2021 Edition

Resolving Societal Issues
Through Innovation
--- Listings of Societal Issues

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

Mitsubishi Research Institute

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.

One year 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 Co.,Ltd.　　　　　ヘラルボニー

The art featured on the cover is by Katsumi Sasayama, a contract artist for the ICF member HERALBONY Co., Ltd and an artist member of the project unico of Asaka Aiikuen, a social welfare service corporation, Fukushima Prefecture. The work is titled "Untitled." 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) Katsumi Sasayama

Powerful circles and colorful lines—She draws them outward from her chest carefully and forcefully, one by one, while sitting with her upper body forward over her desk. In many of her works, her brushstrokes protrude from the paper, showing her strength and easy-going personality.

RELEASE OF 2021 EDITION

1. Preface

Half a century has passed since the Club of Rome warned in *The Limits to Growth* that global growth would reach its limits sometime within 100 years due to depletion of resources and environmental pollution. Since then, the world population has more than doubled from 3.7 billion to 7.8 billion and nominal GDP has increased nearly 30 times from $3 trillion to $85 trillion. Meanwhile, economic disparities are widening, and the world is confronting a wide range of problems, such as frequent natural disasters due to extreme climate change, serious water and food shortages, and aging populations. Those problems and issues, including the recent pandemic, are becoming increasingly compounded, complicated, and globalized.

In an era of industrialization, economic growth has expanded from developed countries to emerging countries, and demand has been met to such a degree that a state of saturation has resulted. In the information and digital society of the 21st century, new technologies are being developed not only to overcome the quantitative limits of growth and prosperity but also benefit qualitative factors such as the global environment, safety, and equality. The Sustainable Development Goals (SDGs) adopted by the United Nations also set 17 goals covering both quantity and quality, aiming to achieve, by 2030, a sustainable world to "Leave No One Behind".

In the same spirit, the ICF aspires to realize "a sustainable society where ten billion people can live in affluence to the age of 100". In order to achieve sustainability, solutions should not be sought after through conventional and quantitative approaches of spending limited resources and injecting fiscal funds. Instead, they should come from innovations that utilize leading information and technology, along with effective business models to leverage impacts. In addition, resolving complex issues requires coordination and cooperation in aligning efforts to apply knowledge and technology along with organizations to serve as actors throughout the process. Therefore, ICF emphasizes open innovation and the creation of collective impacts with a strong focus on startups and venture companies.

Resolving Societal Issues Through Innovation – Listings of Societal Issues (hereinafter called "the Listings") selects and organizes societal issues with significant impacts faced by the current and future societies. These serve as the starting point for ICF's co-creation activities. The Listings includes analysis of the facts and causes of problems, evaluation of their importance and priorities, setting of issues to resolve, and clues leading to specific solutions. It also indicates the estimated time of practical application for each solution or idea explained. Since the establishment of the INCF in 2017, the Listings has been revised every year. This year marks its 5th edition enriched with updated and newly added content.

Societal issues will continue to change and evolve. While some issues will be mitigated or resolved, it is necessary to keep an eye on and quickly detect new, important societal problems as soon as they arise. Of course, technologies and ideas that help solve problems will also continue to advance day by day. There are possibilities that completely new solutions will be derived from new technologies and innovations. Those solution may also lead to a future society beyond past imagination. The ICF Secretariat will continue to observe the world as it changes from both macro and micro level perspectives. The Listings will continue to be updated based on the constant exchange of information and ideas among ICF members.

2. New Trends in Societal Issues

(1) New phase of societal problems

In recent years, a wide variety of unprecedented phenomena are being observed in the social environment. As they tend to interact with each other and often result in further problems and issues, these trends look overwhelmingly complex at first glance. In addition, the rapid pace of change, coupled with quick and wide spreading of its impact, makes it even more difficult to understand the whole spectrum of problems.

During the years of industrialization and high economic growth in Japan, problems were relatively clear, and many of them could be resolved through technological innovation. For example, it was clear that air pollution caused by rapid motorization required reductions to the density of pollutants in exhaust gases. Furthermore, technical challenges necessary to overcome problems were also clear and their solutions immediately led to resolving societal issues. With clear goals, Japan has shown its strength for intensive teamwork and collaboration in overcoming issues. Consequently, Japan has led the pack of industrial nations in confronting and successfully resolving a wide variety of societal issues.

However, as societal problems become more complex, the situation changes dramatically. For example, the rapid aging of the population places a huge strain on social security costs and makes people anxious about the future. It is by no means easy to find one way to resolve this problem that satisfies all. It is obviously desirable that older people stay healthy and enjoy longer lives. If, however, they need more medical care, greater burdens, financial or otherwise, will persist for themselves and those around them. Concurrently, carrying forward the burden to the younger generation, another easy solution, would only exacerbate the problem. This is exactly how attempts at resolving societal problems can trigger other problems or a chain of negative impacts instead of the intended chain of positive impacts.

In light of the COVID-19 pandemic, the living environment, lifestyles, and workstyles of people have dramatically changed. Examples include the rapid spread and establishment of online meetings and work-from-home, and the lowered barriers for online education and medical care. A chain of positive impact is at work here in how some long-standing issues were resolved immediately in a series of policy decisions. A chain of negative impact may also be amplified, as the world sees rapid and widespread change, and the intertwining of societal problems. Examples of adverse and unintended effects of extended work-from-home include increasing loneliness and inequality. As the world fumbles for solutions to current issues, new ones may arise while sights are focused elsewhere.

For success against issues moving forward, it is important first to recognize that societal problems have entered a new phase. Then new, additional issues should be identified along with structural analysis of causes and situational factors. The collective path to resolve complex problems can be found by careful study and understanding at the onset.

(2) A new paradigm of methodologies for resolving issues

The goal of the Listings is to realize "a sustainable society where 10 billion people can live in affluence to the age of 100". To achieve this, the ICF is seeking ways to resolve both current and prospective societal issues.

While the situation that triggers societal problems becomes more complex, applicable technologies that can help resolve them are also becoming more innovative and diversified.

Therefore, in order to effectively resolve those problems, it is necessary to select applicable technologies from many candidates, combine them to find the best solution, and implement it in society after trial and error. There are many stakeholders in this process, and there can be some cases where changes in regulation, law, and systems are required.

To decisively resolve issues, it is necessary to involve a wide range of supporters and participants. A mechanism is also needed that is designed to facilitate co-creation.

There are several approaches for fostering co-creation. One of them is to align the direction and magnitude of activities. Under a shared recognition of the issues, even people with different values will be able to move together in the same direction and toward the same goal. This will result in substantial collective impact for society. In addition, the concept of back-casting is also important to generate a greater social impact. While forecasting uses the present status as its starting point in designing future scenarios, back-casting commences from a vision of the desirable future and then considers the path forward to realize that vision. There is no need to be bound by current constraints. All can choose the best path from various options to reach to the ultimate goal. Thus, connecting the activities of people who share common goals makes it possible to resolve major issues otherwise difficult to resolve on an individual basis.

(3) Sustainable solutions from private businesses

Resolving societal issues has long been recognized as mainly the responsibility of the government. While the government must continue to fulfill its role, it is also true that the government alone cannot resolve every societal issue efficiently and effectively. As a result, expectations and needs are growing for the private sector to play a proactive and leading role in resolving societal issues.

The private sector is now able to participate in fields that have traditionally fallen under the domain of public administration. As with public-private partnerships, most cases for deregulation are aimed at rationalizing government spending and improving the level of services. This suggests a new direction for resolving societal issues. Basically, private companies value continuous business development. Therefore, incorporating the capacity of private businesses and working with them will be an effective measure to keep solutions working in an autonomous and sustainable manner.

Resolving complex problems also requires the combination of outstanding technologies and innovations. Companies, particularly venture businesses, are increasingly taking the place of the government in leading the creation of solutions. Excellent venture businesses have the potential to drive innovation with superior technical capabilities, innovative mindsets, and agility. The key is for the unique advantages of venture businesses to be fully engaged and empowered through co-creation activities, including collaboration between private industry and government.

3. Perspective to Address Societal Issues

(1) New role for Japan

Japan has been caught in various societal problems, many of which it is the first in the world to face. A prime example is the nation's aging and declining population. Therefore, Japan must strive to also maintain its worldwide lead in resolving these problems. In this regard, Japan has the first opportunity to take on the challenge.

In recent years, the development of advanced technologies has been remarkable, and new technologies are emerging one after another. Applying a single technology does not work in resolving complex societal issues. It requires combination of various technologies and a system to craft solutions. In addition to the ability of selecting and deciding the technologies to be adopted, strong leadership is also required to coordinate a team of multiple participants. Japan's strength lies in its culture of organizing and managing teams for constructive collaboration. The country also has a proven track record of cutting-edge technology and collaborative practice in the production field. Its new role in the international arena is to take the initiative in resolving societal issues by combining these strengths, especially making the best of collaboration in the field to generate collective impacts.

(2) Focus in resolving societal issues

There are several different approaches in resolving societal issues. .

The first approach is the outright removal of the problems. The idea here is to mitigate the negative impacts of the issue. Example include getting rid of the source of pollution, or identifying and improving the cause of accidents.

The second approach is not just to eliminate problems, but to improve the situation and create positive impacts. Mitigating problems, or symptoms, tends to take a reactionary approach, commencing only after problems become apparent. It is much wiser to anticipate them in advance and prevent or prepare for them. This approach may also result in a society where probability of problems is mitigated. Preventive medicine and various innovation experiments are aiming for similar effects.

The ICF aims to go even further. This Listings sets out a new vision of the future: a sustainable society where 10 billion people can live in affluence to the age of 100. The ICF sets goals in six focus areas (described later) and covers various issues to be overcome in order to achieve these goals. With significant advances in technology and the availability of massive amounts of data that can be quickly collected, the world is making progress toward achieving the ideal goal for this new form of affluence. The emergence of new methods for resolving issues will enable to achieve a vision of the future that previously had been thought impossible.

(3) How to drive collective impact

One particular obstacle has remained persistent in resolving societal issues. Even with recognized societal value, proposed solutions fail to make smooth progress the instant their market value receives low estimates. However, this trend is beginning to change. People have begun to recognize and appreciate activities with low market value but high societal value. In some specific areas, a number of supporters join to help ensure steady progress toward resolving societal issues. A good example is found in the creation and expansion of work, jobs, and activity opportunities for seniors and people with disability, who have at times faced difficulty participating in society. Peoples' changing values are at play in the foreground, shifting from a focus only on economic growth to paying more attention to quality of life. It is increasingly important to share values and set goals that can be agreed on throughout society.

From a corporate perspective, too, societal value and market value do not consist in trade-offs. They can co-exist, particularly in sustainability management. Sustainable growth cannot be expected by focusing simply on sheer profit. A new concept has become widely accepted that the scope of corporate activities will expand under better-balanced management. This is in line with the principles of ESG and impact investments where market value is prioritized in tandem with societal value. This trend is one of the major factors to accelerate resolving societal issues.

There are a few points to be recognized in attempting to achieve collective impact. In particular, it is effective to establish a group of people who share a common goal or purpose. This requires explanation of the new value to be created, which is often the result of networking and connections among peers. The prevailing trend to emphasize both market value and societal value is also expanding the scope of focus in societal issues.

In addition to building relationships with mutual recognition and respect of diverse values, co-creation activities must involve those with diverse *ways of thought and experiences.* Without these, activities will not be sustainable. To serve as a starting point for co-creation activities, the Listings identifies societal issues and provides various paths to their solutions.

4. Commentary on the Listings of Societal Issues

(1) Chronology of the Listings

The Listings were first published by INCF, one of the predecessors of ICF, in the summer of 2017. A global perspective was added in the FY 2018 edition, and technological and regulatory trends were added as clues to solutions in the FY 2019 edition. The most recent FY 2020 edition has taken into account the effect of COVID-19 pandemic and also incorporated perspectives on the pursuit of new affluence.

The FY 2021 edition, the fifth in the series, has assumed and made revisions from the previous editions published by INCF, updating the ongoing issues as well as incorporating new changes in the social context. Specifically, the following nine new themes have been added.

Societal issues newly addressed in the FY 2021 edition

Wellness	• Increasing health risks for women • Worsening harm caused by loneliness and isolation
Water and food	• Unhealthy food that remains in prosperous societies • The shift toward greater respect for food diversity • Lack of communication through food
Energy and environment	• Loss of biodiversity
Mobility	• Rapid changes in means of transportation and opportunities utilizing digital technologies
Disaster prevention and infrastructure	• Larger number and harsher types of cyberattack
Education and human resource development	• Lack of diversity in human resources

(2) Use of the Listings

The Listings annually compile the various societal issues that global society is either experiencing or newly creating. The Listings re-visits issues to be addressed and prioritizes them through potential impact assessment. 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. These will offer 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 will serve of use in:

> • Providing clues to create new businesses that help resolve societal issues and achieve SDGs
> • Applying in-house technologies to help develop businesses in new fields and resolve societal issues
> • Encouraging open innovation using the technology and knowledge of other companies

The Listings is intended to help companies that currently incorporate societal issues and SDGs into their corporate strategy and are considering new business developments. The objective of the Listings will be fulfilled if readers can identify that their technologies could resolve issues in a certain area or that the companies described in the examples are likely to possess the technologies they lack.

(3) Highlights of the FY 2021 edition

This section describes the main highlights of this review and update.

The added focus of societal issues to be addressed include the introduction of diversity and inclusion, the negative factors behind the many benefits through digital transformation, and likely changes beyond the COVID-19 pandemic and its aftermath.

<New focus: Diversity and inclusion>

The FY 2021 edition incorporates diversity and inclusion as a new concept. The prevailing view is that the diversity of human resources contributes to building an environment where new innovations are born. However, particularly in Japan, the utilization of diverse human resources is insufficient. Moving forward, workplaces must be made to ensure that all individuals, not just one type of employee, can work effectively. Another important aspect of diversity is the greater advancements of women in society. To achieve this goal, it is essential to maintain and improve the health of women. From this viewpoint, new issues have been added in the areas of *education and human resource development* and wellness.

<Paying close attention to the negative chain reaction of digital transformation>

Resolving societal issues creates not only sequence of positive results but can also trigger a negative chain reaction. The FY 2021 edition covers the negative aspects of the progressing digital transformation. One of the examples is cyber-attacks. The networking of social and economic activities has offered individuals and corporations with potential to boost the speed and scope of their activities. At the same time, however, it has aggravated the risk of cyber-attack on critical infrastructure such as power supply and oil pipelines. In addition, filter bubbles have surfaced as a problem in their own right. The development of social media has created a society where information can be obtained anytime and anywhere. However, the world has been flooded with personal information and communication records. Users often receive only content that has been filtered; concerns are growing regarding informational bias.

<Signs of changes expected in a post-COVID society>

The FY 2021 edition continues to point out that stay-at-home due to the pandemic is causing negative problems such as lifestyle-related diseases, loneliness, and isolation. In addition, it also refers to new issues anticipated for the post pandemic world.

In the mobility area, it highlights the potential for the expansion of new activities and communication due to changes in work practices resulting from the spread of work-from-home. In the water and food area, the benefits of communication through food have been added as a new theme because they are expected to attract attention in the future as more people eat alone.

(4) Framework of the Listings

\<Identifying societal issues in the six focus areas set by ICF\>

ICF organizes and structures societal issues throughout the world, including Japan, from a macro-level perspective and identifies six focus areas: "wellness," "water and food," "energy and environment," "mobility," "disaster prevention and infrastructure," and "education and human resource development." The Listings identifies problems and defines issues to be addressed in these six focus areas.

Goals set by ICF in the six areas

\<Three global perspectives\>
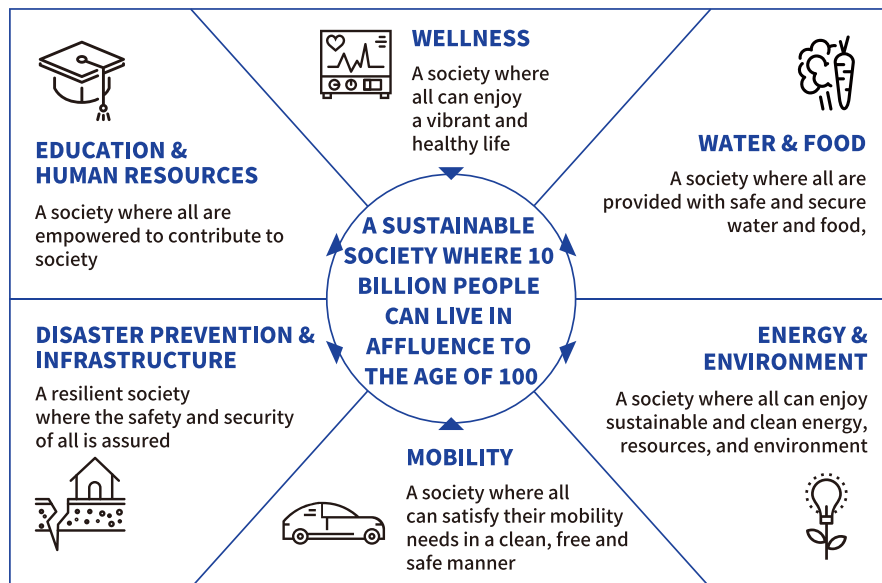
The Listings summarizes the process of and Japan's role in resolving societal issues using three global perspectives:

(1) Issues that have already been resolved in Japan yet remain present in certain regions of the world

Japan Resolved ⇒ World Unresolved

-> Japanese technology can contribute to resolving global issues
 (e.g. measures to cope with newborn mortality)

Japan Resolved -> World Unresolved

(2) Issues that have yet to be resolved in Japan and throughout the world

Japan Unresolved ⇒ World Unresolved

-> Japan can contribute globally by resolving these issues ahead of other countries or co-creating solutions with them through open innovation
 (e.g. measures to cope with lifestyle-related diseases)

Japan Unresolved -> World Unresolved

(3) Issues, in Japan and around the world, that are foreseen to emerge in the future

World Unresolved ⇒ Japan Unresolved

-> Taking the lead in proactively addressing these global issues in advance can benefit both Japan and the rest of the world
 (e.g. measures to cope with the difficulty in procuring protein).

<Identifying societal problems>

The Listings cover major societal problems in the six focused areas, derived from an overview, analysis and forecast of megatrends in the macro-environment, such as politics, economy, society and technology. The ICF updates the Listings every year 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 by two axes: the potential degree of impact from resolving problems on the horizontal axis and the potential for new businesses on the vertical axis.

ICF highlights problems by focusing on the upper right quadrant, where impact is large and business possibilities are abound. It also draws attention to the lower left quadrant where evaluations of the potential impact and businesses are low.

Problems related to inclusion, for example, require attention and span topics such as the greater independence of those with disabilities, terminal stage medical treatment, and children in poverty and suffering child 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 context may increase the potential for problem-solving.

