate change, droughts and other problems caused by lack of access to water are also occurring in many parts of the world. In terms of societal problems, water is both a cause and a solution to all kinds of problems.

From rainfall to water flowing into the oceans, how do we interact with and live alongside water is a longstanding challenge for all humanity. While Japan is blessed with abundant water resources in the world, it also grapples with various water-related problems. For each year, droughts occur in many regions, and the amount of virtual water imported every year is equivalent to the size of 65,000 Tokyo Domes. For Japan, which is surrounded by rich water resources from seas and rivers, it is important to have a heightened awareness of water-related issues while continuously promoting technological development in the real-world testing ground in front of it in order to lead the way for other nations.

06

A Society where all people are empowered to contribute to their community and the world

Education And Human Resource Development

When considering the field of education and human resource development, ICF defines the ideal future society as one "where all people are empowered to contribute to their community and the world." As science and technology advances and societal change begins to intensify , it is increasingly important that individuals continue learning throughout their lives voluntarily in order to live a vibrant 100-year life.

It is necessary to provide appropriate learning opportunities all the way through each stage of life, from preschool, to elementary and secondary, and to higher education, in order to establish the foundational skills and knowledge that become essential later in life. This education must also be provided in accordance with the interests, focus, and characteristics of each individual. The use of ICT (EdTech) will be key to achieving such individualized and optimized learning.

Differences in geographic area and economic conditions often create disparities in opportunities for appropriate education and in the motivation to continue voluntary learning.By introducing ICT, or EdTech, into education, the gap in educational opportunities due to differences in the economic situation of families and where they live can ideally be minimized.

Today, people need to continue working longer than before in this era of 100-year lives, and the idea of reskilling has gained popularity in corporate management strategies. There has been a growing focus on relearning, such as through recurrent education and by reskilling for working people.

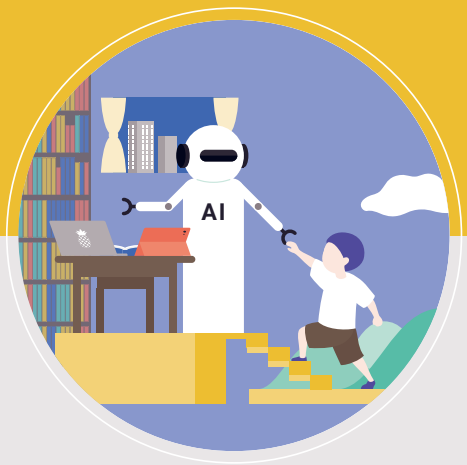
While the pervasive popularity of the Internet has brought easy access to a wide range of information, it has also created problems like information flooding and the proliferation of biased information which may result in further social divisions. Hopefully, digital technologies can instead be used to create cordial and friendly spaces, where people with common interests and values can freely interact with one another.

In order for people from diverse backgrounds to play active and fulfilling roles in society, it is essential to provide appropriate and fair employment opportunities and to ensure psychological safety in the workplace. Diversity, Equity, & Inclusion (DEI) are indispensable components for realizing a society where everyone is empowered to contribute.

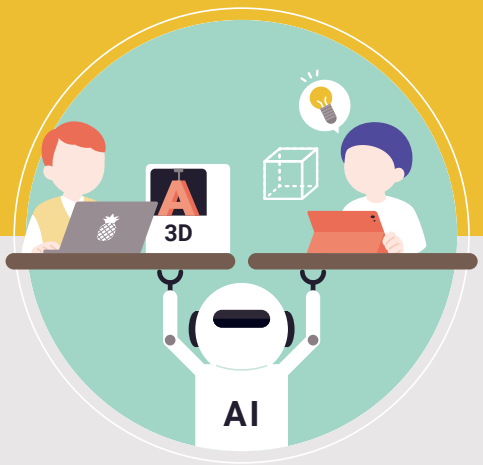
ICF has identified the following four aspects of problems and issues in the fields of education and human resource development:

The ability to survive in the age of AI depends on qualitative differences

Skill development for survival in the age of AI is also determined by disparities between and within families and communities.



Provide every child with the opportunity to gain the power to shape his or her future, focusing on individual talents and characteristics



Providing inexpensive, high quality, personalized education for all children using digital platforms

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

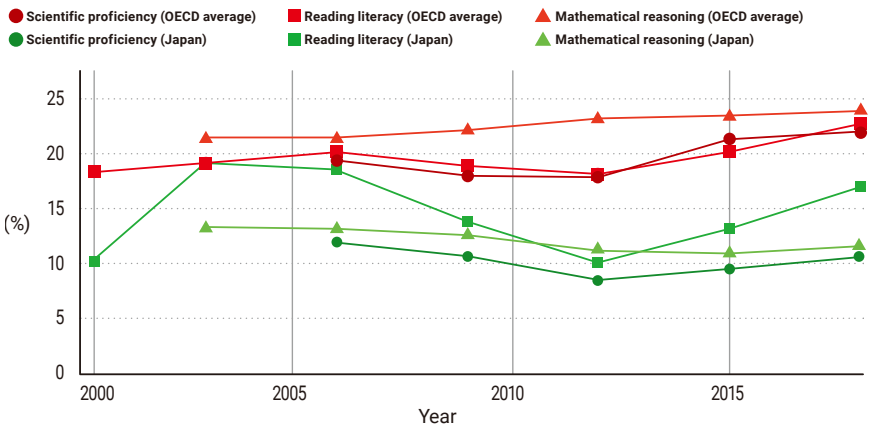
Solutions **Clues to Solutions**

Problems Insufficient skill development in new technologies and processes

Reading comprehension is becoming increasingly important as a skill that is difficult to replace with AI. However, the average scores of reading comprehension of students in Japan have declined according to a study conducted by the OECD's Programme for International Student Assessment (PISA). (See figure below.) The number of students categorized at or below Proficiency Level 1 is increasing both in Japan and on average within the OECD.[1]

There is a noticeable disparity in educational opportunities depending on where students live and their economic situation. In particular, children and young people from low-income families lack educational opportunities.

Percentage of children with academic challenges(Japan and global)



Source: OECD Programme for International Student Assessment (PISA), The National Institute for Education Policy Research.