The FY 2021 edition addresses the new theme of loneliness and isolation, which has been aggravated by the pandemic. Based on a recent study, loneliness and isolation may increase health risks such as dementia and stroke.
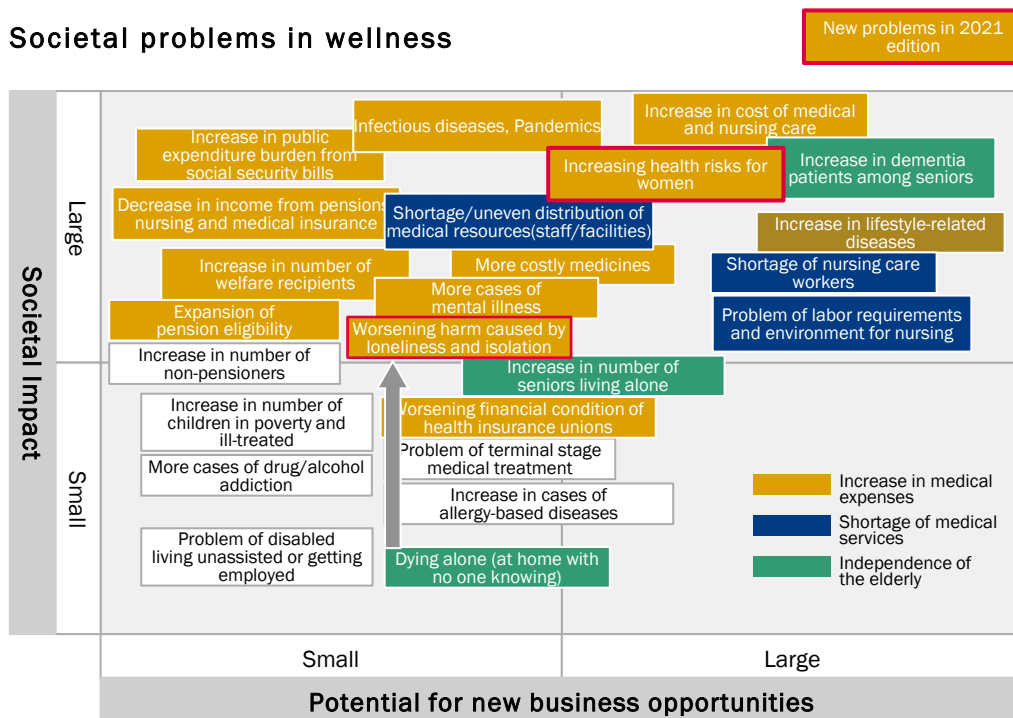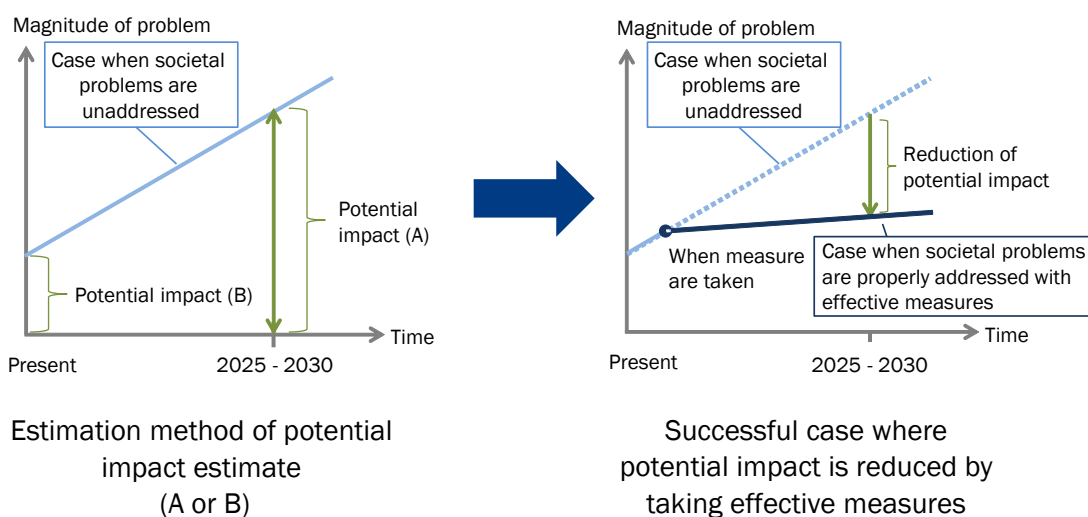

Note: Red boxes indicate societal issues added in the FY 2021 edition

\<Estimating the Potential Impact>

Potential Impact is defined and quantified as the difference between the "as-is" case, where the current problems are left unchanged, and the "goal" case, where the 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 monetary terms.

For the negative impact of each societal issue, MRI employs an approach of either (A) or (B) and refers to precedent research or conducts its own estimation to measure and quantify the possible impact.

(A)   The maximum financial, human, and societal impact by 2025 to 2030 if no effective countermeasures are taken

(B)   The maximum financial, human, and societal impact by 2025 to 2030 if no effective countermeasures are taken

---

Estimation method of potential impact estimate (A or B)

Successful case where potential impact is reduced by taking effective measures

"(C)" indicates figures for new value that might arise alongside resolving a particular issue, benefitting a host of fields from business to welfare. This is particularly the case for themes being explored in light of the pursuit for new affluence.

Example of estimation: Approximately 20 million m3 of timber and branches after tree thinning are left neglected annually on forest land. If the neglected wood is used for biomass power generation, then the total fuel value would be equivalent to JPY 160 billion per year. In addition, the amount of CO_2 reduction would be 43.44 million metric tons per year, or 4.5% of the total CO_2 reduction in Japan, which is equivalent to JPY 28.3 billion per year in carbon credits. (C)

\<Defining societal issues\>

Following the identification of problems and the estimation of potential impact, societal "issues" are defined in terms of themes to be addressed or short-term goals, considering the necessary elements, viewpoints, and directions for resolving problems. (The Listings clearly distinguishes problems from issues and describes them separately.)

In comparing to the Sustainable Development Goals (SDGs) of the United Nations, ICF's hallmark philosophies, *solutions through innovative technology and solutions through business*, can be applied to 64 out of the 169 targets across the 17 goals. The Listings identified these targets to better organize and define 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 collects and updates clues to specific actions toward resolution in as much detail as possible.

As described in the previous section, ICF's basic concept is to start from societal problems, followed by logical steps and finally co-creating solutions through open innovation and viable business models. The societal issues set and defined in the Listings, along with specific solutions, ideas, and innovation introduced herein, are expected to effectively contribute to creating the ideal future. That is achieved not only by resolving problems and issues, or bringing effects from negative to neutral, but also to creating changes from neutral to positive.

Contents

14

1. WELLNESS

A SOCIETY WHERE ALL CAN ENJOY A VIBRANT AND HEALTHY LIFE

Over the past half-century, the remarkable economic growth and the rapid extension of life expectancy have benefited not only developed nations but also emerging nations. Concurrently, however, the numbers of patients with cancer, dementia, and lifestyle-related diseases are also increasing rapidly. As people continue to live longer, our life after middle age becomes longer. Here, ICF anticipates a new evolution to realize a society where all people can enjoy a vibrant and healthy life through technological innovation that supports longer healthy lifespans. It is crucial to develop treatment methodologies and drugs for diseases and secure access to medical and long-term care services. It is also necessary to prevent seniors from facing difficulties in living unassisted, in addition to rehabilitation methods, to keep their mental and physical health.

In recent years, women have made advancements in society, but issues have also surfaced unique to women and include health conditions. Remarkable technological developments have unfolded with gender equality in mind spanning the fields of medicine and biochemistry. In addition, loneliness and isolation have caused a rise in health risks, now a global problem. The causes of loneliness and measures of dealing with it differ according to factors such as age, gender, and environment. The spread of COVID-19 has dramatically changed our perception of infectious diseases and our way of living. All countries in the world must continue to work together searching for measures to tackle and to co-exist with new infectious diseases that are expected to erupt in the future on a global scale.

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.

(1) Rising medical costs due to lifestyle-related diseases	→ Improvements in technology and measures to detect early signs of disease and prevent them from becoming severe
(2) Insufficient access to medical and nursing services	→ Securing services and improving quality regardless of patients' location or distance
(3) Intensifying shortage of care workers	→ Expanding science-based nursing care to enhance productivity while ensuring quality
(4) Increase in the number of people suffering from mental illness	→ Support ranging from prevention and detection of early signals to treatment and rehabilitation
(5) Increasing health risks for women	→ Development of products focused on women's health and social systems to support women's participation in society
(6) Worsening harm caused by loneliness and isolation	→ Early detection of potential victims, implementation of preventive measures, and reduction of adverse effects
(7) Frequent and severe pandemics	→ Preventive measures against the spread of the virus to improve resilience against infectious diseases

Legend

Potential impact estimates

(A) The maximum impact on financial cost and future population by 2025 to 2030 if no effective countermeasures are taken

(B) The maximum impact of the worst-case scenario that can be reasonably expected to occur at present

Issues and Challenges are classified into three categories:

Japan	World		Japan	World		World	Japan
Resolved	➡ Unresolved		Unresolved	➡ Unresolved		Unresolved	➡ Unresolved

(1) Issues that have already been resolved in Japan, and utilizing Japanese technologies that can be of help in resolving global issues;

(2) Current issues that also exist in Japan. By becoming the first country to resolve them, Japan can lead the pack on global issues; and

(3) Early tackling of future global issues will lead to resolving them in Japan in the future.

Societal Problem (1)	Rising medical costs due to lifestyle-related diseases

- Lifestyle-related diseases in Japan cause 60% of all deaths and 30% of all medical costs. As the population continues to age, these medical costs will increase further

- The voluntary stay-at-home and work from home under the COVID-19 pandemic have reduced people's physical activities and increased the risk of lifestyle-related diseases. Obesity and some lifestyle-related diseases also lead to the higher risk of increased severity in COVID-19 symptoms[1]

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 lifestyle-related diseases. Share of lifestyle-related diseases in total medical cost (in 2013)[2] × Total medical cost at institutions[3] in 20252 = 34.4% × JPY 42.54 trillion = JPY 14.63 trillion.

World **Potential Impact estimates** If the global trend of diabetes continues to increase, associated economic costs will double (from $1.3 trillion in 2015 to $2.5 trillion in 2030).[4] (A)

Japan **Unresolved** ➡ World **Unresolved**

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

Key Points for Resolving Issues

People at Risk for Lifestyle-Related Diseases: The key is to sustain lifestyle behavioral changes.

- External incentives, such as evaluations, rewards, and enforcement, will not sustain lifestyle improvements. The effect of economic incentives varies widely among individuals (People who value loss and gain or who are already health conscious are more likely to respond.)

- The key to improving one's lifestyle is motivation. Spontaneous motivation often arises from collaboration with close peers and communities, a phenomenon which MRI coined as the *mutual sphere*. For example, the Hirosaki University Center of Healthy Aging Innovation collects and analyzes the physical examination data of residents in Aomori Prefecture. The data and analysis helps the development of health 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, a new approach to behavioral modification is expected that makes use of neuroeconomics, an interdisciplinary approach that combines psychology, brain science, and behavioral economics, as well as cognitive-behavioral therapy

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Patients with Lifestyle-Related Diseases: **Promoting behavioral change to prevent diseases from worsening**

- Lifestyle-related diseases are characterized by a lack of easily perceptible symptoms. Patients often take repeated actions that deviate from the instructions of their doctors, resulting in the intensification of symptoms. It is essential to educate patients on the serious implications of intensified symptoms. It is also important to provide clear evidence through numerical data on improvements to their health, emphasizing the importance of their continued daily efforts

- For patients with possible severity of their illness, local government officials make individual calls, and health insurance associations are provided with specific health guidance. However, these measures have not proven to be sufficiently effective

Clues to Solutions

Technological Trends

People at Risk for Lifestyle-Related Diseases -

Realization Timeline ▼

Prior assessment of risk for developing lifestyle-related diseases

- It has been proven that bacterial composition in the intestine is correlated with control of blood glucose levels. Research on the improvement of gastrointestinal microbiota, or gut flora, is also underway | 2020 to 2025

- An AI-assisted technology analyzing health-checkup data was developed to predict the risks of lifestyle-related diseases[5] | 2020 to 2025

    Example

    Sompo Holdings, Inc. and Toshiba Group have jointly developed an AI system that predicts the risk of three lifestyle-related diseases: type-2 diabetes, high blood pressure, and dyslipidemia.[6]

- Non-invasive blood glucose sensors are being developed for home use. They are expected to be effective for prevention and detection of early stage diabetes [7, 8] | 2020 to 2025

- In addition to conventional biomarkers such as blood pressure, blood glucose, neutral lipid, and cholesterol, new types of biomarkers are being studied to identify and prevent lifestyle-related diseases (e.g. hormones such as adiponectin and leptin) | 2025 to 2035

Technological Trends

People at Risk for Lifestyle-Related Diseases -

Realization
Timeline
▼

Prevention of lifestyle-related diseases

■ Insurance companies have developed products that reflect the results of exercising and physical examinations on insurance premiums. This incentive is expected to improve health awareness, physical activity, and quality of life

20**20**
to
20**25**

> Example
>
> SUMITOMO LIFE INSURANCE COMPANY offers a product, Vitality. The policyholder earns reward points according to efforts made toward healthy living, such as the number of steps walked per day, visits to fitness centers, and participation in events. Based on the earned points, the insurer gives up to a 30% discount on the premium. If the policyholder does not participate in the health promotion program, the insurer will increase the premium up to 10%.[9]

■ Research is underway to suppress appetite by stimulating the central nervous system

20**20**
to
20**25**

> Example
>
> Modius, 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.)

■ Research is being conducted to reduce food intake by making it appear slightly larger through augmented reality, (AR)

20**25**
to
20**35**

> Example
>
> Taking advantage of the augmented satiety enabled by changing the apparent size of food, the amount of food intake can be increased or decreased by about 10% (Hirose Tanikawa Narumi Lab., Graduate School of Information Science and Technology, the University of Tokyo.)[10]

Behavior change based on behavioral economics and public health

■ Studies are beginning to clarify the brain mechanisms that evaluate future risk with present profit-loss arithmetic or empathy with others. There is hope in the nudge approach that unconsciously alters behaviors

20**20**
to
20**25**

> Example
>
> MHLW (Ministry of Health, Labour and Welfare) published a handbook, *Start the Nudge Theory, Tomorrow*. The book introduces ideas for increasing the rate of use of specified health checkup guides and improving the rate of repeat colorectal cancer screening tests. (The book is produced by Cancer Scan Co., Ltd.) [11]
>
> Some municipalities have succeeded in enhancing the rate of vegetable consumption by increasing the variety of vegetable-centered dishes at local restaurants. Other ideas include selling pre-cut vegetables at grocery stores. The key to success is to create an atmosphere where people's appetite will be spontaneously directed towards vegetables. (Adachi Ward, Tokyo) [12]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Patients with Lifestyle-Related Diseases ----------------------------------

Realization Timeline ▼

Treatment of lifestyle-related diseases

■ The practical application of monitoring technology through wearable devices continues to make advances. The effectiveness of diet and exercise therapy can be improved through the continuous collection of data on blood glucose levels

2020 to 2025

> Example
>
> Abbott commercialized a device (FreeStyle) that can monitor blood glucose levels 24-hours a day for two consecutive weeks by attaching a sensor to the upper arm.
> The sensor is about the size of a 500 Japanese yen coin or a US quarter dollar.[13]

■ Insulin pump therapy, one of the standard anti-diabetic treatments, places a heavy burden on patients, requires machine maintenance, and has high operating costs. The development of an autonomous insulin pump that does not require a machine or an electrical drive is underway to overcome these constraints[14]

2020 to 2025

> Example
>
> Development is underway of an artificial pancreas with a microneedle that detects blood glucose levels and automatically adjusts insulin supply.
> The research group, which includes Tokyo Medical and Dental University, Kanagawa Institute of Industrial Science and Technology, and others, succeeded in its experiments using laboratory mice with diabetes.

■ Seven gene clusters have been discovered that are related to the development of type 2 diabetes, representing 90% of all cases. This discovery expands the potential of personalized medicine[15]

2025 to 2035

■ A newly developed method for creating insulin-producing cells from stem cells has led to significant progress in curative care for type 1 diabetes by means beyond conventional transplantation[16]

After 2035

Livelihood support for patients

■ 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 patient communities

2020 to 2025

Technological Trends

Patients with Lifestyle-Related Diseases - Realization Timeline ▼

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 rate). Promotion is underway to develop testing technologies and devices that do not require skilled examiners and are less burdensome for patients

2020 to 2025

■ Liquid biopsy is a method of diagnosing cancer by testing blood or urine. It examines either a microRNA (miRNA) or a circulating tumor DNA (ctDNA)

2020 to 2025

■ A 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 the existence of miRNAs may lead to early cancer detection. 17 The miRNAs are known to be found not only in blood but also in urine. In the future, only small amounts of blood or urine will be necessary to diagnose cancer

2020 to 2025

■ A nematode is an organism about 1 millimeter long that is a sort of experimental guinea pig. It smells the odor released from urine and detects whether a patient has cancer. Though it is not yet possible to identify cancer types, urinalysis may increase the rate of uptake for screening tests

2020 to 2025

■ Precision medicine, or medical care that has been personalized, has seen progress in its application to cancer treatment. Recent attention has honed in on new technologies in cancer immunotherapy, including CART-cell therapy and cancer vaccines. Studies have shown that intestinal bacteria can influence the effectiveness of cancer treatment 18

2025 to 2035

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Regulatory Trends

- In Japan, to strengthen insurers' incentives for preventive care and health promotion, the Japanese government has amended several regulations. (1) The government created a system to support the proactive efforts of insurers as part of the National Health Insurance program operated by municipalities. The system provides subsidies based on evaluation results of a municipality's measures for preventing intensification of diabetes symptoms. (2) The government revised the healthcare system in 2018 to base adjustment of subsidies under the Latter-Stage Elderly Healthcare System to corporate health unions and mutual aid societies on implementation of designated health checkups and health insurance guidance. In addition, the evaluation of measures for cancer checkups and partnership with business owners are considered.[19] Many health insurance institutions are faced with pressing financial situations in Japan. However, if some practical solutions for lifestyle-related diseases are developed in the private sector, they will surely be utilized

- It has also been pointed out that the *Pharmaceutical Affairs Law** hinders innovation in Japan. The law strictly limits the method of advertising specified diseases, such as cancer, to the public who are not medical professionals. Even if data proving effectiveness in prevention and treatment were to be collected, it is necessary to obtain approval as a drug or medical device to sell these products. MLHW has implemented an early approval system, but it is still challenging 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 will become eligible for insurance coverage. Oral care is said to reduce the risk of lifestyle-related diseases, and there is high expectation for preventive dentistry to gain popularity [20]

- In 2020, the government of Japan approved health-insurance coverage for CureAppSC, an application to help smokers quit. This is the very first case in Japan that a software application, not medication, has been covered by insurance. App-based healthcare may become a trend in the coming days [21]

- The national government conducts cancer screening programs for five cancers to reduce the mortality rate. Those five are lung, stomach, colorectal, cervical, and breast cancers. The age, frequency of examination, and recommended examination items are specified in the *Guidelines for Priority Health Education for Cancer Prevention and Implementation of Cancer Screening* (2008) for tests conducted by municipalities. For examinations conducted at companies and workplaces, they are specified in *Manual on Cancer Screening in the Workplace* (2018). Liquid biopsy and nematode testing are promising techniques, but they are not currently included in these lists

23

Regulatory Trends

- 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. It was first noted that prices were very high and usage of drugs limited. However, Opdivo's applicable coverage had steadily expanded since its approval in 2014, and the price has decreased to a quarter of the initial price

- 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 in2019. Currently, testing is limited to patients who have completed the standard care for stage IV or who are not eligible for any of those treatments

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (2)	Insufficient access to medical and nursing services

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

Japan

Potential Impact estimates

The overwork of medical doctors has become a serious problem due to their uneven distribution among regions.[22] One survey shows that more than half of all doctors have no intention of working in rural areas (other than Tokyo's[23] wards, government-designated major cities, or prefectural capitals.) The most frequent reason cited for this is concern for the working environment.(B)

- Globally, 5.6 million children under the age of five died in 2016.8 More than half could have been saved with simple care, treatment, or nutrition support (Deaths are caused by preterm deliveries, diarrhea, pneumonia, malaria, etc.). If all countries had achieved a mortality rate as low as the average for high-income countries, then 87% or 5 million deaths of children under the age of five could have been avoided

World

Potential Impact estimates

Even if the mortality rate continues to decline, 60 million children under the age of five will die between 2017 and 2030. Furthermore, half of these children will be newborns within one month after birth.
The death rate needs to be further lowered. [24] (A)

Japan		World		Japan		World
Resolved	➡	Unresolved		Unresolved	➡	Unresolved

Societal Issues	Securing services and improving quality regardless of patients' location or distance

Key Points for Resolving Issues

Developed Countries: Realizing efficient utilization of resources by healthcare professionals

- Disparity in medical resources exist among certain branches of medicine and geographic regions. Doctors must deal with more outpatients and hospital patients with chronic diseases due to the increase of the elderly population. In Japan, the number of outpatient visits per capita is twice the OECD average. Also, doctors must spend time on non-medical activities. This burden deprives doctors of the resources necessary to focus on the diagnosis and treatment of urgent care patients with acute illness. There is a growing need for an environment in which medical and nursing care workers can concentrate on their primary tasks. This can be achieved by eliminating the uneven distribution of resources and promoting the sharing of knowledge through online medical care and digitalization of medical data. Due to the COVID-19 pandemic, the shortage of hospital beds in Japan has become evident. Efficient use of medical resources has become an urgent issue

Developing Countries: **How to prevent neonatal mortality**

- The mortality rate of children under five is 76.5 per 1,000 in Africa, which is the highest in the world and about eight times that of 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

- Heating and clean water are particularly important in neonatal care, but 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 mobile phones. The key to resolving this problem is the spread of inexpensive and convenient medical services

Clues to Solutions

Technological Trends

Developed Countries - Realization Timeline ▼

Online medical care becoming popular

- Online services will become popular so that patients can see doctors online for initial consultation from the comfort of their homes. They can also have medications delivered to their homes by sharing data with pharmacists

  2020 to 2025

  > Example
  >
  > Amazon offers Amazon Care, a medical service that combines online consultation and in-person visits. [25] In China, Ping An Good Doctor, a free app operated by an insurance company, offers online medical interview services, hospital searches, and appointment arrangement. It also makes possible the online purchase of prescription drugs (Ping An Insurance (Group) Company of China, Ltd.). [26]

- With the prevalence of telemedicine, there is a growing need for wearable devices that record vital data as well as portable testing kits that can be used at home and throughout the community

  2020 to 2025

  > Example
  >
  > 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 introduced AI-powered stethoscopes, and AMI Kabushiki Kaisha developed Super Stethoscope. [27]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Developed Countries -   Realization Timeline ▼

Utilization of AI

■ Many diagnostic imaging centers, 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 to 2025

■ A system in which AI diagnoses CT and MRI images could be put into practical use. Not only would such a system help doctors make decisions, but it also would reduce the hours spent on evaluations

2020 to 2025

> Example
>
> In October 2019, Lpixel Inc. became the first company to receive pharmaceutical approval on a brain MRI device that uses deep learning to detect suspected areas of cerebral aneurysms.

■ A system for navigating surgery through machine learning has been developed

2020 to 2025

> Example
>
> A system is being developed to apply machine learning equipped with AI to endoscopes to guide surgeries. (Olympus Corporation, Oita University, and Fukuoka Institute of Technology).[28]

■ It is difficult to continuously assign specialists to 24-hour intensive care units. Remote monitoring of ICUs (Tele-ICU) is popular in the U.S.[29]

2020 to 2025

> Example
>
> 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 an ICU resident (T-ICU Co., LTD.).[30]

■ In Japan, a project named AI Hospital was launched and aims to develop a system that enables advanced diagnosis and treatment; developers are targeting for practical use by 2022

2020 to 2025

Knowledge sharing among physicians

■ Online services are being used in the areas where specialist physicians are scarce, so that they can share their knowledge and give advice to each other

2020 to 2025

> Example
>
> exMedio Inc. provides a tool called Hippocra where physicians can mutually assist each other. It has become a community of 300,000 registered physicians. They will consult each other on various topics from clinical treatments on certain domains, such as dermatology and ophthalmology, to health insurance points for treatments and drugs.

27

Technological Trends

In Developing Countries - Realization
Timeline
▼

Provision of newborn care

■ Neonatal care networks using ICT, such as mobile phones, enable the timely delivery of necessary information. Pregnant women receive pregnancy information and reminders for prenatal checkups via Short Message Service. This technology can be used as an emergency point of contact as well

2020
to
2025

■ 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
to
2025

> Example
>
> The neonatal incubator Embrace is affordable and easy to use outside of the hospital (Embrace Innovations, India.)[31]

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

2020
to
2025

Regulatory Trends

■ As a measure to eliminate the disparity of medical resources, efforts are being made to realize Japan's vision for region-focused medical care. Through the vision the country aims to realign the role of public medical institutions so that they will focus on care services that only they can provide. The reorganization and consolidation of medical institutions will be considered based on analysis of their medical records and geographical conditions

■ In April 2020, with the spread of the COVID-19, restrictions on the telephone and online medical care and pharmacists' consultation were removed as a temporary and exceptional measure, [32]which included patients' first visits. However, there is a limit to physical examination since doctors cannot palpate or check patients' complexion online. Therefore, these consultations are allowed used only in limited circumstances. The government may expand the list of applicable diseases and medical processes, but they are conducting thorough discussions regarding implementation

■ Efforts are underway to build and operate a medical information network, including electronic health records (EHR) and personal health records (PHR), as well as the establishment and revision of health information and communication standards (MHLW Standards), with the aim of full-scale operation by March 2021

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (3)	Intensifying shortage of care workers

- The proportion of seniors who can enjoy independent living is about 80% for those in their mid-seventies but drops to 10%[33] for those in their late eighties. We currently lack the means to deal with this situation and help seniors maintain a high quality of life even in old age

- COVID-19 changed people's behaviors, such as spending more hours at home. It has been pointed out that the decrease in physical activities and social interaction increases the risk of declined physical and mental functionality

Japan **Potential Impact estimates**	In 2025, when the postwar baby-boom generation reaches the age of 75 or older, the super-aged society era will arrive. Nursing care benefits will increase to JPY 19.8 trillion (240% to JPY 8.4 trillion[34] in 2012). (A)

- As the average life expectancy increases, the number of dementia patients grows. By 2030, dementia cases will grow by 160% to 8.3 million[35] in Japan, and by 160% to 74.7 million[36] in the world

Japan World **Potential Impact estimates**	The social cost of nursing, including both direct costs for medical and nursing and the indirect opportunity cost of families, will total JPY 21.4 trillion in Japan by 2030 (JPY 15.0 trillion in 2015,)[37] and $2 trillion worldwide ($818 billion in 2015.)[38](A)

Japan **Unresolved** ➡ World **Unresolved**

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

Key Points for Resolving Issues

People at Risk for Dementia: Early detection of symptoms and the development of effective countermeasures are key

- Alzheimer's disease occurs after 20 years of the agglomeration of specific proteins (amyloid-beta and tau proteins). Although therapeutic medicine is being developed to treat Alzheimer's disease, early detection and prevention are the key to resolution. According to the recommendations of the Lancet Committee (Lancet Commission on Dementia Prevention, Intervention and Care), one-third of dementia is preventable. The main risk factors for dementia are as follows [39]

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

Care Workers: Ensuring autonomy and motivation, reducing physical and mental burdens of care workers

- The average monthly wage for nursing care workers 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 manpower," followed by "low compensation relative to the workload." [40] To secure human resources in the long run, it is essential to recognize nursing care as a scientific and specialized profession, provide appropriate compensation, and ensure autonomy for higher motivation of the staff. In addition, it is essential to develop an environment that can offer evidence-based scientific care and preventive care from the standpoint of expert knowledge. Training of the personnel is also of utmost importance

- Support for family members acting as caregivers is essential and should address financial, work-life balance, and recovery aspects. [41] Dementia symptoms and behavior, such as wandering, delirium, violence, and verbal abuse, can substantially change by the way people around deal with the patient. Appropriate control of these dementia symptoms can significantly reduce the physical and mental burden on caregivers. It is vital to have a perspective of selecting the most appropriate handling based on each patients' situations and characteristics

- It is difficult to find effective solutions for caregiving when thinking merely of labor-saving and efficiency improvements. For example, the overall burden of the caretakers is not reduced merely by GPS software that tracks wandering patients. 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. A device which can forecast bowel movements will increase in value if individual differences can be learned and refined

Clues to Solutions

Technological Trends

Dementia Patients and People at Risk

Realization Timeline ▼

Establishment of new means to promote and support the self-sustaining of the elderly

- Dementia may progress rapidly when physical inactivity occurs, such as physical difficulty in going out or decreasing contact with other people. For this reason, there is high demand for services that enable people to continue to interact with others while staying at home

2020 to 2025

> Example
>
> A U.K.-based company, Virtue Health Inc., offers LookBack, a digital therapy platform. The platform can stabilize a patient's condition of dementia by its application of the recollection method through VR. [42]

- 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 to 2025

> Example
>
> Based on Scotland's initiative, 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. Support for emotional and daily life is provided so that patients can face the disease and live in close contact with their community.

Prevention and treatment of dementia

- There is a high expectation for early diagnosis (premonition) of dementia by MRI imaging

2020 to 2025

> Example
>
> A technology for the early diagnosis of Alzheimer's disease using AI analysis of MRI images has been commercialized. (Darmiyan, Inc., U.S.) [43]

- New services are emerging in such measures as dementia prevention insurance and dementia prevention apps [44]

2020 to 2025

- Research institutions around the world are exploring biomarkers for the early detection of dementia. Examples of the focus of the research are concentration levels of three types of proteins in the blood (apolipoprotein, transthyretin, and its complement) as well as the ratio of amyloid-beta to its precursor, APP[45]

2025 to 2035

- Japan leads in amyloid-beta PET inspection technology, which visualizes amyloid accumulation. The mechanism (glymphatic) of discharging wastes, such as amyloid-beta, from the brain continues to be better understood. The importance of sleep has been highlighted as the discharge function increases during sleep

2025 to 2035

Technological Trends

Dementia Patients and People at Risk ----------------------------------

Realization Timeline ▼

■ Intestinal bacteria may produce inflammatory substances that somehow affect the brain. People with 30% or more resident bacteria (Bacteroidales) in the intestine are 90% less likely to have dementia than others, raising interest in new research on the correlation between enteric bacteria and dementia[46]

20**25** to 20**35**

■ The Alzheimer's vaccine, developed by a major pharmaceutical company, widely disappointed as its effectiveness could not be proven in clinical trials. However, the underlying basic research, further clarifying the mechanism of amyloid production and degradation, is expected to lead to the realization of a drug that cures dementia in the long term

After 20**35**

> Example
>
> 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.
> It is expected to slow down the progression of Alzheimer's disease. [47]

Inhibition in aging

■ It has been suggested that controlling telomeres, the edge of a chromosome, may reduce the prevalence of many diseases caused by aging

After 20**35**

Caregiver ---

Ensuring autonomy and motivation of care workers

■ Coordination between medical treatment and nursing care is the key to achieving comprehensive care services in a community. The growth stage has shifted into gear for IT systems that support the cooperation and communication between the two functions

20**20** to 20**25**

■ Tools are being developed to collect, analyze, and use data to help care managers improve the quality of life of service users based on scientific indicators. It is also essential to provide incentives to the care workers for improvement of the level of care needed by the recipients

20**20** to 20**25**

■ Aggregation and visualization of regional resource information. Research and development are underway on a system that uses ICT and AI to find and propose nursing care services that are appropriate for users[48]

20**20** to 20**25**

> Example
>
> An information database called MILMO net has been introduced in Yokohama and Fukuoka cities by WELMO INC.
> They are also researching and developing Care Plan Assistant, AI to help create a care plan, to reduce caregiver workload and stress by compensating for gaps in knowledge and experience (WELMO, INC.) . [49]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Caregiver

Realization Timeline ▼

Reducing the burden of nursing care

- The introduction of nursing robots is reducing the burden of caregivers. As low-price power-assisted suits have become readily available, more care providers have adopted them because they help prevent lower back pain

  2020 to 2025

- Contactless care is being carried out to ensure infection control across everyday caregiving operations. By combining sensors with AI-powered information analysis, the daily lives of the elderly people can be remotely monitored. This reduces the burden on caregivers

  2020 to 2025

- A robot needs an actuator for every moving joint, which makes it difficult to reduce manufacturing costs. When developing nursing robots, one shortcut to commercialization is to reduce the number of moving joints and focus on adding sensors using AI and other forms of ICT

  2025 to 2035

- Efforts are underway to introduce Humanitude®, a dementia care technique invented in France, using ICT and AI

  2020 to 2025

  > Example
  >
  > ExaWizards Inc. has introduced the dementia care technique Humanitude®. 50
  > With this technology, it is possible to improve the quality of care and to reduce the burden placed on caretakers by suggesting optimal coping methods using AI-assisted image and speech recognition.

33

Regulatory Trends

■ MHLW aims to realize a society where the wishes of dementia patients are respected, enabling them to live in a pleasant environment in their neighborhood for as long as possible. The ministry and other relevant ministries and agencies formulated the *Comprehensive Strategies for Promoting Countermeasures for Dementia: Developing Communities Friendly to the Elderly with Dementia* (New Orange Plan, released on January 27th, 2015). [51] The comprehensive countermeasures consist of the following seven pillars: prevalence and education, medical and nursing care, juvenile dementia, support for caretakers, building a community that is friendly to the elderly with dementia, research and development, and emphasis on the perspective 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; many 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 database, LIFE, started its full-scale operation in 2021. [52] 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 in FY 2024 and FY 2027 may make data provision and data utilization mandatory

 LIFE: Long-term care Information system For Evidence

 VISIT: monitoring & eValuation for rehabIlitation ServIces for long － Term care

 CHASE: Care, HeAlth Status & Events

■ Due to the COVID-19 pandemic, the shortage of workforce at nursing care sites has become a severe problem. In April 2021, MHLW launched a loan program for those seeking employment as a caregiver in the nursing care industry. In this program, a JPY 200,000 loan per person is provided to those seeking a career change from other sectors to become a caregiver in nursing care or welfare for persons with disabilities. The repayment of the loan will be waived if the borrower works at nursing or welfare sites for two years

Societal Problem (4) Increase in the number of people suffering from mental illness

- The number of patients visiting medical institutions due to mental disorders 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 increasing among women and children, a tragic trend[53]

- It has been pointed out that presenteeism syndrome, a health/mental problem, is not a disease per se but will nevertheless decrease productivity. The Unstable mental condition of children and the youth, and isolation of seniors are also pointed out. The losses caused by presenteeism accounts for 78% of companies' total health-related costs, including medical care and sick leave[54]

Japan **Potential Impact estimates**

Psychiatric disorders are affecting approximately 3.9 million patients.[55] 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.[56] 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.[57](B)

- Mental health management is also a vital issue overseas, but trends differ from those in Japan, as they are more biased towards drug and alcohol addictions. Unlike Japan, where universal health insurance is available, people are responsible for their healthcare in the U.S. Americans also tend to speak more openly about their mental problems compared with Japanese

World **Potential Impact estimates**

There are 792 million cases of mental illness worldwide. 9.3% of men and 11.9% of women suffer from some sort of mental illness.[58] (B)

Japan **Unresolved** → World **Unresolved**

Societal Issues Support ranging from prevention and detection of early signals to treatment and rehabilitation

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 control of appropriate working hours, measures to deal with harassments, and promotion of active communication. The worsening of mental symptoms can be staved off through the early detection of warning signs and appropriate support so that mental difficulty can be contained. To make this possible, mental health monitoring must start when the patient is healthy and able to alert others of any concerning signs. It is also important to build a mechanism that continuously motivates people to use the service

- Early signs can be detected through: pre-installed sensors in smartphones or small devices and data of daily activities as well as self-assessment. It is also important to integrate sensing into daily life to acquire data from a person's healthy state, enabling the comparative analysis with concerning data

- In addition to using big data and AI for analysis, there is a possibility of more detailed sensing of brain waves and neurotransmission becoming available in the future. Academic research into the functions of the brain and neurotransmitter systems is also underway. For example, brain functions are being studied, such as the network responsible for consciousness and unconsciousness along with another network that switches from one to the other. There are other studies on subjects, such as the relationship between learning and synaptogenesis. For accurate monitoring, it is important for these analyses to be combined with the latest knowledge on the central nervous system

Appropriate Intervention: **From preventing mental deterioration to promoting inclusion and re-entry to the society**

- The mental condition of patients can be stabilized through appropriate intervention based on the result of monitoring. One approach is to support self-control for potential patients, and the other is third-party support to patients already with mental illness

- Examples of supporting self-control include periodic checkups, taking measures based on alert signals from monitors, and monitoring at specific timing such as during sleep. The appropriate support for patients with disease is to have them visit medical institutions. In the U.S., online medical services are utilized to diagnose patients and even to prescribe medicine. Online counseling services are also becoming popular in Japan. As for post-medical assistance, it is crucial to address the possibility of recurrence and to provide inclusive support, assistance for patients in rejoining society. The latter aims to maintain continuous social participation after recovery namely by helping patients secure a proper work environment and find a job that best meets the goals of all involved

Clues to Solutions

Technological Trends

Sensing and Analyzing Mental Health Data

Realization Timeline ▼

- It is now possible to understand mental states by sensing and analyzing biological and daily behavioral data. This method evaluates patients' health status as healthy, deteriorating, or detecting signs of recurrence

2020 to 2025

> Example
>
> PST Inc. offers MIMOSYS, an app that analyzes state of mind based on fluctuations in voice frequency, focusing on the involuntary movement of vocal cords.[59]
> Research is making progress on the diagnosis of depression by measuring blood PEA levels.

- Sensing devices are becoming smaller. Sufficient data are acquired by smartphones with less physical and psychological burden on users

2020 to 2025

> Example
>
> An Israeli startup Binah.ai offers a service to measure users' heartbeats and level of mental stress from a camera-captured video of users' faces.[60] Binah.ai collaborates with Sompo Himawari Life Insurance Inc., in Japan.[61] The iPhone healthcare app records users' activity, sleep, mindfulness, nutrition, and provides analysis and recommendations based on the data.[62]

Maintaining mental health

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

2020 to 2025

> Example
>
> A U.S. unicorn company, Calm, offers various voice programs to help users manage anxiety, depression, and insomnia.[63] The annual plan is priced at $5/month.
> An MIT startup, Ginger.io, uses AI to analyze user's smartphone usage and allows users to have video conferences with therapists and psychiatrists when necessary.[64]
> Lyra Health, Inc. uses AI to connect patients and counselors with good chemistry together thus improving counseling effectiveness.[65]

Stimulation of cranial nerves and expanding functions

- Understanding of the mechanisms and functions of the brain and neurotransmission has 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 to 2025

> Example
>
> Hacosco Inc., a neuroscience-based service provider, has partnered with the streaming music company, Spotify, to offer an app that allows users to create music playlists for different purposes such as improving concentration and relieving anxiety and frustration. Hocosco Inc. describes the service as Brain Music that stimulates the brain.[66]

Technological Trends

Stimulation of cranial nerves and expanding functions

Realization Timeline
▼

- Research is also being conducted to improve the mental ability by expanding cranial nerve functions and actively utilizing it to maintain health and achieve well-being

After 2035

Support for working environment

- Working environment must respond to different types of needs to deal with issues arising from mental health including: physical difficulty in going to the office despite desire to continue working; and uncomfortable with work that requires face-to-face interaction

2020 to 2025

Robotic care

- 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 integrating robots as family members, cases were found where robots improved mental health of family members

2020 to 2025

Example

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, acts as a family member, integrating itself into people's lives by learning, reacting, and observing.[67]
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 interaction with robots leads to better participation in activities with others.[68]

Clues to Solutions

Regulatory Trends

- The revision of the Industrial Safety and Health Act in June 2014 made it mandatory to conduct a stress test on employees and take necessary measures at all workplaces where 50 or more workers are regularly employed. The employer must conduct the test once a year and report results to the Labor Standards Offices

- MLHW promoted a collaborative health concept and 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 health improvement of employees and their families. The guideline shows a quantitative evaluation of health-related costs of presenteeism and absenteeism, describing the actual process of health management through cooperation between the insurer and the company, including data utilization. Presenteeism is a state in which employees are at work, but productivity is declining, while absenteeism is a state in which employees are absent from work

- Transformative technologies are helping the pursuit of well-being by utilizing academic accomplishments in fields such as neuroscience. In this field, specific regulation has not yet been updated. However, the commercialization of related services will require discussions on various issues, such as regulations over how much access to and stimulation of the brain and neurotransmitter systems should be allowed, social acceptability, and ethics in technology for developers

Societal Problem (5)	Increasing health risks for women

- The proportion of women in the total labor force is on the rise, reaching 44.4% in 2019 compared to 39.7% in 1985.[69] The increasing empowerment of women in society has been accompanied by health risks growing, especially for working women, in scope of impact and number of cases. These health risks jeopardize the quality of life, healthy life expectancy, and further participation in society of women; even companies are negatively affected in their productivity

- A survey found that 52% of women employees have experienced issues related to health including menstruation, PMS (premenstrual syndrome), and menopause[70]