World
Potential impact estimates

In 2030, nearly 1 billion school-aged children will be without access to basic secondary education, and more than 1.5 billion adults will have no additional education beyond primary school.[2] In an experiment conducted in the U.S., it was estimated that educational support for low-income preschool-aged children directly and significantly improves non-cognitive skills and psychological measurements like the motivation to learn. The return on this kind of investment can reach 15-17% because it will raise the income of the recipient children in the future and decrease the rate of welfare benefit recipients.[3] (C)

Japan
Potential impact estimates

Those at age 15 will lose a total of JPY 2.9 trillion in presumed lifetime income if no measures are taken for people in poverty (recipients of welfare benefit, foster children, or children of single-parent households in poverty) and the number of students who advance to high schools and colleges is left unchanged. The shortage of lifetime income for these youth will result in a JPY 1.1 trillion loss in tax and social security collections.[4] (A)

Issues

Providing learning opportunities to all children and youths

Key Points for Resolving Issues

Defining Essential Education

[Clarifying educational content required to keep up with the times]

In education, the ideal qualities and abilities to foster differ depending on the physical and mental developmental stage of each child and youth. In modern society, the amount of information and number of choices given to students have increased with technological innovation, and, with it, the required contents of compulsory education tend to expand and become specialized. It is thus necessary to clearly define the knowledge and skills required for children and youths living in the coming era. Each country and region should then organize the required knowledge into teachable lesson plans suitable for schools and other education spaces. Emphasis should be placed on the skills of continuous learning and skills for teaching others, as well as problem-setting skills and non-cognitive abilities.

Key Points for Resolving Issues

Individually Optimized Learning

[Providing education tailored to children's characteristics and backgrounds]

Each human being has different cognitive characteristics. These archetypes can be roughly divided into either visual-dominant types, who are good at processing information they see with their eyes, and auditory-dominant types, who are good at processing information they hear with their ears. It is necessary to implement both personalized teaching, in which teaching methods are flexibly utilized according to the characteristics and achievement level of each child, and personalized learning, in which learning is deepened according to the interests of each child, at same time. Advancing educational ICT and EdTech, which is a combined use of technology and educational theory and practice, can provide individualized and optimized education for all children and youths through collaboration between schools and business operators.By using remote education, it is even possible to provide interactive and high-quality education to students living on isolated islands or in remote areas.

During the temporary school closure due to the COVID-19 pandemic, the Global and Innovative Gateway for All (GIGA) School Program explored new ways of providing education. Under the program, each student received an electronic device pre-loaded with digital textbooks. In trying to enhance the resilience of the education system, EdTech provides effective and efficient alternatives to traditional learning.

By utilizing learning records and logs of past digital materials, it is also possible to teach according to individual comprehension levels, which is called adaptive learning. In addition, research is currently underway on the impact that generative AI, such as ChatGPT, will have on education. The development, introduction, and establishment of new educational services are expected to be realized through cooperative efforts between industry, academia, and government using educational ICT, EdTech, and AI.[5]

Solutions

Clues to Solutions [Technological Trends]

1. Early Childhood Education

Practical implementation period

2020-25

Preschool Education

- In addition to cognitive skills like language comprehension, children need to develop non-cognitive skills, such as emotional attachment, self-motivation, and self-control, in order to understand fundamental pieces of knowledge before standard schooling begins.

Case study

In the United States, the Missouri state government provides free home visits by education specialists and educational programs under its Educare program to child-care providers of children under the age of [6]

2.Primary and Secondary Education

2020-25

ICT-based learning and schoolwork support

- Schools are increasingly using e-learning apps as supplementary teaching materials that were primarily employed only for personal use in the past.[7]

Case study

Apple is bringing iPads to classrooms in attempts to introduce augmented reality in education.[8] They intend to provide students with opportunities to see life-size artifacts in history classes, measure everyday objects in math classes, and learn anatomy by dissecting virtual frogs in science classes.

- Programming with robots, 3D printers, and drones is also gaining popularity as educational material for STEM/STEAM.[9] 2020-25
- Fab labs (fabrication laboratories), through which users can experience digital manufacturing in person, are being developed in various locations. In the future, fab labs will need to be built in more familiar places, such as schools and childcare facilities. 2020-25
- Tablets are being used to improve the quality of ESL (English as a Second Language) education by providing students the opportunity to receive more accurate pronunciation lessons.[10] 2020-25
- Some schools are experimenting with a flipped classroom model, where students prepare at home for classroom learning using tablets, increasing the amount of time available for Q&A and problem solving.[11] 2020-25
- Services have emerged that provide proficiency level assessments and personalized teaching by utilizing AI. There is also hope for the development of carefully crafted teaching systems that identify the causes of errors in each student's thought process and sets them on the right track.[12] 2020-25

Case study

Qubena offers AI-assisted learning material on tablets, with the developer, COMPASS Inc., also acting as the service provider. Qubena is used to analyze the strengths and weaknesses of individual children and leads them to personalized problemsto be solved.[13] Atom Learning Ltd., a U.K. EdTech startup, offers a fee-based service to fill learning disparities that are often overlooked in standard education.[14]

- As the challenges facing schools become increasingly complex and difficult, it is important to reduce the burden of schoolwork and enable teachers to spend their time improving the quality of education. In response, the national and local governments, schools, and other sectors in Japan are promoting reforms in the way teachers work. 2020-25
- As part of this effort, efforts to reduce teacher workloads by introducing ICT into school businesses are spreading. Teachers will be able to spend more time preparing lessons and dealing with students, which is expected to help solve the complex and challenging issues that schools face. 2020-25
- The Ministry of Education, Culture, Sports, Science and Technology in Japan (MEXT) has compiled the Case Examples of Work-style Reform in Schools Across Japan to introduce and showcase initiatives to reduce the burden of schoolwork using groupware. 2020-25

Education tailored to cognitive characteristics

- Progress in the research of cognitive characteristics has helped integrate individually tailored learning methods into standardized education. 2020-25

Case study

An examination was conducted for two groups of high school students, one with auditory dominance and the other with visual dominance. Both groups scored better in English writing when the teaching method adapted was tailored to the selected cognitive characteristic.[15]

Fostering the ability to discover and explore questions through inquiry-based learning

- With the revision of the Course of Study in March 2018, the Period for Inquiry-Based Cross-Disciplinary Study was introduced in high schools. Based on comprehensive studies in elementary and junior high schools, this new program attempts to provide students with multiple perspectives and ways of thinking about problems in a thorough and integrated manner according to the characteristics of each individual. In addition, students are required to develop their ability to discover and explore questions based on their lifestyles, in hopes of more directly linking education to career development. — 2020-25
- There has been an increase in the number of exploratory studies offered through collaborations between schools, companies, and local communities. — 2020-25
- The role of external education providers is expected to grow and evolve with the application of these new approaches to teaching. There is additionally a growing need for a service that is capable of connecting students and community members to the appropriate human resources and contacts.[16] — 2020-25

Solutions Clues to Solutions [Regulatory Trends]