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.[71] (B)

- Globally, 75% of uncompensated care such as household chores, childcare, and nursing care are performed by women. This burden affects both women's mental and physical health.[72] If these non-paid working hours are added to the time at a job, the sum will exceed the statutory maximum of 40 hours per week

- The development of medication often overlooks the side effects particular to women and results in a lack of supply to women

Japan **Unresolved** → World **Unresolved**

Societal Issues	Development of products focused on women's health and social systems to support women's participation in society

Key Points for Resolving Issues

Medical Perspective: Product development that considers health issues unique to women

- Women's QOL and labor productivity are significantly affected by various gynecological illnesses such as menstrual symptoms, breast cancer, cervical cancer, and endometriosis. Women-specific difficulties also include infertility treatment, postpartum depression, and menopausal disorders. Women themselves need to both have enough knowledge and sufficient visits to a gynecologist. At the same time, men should acquire knowledge of prevention and treatment of women's diseases along with plans concerning pregnancy and childbirth

- Femtech is increasingly gaining attention as a technology that solves women-specific health problems. Other products that have been developed include new sanitary goods, items to care for pelvic floor muscles, and health management apps

The Perspective of Equality in Society: 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 by visualization, fair evaluation, and work-sharing. Efficiency can also be improved by ICT technology and services outsourcing household cleaning, baby-sitting, and nursing care

- The problem is not limited to the pharmaceutical area. The size and weight of various equipment are often designed to fit with average men, such as seat belts of automobiles, agricultural equipment, construction machinery, and protective clothing. Thus, women have been noted to see higher injury rates. 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

Clues to Solutions

Technological Trends

Products with Women-specific Health Issues in Mind - Realization Timeline ▼

Providing health and medical information

- A service has been launched that provides necessary information in line with the life stages of women such as pregnancy, childbirth, childcare, menopause transition, and postmenopause | 2020 to 2025

  > Example
  >
  > FamiOne, Inc. provides chat services to support expecting and nursing mothers.
  > It also provides companies with informational seminars for not only female workers going through fertility treatment but also managers and young employees.[73]

  > Example
  >
  > TRULY provides products and services that cover: information about vaginal care and menopause caused by changes in female sex hormones; self-check of the severity of menopause; and online consultation by women physicians.[74]

- A wearable device and app have been developed that track the morning sickness cycle during pregnancy and provide personalized advice to relieve the symptoms | 2020 to 2025

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Products with Women-specific Health Issues in Mind - Realization Timeline ▼

Reducing the burden in checkups

■ Patients tend to hesitate to take gynecological checkups due to a sense of embarrassment, pain, and fear. Checkup technologies and devices are being developed to ease the patient burden

| 20**20** to 20**25** |

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

■ Practical use is underway for liquid biopsy breast cancer screening[75]

| 20**20** to 20**25** |

Reducing Burden of Care Work -

■ Women's career advancement is often hindered by a shortage of bearers of household chores in dual-income households. Focusing on this fact, new services are becoming popular that support the sharing and outsourcing of household chores

| 20**20** to 20**25** |

> Example
>
> DAIWA HOUSE INDUSTRY CO., LTD. Has proposed a Household Chore Share House concept in which the household members share chores.[76]
> TASKAJI Inc. , provides cleaning, cooking, and childcare services through outsourcing.[77]

Gendered Innovations -

Product tailored to women's body-build

■ New products tailored to women's body-build are popular in the market and include: a 7/8-sized keyboard for pianists with smaller hands[78]; a smartphone that women can operate with one hand; and a VR headset matching the average size of a women's head. It has been advocated that protective equipment such as life jackets, safety shoes, and seat belts should be made with women's body-build in mind

| 20**20** to 20**25** |

> Example
>
> The latest foldable phone, the Galaxy Z Flip, is getting high level of attention for its small size that fits well in women's hands and features a vertically foldable function.[79]

Increasing participation of women in clinical trials

■ The promotion of virtual clinical trials conducted at participants' homes or nearby medical institutions could facilitate women's participation previously prevented due to time constraint. *Virtual clinical trial (VCT) is an MRI created term.[80] It has various names, such as decentralized clinical trial (DCT) and remote clinical trial

| 20**25** to 20**35** |

Clues to Solutions

Regulatory Trends

- In Japan, fertility treatment will be covered by health insurance starting April 2022. It is further expected that the scope of treatment to be covered by insurance will be clarified and the cost borne by patients to be reduced

- The Maternal and Child Health Act encourages health checkups to expecting mothers. 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 health checkups. Municipalities are also responsible for implementing the initiative as well as prenatal and postnatal support programs[81]

- 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 and childcare

- In the U.S., it is illegal to exclude women from government-funded clinical trials in an effort to address the gender gap in drug development; Australia has similar rules. The EU goes further requiring that experiments conducted on animals in the preclinical phases must be done on both sexes; the U.S. followed suit applying the same requirement in 2016

- In the U.S., crash test dummies based on female body-build have been used in car crash safety tests since 2011. Car accidents are the leading cause of stillbirth, and there have been calls to mandate the use of crash test dummies based on pregnant-women body-build

Societal Problem (6)	Worsening harm caused by loneliness and isolation

- In 2020, the number of suicides in Japan increased for the first time in 11 years. Loneliness, a subjective concept, and isolation, an objective one, are major causes of increased suicide under the COVID-19 pandemic

- Loneliness and isolation are becoming severe societal problems and are called *syndemics*, a coined word consisting of synergy and epidemic, as they both increase mental and physical health risks and become pervasive

World **Potential Impact estimates**	The physical and mental damages of loneliness increase a host of health risks: death by 26%, dementia by 64%, coronary artery disease by 29%, and stroke by 32%.[82] (B)
World **Potential Impact estimates**	The cost of loneliness is estimated to be £2.5 billion (JPY 380 billion) annually in the U.K. This is calculated by 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)

Japan		World
Unresolved	➡	Unresolved

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

Key Points for Resolving Issues

Early Detection of Potential Victims (Patients) and Implementation of Preventive Measures: Support to prevent unwanted loneliness

- Loneliness can be defined as a subjective syndrome, while isolation is an objective phenomenon such as having little contact with family or community. While the lack of social connection itself is not an issue, undesired loneliness is a problem when people cannot rely on or talk with others despite their wishes to do so

- Causes and solutions for loneliness and isolation differ according factors such as age, gender, and environment. Loneliness and isolation affect a wide range of people:

  - Mothers tend to feel lonely while raising children
  - People aged 75 or older are at high risk of isolation
  - Minorities tend to feel lonely and be isolated

It is important to detect potential victims early and implement effective prevention and support measures tailored to each type of group

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Mitigating Adverse Effects: Maintaining the physical and mental health of people in loneliness

- Loneliness is a significant societal problem also from the viewpoint of preventive medicine. It is necessary to establish a system that enables people with limited social connections, or otherwise in a state of isolation, to maintain their physical and mental health so as not to become 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 such as a stop in smoking, a balanced diet, and moderate exercise[83]

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

Clues to Solutions

Technological Trends

Support to Avoid Unwanted Loneliness - Realization Timeline ▼

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

- Social media and chat services are said to be more effective than telephone consultation in communicating with young audiences. Online and chat services by counselors are carried out in many countries | 2020 to 2025

  Example

  IbashoChat.org, a nonprofit organization, provides a 24/7 chat counseling service.
  Eighty percent of its users are teenagers or in their 20s.

Those in their 30s to 50s: Support for creating connections

- Encouraging casual conversation and communication at the workplace often leads to better connections among employees | 2020 to 2025

  Example

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

Technological Trends

Support to Avoid Unwanted Loneliness -

Realization Timeline

■ Local currencies are expected to help creating connections. They are used as compensation for those who provide services in preventive nursing care and childcare

2020 to 2025

> Example
>
> Aloha Coin was issued to revitalize local communities in Hawaii.[84]
> The private-sector initiative has at its core a mechanism that creates spontaneous connections.

Support to Prevent Unwanted Loneliness -

Those in their 60s and above: Data monitoring and community support

■ Efforts are underway to identify and help people from data who have the tendency to suffer from loneliness. Demand is on the rise for monitoring services using sensors, and seniors too must not be left behind in the digitalization process

2020 to 2025

> Example
>
> A heat map, the visualization of the geographical distribution of loneliness, was created with marital and health status data.
> The map, identifying vulnerable areas and people, is disclosed to the public so that additional support may come when and where it is needed (Age UK).[85]

> Example
>
> Shumito Club is a social network service mainly for seniors, where members participate in activities based on various hobbies.[86]
> A group of senior citizens in London is lobbying to improve the local environment by installing benches in parks and upgrading bus stops.
> The group's activities include twice-monthly walks with refreshments, exercise sessions, and film screenings.[87]

■ Continuing care retirement communities, or CCRC for short, are housing facilities for seniors that provide continuous care starting from when residents are healthy to when they need nursing care at a later stage. Widespread in the U.S., the CCRC model is attracting attention due to the fact that seniors move into these facilities when they are still healthy, rather than after a need for nursing care arises. Also, CCRC facilities enable residents to form connections with their peers who share hobbies and values

2020 to 2025

> Example
>
> A leading example of the Japanese version of the CCRC is Share Kanazawa.
> The community consists of serviced housing for the elderly people, a childcare facility, a student accommodation, and a spa for residents in the neighborhood.
> The residents operate the store located within the community.[88]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Reduce the Adverse Effects by Loneliness
Maintaining physical and mental health of those affected by loneliness

- Healthy lifestyle plays an important role in preventing illnesses spurred by loneliness and isolation. Smoking, a poor diet, and a lack of exercise are to be avoided. There are high hopes for utilization of technologies and services that support lifestyle improvement (See "Increasing medical costs due to lifestyle-related diseases" on p. 2.)

Realization Timeline ▼

2020 to 2025

- Communication robots have proven effective in relieving the loneliness of people who have difficulty in keeping pets, despite their wish to do so

2020 to 2025

Example

Yamaha Corporation launched a robot named Charlie under the catchphrase "More than a pet but not quite a lover". The miniature human-like robot responds when spoken to and can even sing.[89]

- It is effective to take ideas from findings in psychology to sustain mental health

2020 to 2025

Example

The UK's National Health Service (NHS) is promoting the Gratitude Visit national movement calling for participants to write a thank you letter to their parents or anyone else they might want to express gratitude to—even those who have already passed away. Participants themselves are expected to deliver and read aloud the letter to its recipient. The movement has proven effectiveness acknowledged in the field of psychology.

Reduce the Adverse Effects of Loneliness
Safety monitoring

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

2020 to 2025

Example

In 2018, a nonprofit organization, enrich, launched a new service using the LINE messaging application to protect the working generation from solitary death.
It 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 mobile phone. If that also fails, the system informs the user's relatives.[90]

Regulatory Trends

- The U.K.'s Prime Minister appointed the Minister for Loneliness in 2018 and announced that £20 million (approximately JPY 2.87 billion) would be budgeted for measures coping with loneliness. A *social prescription* will be applied nationwide by 2023 where loneliness is addressed via social connection rather than drugs. Patients whom the physician deems to require a social prescription are referred to a community worker called a *link worker* who arranges participation in community activities[91]

- In 2021, Japan's Prime Minister appointed the Minister of Loneliness and Isolation, following the UK. This appointment is to deal with the problem of loneliness and isolation, a phenomenon aggravated during the COVID-19 pandemic

- In Japan, the Act on Self-reliance Support System for the Needy Persons was implemented in 2015, enabling local governments to consult residents on social isolation and other issues. Regional networks have been formed under the Hikikomori (seclusive syndrome) Support Promotion Program, including nationwide Hikikomori Community Support Centers. The MLHW notified municipalities to work on the following items by the end of FY 2021: (1) To clarify and spread information on the consulting desk for hikikomori, those facing seclusive syndrome (2) To survey the situation and needs of the people who require support (3) To establish and operate municipal platforms[92]

- MLHW launched the Community Support Center for Childcare Program in FY 2007. It aims to provide young families with opportunities to interact with other similar families in order to prevent childcare in a solitary circumstance

- MLHW promotes 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 their final days[93]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (7)	Frequent and severe pandemics

- The infectious disease COVID-19 has become a pandemic, causing tremendous damage worldwide, and is still prevalent. Countermeasures, such as lockdowns, have caused enormous health hazards and social and economic damage, changing the social landscape

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

Japan World Potential Impact estimates	More than 180.94 million people worldwide have contacted COVID-19, and more than 3.91 million have died. (As of June 2021)[94] In the case of a moderate to a severe pandemic, predicted global mortality falls between 14 and 71 million.[95] Annual global economic loss that would occur at present in the case of a pandemic is estimated to be $570 billion.[96] (B)

- With regard to other infectious diseases, about half of the world's population, mainly in Africa, is at risk of malaria, and the number of people infected reached 228 million.[97] In addition to malaria, traditional infectious diseases such as tuberculosis and HIV remain a threat in many countries

World Potential Impact estimates	Mortality from malaria was estimated to be 445 thousand in 2016. The disease slows down the economic growth of African countries by 1.3% per year, and $12 billion of GDP has been lost annually.[98] (A)

Japan	World	World	Japan
Unresolved ➡	Unresolved	Unresolved ➡	Unresolved

Societal Issues	Preventive measures against the spread of the virus to improve resilience against infectious diseases

Key Points for Resolving Issues

Developed Countries: The key is balancing information-based prevention, control of outbreak, medical resources, and economic activities

- It is essential to quickly acquire information worldwide on the outbreak and transmission of epidemic and take immediate actions and avoid outspread of transmission. It is also important to take public health measures, including social distancing, to avoid clusters and prevent medical collapse. Simultaneously, it is important to implement measures to maintain economic activities, provide appropriate information, and implement support policies to prevent confusion

49

> **Developing Countries:** Improving sanitation in developing countries, where pandemics may hit more severely
>
> - In case of a pandemic, developing countries with poor sanitation are more likely to be hit more severely. The positive effect has been that developed countries have taken the initiative in producing a vaccine and 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

Clues to Solutions

Technological Trends

Developed Countries ---

Realization Timeline ▼

Detection and prediction of the spread of infection

- There are high expectations for a surveillance system[99] to detect epidemics of new infectious diseases in normal times and the possibility of infectious diseases using AI to analyze travel records and the symptoms of hospital visitors

  2020 to 2025

- There are useful tools after an outbreak, such as a system that allows people to anonymously check whether they have had close contact with an infected person, translation tools for assisting foreigners who are not feeling well, and AI to analyze medical questionnaires

  2020 to 2025

  > Example
  >
  > In response to the COVID-19 outbreak, Kanagawa Prefecture provided 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 risk of close contact with those infected arises. An alert function has been added to inform users to leave restaurants after a pre-determined amount of time, usually 90 minutes.[100]

Collecting and sharing information

- Systems are needed to appropriately collect and disclose relevant information, including evidence on transmission routes, recovery, recurrence, death, medical resources, and availability of healthcare professionals

  2020 to 2025

- Research and development activities are also being carried out to collect information from infrastructure such as sewerage. Work is underway to detect COVID-19 in sewage[101]

  2020 to 2025

  > Example
  >
  > Code for Japan, a nonprofit organization based in Tokyo, launched a website focused on COVID-19.[102] The site was developed with open-source software in a short period.
  > They made their code available on GitHub, thus enabling local governments nationwide to launch similar sites.

Clues to Solutions

Technological Trends

Developed Countries -   Realization Timeline ▼

Online medical service

- A noncontact consultation and drug delivery system is effective in preventing transmission. However, its application and usage need to be defined through policy since physical findings obtained online are limited compared to physical examinations   `2020 to 2025`

Development of rapid test kits, therapeutic medicine, and vaccines

- A rapid test kit that can screen infection quickly is effective in promoting preventive actions and preventing the transmission of disease. Distribution at a low price is desired   `2020 to 2025`

- Existing drugs may also be effective for new types of infections. AI is being looked into to identify candidate drugs from existing ones   `2020 to 2025`

- The development of a vaccine is also important to prevent further transmission and subsequent waves of the pandemic. mRNA saw practical use in a vaccine for the first time due to its role in battling the COVID-19 pandemic   `2020 to 2025`

  | Example |

  A research team on silkworms 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 vaccine candidate.[103]

Developing Countries -

Addressing public health issues

- Insect repellent nets, soaps that can be used without water, water purification tablets, and excrement decomposing agents have been developed   `2020 to 2025`

  | Example |

  Countermeasures against infectious mosquitos have been developed, such as insect-repellent mosquito nets, Olyset® Net (Sumitomo Chemical Company, Limited, Japan),[104] and Photonic Fence, a laser that selectively kills female mosquitoes (Intellectual Ventures Management LLC, U.S.).[105]

- Inexpensive and safe sewage and sanitation facilities are in demand   `2020 to 2025`

  | Example |

  SATO toilets are designed for developing countries, which require only a small amount of water (LIXIL Group Corporation, Japan.)[106]

Technological Trends

Developing Countries - Realization Timeline ▼

Addressing public health issues

■ ICT can be used to collect the latest information on the risk of infectious diseases and to raise immediate awareness
<div align="right">2020 to 2025</div>

> **Example**
>
> Google Flu Trends allowed users to see how the flu epidemic was trending in real-time via search terms (The service has been terminated).

■ The pandemic sparked the development and practical use of an autonomous disinfection robot
<div align="right">2020 to 2025</div>

> **Example**
>
> PATORO, a robot developed by ZMP INC., provides autonomous security and disinfection. It is equipped with an electric disinfectant sprayer and patrols on its own both indoor and outdoor spaces sterilizing surfaces as it goes.[107]

Storage and transportation of vaccines at room temperature

■ Rice-based oral vaccines for cholera and other viral diarrhea can be stored at room temperature, making it much easier to handle in developing countries than conventional ones
<div align="right">2020 to 2025</div>

■ Vaccines can be transported to remote islands by drones. If all vaccines could be stored at room temperature, as in the case of rice-based vaccines, the use of drones for delivery would increase
<div align="right">2020 to 2025</div>

■ Research and development for new vaccines (percutaneous, rice-based, DNA vaccines, etc.) are progressing. Percutaneous (also known as skin patch) vaccines can be stored at room temperature and immunized in the absence of medical personnel
<div align="right">2020 to 2025</div>

Clues to Solutions

Regulatory Trends

- In April 2020, with the spread of the COVID-19, restrictions were removed for medical care and drug consultation on the telephone and online, including for patients' first-time visits, as a temporary and exceptional measure (Refer to "Insufficient Access to Medical Services" in p.7)

- Some countries and regions implemented lockdown measures, restricting citizens' activities, in response to the COVID-19 pandemic. These lockdown measures strictly prohibited people from leaving home except for essential grocery shopping—commuting was otherwise prohibited. In Japan, the government requested its citizens to refrain from leaving home and lacked any penalties or enforcement, yet these measures demonstrated a certain degree of effect. Debate is still taking place as to whether Japan should implement stricter enforcement to cope with the further expansion of infectious diseases

- In the U.S. and major European countries, vaccination is covered by health insurance. In Japan, only those designated by national and local governments are covered by health insurance, and the cost of others is borne entirely by individuals. The vaccination for mumps, which has become a global standard, is not eligible, reducing the vaccination rate and leading to hearing loss and meningitis. Routine vaccination for influenza is limited to the elderly, and other generations must pay out of pocket. Delays in the vaccination system compared with those in major overseas countries have been criticized as a so-called vaccine gap. There is also a need to shift to regular vaccinations principally financed by government funds. Introduction of new vaccines is also keenly needed

- CARB-X, the world's largest nonprofit organization, was established in 2016 to respond the antimicrobial resistance (AMR). It aims to promote antimicrobial research and is funded by the U.S. government.[108] Japan established the Agency for Medical Research and Development (AMED) in 2015 to support the creation of antimicrobial resistance medication. It is, however, pointed out that increase in budget may be necessary

- In June 2021, Japan decided on 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 in emergencies to produce vaccines

- 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 not strict in developing countries, so the use of drones in the vaccine transportation could increase

ICF issues with targets in UN SDGs

Problems	Issues
(1) Rising medical costs due to lifestyle-related diseases	**Improvements in technology and measures to detect early signs of disease and prevent them from becoming severe**
	Targets in UN SDGs
	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
(2) Insufficient access to medical and nursing services	**Securing services and improving quality regardless of patients' location or distance**
	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
(3) Intensifying shortage of care workers	**Expanding science-based nursing care to enhance productivity while ensuring quality**
	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
(4) Increase in the number of people suffering from mental illness	**Support ranging from prevention and detection of early signals to treatment and rehabilitation**
	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
	3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol
(5) Increasing health risks for women	**Development of products focused on women's health and social systems to support women's participation in society**
	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
(6) Worsening harm caused by loneliness and isolation	**Early detection of potential victims, implementation of preventive measures, and reduction of adverse effects**
	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
(7) Frequent and severe pandemics	**Preventive measures against the spread of the virus to improve resilience against infectious diseases**
	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

Notes and References

All URLs were viewed on September 1st, 2021.

1   Tanaka, K., "Remote work and stay home raise the risk of lifestyle-related diseases due to lack of exercise," web page, Japan Preventive Association of Life-style Related Disease, April 2020. (in Japanese)
http://www.seikatsusyukanbyo.com/main/opinion/001.php

2   Ministry of Economy, Trade and Industry, Japan, "Efforts concerning medical and nursing care to enrich consumers' lives," discussion paper, Meeting for Complete Structural Reform "Medical and nursing – to enrich consumers' daily lives" at Future Investment Conference, October 20th, 2016. (in Japanese)
https://www.kantei.go.jp/jp/singi/keizaisaisei/miraitoshikaigi/suishinkaigo_iryokaigo_dai1/siryou3.pdf

3   JPY 60 trillion (national medical expenditure in 2025) × 70.9% (share of medical cost at institutions in 2015) = JPY 42.54 trillion Ministry of Health, Labour and Welfare, Japan, "Overview of national medical care expenditure, 2015", September 13th, 2017. (in Japanese)
https://www.mhlw.go.jp/toukei/saikin/hw/k-iryohi/15/dl/data.pdf

4   Bommer, C. et al., "Global Economic Burden of Diabetes in Adults: Projections from 2015 to 2030," Diabetes Care, Vol. 41, No.5, pp. 963-970, May 2018.

5   UIC Today, "Gut bacteria may contribute to diabetes in black males," March 5th, 2015.
https://today.uic.edu/gut-bacteria-may-contribute-to-diabetes-in-black-males

6   Japan Preventive Association of Life-style Related Disease, "Developed an AI system to predict the risk of lifestyle-related diseases to analyze health checkup data of 1 million patient," October 24th, 2018. (in Japanese)
http://www.seikatsusyukanbyo.com/calendar/2018/009716.php

7   Provigate
https://provigate.com/en/projects/

8   Light-Touch Technology, Inc. "Light-Touch-Tech- "
http://www.light-tt.co.jp/product?lang=en

9   SUMITOMO LIFE INSURANCE COMPANY, "Vitality." (in Japanese)
https://vitality.sumitomolife.co.jp/

10   Hirose Tanikawa Narumi Lab., Graduate School of Information Science and Technology, the University of Tokyo
http://www.cyber.t.u-tokyo.ac.jp/ja/projects/

11   Cancer Scan Co. Ltd., Division of Health Sociology, Health Sociology Division of National Cancer Center Japan (eds.), Handbook of Measures to Improve the Rate of Medical Examinations -- Nudge Theory: Starting Tomorrow--, Ministry of Health, Labour and Welfare, Japan, April 2019. (in Japanese)
https://www.mhlw.go.jp/content/10901000/000500406.pdf

12   Kotake, A., "Delicious relationship among Adachi Ward and The University of Tokyo," June 12, 2019. (in Japanese)
https://www.u-tokyo.ac.jp/focus/ja/features/z0508_00132.html

13   FreeStyle Libre.
https://jp.abbott-diabetescare.com/patient/products.html

14   News, Diabetes Network, January 23rd, 2019. (in Japanese)
https://www.dm-net.co.jp/calendar/2019/028844.php

15   News, Diabetes Network, February 18th, 2016. (in Japanese)
https://www.dm-net.co.jp/calendar/2016/024723.php

16   News, Diabetes Network, February 14th, 2019. (in Japanese)
https://www.dm-net.co.jp/calendar/2019/028906.php

17   "Find it before you see it!? For 'super' early detection of cancer," Website for MRI's 50th Anniversary Celebration Project. (in Japanese)
https://www.mri.co.jp/50th/columns/genomic/no02/

18   National Cancer Center, Press Release, March 13th, 2018. (in Japanese)
https://www.ncc.go.jp/jp/information/pr_release/2018/0313/index.html

19   Division for Health Care and Long-term Care Integration, Health Insurance Bureau, Ministry of Health, Labour and Welfare, Japan, "Revision of the payment adjusting system for Old-Old Aid (FY 2018 to FY 2023)." (in Japanese)
https://www.mhlw.go.jp/file/05-Shingikai-12401000-Hokenkyoku-Soumuka/0000146384.pdf

20   Ministry of Health, Labour and Welfare, Japan, "Mouth care for preventing lifestyle-related diseases," *Seminar for health insurer on teeth and mouth care*, an FY 2015 project. (in Japanese)
https://www.mhlw.go.jp/file/06-Seisakujouhou-12400000-Hokenkyoku/0000124753.pdf

21   Marumoto, Y., "Japan's first anti-smoking treatment app approved for insurance," *Nikkei Medical,* November 12, 2020. (in Japanese)
https://medical.nikkeibp.co.jp/leaf/all/hotnews/int/202011/567850.html

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Notes and References

All URLs were viewed on September 1st, 2021.

22   According to a survey by MLHW, 27.7% of male and 17.3% of female medical doctors work more than 60 hours per week. (Source: see Note #24
https://www.mhlw.go.jp/file/05-Shingikai-10801000-Iseikyoku-Soumuka/0000161146.pdf

23   Health Policy Bureau, Ministry of Health, Labour and Welfare, Japan, "Survey on medical doctors' attributes and attitudes for work," 04/06/2017. (in Japanese)
https://www.mhlw.go.jp/file/05-Shingikai-10801000-Iseikyoku-Soumuka/0000161146.pdf

24   "Health at a Glance," OECD Library, November 10th, 2017.
https://doi.org/10.1787/19991312

25   "Amazon Care to launch across U.S. this summer, offering millions of individuals and families immediate access to high-quality medical care and advice — 24 hours a day, 365 days a year," March 17, 2021.
https://www.aboutamazon.com/news/workplace/amazon-care-to-launch-across-u-s-this-summer-offering-millions-of-individuals-and-families-immediate-access-to-high-quality-medical-care-and-advice-24-hours-a-day-365-days-a-year

26   Ping An Good Doctor
http://www.pagd.net/

27   Sonavi Labs, AI stethoscope
https://sonavilabs.com/

28   Olympus News Release, March 7th, 2019.
https://www.olympus.co.jp/news/2019/contents/nr01159/nr01159_00000.pdf

29   Phronesis, No. 19, p. 100, September 2018. (in Japanese)
https://www.mri.co.jp/knowledge/magazine/phronesis_019.html

30   T-ICU Co. LTD.
https://www.t-icu.co.jp/

31   Embrace
https://www.embraceinnovations.com/

32   Ministry of Health, Labour and Welfare, Japan, "Webpage for online medical services." (in Japanese)
https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/kenkou_iryou/iryou/rinsyo/index_00010.html

33   Akiyama, H., "The concepts of science and society in the era of longevity," *Science Journal KAGAKU*, Iwanami Shoten, Publishers, Tokyo, Vol. 80, No. 1, pp. 59-64, January 2010. (in Japanese)

34   Ministry of Health, Labour and Welfare, Japan, "On revising the future estimate of expenses related to social security," March 2012. (in Japanese)
https://www.mhlw.go.jp/seisakunitsuite/bunya/hokabunya/shakaihoshou/dl/shouraisuikei.pdf

35   Cabinet Office, Government of Japan, Annual Report on the Aging Society [Summary] FY 2017, 2017.
https://www8.cao.go.jp/kourei/whitepaper/w-2017/html/gaiyou/s1_2_3.html

36   Alzheimer's Disease International, World Alzheimer Report 2015 --The Global Impact of Dementia - An Analysis of Prevalence, Incidence, Cost and Trends -, August 2015.
https://www.alz.co.uk/research/WorldAlzheimerReport2015.pdf

37   Economic Impact of Dementia in Japan, Dementia Countermeasure Comprehensive Research Project, Ministry of Health, Labour and Welfare, Japan, March 2015 (in Japanese)
https://csr.keio.ac.jp/pdf/2014年度認知症社会的コスト総括分担報告書.pdf

38   ibid.

39   Livingstone, G. et al., "Dementia prevention, intervention, and care," *The Lancet*, 390 (10113), 2673-2734, December 16, 2017.
https://doi.org/10.1016/S0140-6736(17)31363-6

40   Care Work Foundation, "Results of FY 2019 survey on care work," press release, August 7, 2020. (in Japanese)
http://www.kaigo-center.or.jp/report/pdf/2020r02_chousa_kekka_0818.pdf

41   National Institute of Population and Social Security Research, "FY 2017 report on the current status of family care under the Long-Term Care Insurance System," *IPSS Research Report*, 80, March 31, 2018. (in Japanese)
http://www.ipss.go.jp/syoushika/bunken/data/pdf/shonai80.pdf

42   LookBack - Virtue Health
https://www.virtue.io/lookback/

43   For potential dementia patients: Early diagnosis of dementia by MRI images analyzed with ICT/AI.
https://www.darmiyan.com/

44   TAIYO LIFE INSURANCE COMPANY, "Taiyo Life Insurance has sold more than 700,000 Dementia Insurance," press release, June 11, 2021. (in Japanese)
https://www.taiyo-seimei.co.jp/company/notice/download/press_article/2021/20210611.pdf

45   National Center for Geriatrics and Gerontology, News and Topics, January 31st, 2019. (in Japanese)
http://www.tsukuba-sci.com/?p=5805

Notes and References

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

All URLs were viewed on September 1st, 2021.

46   National Center for Geriatrics and Gerontology, News and Topics, February 1st, 2019. (in Japanese)
      https://www.ncgg.go.jp/monowasure/news/20190201.html

47   "FDA approved for a new drug for Alzheimer's disease – Joint development by Eisai," NHK News, June 8, 2021.
      (in Japanese)
      https://www3.nhk.or.jp/news/html/20210608/k10013072991000.html

48   A platform by MILMO net that compiles local resource information, both covered or not covered by the Long-Term
      Care Insurance, so that care managers can present a broader range of options to users. (in Japanese)
      https://welmo.co.jp/service/milmo-net/

49   WELMO, INC. (in Japanese)
      https://welmo.co.jp/

50   ExaWizards Inc.
      https://exawizards.com/business/caretech

51   Ministry of Health, Labour and Welfare, Japan, "Science-based nursing care for promoting LIFE (VISIT and CHASE),
      " The 185th Long-Term Care Benefit Expense SIG, Social Security Council, September 14, 2020. (in Japanese)
      https://www.mhlw.go.jp/content/12301000/000753792.pdf

52   Ministry of Health, Labour and Welfare, Japan, "Science-based nursing care for promoting LIFE (VISIT and CHASE),
      " *The 185th Long-Term Care Benefit Expense SIG, Social Security Council*, September 14, 2020. (in Japanese)
      https://www.mhlw.go.jp/content/12301000/000753792.pdf

53   Ministry of Health, Labour and Welfare, Japan, *"Outline of the Survey on Mental Health of COVID-19 Patients,"* December
      25, 2020. (in Japanese)
      https://www.mhlw.go.jp/stf/newpage_15766.html

54   Ministry of Health, Labour and Welfare, Japan, Collaborative Health Guidelines, p. 35, 2017. (in Japanese)

55   Ministry of Health, Labour and Welfare, Japan, Patient Survey 2017.
      https://www.mhlw.go.jp/content/12200000/000462293.pdf

56   Estimates of the Social Costs of Mental Illness, project report, Ministry of Health, Labour and Welfare, Japan.
      (in Japanese)
      https://www.mhlw.go.jp/bunya/shougaihoken/cyousajigyou/dl/seikabutsu30-2.pdf

57   Human Resource and Labor Management. (in Japanese)
      https://www.kaiketsu-j.com/index.php/topix/121-iryo/2783-ikoh-781

58   "Mental health," Our World in Data.
      https://ourworldindata.org/mental-health

59   PST Inc. "MIMOSYS" (in Japanese)
      https://medical-pst.com/products/mimosys

60   Binah.ai.
      https://www.binah.ai/

61   Sompo Himawari Life Insurance Inc.
      https://www.himawari-life.co.jp/~/media/himawari/files/company/news/2018/a-01-2019-01-16.pdf

62   iOS Healthcare.
      https://www.apple.com/jp/ios/health/

63   Calm.
      https://www.calm.com/

64   ginger.io.
      https://www.ginger.io/

65   Lyra Health
      https://www.lyrahealth.com/member-experience/

66   GoodBrain. (in Japanese)
      https://goodbrain.jp/brainmusic/

67   LOVOT. (in Japanese)
      https://lovot.life/

68   Qoobo conducted an on-site experiment of a robot at a care facility to probe it moved seniors with its wagging tail.
      (in Japanese)
      https://prtimes.jp/main/html/rd/p/000000090.000015618.html

69   Ministry of Health, Labour and Welfare, Japan, *"Overview of working women," Facts about Working Women FY 2019 Edition.*
      (in Japanese)
      https://www.mhlw.go.jp/bunya/koyoukintou/josei-jitsujo/dl/19-01.pdf

Notes and References

All URLs were viewed on September 1st, 2021.

70   The Japan Research Institute, *Survey on the Health Promotion of Working Women*, FY 2017 Research Report commissioned by Ministry of Economy, Trade and Industry, Japan, pp. 56-186, March 2018. (in Japanese)
https://www.meti.go.jp/policy/mono_info_service/healthcare/downloadfiles/H29kenkoujumyou-report-houkokusho-josei.pdf

71   Health and Global Policy Institute, *Survey on Health Promotion and Working Women*, January 21, 2016. (in Japanese)
https://hgpi.org/wp-content/uploads/
%E8%AA%BF%E6%9F%BB%E5%A0%B1%E5%91%8A%E6%9B%B8_%E5%83%8D%E3%81%8F%E5%A5%B3%E6%80%A7%
E3%81%AE%E5%81%A5%E5%BA%B7%E5%A2%97%E9%80%B2%E8%AA%BF%E6%9F%BB_1.5.pdf

72   Mckinsey Global Institute, *The Power of Parity: How Advancing Women's Equality Can Add $12 Trillion To Global Growth, full* report, September 2015.
https://www.mckinsey.com/~/media/McKinsey/Industries/Public%20and%20Social%20Sector/Our%20Insights/
How%20advancing%20womens%20equality%20can%20add%2012%20trillion%20to%20global%20growth/
MGI%20Power%20of%20parity_Full%20report_September%202015.pdf

73   FamiOne, Inc. (in Japanese)
https://famione.co.jp/

74   TRULY (in Japanese)
https://www.truly-japan.co.jp/

75   Report Ocean, "The global market size of the liquid biopsy for breast cancer is expected to reach $357,051,000 by 2027," *PR TIMES*, April 21, 2021. (in Japanese)
https://prtimes.jp/main/html/rd/p/000001869.000067400.html

76   Daiwa House Industry Co., Ltd., "Kaji share house." (in Japanese)
https://www.daiwahouse.co.jp/jutaku/lifestyle/kajishare/solution/

77   Tuskaji Co., Ltd. (in Japanese)
https://taskaji.jp/

78   Boyle, R., Boyle, R.G., "Hand size and the piano keyboard. Literature review and a survey of the technical and musical benefits for pianists using reduced-size keyboards in North America," *Proceedings of the 9th Australasian Piano Pedagogy Conference: Expanding Musical Thinking*, Sydney, Australia, July 2009.
https://www.researchgate.net/publication/264457999_Hand_Size_and_the_Piano_Keyboard_Literature_Review_
and_a_Survey_of_the_Technical_and_Musical_Benefits_for_Pianists_using_Reduced-Size_Keyboards_
in_North_America

79   Galaxy Z Flip & Z Flip 5G (in Japanese)
https://www.galaxymobile.jp/galaxy-z-flip/

80   Kawakami, A., Orii, M., Yanase, T., "Key to promoting virtual clinical trials: Appropriate understanding and active participation of patients and citizens," MRI Trend Review, April 7, 2021. (in Japanese)
https://www.mri.co.jp/knowledge/column/20210407.html

81   Ministry of Health, Labour and Welfare, Japan, "Current state of health and medical care for pregnant and nursing women and related measures*," Study Group on the State of the Health and Medical Care System for Pregnant and Nursing Women*, February 15, 2019. (in Japanese)
https://www.mhlw.go.jp/content/12401000/000479245.pdf

82   Ozora, K. "Measures against loneliness and isolation," *Urgent Forum to Prevent Loneliness & Isolation, Show Solidarity to Anxiety, and Connect,* Cabinet Secretariat, February 25, 2021. (in Japanese)
https://www.cas.go.jp/jp/seisaku/kodoku_tsunagaru_forum/dai1/siryou2.pdf

83   Nonogi, H., "Myocardial infarction & angina pectoris - Prevention and treatment," *Facts about Cardiovascular Disease*, Vol. 34, Cardiovascular Information Service, National Cerebral and Cardiovascular Center, September 1, 2002. (in Japanese)
http://www.ncvc.go.jp/cvdinfo/pamphlet/heart/pamph34.html

84   ALOHA COIN
http://alohacoin.info

85   *Loneliness Map,* Age UK, April 26, 2021.
https://www.ageuk.org.uk/our-impact/policy-research/loneliness-research-and-resources/loneliness-maps/

86   Shumito Club, "SNS of the adult generation that can connect through hobbies and make friends." (in Japanese)
https://smcb.jp/

87   "Case Study 11: Kilburn Older Voices Exchange," Promising Approaches Revisited: Effective Action on Loneliness in Later Life, p 43, October 2020.
https://www.campaigntoendloneliness.org/wp-content/uploads/Promising_Approaches_Revisited_FULL_REPORT.pdf

88   Matsuda T., Chapter 3, p. 68, Understanding the Japanese Version of CCRC, Hoken, 2017. (in Japanese)

89   Yamaha Corporation, "Charlie." (in Japanese)
https://charlie.yamaha.com/

Notes and References

All URLs were viewed on September 1st, 2021.

90   Our services: Enrich's safety confirmation service via LINE. (in Japanese)
      https://www.enrich.tokyo/service.html

91   Tannnai, A., "The U.K., the first country in the world to consider the isolation as a social problem," *The Asahi Shimubun GLOBE +,* January 8, 2020. (in Japanese)
      https://globe.asahi.com/article/13016730

92   Policy Research Council of the Liberal Democratic Party, *First Proposal for Social Participation of Hikikomori* (Draft), May 8, 2021. (in Japanese)
      https://www.saito-ken.jp/wp/wp-content/uploads/2021/05/20b84d83e43e26c20d7902dc61300b2f.pdf

93   Ministry of Health, Labour and Welfare, Japan, *Comprehensive Community Care System*. (in Japanese)
      https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/hukushi_kaigo/kaigo_koureisha/chiiki-houkatsu/

94   "The world map of COVID-19," the Nikkei. (in Japanese, accessed on September 30th, 2020)
      https://vdata.nikkei.com/newsgraphics/coronavirus-world-map/

95   Avian Influenza (A/H7N9) Infectious Diseases, National Institute of Infectious Diseases. (in Japanese)
      https://www.niid.go.jp/niid/images/idsc/kikikanri/H25/20131016-03.pdf

96   The World Bank, "Pandemic preparedness and health systems strengthening-Pandemics, which are large disease outbreaks that affect severe countries, pose major health, social, and economic risks."

97   World Health Organization (WHO), "Malaria."
      http://www.who.int/en/news-room/fact-sheets/detail/malaria

98   Gallup, J.L. and Sachs, J.D., "The economic burden of malaria," in The Intolerable Burden of Malaria: A New Look at the Numbers, American Journal of Tropical Medicine and Hygiene, Vol. 64, No. 1 (supplement), pp. 85–96, 2001.