- While the restriction on remote high school classes was lifted in April 2015, students can only acquire 36 credits out of the 74 required for graduation from these classes. The remainder must be earned through regular in-person classes. However, a measure has been proposed to raise the upper limit on the number of credits attainable from remote classes, and to lift the restriction at the compulsory education level at the Council for the Regulatory Reform of the Cabinet Office.[17,18] Deregulation is also occurring in other areas of education; starting in 2019, digital textbooks have been permitted for use in the classroom setting.[19]
- METI is in the process of verifying the Classroom of the Future concept as a new social system for learning. New educational services are expected to be created by private education-related business, educational-content business, ICT vendors, NPOs, and others.
- In addition, METI operates the Support Program for Innovation Creation to foster an educational industry that will lead to innovation in Japan's education. The program features mentoring services, seminars, and pitch events for seed/early-stage education companies, companies that have just entered the education field from different industries, and companies who plan to enter the field. These national projects aim to realize the societal implementation of new education/EdTech services in the education sector.
- In January 2021, the Central Council for Education compiled a report titled Toward the Formulation of Japanese-style School Education in Reiwa Era: Achieving Optimal Individual Learning and Collaborative Learning to Elicit the Potential of All Children. In this report, various proposals were made in anticipation of the rapidly changing world under Society 5.0 and the effects of COVID-19. This report is part of the MEXT's wide-ranging elementary and secondary education reforms.
- In response to the first recommendation by the Council for the Creation of Future Education in May 2022 and the Basic Policy on Economic and Fiscal Management and Reform 2022 in June 2022, the MEXT has initiated major reforms of the scholarship system. The ministry is promoting significant revisions of the scholarship system to enable parents to have and raise children without worrying about college payments. Measures include the expansion of applicants for tuition exemptions to include middle-incomes, the establishment of a deferred payment tuition system for graduate school students studying for master's degrees, and a review of the exemptions for student loans.

Relevance to the SDGs

Problems

Insufficient skill development in new technologies and processes

Societal Issues

Providing learning opportunities to all children and youths

Relevance to the SDGs

4.2 By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education

4.3 By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university

4.6 By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy

Adults are extremely averse to relearning

In order to grow personally and support upward career movement, continued education is a necessity, but adults tend to avoid work outside of their jobs

Create an environment where companies, education institutions, and working adults value and respect ever-evolving career positions

Disseminating learning services that encourage people to take an active role in their education and career

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Few working adults return to school or seek recurrent education

In the era of 100-year life spans, companies are increasingly interested in investing in human resources in the context of human capital management. As a result, the conventional lifestyle pattern of people learning at school, then working for a company, and then spending the rest of their years in retirement should be altered to offer a wider variety of ways to work and live.In addition, changes in the industrial structure, the mobility of human resources, and the need to respond to DX/GX, new technologies, and industries with globally increasing demand (AI, semiconductors, etc.) will cause a major shift in the balance of supply and demand for human resources by occupation. As a result, more people will be required to acquire new skills midway through their careers.

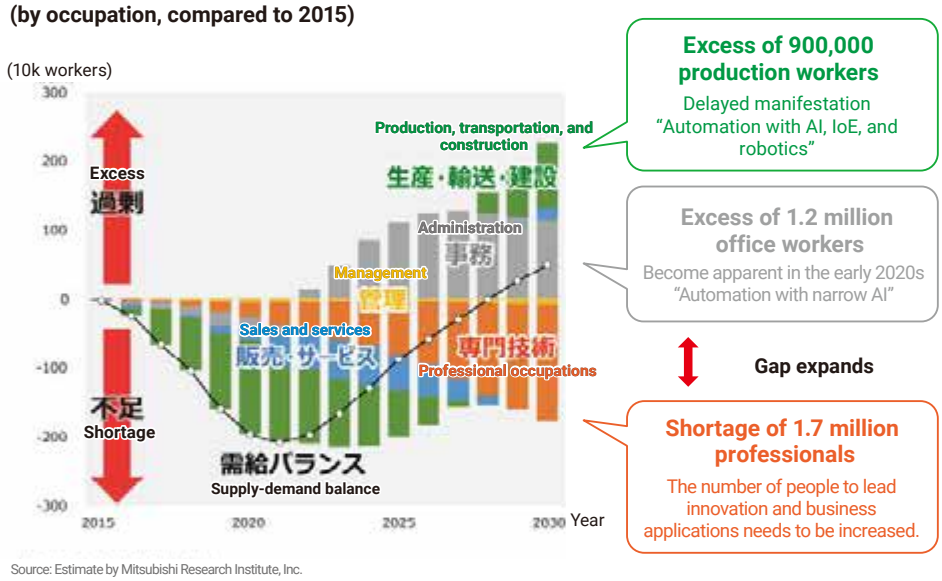
World

Potential impact estimates

Given the spread of digital technologies in response to the COVID-19 pandemic, the supply-demand balance of human resources is expected to shift from an excess of demand to an equilibrium or even an excess of supply in FY 2022. Mismatches are predicted among many occupations and sectors, such as a shortage of 1.7 million professional and engineering workers, compared to an excess of 1.2 million office workers and an excess of 0.9 million manufacturing workers (see figure on next page).

A survey of working adults revealed that only 26% of the respondents studied something new in the previous year, and that 74% had studied nothing. On the other hand, 34% of this group had studied something before and were motivated to learn in the future. People in this segment are eager to learn and want to keep learning for the rest of their lives[20].

Time-series changes in the supply of human resources (by occupation, compared to 2015)



Source: Estimate by Mitsubishi Research Institute, Inc.

Issues

Providing continuous opportunities for learning and modernizing skillsets and promoting reskilling

Key Points for Resolving Issues

Workers

[Achieving Self-directed Career Development]

As the working population declines due to the falling birthrate and aging population, it is becoming increasingly difficult for companies to attract new workers. In light of this, the eligible age for the remuneration-related portion of the Employees' Pension Insurance benefit has been raised, creating an environment that allows people to continue working until age 65, thereby increasing their participation in the workforce. In order to continue working for longer periods of time, and given that the qualities and abilities required of workers are rapidly changing, each individual must learn autonomously throughout their lives and responsively evolve their qualities and abilities.

In response to major changes in industrial structure, such as the changes in the business environment through DX and GX and the significant impacts on working styles after the COVID-19 pandemic, interest in human resource investment and human capital management has increased in recent years. Particular attention is being paid to "self-directed career development," in which employees design and enact their career vision autonomously. In order for employees to achieve self-directed career development, it is also necessary for companies to clarify their human resource strategies and make efforts to be selected by prospective employees for their support.

Key Points for Resolving Issues

Companies

[Realizing and Utilizing Human Capital Management]

Human capital management is a form of management in which human resources are viewed as capital and their value is maximized to improve corporate value over the medium to long term. The linkage between management and personnel strategies is essential to human capital management. Furthermore, in order to strengthen this linkage, it is necessary to consider the dynamic human resources portfolio that supports the ideal business model and management strategy. This portfolio, if fostered correctly, will also significantly help reduce gaps in skill supply and demand.