99   ST Japan Co., Ltd., "Path Sensors will launch a biosensor for COVID-19 virus in June," news release, March 25, 2020. (in Japanese)
      https://www.stjapan.co.jp/news/2661

100   Kanagawa Prefecture, Japan, "[For residents] Users manual for the LINE COIVID-19 Alert System," July 21, 2021. (in Japanese)
      https://www.pref.kanagawa.jp/docs/ga4/corona/osirasekenmin.html

101   Kato, S., "Infectious diseases and sewage -- Risks and possibilities," *Column*, Mitsubishi Research Institute, June 23, 2020. (in Japanese)
      https://www.mri.co.jp/knowledge/column/20200623.html

102   Latest infection trends in Tokyo Metropolis.
      https://stopcovid19.metro.tokyo.lg.jp/

103   Kyushu University, "Two major research results on Novel Coronavirus vaccines and therapeutics." (in Japanese)
      https://www.kyushu-u.ac.jp/f/39818/20_06_26.pdf

104   Sumitomo Chemical Company, Limited, "Providing Support with Olyset® Net."
      https://www.sumitomo-chem.co.jp/sustainability/social_contributions/olysetnet/initiative/

105   Intellectual Ventures Lab, "Photonic Fence."
      https://optics.org/news/7/5/37

106   LIXIL, "SATO."
      https://www.lixil.co.jp/minnanitoirewopj/sato.htm

107   ZMP INC., " 'PATORO' an unmanned security and disinfection robot." (in Japanese)
      https://www.zmp.co.jp/products/lrb/patoro

108   Carb-X
      https://carb-x.org/

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

2. WATER AND FOOD

A SOCIETY WHERE ALL ARE PROVIDED SAFE AND SECURE WATER AND FOOD

In overviewing "food and water," ICF defines the ideal future society as "A Society where everyone has access to clean water and safe, nourishing food."

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

It is necessary to improve the overall efficiency of water circulation, as well as production, distribution, and consumption of food, in order to achieve stable water and food supply for all. Labor-saving and better productivity will make the agriculture and fishery industries more attractive, resulting in the securement of workers and products.

It is essential not only to secure and maintain a sufficient amount of food but also improve access to healthy meals. While a better and healthier diet continues to be explored, low-income people in many countries tend to consume cheaper processed foods, leading to higher obesity rates—another societal issue. There is an increasing demand for food diversity based on ideology, religion, age, and whether the food agrees with the individual. Diversity and personalization are also becoming keywords in the food domain.

Good tasting and delightful meals 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 farm work and cooking.

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 categorized into the following seven aspects.
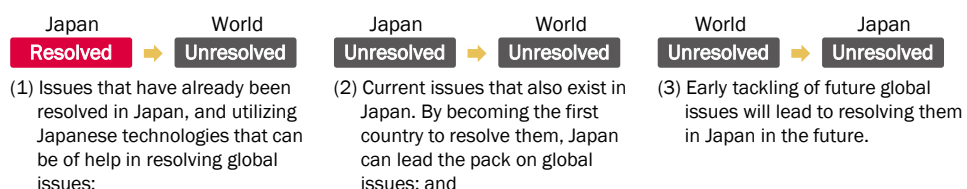
(1)	Decline in food supply capacity	→ Improve productivity through industrialization of food production and securing manpower
(2)	Difficulties in food procurement due to population growth	→ Secure ample food supply to meet the rise in global demand
(3)	Insufficient usable water resource	→ Securing and improving water infrastructure and better functionalities
(4)	Increase in food loss and waste	→ Streamlining food supply chain across all stages from production to supply and consumption; reducing food waste
(5)	Unhealthy food that remains in prosperous societies	→ Providing and improving access to healthy meals
(6)	The shift toward greater respect for food diversity	→ Improving the diversity and quality of food to conform to the needs of individuals
(7)	Lack of communication through food	→ Promoting communication through all aspects of food from farming and cooking, to the dinner table

Legend

Potential impact estimates

(A) The maximum impact on financial cost and future population by 2025 to 2030 if no effective countermeasures are taken

(B) The maximum impact of the worst-case scenario that can be reasonably expected to occur at present

Issues and Challenges are classified into three categories:

Japan	World	Japan	World	World	Japan
Resolved ⇒	Unresolved	Unresolved ⇒	Unresolved	Unresolved ⇒	Unresolved
(1) Issues that have already been resolved in Japan, and utilizing Japanese technologies that can be of help in resolving global issues;		(2) Current issues that also exist in Japan. By becoming the first country to resolve them, Japan can lead the pack on global issues; and		(3) Early tackling of future global issues will lead to resolving them in Japan in the future.	

- Productivity in agriculture and fisheries tends to be lower compared to other industries worldwide. They are not attractive career options for young people. This results in a labor shortage which raises concern about whether agriculture and fisheries can be maintained as industries in the future. Japan is also facing a continued aging and severe shortage of workforce. The problem is particularly apparent among part-time farming families

Japan **Potential Impact estimates** | The number of people working in agriculture is continuously declining. The average age reached 66.6 years[1] in the year 2017. If the current trend continues, the number of agricultural workers in 2025 will be reduced by 22% from 2010 to reach 1.7 million.[2] The number of workers who are 70 and above is expected to reach 830,000. (A)

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

World **Potential Impact estimates** | One third of the world's land has dropped to the "moderate to severe" level. The causes are erosion, salinization, consolidation, acidification, and chemical contamination.[3]

- A growing percent of the world's population faces food insecurity due to economic stagnation caused by regional conflicts and epidemics, as well as disasters and famines caused by extreme weather

World **Potential Impact estimates** | In 2020, 155 million people in 55 countries and regions experienced acute food shortage, which was an increase of about 20 million people from 2019 levels.[4]

Japan	World	Japan	World
Resolved →	Unresolved	Unresolved →	Unresolved

| Societal Issues | Improve productivity through industrialization of food production and securing manpower |

Key Points for Resolving Issues

Japan

Elderly Farmers and Fishery Workers: Mechanization, large-scale, and high value-added

- Many farmers are leaving the industry due to the aging of the farming population. This phenomenon presents a particular issue in the rice-growing regions where part-time farming is prevalent. It is crucial to improve productivity to secure workforces in the agriculture and fishery industries. This can be achieved through labor-saving practices, the full automation of processes, and pursuit of advantage of scale and high value-added. Wealthy farmers with more than 50 hectares of land and above JPY 20 million in annual income are more likely to secure successors. In fisheries, the focus has become adding value through diversification. Diversification methods include tapping into new fishery resources, improving fishing equipment and techniques, and creating diversified consumption needs for a wider variety of local fish

New Members Engaging in Agriculture: Industrialization and expansion of opportunities coupled with smooth transfer of expertise

- Large-scale operations by enterprises will improve productivity and industrialization in agriculture. This change will provide potential farmers with more opportunities to participate. For the new farmer, rather than starting farming from scratch, acquiring land and expertise from predecessors will reduce costs and risks. People who wish to change jobs and start farming are in need of better access to industry information and a service that can propose specific regions and crops to specialize in. New farmers need support so that they can achieve high levels of productivity especially in avenues such as inheriting, in the transfer of expertise, in labor-saving, and in enhancing value-added

Global

Countermeasures for Climate change, 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. The Norwegian Fishermen's Association lists on a real-time basis the quota and the catch to date for each vessel on its website. It operates a mechanism of controlling the catch to prevent overfishing and increase profits.[5] Technology must be developed to promptly reduce the number of pest insects, such as grasshoppers, so that crops will not be eaten up by their temporary increase

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Elder Workers in Agriculture and Fishery -

Realization
Timeline
▼

Improving productivity by higher efficiency of agricultural work

■ Power-assist suits and robots can be used to support strenuous work or reduce workloads, easing the burden on farmers

2020 to 2025

■ Efforts are underway to downsize non-destructive inspection equipment that can identify and collect only product that has reached a designated level of ripeness

2020 to 2025

■ Improvements in agriculture have been achieved through a Farm Machine Relay. Farming machinery and personnel are shared between regions with different farm work periods in a form of relay. The relay contributes to an increased operating rate of machinery and reduces costs

2020 to 2025

> **Example**
>
> "Shared leasing of farm machinery," which provides large combine harvesters for joint use by rice and wheat farmers, is a new type of business venture in Japan by JA MITSUI LEASING, LTD. and ZEN-NOH (National Federation of Agricultural Cooperative Associations).

■ Technological innovations have been made through the combination of GPS and sensors. For example, despite declines in physical capacity, veteran farmers have maintained their position in the industry thanks to labor-saving measures through the autonomous combination of rice-planting and harvesting machines. However, the technology has yet to reach a state of total autonomy as emergency shut-down mechanisms and the total overseeing of safety must be performed manually. This provides a hurdle for completely autonomous farming

2025 to 2035

Improvement of efficiency at the production stage and effective utilization of surplus food

■ Expectations are high for a production adjustment system that responds to market demand, food production in areas closer to consumption, and super water-saving agriculture (precision agriculture)

2025 to 2035

■ Development is underway of low-cost, nutrition-maintained cut-vegetables and techniques to clean, sterilize, and repel insects for frozen vegetables

2020 to 2025

■ Diversification demonstrates potential to enhance the added-value to fisheries. Measures foreseen for the future include conservation of the marine environment, such as the impact on the ecosystem, through identification and utilization of microorganisms and plants that absorb pollutants

2020 to 2025

> **Example**
>
> Gate Inc. developed a business model that utilizes fish that are usually wasted.
> In the business model, fish are cooked and served at pubs and taverns in Tokyo. Gate Inc. is also working on marine resource management through undersea monitoring.[6]

Technological Trends

New Members to Engage in Agriculture

Realization Timeline ▼

Matching human resources and 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 various industries

  2020 to 2025

- Expectations are high for a service that matches farmers seeking successors with new candidates and support services for those new farmers

  2020 to 2025

  > Example
  >
  > Rakuten Farm provides services for farmers and consumers.
  > Specifically, consumers prepay for crops, which stabilizes farmers' income. In return, the service provides consumers with a virtual farm work experience through a smartphone app (Rakuten Agriculture, Co., Ltd.[7]).

- A new service has emerged that formulates cultivation expertise and provides instruction in cultivation based on soil and weather data

  2020 to 2025

  > Example
  >
  > Sagri[8] is an agricultural management app that analyzes farmland and relays the appropriate amount of required pesticide and fertilizer. This has been developed and operated by Sagri Co., Ltd. The cultivation optimization support system, AI-RICH, gives instructions on better growing conditions based on environmental information of crops obtained from various sensors. (Plant Life Systems Co., Ltd.)[9]

Global

Development of technology for stable food supply

- Progress is being made in the development of crops that is resistant to climate change and pests. Research and development efforts have their sights set on increasing seed germination rates

  2020 to 2025

- Advancements have been made in the practical application of biofortification. The technology develops new varieties of crops enriched by micronutrients such as minerals and vitamins

  2020 to 2025

  > Example
  >
  > Between 2004 and 2018, HarvestPlus, a pioneer in biofortification research, published more than 340 fortified varieties of crops in over 40 countries. Their goal is to provide fortified varieties to one billion people by 2030.[10]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Development of technology for stable food supply

- An issue to be resolved is the lack of cultivation techniques and knowledge of local farmers in developing countries

- The development of desalinating crops with high salt absorption capacity may help to remove salt from agricultural land, as well as irrigation in dry soil with accumulated salt[11]

  > Example
  >
  > Brassica, sunflower, cotton, and tomato are typical salt-tolerant plants that even 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.

Regulatory Trends

- Productive green zones: In 2022, exemptions will be extended to 80% of the land currently designated as productive green zones that are required to be used for farming operations[12]

- The *Main Crop Seeds Act*: The Act was abolished in 2018, and hopes are high for 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's border. This amendment is expected to prevent the cross-border outflow of high-quality varieties[13]

- The *Cropland Act*: The law has been revised to remove barriers facing companies wishing to enter the agriculture business

- Agricultural drones have been used mainly to spray 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 expand to include use in surveying field growth and in transporting harvested crops

- In order to prevent fishery declines due to overfishing, management of fishery resources is essential. Fishing countries such as New Zealand, Iceland, and Norway have introduced fishing quotas in the 1980s, and Japan finally adopted fishing regulations when the *Fisheries Law* was enacted in December 2018

- In Japan, the Catch and Landing Data Platform (CALDAP) was launched in 2018 to record and provide information on the catch of fish and its landing. It is utilized for providing data and issuing certificate necessary for export.[14] The system still requires standardization of its specifications and development of a rule in expanding the target fish species

Clues to Solutions

Regulatory Trends

- In January 2018, the United States implemented the Seafood Import Monitoring Program (SIMP). The program requires importers to provide data from the harvest to entry to the U.S. on fishery products made with specific fish species[15]

- There is no international standard on the content of minerals and vitamins used for biofortification today. An international standard and certification systems are expected to be developed in the future. Discussion is taking place at the United Nations, based on empirical research by the WHO and the International Food Policy Research Institute (IFPRI)[16,17]

Difficulties in food procurement due to population growth

- Protein demand is expected to surpass its supply around 2030, resulting in a Protein Crisis, which has been recognized as a global issue. Stable procurement of animal and plant protein sources may become difficult 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. The share of alternative proteins in the animal protein market is expected to increase from 2% to 11% over the same period.[18] (C) |

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

| World | Potential Impact estimates | The world population will reach 8.6 billion around the year 2050. To secure enough food for all, production of staple crops such as grains must increase by 70%[19] compared to 2010.(B) |

Japan
Unresolved ➡ World
Unresolved

| Societal Issues | **Secure ample food supply to meet the rise in global demand** |

Key Points for Resolving Issues

Protein: **Improving food productivity and securing new protein resources**

- There are two approaches for resolving food shortages: "efficient food production" and the "development of new food sources." Technologies are being developed and improved to enhance efficiency and productivity in food. Examples of the initiatives taken are plant factories, feeding systems, aquafarming, cultured meat, and livestock farming using genome editing. In the development of new cooking ingredients, new sources of protein are particularly needed. Because animal proteins depend on plant proteins, plant proteins have an advantage over animal proteins in terms of production efficiency. Development of alternative meat, a plant protein substituting animal protein, is underway, along with the development of algae that produces protein more efficiently than terrestrial plants

Grain: **Stable supply of food**

- Developing countries are particularly vulnerable to food shortages caused by unseasonable weather and natural disasters. As a result, they suffer from the price increase in the grain market. There is call for the development of crops that are resistant to climate change. There are also needs for improving grain self-sufficiency rates and strengthening of regulations on grain trade. About half of the world's grain is used as feed crop today. If the plant-based protein supply can replace animal-based production, it may reduce the overall demand for grain

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Protein

Realization Timeline ▼

Efficient aquaculture production of marine proteins

■ Attention is being given to energy-saving aquaculture technology (e.g. utilization of waste heat, setting up a fish preserve in a cave where constant water temperature is maintained, etc.). Efficiency can be improved in feeding systems through better utilization of ICT

2020 to 2025

> Example
>
> 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).[20]

■ The technology of creating fish meat by cultivating fish cells is drawing attention

2020 to 2025

> Example
>
> A U.S. biotechnology firm, Finless Foods, Inc., is developing plant-based tuna as well as cell-cultured tuna.[21] Avant Meats Limited, a Hong Kong-based startup, aims to commercialize cultivated fish products.[22]

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

2025 to 2035

Efficient way to produce meat

■ Progress has been made in the practical application of efficient livestock production improved by genome-editing technology (e.g. increasing the amount of meat and making it less susceptible to disease)[23]

2025 to 2035

■ Livestock stem cells have gained note as a means to produce cultured meat. Along with the improvement of culture technology and product quality, the cost reduction through mass production has induced greater acceptance of cultured meats in the market

After 2035

Technological Trends

Protein - Realization Timeline ▼

Development of new protein resources and cooking ingredients

■ Insects are currently consumed as food for livestock and humans. Current 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 to 2025 |

Example

Manufacturers and retails are selling cereals and cookies containing cricket powder in the U.S. (Edible insect producer and retailer, Exo, and edible insect venture Six Foods LLC, U.S.).[24]

■ Plant-based meat substitutes made from soybeans and other ingredients have also been put into practical use. In addition to improving production efficiency, the future challenges are how to replicate the flavor and texture of real meat, and also how to ensure safety

| 2020 to 2025 |

Example

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

Grain -

Development of mechanisms for stable food supply

■ Interest is growing in developing countries concerning meal support systems at schools[25]

| 2020 to 2025 |

Example

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 offering in Vietnam (AJINOMOTO VIETNAM CO., LTD.).

*For developing technologies for stable food supply in developing countries, see "Societal Problem (1) Decline in Food Supply Capacity."

Regulatory Trends

- In January 2018, a regulation on novel foods was 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 from non-edible parts of food so that biofuel production will not induce food shortages and increases in price. On the other side of the Atlantic, the U.S. both encourages the production of biofuel and allows the edible parts of food to be used[26]

- Global controversy grows over whether it is acceptable to label alternative meat products with the word *meat*. For example, in the U.S., beef producer groups have been demanding to introduce laws and regulations concerning the labeling of meat, arguing that an explicit distinction should be made between alternative meat and conventional meat products. Bills are being considered and developed at the state level. The State of Missouri passed a law in 2018 that allowed *plant-based* meat alternatives to continue using the *meat* label, as long as the words *plant-based* are specified. The State of Texas banned *meat* entirely from labels for alternative meats in 2021. In Japan, suppliers are required to avoid labeling that may mislead consumers. Aside from the name of the product, such descriptions as *Produced with soybeans* or *A non-meat product* are required[27]

- In 2019, the E.U. officially ruled that insects currently being sold in the market as edible will remain legal. Still, all further attempts at merchandizing edible insects would require in-depth safety assessments. In the U.S., concerns of allergy over the insect-derived food additives such as carmine and cochineal extract led to FDA mandating warning labels on the products.[28] In Japan, food allergy labeling on edible insects is not currently required because insects are not listed in the Specified Raw Materials under the current food allergy labeling regulation

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

- While global water demand continues to increase, many areas are not keeping up with developing fundamental water infrastructures, including seawater desalination plants. Global warming causes a change in the rainfall patterns bringing droughts and floods, resulting in shortage of water resources for drinking and agriculture

World Potential Impact estimates	By 2025, 5.5 billion out of the 8.2 billion global population will face water stress, and 1.8 billion will fall into absolute water scarcity[29] (A) * Yearly water demand for agriculture, manufacturing, energy, and the environment is estimated at 1,700 m3 per capita. *Water stress* is defined as a condition in which the annual usable water volume per capita is less than 1,700 m3, and *absolute water shortage* as less than 500 m3.
World Potential Impact estimates	The global expenditure on desalination was USD 2.72 billion in 2015. It has been estimated to increase to USD 4.99 billion in 2020.[30] (A) * Major desalination methods include the thermal method to distill seawater and the membrane method to physically filter out saline matter using reverse osmosis membranes. Use of the membrane method is growing, and in 2020, expenditure is expected to be 600 million for thermal and USD 4.4 billion for membrane methods.
Japan Potential Impact estimates	Japan imports about 80 billion m3 of virtual water*. Most of the virtual water is attributed to food.[31] * Virtual water: A visualization of the total amount of water a country uses, including that which was used to make the products that that country imports.

World Unresolved ➡ Japan Unresolved

Societal Issues	Securing and improving water infrastructure and better functionalities

Key Points for Resolving Issues

Countries and Regions That Lack Clean Water: Securing the absolute quantity of water and improving the quality of water are key

- The amount of water in a river basin is defined as the residue of precipitation deducting the run-offs. The run-offs can be rainwater flowing into rivers, soaking into ground, or evaporation. In areas with low rainfalls, it is imperative and achievable to secure water supply through recycling of drainage water and seawater desalination. Some areas have enough water resources but cannot secure sufficient clean water due to a polluted environment caused by garbage, a lack of toilets that flush, and pollution. Improvement of water quality is necessary to solve these problems. Most cities are located in areas where a certain amount of rainfall is expected. However, due to global warming and other factors, the wild swing between the extremes of heavy rainfall and drought is becoming a normal phenomenon. Rainwater storage is becoming more difficult due to localization, concentration, and severity of rainfall. Efficient recovery systems and storage technologies for water resources are in urgent need

Water Infrastructure Operators: How to manage to meet demand

Efficient management of water infrastructure is a societal issue even in countries and regions where gross water demand is fulfilled. It is important to improve the finances of the existing infrastructure through privatization and coordinated management of water and sewage. It is also imperative, when building or renewing infrastructure, to design an efficient model that will meet the fluctuating demand for water. To achieve sustainable water resource in each basin, we must conduct the following three activities:

[1] Identification of available water resources

Need for visualizations of the total water resources, including surface water and groundwater.

[2] Estimation of the demand

The use of AI and ICT is effective, especially for developing countries that need to overhaul the infrastructure. By designing small scale reservoirs to meet the real-time demand forecast, an efficient management becomes possible.

[3] Flexible water supply to meet fluctuating demand

It is effective to install dispersed small scale equipment for water storage and wastewater treatment in each area.

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Countries and Regions Lacking Clean Water - Realization Timeline ▼

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

- For the areas where constructing water facilities is difficult due to the geography and environment, an inexpensive and simple alternative technology is in demand

  2020 to **20**25

  > Example
  >
  > India has begun to make use of automatic and acoustic leak detection devices to detect water leaks from pipes.[32] Hippo Rollers and Waterwheels are low-cost and simple devices capable of transporting water by rolling water tanks, allowing for efficient water transportation.

  > Example
  >
  > By installing water flow sensors utilizing IoT networks in northern Kenya, it has become possible to promptly detect water leaks or theft (Kenya Resilient Arid Lands Partnership for Integrated Development (RAPID) program, IBM).[33]

- Development of water-related products that can save and recycle water is progressing

  2020 to **20**25

  > Example
  >
  > A spray has been developed and is in practical use which, by coating the surface of a toilet bowl, reduces the water needed to flush off the stains. The technology is said to cut the water consumed at the world's toilet in half. (the Liquid-Entrenched Smooth Surface (LESS) coating, The Pennsylvania State University).[34] 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).[35]

- Real-time monitoring of river pollution clarifies who is responsible for the treatment of drainage. Expectations are high for wastewater treatment technologies of Japanese firms, which are some of the most advanced in the world

  2025 to **20**35

- Possible methods to recover water resources are filtration and desalination of seawater, recycling drainage water, and storing rainwater in tanks

  2025 to **20**35

  > Example
  >
  > 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.).[36] 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).[37]

Development of water-saving technology

- The effort of Precision Agriculture is making progress. Systems with sensors are being developed to precisely monitor the weather and crops' growth for efficient fertilization and watering

  2020 to **20**25

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Operator of Water Infrastructure --- Realization Timeline ▼

Strengthening the operational base of the water infrastructure business

- Utilization of ICT and AI enables maintaining asset records for the infrastructure, recognizing the status of pipelines, and improving operational efficiency such as demand forecasting

  2025 to 2035

- 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 be simulated, while the surface water can be monitored by satellites[38]

  2025 to 2035

> Example
>
> GETFLOWS is a simulation system to analyze the terrestrial hydrological cycle, including the inter-exchange of surface water and groundwater. The system applies 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) applied the simulation system to analyze the hydrological cycle of Ono Basin, Fukui Prefecture, raising expectations for further applications.

Building an efficient water infrastructure

- Promoting dispersed water use utilizing decentralized equipment for drainage treatment is helpful in communities with low population density

  2020 to 2025

Regulatory Trends

- Regulations are being promoted in developing countries concerning the pollution of rivers. The Ministry of the Environment (MOE) supports the implementation of effective wastewater regulations to improve the quality of the Chitarum River in Indonesia[39]

- 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)

- With the increase in the number of privately owned and exclusively used water supply with groundwater, there has been a decline in revenues for water utilities. It is possible that related legislation will be developed to address this issue. Kyoto City established the Water Facility Maintenance Fee System. The program requires the groundwater users who meet certain conditions to bear a part of the maintenance cost of the water system[40]

Societal Problem (4)	Increase in food loss and waste

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

Japan Potential Impact estimates	Japan generates 28.42 million metric tons of food waste per year. This includes 6.46 million metric tons of otherwise consumable food. Such a massive amount of food waste far exceeds the 3.2 million metric tons of global food aid made granted to people in need.[41] (B)
World Potential Impact estimates	Food waste accounts for one-third of all food produced, or 1.3 billion metric tons, globally. Food waste causes economic losses equivalent to USD 680 billion in developed countries and USD 310 billion in developing countries.[42] (B)

World Unresolved → Japan Unresolved

Societal Issues	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

- Damage to fish, including cuts and bruising, results in the dumping of 9 to 15 % of marine catches in developed countries and 6 to 8% in developing countries.[43] Harvesting techniques can help to solve this problem (e.g. catch equipment that does not damage fish). In bumper crop years, market prices are often maintained by disposing of part of the harvest. In reducing the food loss at the origin, transportation cost poses a major barrier between producers and consumers including food banks. Producers and distributors must collaborate with each other to reduce the transportation cost and provide surplus food to consumers and food banks. Distributors can help 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. Issues can be addressed through improved temperature control for logistics and better education regarding sanitation

Retail and Consumption Stages: Demand-driven procurement and manufacturing

- A significant factor in food loss is excessive stocking by restaurants and retail stores. Excessive stocking in fear of losing sales leads to returns of products and loss of food. Procurement based on scientific forecast of demand using weather information and ICT would lead to reduction of food loss. Another countermeasure for food loss is improving consumers' understanding and tolerance regarding out of stock items and products close to best-by dates. Conventionally in Japan, most convenience stores do not mark down the price 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, the product shelf life is shorter in Japan than in Europe and the U.S., resulting in more food loss. In this respect, there are growing expectations for ICT as a tool to enhance communication among producers, distributors, and consumers. Upgrading the food supply chain, through ways such as on-demand manufacturing, can effectively reduce food loss at the retail stage. In developed countries, it is common to see a substantial amount of household food waste. In addition to edible part of foods going unused during cooking and as leftovers, spoiled products left in the refrigerator are often thrown away. Smart home appliances are gaining popularity that help consumers avoid over-purchasing groceries, use them efficiently in cooking, and finish plates entirely

Clues to Solutions

Technological Trends

Production and Processing Stages

Realization Timeline ▼

Waste reduction in production and harvest

- In addition to fishing equipment that does not harm fish, researchers have also developed techniques to restore cut/bruise-type damages made to fish. Manufacturers can make use of fish that otherwise cannot be distributed as processed food or as feed

  2020 to 2025

  > Example
  >
  > Low-salinity treatment technology is being developed that prevents cut/bruise-type damages from becoming worse and reduces the time to recovery (Fisheries and Marine Technology Center, Hiroshima Prefectural Technology Research Institute, Japan).

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Production and Processing Stages -

Realization
Timeline
▼

Food loss reduction during processing and distribution

■ Improvements are essential in logistics systems and infrastructure to reduce food losses. Efficient logistics can be achieved by building inexpensive cold chains and monitoring with sensors

2020
to
2025

■ Distribution time and costs can be saved by building agricultural and aquaculture systems, including vegetable factories, in the vicinity of consumption areas

2020
to
2025

■ Efforts are also underway to reduce overstocking and food losses by utilizing demand forecasts based on meteorological data

2020
to
2025

> Example
>
> A service called *Feels-like Temperature/Perceived Temperature* was designed to reduce food loss by using meteorological and SNS data to forecast demand. The service name, *Perceived Temperature*, alludes to consumer perceptions and covers not only physical but psychological factors as well. (Japan Weather Association, eco+logi Project).[44]

Retail and Consumption Stages -

Waste reduction at the retail stage and recycling of waste food

■ Waste food can be utilized for purposes other than food consumption including feed, fertilizer, and energy generation via methane gas

2020
to
2025

> Example
>
> A feed in liquid form has been manufactured by sterilizing and fermenting food waste.
> It is known to reduce feeding costs by 50% and contribute to producing high-value-added pork. (JAPAN FOOD ECOLOGY CENTER, INC.).[45]

■ The enhancement of the food supply chain will enable safe and secure food distribution and storage. Future progress in rectifying food loss will likely be fueled by initiatives such as quantifying recipes, optimizing procurement based on actual sales, matching supply and demand, and building a common platform for food bank business

2025
to
2035

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Retail and Consumption Stages

Realization Timeline ▼

Reduction of food loss at the consumption stage

■ Several food-sharing applications have been developed that offer safe, edible, unsold food items to users at a fixed monthly rate and prevent food disposal46

| 2020 to 2025 |

■ Smart home appliances are expected to help reduce waste from the household. They can be used in a variety of situations: by alerting prior to its best-by date; providing the first-in, first-out (FIFO) food storage method; advising on the development of menus; automatically replenishing food stocks; and managing optimum storage temperature. If food preparation and disposal (including composting) could be automated in the future, food losses could be greatly reduced

| 2025 to 2035 |

> Example
>
> Stock Manager is a service that provides help 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).[47]

Regulatory Trends

■ The Ministry of Agriculture, Forestry and Fisheries has set a target value for limiting the creation of food waste and has been persuading food-related businesses to reduce waste. The ministry is also considering setting targets for industries that have been exempt from the system. When food is provided to a food bank, its cost can be tax-deductible, and the donations will receive tax benefits

■ Other countries are also making an effort to reduce food loss. The best-by date was replaced with the expiration date in France to reduce food loss. A new law banning food waste has been enacted that replaces the VAT refund scheme for donors of food to charity. Under this law, people will be fined for disposing of food that could otherwise have been consumed

■ There is no regulation in Japan on the expiration dates of food products with long shelf life. It is expected that the introduction of rules will promote market distribution[48]

■ 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.[49] 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 argue that requiring the examination of food is an excessive burden on donors

| Societal Problem (5) | Unhealthy food that remains in prosperous societies |

- The diet of low-income families tends to concentrate on inexpensive processed foods, and it is challenging for them to eat healthy meals. Regions that face this phenomenon are referred to as *food deserts* and have become a major societal problem worldwide

| 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, more than one mile in urban areas or more than ten miles in rural areas.[50] In the U.S., the adult obesity rate has reached 40%, and the federal government spends USD150 billion per year on health care for obese patients.[51] |

- 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 the case of financially insecure families, people have a higher tendency to eat instant noodles and sweet foods including pastries

| Japan Potential Impact estimates | According to a survey of parents with two- to six-year-old children, 60.5% of financially secure families consume vegetables at least twice a day, compared to 46.4% in economically insecure families.[52] |

Japan Unresolved → World Unresolved

| Societal 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 with reliable data. Various reliable studies report that healthy foods include fish, vegetables and fruits, unrefined carbohydrates, olive oil, and nuts.[53] Additionally, even if the food itself is healthy, overeating remains harmful. Research is advancing on dietary methods such as carbohydrate restriction and fasting

- The suitability of a diet depends on whether certain food agrees with the individual. Age and lifestyle, including the amount of exercise, are other important 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

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Improved Access to Healthy Diets: Delivering healthy meals to many people

- Though people know that vegetables and fruits are good for their health, many people cannot access healthy meals because they are not sold in their neighborhood 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 are starting to take hold that take sub-standard fruits and either donates them for free or distribute them as processed products

- Development is under way for foods that provide a good balance of necessary nutrients, such as foods aimed at fulfilling a certain function and meal replacements. Rare sugar, which is being researched and developed in Japan, is being considered to help prevent obesity and lifestyle-related diseases[54]

Clues to Solutions

Technological Trends

Defining the Healthy Meals - Realization Timeline ▼

Providing information on food and health

- There is a service to provide information on healthy food on a regular basis   2020 to 2025

  > Example
  >
  > snaQme is a subscription service that delivers personalized snacks on a regular basis. It also delivers an informational booklet on healthy and environmentally friendly confectioneries. (snaq.me, Inc.).[55]

Personalization

- IoT is being used to provide food tailored to the physical condition of an individual   2020 to 2025

  > Example
  >
  > A teapot that automatically extracts the most suitable tea for the user has been in 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.).[56]

- Efforts are also being made to support optimal food selection based on DNA analysis   2020 to 2025

  > Example
  >
  > DnaNudge performs DNA analysis on saliva at the supermarket entrance for its customers. The company provides a service that nudges customers to select healthier food based on the test result. When a customer reads 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.)[57]

81

Technological Trends

Improved Access to Healthy Meals -

Functional food

■ Genome editing has led to development of food that helps maintain and promote health

> | Example |
>
> Eating one to two pieces of high-GABA tomatoes a day is expected to help prevent high blood pressure (Sicilian Rouge High GABA by Sanatech Seed Co., Ltd.).[58]

20**20**
to
20**25**

■ Efforts are also underway to provide healthy food in an easy-to-eat form

> | Example |
>
> TOFU BAR, a condensed portable form of tofu, is sold in convenience stores as a functional food and places an emphasis on its health benefits (Asahico Corporation).[59]

20**20**
to
20**25**

Perfect food

■ Food products have been developed that can provide balanced nutrients for daily requirements—work is ongoing to improve their taste and price

> | Example |
>
> BASE BREAD is a bread with perfect nutrients, such as protein, dietary fiber, vitamins, and minerals. It is aimed at people too busy to cook for themselves (BASE FOOD, Inc.).[60]

20**20**
to
20**25**

Utilization of school lunch system

■ Japan's school lunch system is internationally renowned for its reasonable cost, balanced nutrition, and quality taste. It is also known for serving homemade warm meals. The *School Lunch Program* Act enables allocating nutrition instructors and putting cooking and delivery system in place. The system can be applied to schools in developing countries[61]

> | Example |
>
> 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 a software that enables staff with limited knowledge and experience to create nutritionally balanced menus. The software was introduced to schools in Vietnam.[62]

> | Example |
>
> 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 healthy, large serving menu and a special menu for people with food allergies designed by registered dietitians.[63]

20**20**
to
20**25**

Regulatory Trends

- In 2015, the *Foods with Function Claims System* came into effect, so that businesses are now responsible for labeling 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 a notification to 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 fruit be included each day in school lunches along with whole grains. The universal free school lunches implemented in 2020, in response to the COVID-19 pandemic, were extended through 2022. The 2022 federal budget includes subsidies to improve nutrition in school lunches[64]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (6)	The shift toward greater respect for food diversity

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

World **Potential Impact estimates**	Food spending of Muslim people is on the rise and is projected to reach USD 1.38 trillion in 2024.[65] The percentage of Muslims in the world population is also on the rise, predicted to reach 26.4% in 2030.[66] (C)

- In Japan, among the people suffering from food allergies, infants make up the highest proportion (34% at age 0). It decreases with age, but 5% of the population over 18 suffer from some kind of allergy. Eggs, milk, and wheat account for a large proportion of the foods causing allergies, and others include seafood, fruits, soybeans, and peanuts[67]

World **Potential Impact estimates**	The prevalence of food allergies is increasing worldwide. Approximately 10% of preschoolers in developed countries have some sort of food allergy.[68]

Japan **Unresolved** ➡ World **Unresolved**

Societal 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 to Various Beliefs and Religions: Development of new ingredients and cooking methods

- Diversity of food is increasingly required due to a growing trend toward vegetarianism and veganism in addition to the dietary prohibitions related to religions. Alternative meats may enable various people, including those who are restricted from eating meat, to sit around the same table and share a culinary experience. Promoting new foodstuffs and protein sources, such as insects and alternative meat, requires additional merits such as pleasant taste, nutrition, and safety. It also requires measures to reduce the negative inclinations of people to feel aversion to the products or outright reject the concept

Food Tailored to Age and Constitution: Visualization of necessary elements and reduction of burden

- Factors of diversity in food experience are widespread, including allergies, tooth decay, and age. The required calories and nutrients are significantly different between those who are on a diet and athletes building muscles. Some seniors and dementia patients often experience declining sense of taste and smell.[69] It takes substantial effort to prepare variety of meals for each member of the family. In a survey, 33.5% of the guardians of children zero to two years and younger responded that preparing baby food is tough work.[70] It is necessary to reduce these burdens

Technological Trends

Improving Food Quality by Accommodating to 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

Realization Timeline ▼

2025 to 2035

> **Example**
>
> 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 others for athletes and dieters.[71]

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

2025 to 2035

> **Example**
>
> 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-high-efficient plant factories, bio-food reactors, and augmented ecosystems. They also provide solutions to improve the quality of life in food, including automated kitchens, communication experiences through food, and meal replacements.[72]

■ The potential of edible insects is gaining attention. For example, formic acid, found in ants, has a strong and unique fragrance. Thus, the acid is attracting attention due to its potential as an ingredient in condiments that would result in unique flavors that cannot be replicated by other ingredients[73]

2020 to 2025

> **Example**
>
> 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, and are already used in minestrone soup, snacks, and hamburgers. Surprisingly, the hamburgers contain 50% silkworm.[74]

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

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Food Tailored to the Age and Characteristics of Individuals' Body

Realization Timeline ▼

Cooking Appliances

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

  2020 to 2025

  > Example
  >
  > DeliSofter, a cooking appliance, went on sale in 2020. Just by pressing a button, it softens ingredients or cooked food so that users can crush them with their gums or tongue (GIFMO Co., Ltd., a spin-out venture company from Panasonic Corporation, Japan).[75]

- Expectations are high for cooking appliances that not only soften foods but also easily remove specific allergens or reduce calories

  After 2035

Regulatory Trends

- In Japan, the *Third Basic Plan for the Promotion of Shokuiku* is promoted based on the Basic Act on Shokuiku. The plan states five priority issues for promotion of education through food, or Shokuiku; (1) focusing on youth, (2) adapting to diverse lifestyles, (3) contributing to the extension of healthy life expectancy, (4) developing awareness of food circulation and the environment, and (5) passing on Japanese food culture to subsequent generations[76]

- In January 2018, regulation was implemented in the EU regarding novel foods. The regulations liberalized 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 set a standard for the use of the name halal food. On the other hand, a committee within the Standards & Metrology Institute for Islamic Countries (SMIIC) is discussing on how to harmonize the different definitions and standards of halal among Muslim countries

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (7)	Lack of communication through food

- An increasing number of people eat alone. Also, 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; this percentage is on the increase.[77] It is also recognized as a problem that eating in isolation leads to unbalanced or insufficient nutrition. Solitary eating in childhood is connected to negative impacts on physical and psychological growth

- A wider variety of communication using food is expected in the post-pandemic society. Food plays a significant role in realizing an affluent society. This role ranges from providing quality food during disasters as well as providing delicious food to children and senior adults 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. These percentages are on the rise.[78]

In fact, not only 93% of the seniors living alone but also 20% of those living together with their families eat alone. Seniors' malnutrition and low BMI are said to be caused by eating meals alone.[79]

Japan **Unresolved** ➡ World **Unresolved**

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

Key Points for Resolving Issues

Communication through Food

- The most influential attribute that explains human happiness is identified as satisfaction in the communication among family members, and within this family communication satisfaction, the satisfaction of meals contributes the most.80 Eating provides the nutrition necessary for life and satisfies the physiological desire of consumption. Communication with people at the table too is important as it satisfies the related motivations of love and companionship. Furthermore, eating serves as an opportunity to feel a connection with food producers and distributors and as education of the seasonal and local culinary culture of a region—these all contribute to the need of self-actualization. Under the COVID-19 pandemic, conversation was restricted during meals to prevent infection. It is necessary to secure communication over food, such as overcoming the disadvantage of sparsely populated areas by utilizing VR

Promotion of Communication Using Food: New experiences with food

- Communication can be performed not only in conversation during meals but also while growing crops and cooking. 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 will facilitate active communication within the family

87

Technological Trends

Promotion of Communication over Food ---------------------------------------

Realization
Timeline
▼

Communication in the production process

■ Agro-healing, in which stress is reduced by farm work, is attracting attention

2020
to
2025

> **Example**
>
> Juntendo University and NTT Communications Corporation conducted a practical experiment to measure stress levels to see the effectiveness during agro-healing activities. They visualized stress reduction with wearable biosensors.[81]

■ Homemade food items are used as an opportunity to build community

2020
to
2025

> **Example**
>
> Panasonic Corporation and Marukome Co., Ltd. jointly operate a service, Ferment 2.0, to make homemade miso, a soybean paste, without using preservatives or additive substance. The service enables consumers to make their favorite miso using sensor sticks. A consumer community, Miso BALL CLUB, is also being planned.[82]

Communication in the cooking process

■ Kitchens can be a place for communication. A user-friendly prototype is designed particularly for children and seniors that will also make it easy for people to get together

2020
to
2025

> **Example**
>
> The Four Generation Kitchen is a concept of a kitchen where four generations, from children to seniors, can safely enjoy cooking together.
> It focuses on the ability of seniors to continuously participate in cooking.[83]

■ Collaborative cooking is being provided as a service for employee training and team building

2020
to
2025

> **Example**
>
> A company is introducing a cooking class, Cooking to Build a Team, for as part of employee training program, aiming to encourage communication (ABC Cooking Studio Co., Ltd.).[84]

Clues to Solutions

Technological Trends

Promotion of Communication over Food ----------------------------------

Communication in the eating process, and new experiences

- The trend of "local production for local consumption" is narrowing the distance between the two. It has evolved to the point that production and consumption can even be found in the same building

  2025 to 2035

  > Example
  >
  > CAFÉ Stylo at Ginza Itoya serves salads and other dishes made with vegetables produced in the plant factory one floor below the restaurant.[85]

- Virtual reality is also being used to share tables online

  2020 to 2025

  > Example
  >
  > Awaji City is trying to solve the solitary-eating problem by providing a virtual eat-together experience through VR, Awaji Koku VR Verchan Reality.[86]

Regulatory Trends

- UNESCO listed 和食 (pronounced: Washoku), the traditional culinary culture of the Japanese, as Intangible Cultural Heritage in 2013. The Ministry of Agriculture, Forestry and Fisheries (MAFF) is actively promoting and offering information in order to pass on the culinary culture to the next generation. 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 hometown cuisine[87]

- In FY 2020, the Ministry of Health, Labour/Labor and Welfare (MHLW) implemented the Project for Strengthening the Care-giving of Aid-Requiring Children. Under the project, MHLW subsidizes the private entities that operate *Kodomo Shokudo*, which are cafeterias or home-delivery meals for children in need[88]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

ICF issues with targets in UN SDGs

Problems	Issues
(1) Decline in food supply capacity	**Improve productivity through industrialization of food production and securing manpower**
	Targets in UN 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
(2) Difficulties in food procurement due to population growth	**Secure ample food supply to meet the rise in global demand**
	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
(3) Insufficient usable water resource	**Securing and improving water infrastructure and better functionalities**
	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
(4) Increase in food loss and waste	**Streamlining food supply chain across all stages from production to supply and consumption; reducing food waste**
	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
(5) Unhealthy food that remains in prosperous societies	**Providing and improving access to healthy meals**
	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
(6) The shift toward greater respect for food diversity	**Improving the diversity and quality of food to conform to the needs of individuals**
	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
(7) Lack of communication through food	**Promoting communication through all aspects of food from farming and cooking, to the dinner table**
	-

Notes and References

All URLs were viewed on September 1st, 2021.