Key Points for Resolving Issues

Educational Program Providers

[Providing quality educational programs that reflect rapidly changing needs]

There is a lack of educational programs available to acquire or practice the qualities and abilities needed in the present day and age. In addition to universities and vocational schools, there is a growing demand for educational programs that allow students to learn system-level knowledge and skills through private educational and training providers. It is important to provide learning methods that focus on practical implementation, such as on-the-job training and project-based learning (PBL). This will enable learners to practice the acquired knowledge and capabilities that classroom lectures and off-the-job training alone cannot fulfill.

*"Recurrent education" is defined asan overall lifelong learning process, performed on a timely and spontaneous basis after graduating from school, in order to continuously refine the abilities required for work. This definition by the Ministry of Health, Labour and Welfare, Japan (MHLW)[21] is broader than that of other countries.

Solutions

Clues to solution [Technological Trends]

Practical implementation period

1.Workers

Career development support services

- Services are beginning to appear that allow users to enter their work history, education, qualifications, skills, etc., and receive recommendations on appropriate job titles, career paths, and skills to learn.

2020-25

Case study

O*NET OnLine, a U.S. database, stores quantitative and qualitative data on approximately 1,000 job categories, including job descriptions, required experience, education, and training. This occupational database has been updated for Japan, equipped with an occupational dictionary consisting of approximately 1,000 job categories and 20,000 tasks (duties). The service cross-references job seekers' experiences and companies' job requirements so that both parties can perfectly matched. This service is now being offered to help improve the productivity of the placement process by uncovering matching opportunities that were previously lost due to reliance on human intuition and experience (Mitsubishi Research Institute, Inc.).[22]

2. Companies

Clarifying human resource requirements

- It is expected that the job database will become a common language between employers, educational institutions, and job seekers, and that it will be used to create job descriptions for openings and to present relevant skills to educational institutions.

2025-35

3. Educational Program Providers

New recurrent education and reskilling programs through collaboration betweenindustry, academia, and government

- In order to respond to rapid changes in industrial structure such as DX and GX, the need to develop high-level, highly specialized human resources is becoming urgent. Businesses have begun to collaborate with higher education institutions to develop highly specialized human resources.

2020-25

- In the private sector, new reskilling services have emerged to provide comprehensive support from human resource development to the execution of business strategies toward realizing DX and GX.

2020-25

Case study

The METI is supporting an industry-academia collaboration project in which companies set up and run courses to develop highly skilled human resources at higher education institutions.[23]

Online DX learning and training services to support the development of digital human resources and DX implementation are also now available as a comprehensive consulting service. (Aidemy Inc.)

- A service has emerged to match employees from large and mid-sized companies with temporary transfers to venture companies to gain practical skills in innovation.[24]

2020-25

Case study

The METI has started the Program for Supporting Career Advancement through Reskilling to facilitate workers' reskilling and smooth labor mobility. The program provides integrated support for workers through career counseling on their careers, reskilling courses, and career change support based on counseling and reskilling attempt results. Various businesses specializing in career change will provide support to startups and small and medium-sized enterprises (SMEs).[25]

Scientific measurement of educational effectiveness

- New methods are expected to emerge that can measure training and education effectiveness, including cerebral blood flow measurement and computer vision.[26,27]

2025-35

Solutions

Clues to solution [Regulatory Trends]

- Regarding recurrent education, the visualization of learning outcomes and their dissemination were highlighted as important issues at the Council for the Creation of Future Education. In addition, the Sixth Science, Technology, and Innovation Basic Plan calls for developing indicators to evaluate the effects of recurrent education and its impact on society. Recurrent education, relearning, and reskilling are regarded as critical issues in the following policies by governmental councils: The Basic Policy on Economic and Fiscal Management and Reform 2023 by Council on Economic and Fiscal, Guidelines for Integrated Three-Pronged Labor Market Reforms by the Council of New Form of Capitalism Realization, Children's Future Strategy Policy by the Children's Future Strategy Council, and the Basic Plan for the Promotion of Education.
- In the Basic Policy on Economic and Fiscal Management and Reform 2023, reskilling is not only focused on inthe context of traditional education and skill development but also in broader policies, such as the need for structural labor market reforms to achieve sustainable wage increases.
- The Report of the Study Group on Improvement of Sustainable Corporate Value and Human Capital showcased the so-called 3P/5F Model, with three viewpoints and five common elements required for human resources strategy.[28] One of these five common elements is reskilling and relearning, which highlights the importance of corporate support for individuals' proactive and autonomous career development in order to effectively respond to rapid change in the business environment and to the diversification of individual values.
- The Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT) manages a website called Manapass[29] that allows users to search for educational programs designed specifically for working adults. On this site, users can specify various criteria, such as the field of lectures, qualifications, availability of support, and lecture schedules.

Relevance to the SDGs

Problems

Few working adults return to school or seek recurrent education

Societal Issues

Providing continuous opportunities for learning and modernizing skillsets and promoting reskilling

Relevance to the SDGs

4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship

5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of womenand older persons

The 21st Century version of escapism

Too much information makes people tired of their ability to explore different environments, and they escape into biased opinions

Create diversity in opinions and in thinking on the Internet by developing a wider variety of environments and a more modern education system

Creating a diverse online environment and cultivating skills like utilizing a multitude of differing information sources and feedback

Problems **Societal Problems: What is wrong?**

Issues **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Information flooding and biases

As the time and rate of people using social media expand, internet defamation has become a more serious problem, resulting in bullying, job loss, and at worst even suicide. The number of online human rights violations cases in Japan has tripled in the past ten years.[30]

Most of the information that internet users receive is heavily filtered according to their personal data such as browsing and location histories. This type of algorithmic filtering creates what are known as "filter bubbles," where you are exposed only to the information that you are already likely to enjoy and approve of. The resulting bias and lack of diversity in almost all information online is a problem. There is also concern over the echo chamber effect that limits communication to within only a single community of like-minded individuals. This effect tends to amplify and reinforce one's own beliefs while affirming the consistent rejection of differing opinions.

World
Potential impact estimates

Anyone who uses the internet is, whether consciously or not, caught in some form of filter bubble (about 5.18 billion people).[31] In the U.S., 18.2% of adults gather political information primarily from social media, where filter bubbles are likely to have a substantial impact.[32]

World
Potential impact estimates

During the COVID-19 pandemic in the U.S., false information that opposed vaccination was spread on social networking services and other media. An estimate showed that more than 50 million Americans refused vaccination, resulting in more than 100,000 deaths.[33]

Japan
Potential impact estimates

The number of junior high and high school students suspected of internet addiction has reached 930,000 nationwide in Japan. This number has doubled in the last five years.[34]

* As many as 10.6% of boys (4.4% previously) and 14.3% of girls (7.7% previously) in junior high school have been diagnosed with internet addiction. In high school, the diagnoses increase to 13.2% of boys (7.6% previously) and 18.9% of girls (11.2% previously).

Issues

Ensuring free and open speech and discourse

Key Points for Resolving Issues

Clarifying and Correcting Information Flooding and Biases

[Fair scoring and automated recommendations]

While removing incorrect or biased information from the Internet space is an effective way to correct information flooding and biases, it is difficult to completely eliminate it in liberal countries. The second-best measure is to explicitly identify information that is misleading or biased. To cope with the enormous volume of daily information posted on the internet, a popular proposal involves a system that can automatically score data and provide recommendations using search engines and AI. Social media and search engine providers are also expected to review and change their algorithms for selecting and displaying or providing various information sources. These measures will have direct impacts on users' attitudes and habits on the internet. Offline communication may also mitigate the harmful impact of biased information flooding. For example, it may be possible to create a system where people with different ideas can meet offline and exchange opinions and reward them with community points.

Key Points for Resolving Issues

Communication Education

[Understanding the characteristics of the internet world]

Given the prevalence and influence of social media, it is becoming more important to disseminate information and education materials to improve the "internet literacy rate" for communication online. The first step in mitigating the harmful effects of unsafe internet usage is to recognize the existence of filter bubbles and to understand how they work. For example, mechanisms that encourage users to take specific actions, such as browsing news sites that offer diverse viewpoints, visiting sites that showcasing multifaceted political arguments, and being open to critical feedback about their thoughts, are also an effective measures against filter bubbles. The following adverse effects have been pointed out as an extension of echo chambers and filter bubbles:

- **Spiral of silence**
  People tend to be silent when they think their opinion is in the minority. As a result, public opinion is formed with a larger majority view and a smaller minority view.
- **Easy Groupthink**
  A decision made in a group has a tendency of being one sided and shallower compared to a well-thought-out idea made by each person.
- **Flaming**
  A hostile online interaction defined by bad faith interactions and usag e of offensive language. Studies indicate that less than even a small percentage of internet users participate in flaming.

Solutions

Clues to Solution [Technological Trends]

1. Diversification of Information Sources

Practical implementation period

Internet education

2020-25

- Ideas for education at school include teaching students about the existence and mechanisms of filter bubbles, as well as giving lessons to parents about internet safety. Educating employees at companies is another avenue for mitigating filter bubbles, especially if filter bubble education is incorporated into unconscious bias training courses.

Case study

Since around the year 2000, ICT companies in the U.S. have introduced a series of training programs to eliminate unconscious bias. The Implicit Association Test (IAT) is publicly available to measure users' level of unconscious bias.[35] Microsoft has made its own unconscious bias training for its employees that is also available to the public.

A's Child Inc., a Japanese IT startup, provides a social media network monitoring service that watches over children's SNS information and provides moral literacy seminars for local municipalities, schools, and NPOs.[36]

Changing the internet environment

2020-25

- Concerns surrounding filter bubbles have led to the creation of multiple search engines that do not provide information based on personalized search data.

Case study

Search engines that do not personalize search results include YaCy, DuckDuckGo, Qwant, Startpage.com, and Searx.

2020-25

- Other startups are working to improve the reliability of the Internet's information by using blockchain technology to combat fake news and to score the trustworthiness of online content.

Case study

TrueInChain, an Italian startup, offers a service that utilizes blockchain technology to search for fake news. Factmata, a British startup, uses AI to score and visualize the reliability of information and to quantify the harmful effects of unreliable information that individuals are viewing. Finally, EscapeYourBubble, a U.S. startup, provides a browser extension service to highlight articles that show opposite viewpoints in users' Facebook News Feed.

Measures against defamation

2020-25

- In addition to human surveillance, AI is also being used as a measure against defamation.

Case study

Yahoo News has introduced a function to automatically conceal the comment section of articles and videos if an AI judges that there is an excessive concentration of defamation. (Yahoo! JAPAN)

Utilization of the offline

- Providing opportunities for people of differing ideologies to meet face-to-face offline may help eliminate filter bubbles.

2025-35

Case study

Hi From The Other Side is a website that matches users with others who hold different beliefs. It encourages them to talk on the phone, have discussions online, and to meet in person.

Heineken N.V., a Dutch beer company, provided opportunities to match people with opposing ideas, such as feminists with anti-feminists, environmental activists with global warming skeptics, and transgender supporters with anti-transgender activists, to work together and engage in dialogue. It was broadcasted as a commercial under the concept "Open Your World."

Solutions

Clues to a Solution [Regulatory Trends]

- In October 2019, the Filter Bubble Transparency Act was introduced in the United States. The bill requires Internet platforms to inform users of the existence of algorithmic filtering bubbles and to provide them with the option of viewing unfiltered information. The bill was approved unanimously by the Senate Commerce Committee in July 2023, and attention is now focused on the upcoming Senate and House votes.[37] In 2018, the state of California enacted the California Consumer Privacy Act, which allows internet users to opt out of personal data, search data, and other types of data collection and the sale of said data.
- In 2016, the European Commission announced funding for the media, industry, researchers, and NGOs to investigate issues surrounding filter bubbles. It established an election package of user data protection, election management rules, and guidelines which were later enacted in 2018. The European Union has also taken joint action against false information on social media and the Internet. Facebook, Google, Twitter, and YouTube signed a code of conduct pledging to do the same. It ensures fairness in elections by introducing measures to restrict microtargeted advertising and fake news.
- In Japan, the Ministry of Internal Affairs and Communication (MIC) revised its ordinance on the Provider Liability Limitation Act in August 2020. In the case of defamation accusations, senders must now also disclose their phone number in addition to the previously required items. MIC published the Policy Package for Response to Internet Defamation in September 2020. Specific initiatives include:

  1. raising user awareness to improve information ethics and ICT literacy,
  2. supporting the efforts of platform providers to improve transparency and accountability,
  3. dealing with disclosure of sender identification, and
  4. coordinating and developing frameworks to enhance consultation services.[38]

- It has also been argued that social media addiction should be defined as a formal psychiatric disorder in the International Classification of Diseases (ICD) and as diagnostic criteria for mental disorders.

We often don't hear from the other sides

Japanese companies lack diversity in many areas, including age, gender, and nationality, resulting in one of the lowest ranks among developed countries

Create workplaces that respect the different forms of diversity and transforms them into applicable strengths

Providing education, training, and a work environment that respects diversity and encourages growth

Problems **Societal Problems: What is wrong?**

Issuess **Societal Issues: What needs to be done?**

Solutions **Clues to Solutions**

Problems Lack of diversity in human resources

There is a growing view that higher levels of diversity within a team lead to higher levels, on average, of productivity. Diversity is desirable not only in terms of both physical attributes, such as age, gender, and nationality, but also in ways of thinking, such as values and lifestyles.

The World Economic Forum ranks Japan 125th out of 146 countries in the Global Gender Gap Index in 2023, its lowest ranking ever. This ranking was particularly affected by the uneven political and economic participation by gender.[39]

Though companies are hiring an increasing number of people with disabilities, their retention rate after one year of employment is low.

World
Potential impact estimates

A study showed that firms with above-average diversity in six fields (gender, age, national origin, career path, industry background, and education) have on average 19% higher revenue from innovation and 9% higher profits before tax.[40]

Japan
Potential impact estimates

According to a survey by the MHLW,, the average annual turnover rate of full-time workers, including those with disabilities, is hovering between 14% and 17%. However, about 40% of workers with physical and mental disabilities and more than 50% of workers with psychiatric disorders leave the workplace within one year.[41]

Issues

Develop an environment that accepts and empowers all individuals

Key Points for Resolving Issues

Pursuing Equity
[Education and assessment]

While the need for diversity and inclusion education for both children and adults is growing, there are limits to how much it can be incorporated into the traditional school curriculum. The key is to provide new educational opportunities and environments, not just through public education, but also through private educational organizations, experiential learning activities, and virtual learning environments utilizing ICT.

A mechanism for objectively assessing diversity is also in need. In 2016, the PRIDE Index was established as the first of its kind in Japan. It evaluates institutional efforts to accept LGBTQ and other sexual minorities in the workplace.[42] The Ministry of Economy, Trade and Industry, Japan (METI) released the Revised Diversity Management Diagnostic Toolkit in 2021 to help companies visualize the status of their diversity management level.[43] There are high hopes that the assessments with these indexes and toolkit will improve the personnel system and workplace environment.

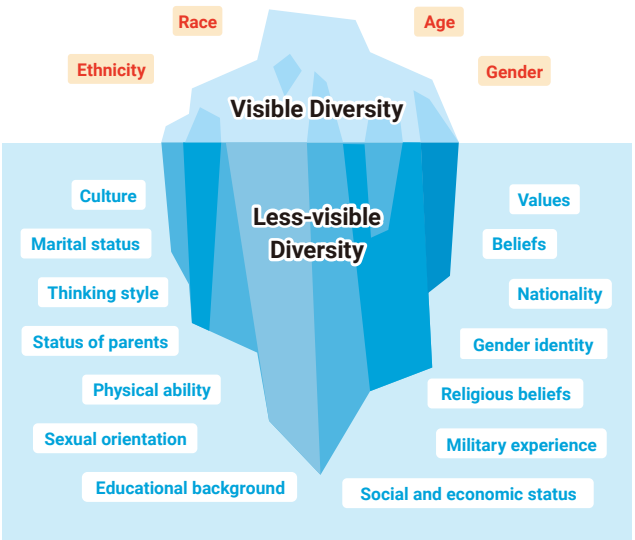
Key Points for Resolving Issues

Maximizing the Potential of Diverse Human Resources to Achieve Organizational Objectives
[Reform of work practices, human asset matching, and psychological safety]

Creating a comfortable work environment for individuals in various circumstances, such as childcare, nursing care, or relearning, will provide opportunities for diverse human resources to be utilized effectively. Efforts to welcome diverse human resources into the business world are progressing, such as support for former athletes to build a second career[44] and placement services for people with disabilities.

It is necessary not only to bring together diverse human resources but to make the most of their various abilities and characteristics. To this end, it is essential to (1) raise the percentage of minorities in the workplace above a certain level, and (2) ensure psychological safety in the workplace.

Visible and Invisible Diversity



Solutions

Clues to solution [Technological Trends]

Practical implementation period

Promoting diverse human resource employment

- Widespread use of satellite offices and telework will enable the employment of more diverse human resources, including people with disabilities who have difficulty commuting to work and people raising children or caring for older family members. — 2020-25

Case study

Activatelab Co, Ltd. (Japan) provides a service to assess whether institutions provide accompanying environments for candidates with disabilities by compiling a report on the constraints of hiring. They support institutions in identifying types of work that can be done at home or through telework.[45]

MotherWorks (U.S.) is a job information site for parents raising children to find remote or hybrid work while achieving a work-life balance.[46]

- Some companies are featuring the art of those with mental disabilities in their branding efforts. — 2020-25

Case study

HERALBONY Co., Ltd. (Japan) solicits artwork created by artists with mental disabilities on their website. The company utilizes high-resolution digital scanning to create and distribute high-quality fashion products and interior goods.

Diversity & inclusion education

- Experiencing the viewpoints of people with different attributes and positions allows people to understand and empathize with the feelings of others. — 2020-25

Case study

Jolly Good Inc. (Japan) has developed a VR system called Yourside for a workplace harassment training. It provides experiences to the executives and managers from the perspective of the employees reporting to them.[47]

- Including diverse characters in movies and educational TV programs contributes to promoting diversity and inclusion in society. — 2020-25

Case study

Sesame Street, a U.S. educational TV program for children, has introduced various characters on its show, including the first African American puppet in 1970, an HIV-positive puppet, a puppet living on food stamps, a father in prison, and a drug-addicted mother.[48]

Cross-cultural understanding through collaborative learning environments

- Some schools in remote areas are connecting to enable online collaborative learning.

2020-25

Case study

Kizuna Across Cultures, a non-profit organization based in Washington, D.C., pairs high schools in Japan and the U.S. by connecting two classes in each country as a single class online to provide a learning environment where students in different countries can collaborate. This provides an opportunity for Japanese students to use the English language skills they have learned in the classroom with native English speakers of the same generation. At the same time, the program promotes cross-cultural understanding and motivates both students to study abroad.[49]

Psychological safety

- To encourage diverse human resources to work effectively, it is important to secure psychological safety in the workplace without fear of others' reactions. Services are being developed that support building teams with high psychological safety.

2020-25

Case study

NAONA is a sensing data platform produced by Murata Manufacturing Co., Ltd. (Japan). The platform supports improvements in psychological safety and productivity by visualizing factors like the number of times a person spoke in a meeting, the pace of conversation, and communication styles.[50]

Solutions Clues to solution [Regulatory Trends]

- In Japan, the Act for Promotion of Employment of Persons with Disabilities sets the legal employment rate for persons with disabilities. The mandatory rate has been gradually raised over time, and will be 2.3% in 2023, 2.5% in 2024, and 2.7% in 2026 for private companies.[51]
- The U.S. stock exchange NASDAQ requires companies listed before August 6, 2021, to include (or explain why they do not include) at least one director with a minority background and to submit a Board Diversity Matrix by the end of 2023.[52] The Goldman Sachs Group, Inc. has also announced in its initial public offering (IPO) underwriting service that it will require Western companies seeking to list to appoint at least one female director.[53]
- Aiming to promote diversity and inclusion, KEIDANREN (the Japan Business Federation) is taking initiatives to:

1. promote women to play active roles in business,
2. additionally promote young and senior workers to play active roles in business,
3. reform work practices,
4. invite highly skilled foreign human resources,
5. create a barrier-free society, and
6. promote a society that embraces the LGBT community.[54]

Relevance to the SDGs

Problems

Lack of diversity in human resources

Societal Issues

Develop an environment that accepts and empowers all individuals

Relevance to the SDGs

4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship

5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of womenand older persons

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Societal Implementation and Public Affairs

Societal implementation creates new markets; and new markets require new rules. These new rules are proactively and strategically implemented through public affairs.

New Rules are Essential for Societal Implementation

Various responses are required to resolve societal problems through business and link them to societal implementation. Even if we can develop the products and services that meet the needs of users with various pain points, if there is no existing market, it is necessary for us to form a new market and create new rules for it.

For the past decades, as various new services proliferate with the spread of the Internet, we are also actively reevaluating regulations and rules to maximize their benefits and minimize their risks. Recently, as new technologies such as autonomous driving, drones, generative AI, and Web3 move toward commercialization, various regulations and rules are rapidly being formed. Furthermore, as ethical elements are have become crucial in the practical application of cutting-edge technologies, it is increasingly necessary to consider not only the legal aspects but also the formation of social rules in a broad sense.

In this context, among the elements supporting societal implementation, public affairs (PA) are becoming increasingly necessary and important at the practical level. PA is one of the corporate activities that involves comprehensive engagement with the entire society, including the government, public opinion, academia, and media work to create new rules and foster societal momentum. It operates on the premise that a company's activities will contribute to the broad public interest, mobilizing society, and influencing politics and government to achieve the necessary rule formation.

Traditional lobbying activities and petitions tend to be characterized as being self-centered and behind-the-scenes activities driven by specific personal connections and lacking systematic organization. On the other hand, PA, especially in Europe and the United States, has been treated from an early stage as an open method by companies that envision societal benefits,.

An Era of Constructing Necessary External Environment by Oneself

At last, the effectiveness of this approach has been recognized in Japan as well, which leads to increasingly active engagement with society. This is underlined by the closer relationship between business and the social environment since the establishment of the SDGs in 2015, making corporate activities themselves untenable without close relationships with various stakeholders.

In fact, around the ICF, professional groups such as Makaira KK, Next Relation, Inc., and ZeLo (a Foreign Law Joint Enterprise), have been actively dealing with PA as actual business services. Their goal is nothing less than integrating PA into the corporate strategic process. The external environment surrounding the market, including various regulations and systems, has long been treated as a "given" factor in business strategy, but there is a growing trend towards active engagement with society and constructing necessary external environment in the future.

Table of Issues

Wellness

Water And Food

Problems	Issues
1 Decline in food supply capacity P60	Strengthening the industrialization of food production by improving productivity Key Points for Resolving Issues Elderly Farmers and Fishers [Becoming more mechanized, larger-scale, and higher value-added industries] Prospective New Farmers [Industrialization, expansion of farming opportunities, and smooth successions] Climate Change Countermeasures, Farmland Conservation, and Prevention of Overfishing Establishment of Sustainable Food Procurement and Security Systems
2 Difficulty in food procurement due to population growth P68	Securing an ample food supply to meet increasing global demand Key Points for Resolving Issues Protein [Improving food productivity and securing new protein resources] Grain [Stable supply of food]
3 Insufficient usable water resources P74	Securing and improving water infrastructure and functionalities Key Points for Resolving Issues Countries and Regions That Lack Clean Water [Securing the absolute quantity of water needed and improving the quality of water] Water Infrastructure Operators [How to manage in accordance with demand]
4 Adverse effects of increasing food loss and waste P80	Streamlining food supply chain across all stages from production to supply and consumption; reducing food waste Key Points for Resolving Issues Production and Distribution Stages [Improvement of post-harvest processing, storage technologies, and logistics] Retail and Consumption Stages [Demand-driven procurement and manufacturing]
5 Unhealthy food remaining widespread in prosperous societies P86	Providing and improving access to healthy meals Key Points for Resolving Issues Identifying a Healthy Diet [Providing science-based information on food and health] Improved Access to Healthy Diets [Delivering healthy meals to many people]
6 The shift toward greater respect for food diversity P92	Improving the diversity and quality of food to conform to the needs of individuals Key Points for Resolving Issues Improving Food Quality by Accommodating to Various Beliefs and Religions [Development of new ingredients and cooking methods] Food Tailored to Age and Constitution [Visualization of necessary elements and burden lightening]
7 Encouraging communication through food P96	Promoting communication through all aspects of food from farming and cooking, to the dinner table Key Points for Resolving Issues Communication through Food Promotion of Communication Using Food [The process of making and cooking]

Energy and Environment

Problems	Issues
1 Need to accelerate decarbonization in the supply side of energy P106	Promote comprehensive decarbonization measures Key Points for Resolving Issues **Development of Energy Production and Conversion Technologies** [Expanding renewable energies and power generation using hydrogen and ammonia] **Development of Energy Storage and Transportation Technologies** [Improving the performance, safety, and affordability of storage batteries] **Development of New Decentralized Energy Systems** [Virtual power plants and microgrids]
2 Large room for energy conservation and decarbonization on the demand side P112	Promote decarbonization in the industrial, household, and transportation sectors Key Points for Resolving Issues **Industrial Sector** [Technological innovations for decarbonizing manufacturing processes and capturing and recycling CO_2] **Buildings (Residential and Services) Sector** [Popularization of energy-saving houses and buildings, as well as energy technology innovation using IoT]
3 Insufficient recycling and ineffective use of resources P120	Create a recycling-oriented society that makes effective use of all resources Key Points for Resolving Issues **Enhancing Resource Utilization throughout Product Life Cycles** [Recycle, reuse, and easy recyclable/reusable design] **Advanced Recycling** [Horizontal recycling that maintains quality levels]
4 Intensifying environmental pollution and deterioration P126	Take immediate action to assess the current situation, analyze underlying factors, and implement countermeasures Key Points for Resolving Issues **Measures to Control Pollution** [Preventing new and clearing existing contamination] **Combating Deforestation** [Enhancing region-based measures s and coordinating global effort]
5 Loss of biodiversity P132	Maintain sustainable coexistence between humans and other living creatures Key Points for Resolving Issues **Visualization** [Understanding the actual condition of ecosystems and their segregation] **Commercialization** [Securing conservation funds through the utilization of ecosystems]

Mobility

Problems	Issues
1 Adverse effects of vehicle-centric transportation systems P144	Optimizing traffic flow and promoting the use of safe and comfortable mobility services Key Points for Resolving Issues **Optimization** [Solutions that promote leveling of traffic volume and congestion time] **Accident Prevention** [Enhancement of safety support functions for vehicles and roads] **Reducing Environmental Impact** [Promoting the spread and use of transportation with low environmental impact]
2 Insufficient logistics processing capacity for increased demand P150	Building a sustainable logistics network Key Points for Resolving Issues **Improving Delivery Efficiency** [Improving loading rates, coordinating supply chains, and determining optimal routes] **Labor Saving and Automation** [Autonomous driving, utilization of delivery robots and drones] **New Delivery Service** [Decentralized personal delivery and mixed-freight consolidation]
3 Difficulty in providing mobility services where transportation is inconvenient P156	Providing mobility services to maintain quality of life Key Points for Resolving Issues **Providing Transportation to Fill Gaps** [On-demand and last-mile transportation] **Purpose-driven Transportation Services** [Collaboration and integration of transportation with goods and services] **Small-scale Services to Meet Diverse Needs** [Improving operational and network efficiency]
4 Rapid changes in mobility opportunities due to digital technologies P162	Providing a wider variety of customer consumer experiences in response to changes in transportation configuration Key Points for Resolving Issues **Diversifying Work Styles** [Improving efficiency in work and creating a better work-life balance] **New lifestyles** [Creating spiritually fulfilling mobility] **Next-generation Mobility** [New types of mobility and associated services] **Urban Digital Transformation (DX)** [Creating open innovation]

Disaster Prevention and Infrastructure

Problems	Issues
1 Insufficient preparation and response to natural disasters P174	Strengthening of disaster response capabilities through innovative technologies and societal infrastructure Key Points for Resolving Issues **Normal Times and During Disasters** [Prediction and assessment of disasters via public-private sharing of information establishing an operating framework] **Emergency Response** [Assisted and un-assisted evacuation of local residents] **Emergency Response and Post-Disaster Restoration & Reconstruction** [Responding to needs during disaster]
2 Poor management of societal infrastructure P182	Improvements to efficient management of infrastructure through better utilization and aggregated, centralized control Key Points for Resolving Issues **Improving the Efficiency of Infrastructure Management** [Labor-saving and automation for efficient operation and maintenance] **Consolidating Infrastructure** [Compact cities and concentrated, efficient infrastructure use over a wide area] **Utilization of Infrastructure** [Multifaceted perspectives for effective use]
3 Urban decay caused by an increasing number of vacant houses P190	Revitalization of local communities by making use of vacant houses Key Points for Resolving Issues **The Situation** [Innovation in methods to research and visualize the market] **Promotion of Effective Use and Repurposing** [Remodeling and renovation]
4 Larger number and harsher types of cyberattacks P196	Security measures based on a Society 5.0 world Key Points for Resolving Issues **Control System** [Establishing security in the cyber and physical realms] **Automated Equipment** [Visualization of potential risks and domestic production of key technologies] **Web Access** [Comprehensive security environment under the zero trust concept]

Education and Human Resourse Development

Problems	Issues
1 Insufficient skill development in new technologies and processes P208	Providing learning opportunities to all children and youths Key Points for Resolving Issues **Defining Essential Education** [Clarifying educational content required to keep up with the times] **Individually Optimized Learning** [Providing education tailored for children's characteristics and backgrounds]
2 Few working adults return to school or seek recurrent education P214	Providing continuous opportunities for learning and modernizing skillsets and promoting reskilling Key Points for Resolving Issues **Workers** [Achieving Self-directed Career Development] **Companies** [Realizing and Utilizing Human Capital Management] **Educational Program Providers** [Providing quality educational programs that reflect rapidly changing needs]
3 Information flooding and biases P220	Ensuring Free and Open Speech and Discourse Key Points for Resolving Issues **Clarifying and Correcting Information Flooding and Biases** [Fair scoring and automated recommendations] **Communication Education** [Understanding the characteristics of the internet world]
4 Lack of diversity in human resources P224	Develop an environment that accepts and empowers all individuals Key Points for Resolving Issues **Pursuing Equity** [Education and assessment] **Maximizing the Potential of Diverse Human Resources to Achieve Organizational Objectives** [Reform of work practices, human asset matching, and psychological safety]

SDGs index

1 No Poverty

2 Zero Humger

3 Good Health and Well-Being

4 Quality Education

5 Gender Equality

6 Clean Water and Sanitation

7 Affordable and Clean Energy

8 Decent Work and Economic Growth

9 Industry, Innovation and Infrastructure

10 Reduced Inequalities

11 Sustainable Cities and Communities

12 Responsible Consumption and Production

13 Climate Action

14 Climate Action

15 Life On Land

Technological Index

Afterword

The Listings has reached its 6th edition since its first publication in 2017. Careful attention has been paid to cover as many perspectives as possible as to not overlook any important issues. In particular, reviews and revisions have been carried out to evaluate the magnitude of societal impact that can be realized through the solution of issues as well as the high potential for sustainable solutions through business.

As society is constantly changing, each edition of the Listings is only a snapshot of a single point in time. However, many new things come to light when issues are continuously reviewed. One aspect of solving problems that warrants consistent attention is the evaluation of their progression. While some issues are seeing swift solution against the backdrop of technological innovation and rapid environmental change caused by the covid pandemic, for others progress remains stalled for a long period of time due to regulatory barriers. In other cases, there are many issues that have been resolved in the immediate sense but that do not lead to major impact.

As analysis was initially carried out in each of the six focus areas, the importance of cross-sectional themes across the areas gradually emerged. The special columns in this edition present new insights, including the acceleration of solutions through society's digitalization and the unique characteristics of water resources. Moreover, there are moments when trends change dramatically after a certain event or point in time. This is exactly one of the insights that can be gained through continuous observation.

The Listings has been updated almost every year, but in FY 2022, instead of updating the list entirely, the Societal Issues Portal, which includes the results of ICF's total societal issue research and convenient video walk-throughs, was published on the ICF website. The portal is designed to make the information within the Listings available to broader audiences, including ICF members.

Following this, the 2023 edition of the Listings focuses on new ways of seeing and presenting societal issues. Leveraging a form of visualization called graphical abstract, the Listings showcases the overall issue solution progression from problem to issue then solution. The cover of the Listings has also been redesigned. As with the Societal Issue Portal, the purpose of these updates is to encourage people to become involved in resolving societal issues. ICF hopes that the Listings stimulates readers' interest in topics that are new to them and helps readers take individual actions to resolve issues.

Societal issues will continue to change and grow in complexity over time. In this sense, the need for multiple broad perspectives will not change. In some cases, however, a new view of the bigger picture may emerge by delving into more specific issues. Without a combination of macro- and micro-level perspectives, oversight easily occurs. Because of this, the Listings is effectively a never-ending project.

With support from ICF members, the Listings will continue to evolve to provide a starting point for creating collective impact.