1   Ministry of Agriculture, Forestry and Fisheries, Japan, "Labor force statistics in agriculture." (in Japanese)
https://www.maff.go.jp/j/tokei/sihyo/data/08.html

2   Ministry of Agriculture, Forestry and Fisheries, Japan, "Foresight of the industry structure in agriculture," discussion paper, 50th meeting of Planning Division at Council of Food, Agriculture and Rural Area Policies, January 28th, 2015. (in Japanese)
https://www.maff.go.jp/j/council/seisaku/kikaku/bukai/H27/pdf/150128_04.pdf

3   *Status of the World's Soil Resources: Main Report, Food and Agriculture Organization of the United Nations,* 2015.
http://www.fao.org/documents/card/en/c/c6814873-efc3-41db-b7d3-2081a10ede50/

4   FSN and Global Network Against Food Crises, *Global Report on Food Crises -2021,* World Food Programme, 2021.
https://www.wfp.org/publications/global-report-food-crises-2021

5   Norges Sildesalgsla (in Norwegian)
https://www.sildelaget.no/no/kvoter-og-fangst/fangst/innmeldingsjournal/

6   Gate Inc. (in Japanese)
http://gateinc.jp/

7   Rakuten Ragri (in Japanese)
https://agriculture.rakuten.co.jp/challenge/

8   Sagri Co., Ltd. (in Japanese)
https://sagri.tokyo/

9   Plant Life Systems Co., Ltd.
https://plantlife.jp/en/

10   HarvestPlus, "Biofortification: The Evidence," 2019.
https://www.harvestplus.org/evidence-document

11   Terasaki, H., "Preliminary and post evaluation of salt removal projects and long-term monitoring of salt transfer in salt-damaged farmland in Tohoku region," March 2016. (in Japanese)
http://www.kokudo.or.jp/grant/pdf/h24/terasaki.pdf

12   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "Revision of the Production Green Land Act." (in Japanese)
https://www.mlit.go.jp/common/001198169.pdf

13   Ministry of Agriculture, Forestry and Fisheries, Japan, "Revision of the Plant Variety Protection and Seed Act." (in Japanese)
https://www.maff.go.jp/j/shokusan/syubyouhou/index.html

14   Japanese Association of Seafood Traceability, "CALDAP." (in Japanese)
http://jast.fmric.or.jp/caldap.html

15   National Oceanic and Atmospheric Administration (NOAA), "Seafood Import Monitoring Program."
https://www.fisheries.noaa.gov/international/seafood-import-monitoring-program

16   Talsma, E.F., Pachón, H., "Biofortification of crops with minerals and vitamins," World Health Organization (WHO), 2017.
https://www.who.int/elena/titles/bbc/biofortification/en/

17   International Food Policy Research Institute (IFPRI), Davis University of California and Nutridemics, "Sustainability of impact: Dimensions of decline and persistence in adoption of a biofortified crop in Uganda*," Household- and Community-Level Surveys*, 2015.
https://doi.org/10.7910/DVN/WWBYML

18   Morach, B., Witte, B., Walker, D., von Koeller, E., Grosse-Holz, F., Rogg, J., Brigl, M., Dehnert, N., Obloj, P., Koktenturk, S., Schulze, U., "*Food for thought: The protein transformation*," Boston Consulting Group, 2021.
https://www.bcg.com/publications/2021/the-benefits-of-plant-based-meats

19   Food Security Division, Minster's Secretariat, Ministry of Agriculture, Forestry and Fisheries, Japan, *Global Food Supply and Demand Estimates in 2015 – Baseline Forecast with Super-longterm Food Supply Prediction System*, June 2012. (in Japanese)
https://www.maff.go.jp/j/press/kanbo/anpo/attach/pdf/190917-1.pdf

20   CHUBU Electric Power Co., Inc., "Seedling production at Shizuoka Prefectural Research Center for Warm Water Utilization." (in Japanese)
https://www.chuden.co.jp/energy/hamaoka/hama_chiiki/hama_kankyo/onhaisui/index.html

21   Finless Foods, Inc.
https://finlessfoods.com/

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Notes and References

All URLs were viewed on September 1st, 2021.

22   Avant Meats Company Limited
     https://www.avantmeats.com/

23   Such as genome-edited pigs by Setsuro Tech Co., Ltd. (in Japanese)
     https://www.setsurotech.com/

24   *Phronesis,* No. 18, p. 43, March 2018. (in Japanese)
     https://www.mri.co.jp/knowledge/magazine/phronesis_018.html

25   "TABLE FOR TWO" donates JPY 20 for school lunches in developing countries upon every purchase of designated meals
     and food.

26   Tenenbaum, D.J., "Food vs. fuel: Diversion of crops could cause more hunger," *Environmental Health Perspectives*, Vol.
     116, No. 6, pp. A254-A257, 2008. https://doi.org/10.1289/ehp.116-a254Sonavi Labs, AI stethoscope
     https://sonavilabs.com/

27   Consumer Affairs Agency, Japan, "Plant-based food information." (in Japanese)
     https://www.caa.go.jp/notice/other/plant_based/#q1

28   Lähteenmäki-Uutela, A., Marimuthu, S.B, Meijer, N., "Regulations on insects as food and feed: a global comparison,"
     Journal of Insects as Food and Feed, Vol. 7, No. 5, pp. 849-856, 2021.
     https://doi.org/10.3920/JIFF2020.0066

29   UN DESA estimates that by 2025, 1.8 billion people will fall into "absolute water scarcity" and two-thirds of the world
     population will be exposed to "water stress." Since the world population in 2025 is estimated to be 8.186 billion (World
     Population Prospects: The 2017 Revision), the number of people who are under water stress will be 5.457 billion. (Source:
     United Nations Department of Economic and Social Affairs (UN DESA), "Water scarcity."

30   Global Water Intelligence, "Global Water Market 2017," June 2017

31   Ministry of the Environment, Japan, "Virtual water." (in Japanese)
     http://www.env.go.jp/water/virtual_water/

32   JICA, Suido Technical Service Co. Ltd, "Summary Report, Verification Survey with the Private Sector for Disseminating
     Japanese Technologies for the Water Leak Detection Service Using a Leakage Monitoring Technology in Bangalore,"
     November 2016. (in Japanese)
     https://open_jicareport.jica.go.jp/pdf/12268553.pdf

33   Kenya RAPID
     https://kenyarapid.acaciadata.com/

34   Wang, J., Wang, L., Sun, N., Tierney, R., Li, H., Corsetti, M., Williams, L., Wong, P.K., Wong, T.S., "Viscoelastic solid-repellent
     coatings for extreme water saving and global sanitation," *Nature Sustainability*, Vol. 2, pp. 1097–1105, 2019.
     https://doi.org/10.1038/s41893-019-0421-0

35   LIXIL Corporation, "LIXIL to pilot household reinvented toilets in partnership with the Gates Foundation," News Release,
     2018.
     https://www.lixil.com/en/news/pdf/181106_BMGF_E.pdf

36   WarkaWater
     https://www.warkawater.org/

37   JICA, Totetsu Mfg. Co., Ltd., myclimate Japan Co., Ltd., "Report, Verification Survey with the Private Sector for Disseminating
     Japanese Technologies for Gap Resolution of Water Demand/Supply by Plastic Underground Rainwater Storage System,"
     January 2016. (in Japanese)
     https://open_jicareport.jica.go.jp/pdf/12254553.pdf

38   National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure, Transport and Tourism (NILIM,)
     "Hydrological cycle analysis in Ono Basin, Fukui Prefecture." (in Japanese)
     http://www.nilim.go.jp/lab/feg/hp/kaisekijirei/oono.pdf

39   Ministry of the Environment, Japan, "Cooperation between MOEJ and KLHK, the Ministries of the Environment Japan and
     Indonesia in improving the quality of the Citarum River. "(in Japanese)
     https://www.env.go.jp/press/files/jp/109798.pdf

40   Water Supply and Sewage Bureau, Kyoto City, "Water Facility Maintenance Due Program," 2020. (in Japanese)
     https://www.city.kyoto.lg.jp/suido/page/0000217032 .html

41   Ministry of the Environments, Japan, "Estimates of food loss and wastes in Japan (FY 2015)", press release, April 17th,
     2018. (in Japanese)
     https://www.env.go.jp/press/105387.html

42   FAO, Save Food: Global Initiative on Food Loss and Waste Reduction.
     http://www.fao.org/save-food/en/

43   Food and Agriculture Organization of the United Nations (FAO). "Global Food Losses and Food Waste," 2011.
     http://www.fao.org/3/a-i2697o.pdf

Notes and References

All URLs were viewed on September 1st, 2021.

44   Koga, E., "Weather-related efforts to reduce food loss — Food loss itself is one of the factors contributing to extreme weather," *SDGs Report*, Vol. 2, Japan Weather Association, 2019. (in Japanese)
https://www.jwa.or.jp/news/2019/10/8459/

45   JAPAN FOOD ECOLOGY CENTER, INC.
https://japan-fec.co.jp/english/index.html

46   TABETE is a food-sharing service that contributes to reducing food loss. (in Japanese)
https://tabete.me/

47   Panasonic Corporation, "Stock Manager: Refrigerator." (in Japanese)
https://panasonic.jp/reizo/function/stock.html

48   Japan Management Association, *FY 2019 Commissioned Survey Report on New JAS Standards*, 2020. (in Japanese)
https://www.maff.go.jp/j/jas/attach/pdf/yosan-28.pdf

49   ExtraFood, "Laws protect food donors."
https://extrafood.org/laws-protect-food-donors

50   U.S. Department of Agriculture, "Documentation," *Economic Research Service*.
https://www.ers.usda.gov/data-products/food-access-research-atlas/documentation/

51   Cawley, J., Biener, A., Meyerhoefer, C., Ding, Y., Zvenyach, T., Smolarz, B.G., Ramasamy, A., "Direct medical costs of obesity in the United States and the most populous states," *Journal of Managed Care + Specialty Pharmacy*, Vol. 27, No. 3, pp. 354-366, 2021.
https://doi.org/10.18553/jmcp.2021.20410

52   Ministry of Health, Labour and Welfare, Japan, *National Nutrition Survey on Preschool Children*, 2016. (in Japanese)
https://www.mhlw.go.jp/file/06-Seisakujouhou-11900000-Koyoukintoujidoukateikyoku/0000134210.pdf

53   Tsugawa, Y., *The World's Simplest Ultimate Meals with Scientific Proofs,* Toyo Keizai, Inc., 2018. (in Japanese)

54   Kimura, T., "Characteristics and use of rare sugars," Agriculture & Livestock Industries Corporation (ALIC), 2014. (in Japanese)
https://www.alic.go.jp/joho-d/joho08_000438.html

55   Snaq.me, Inc., "Snack subscription -- Snack Experience BOX." (in Japanese)
https://snaq.me/

56   Teplo (in Japanese)
https://teplotea.com/

57   DNANudge Ltd.
https://www.dnanudge.com/

58   Sanatech Seed Co., Ltd.
https://sanatech-seed.com/en/

59   Asahiko Corporation (in Japanese)
http://www.asahico.co.jp/

60   BASE FOOD, Inc., "BASE FOOD: a complete nutrition food." (in Japanese)
https://basefood.co.jp/

61   Murayama, N., Ishida, H., "School Meal Programs in Japan and Selected Countries," *The Japanese Journal of Nutrition and Dietetics*, Vol. 76, Supplement 1, S1, 2018.
https://doi.org/10.5264/eiyogakuzashi.76.S1

62   AJINOMOTO CO., INC., "Japanese school lunch is amazing! School Lunch Project to improve children's nutrition in Vietnam," *Story*, 2020. (in Japanese)
https://story.ajinomoto.co.jp/report/020.html

63   "PECOFREE, A school lunch service you can choose with your smartphone." (in Japanese)
https://pecofree.jp/

64   U.S. Department of Agriculture, "Healthy Hunger-Free Kids Act," *Food and Nutrition Service*, 2013.
https://www.fns.usda.gov/cn/healthy-hunger-free-kids-act

65   DinaStandard, *State of the Global Islamic Economy Report*, 2020.
https://www.salaamgateway.com/specialcoverage/SGIE20-21

66   Japan External Trade Organization, Halal-Related Systems, and the Market Trends in Selected Countries. (in Japanese)
https://www.jetro.go.jp/ext_images/_Reports/02/2016/bdf7fdcc48b9a4a7/halal2015.pdf

67   Japanese Society of Pediatric Allergy and Clinical Immunology (JSPACI), *Japanese Pediatric Guideline for Food Allergy*, 2016. (in Japanese)
https://www.jspaci.jp/allergy_2016/index.html

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Notes and References

All URLs were viewed on September 1st, 2021.

68   Prescott, S.L., Pawankar, R., Allen, K.J., Campbell, D.E., Sinn, J.K.H., Fiocchi, A., Ebisawa, M., Sampson, H.A., Beyer, K., Lee, B.W., "A global survey of changing patterns of food allergy burden in children," *World Allergy Organization Journal*, Vol. 6, pp. 1-12, 2013.
      https://doi.org/10.1186/1939-4551-6-21

69   AJINOMOTO CO., INC., "Understanding changes in the body," *A First Guide to Food for Nursing Care*. (in Japanese)
      https://www.ajinomoto.co.jp/nutricare/useful/nursing_care/01.html

70   Ministry of Health, Labour and Welfare, Japan, *Supporters' Guide for Feeding and Weaning Babies*, 2019. (in Japanese)
      https://www.mhlw.go.jp/content/11908000/000496257.pdf

71   IntegriCulture Inc.
      https://integriculture.com/en/

72   SPACE FOOD SPHERE
      https://spacefoodsphere.jp/en/

73   Ishikawa, S., Evolution History of 'Eating -- Cultivated Meat, Insect Eating, and 3D Food Printer, p. 80, Kobunsha Shinsho, p. 80, 2019. (in Japanese).

74   Ellie Inc. (in Japanese)
      https://www.ellieinc.co.jp/

75   DeliSofter (in Japanese)
      https://gifmo.co.jp/delisofter/

76   Government Information Online (in Japanese)
      https://www.gov-online.go.jp/useful/article/201605/3.html

77   Ministry of Agriculture, Forestry and Fisheries, Japan, Shokuiku Promotion Measures of Fiscal 2017. (in Japanese)
      https://www.maff.go.jp/j/syokuiku/wpaper/attach/pdf/h29_wpaper-30.pdf

78   Ministry of Agriculture, Forestry and Fisheries, Japan, "Actual conditions of people eating alone and with others," Chapter 3, *Shokuiku Promotion Policies: FY 2016 (White Paper on Shokuiku)*, 2017. (in Japanese)
      https://www.maff.go.jp/j/syokuiku/wpaper/h28/h28_h/book/part1/chap1/b1_c1_1_03.html

79   Kaneko, J, Hanada, M., "Why do elderly individuals in Japan eat alone?" *Journal of Rural Problems*, Vol. 52, No. 3, pp. 166-171, 2016. (in Japanese)
      https://doi.org/10.7310/arfe.52.166

80   MRI Research Associates, Inc. conducted a decision tree analysis in evaluating happiness with a questionnaire survey of 30 thousand mif participants in 20200

81   Juntendo University, "Juntendo University and NTT Communications Corporation launch a demonstration experiment on reducing stress from agricultural work," *Press Release*, 2018. (in Japanese)
      https://www.juntendo.ac.jp/news/20181107-01.html

82   Ferment 2.0
      https://gccatapult.panasonic.com/en/ideas/ferment2.php

83   Johnny Grey Studios – Kitchen Designers, The four generation kitchen prototype-Enhancing home life through kitchen design, *YouTube*, 2020.
      https://youtu.be/DjK0nHmaptY

84   *ABC Cooking Studio Co., Ltd., "The Cooking to Build a Team program to enhance the training achievements." (in Japanese)*
      https://www.abc-cooking.co.jp/promotion/teambuilding/features/

85   CAFÉ Stylo (in Japanese)
      https://www.ito-ya.co.jp/food/index.html

86   Awaji Koku VR Verchan Reality (in Japanese)
      https://awajikoku.com/about/

87   Ministry of Agriculture, Forestry and Fisheries, Japan, "Celebrating the fifth anniversary of Washoku's registration as a UNESCO Intangible Cultural Heritage." (in Japanese)
      https://www.maff.go.jp/j/keikaku/syokubunka/wasyoku_unesco5/unesco5.html

88   Ministry of Health, Labour and Welfare, Japan, "Supporting Kodomo Shokudo (children's cafeteria that provides free or low-cost meals)." (Originally appeared *in Kosei Rodo*, October 2020. (in Japanese)
      https://www.mhlw.go.jp/stf/houdou_kouhou/kouhou_shuppan/magazine/202010_00002.html

3. ENERGY AND ENVIRONMENT

A SOCIETY WHERE ALL CAN ENJOY SUSTAINABLE AND CLEAN ENERGY, RESOURCES AND ENVIRONMENT

Countries around the world are taking initiatives to help reduce the risks and impacts of global warming. At the COP 26 summit held in November 2021, it was stipulated explicitly that efforts should be made to limit global warming, aiming for 1.5 °C above the pre-industrial level. More than 120 countries and regions, including Japan, declared their intention to achieve carbon neutrality by 2050. Private companies are also expected to put in effort in the context 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. The world is shifting to renewable energy supplies at significantly accelerating in pace. Renewable energy is not only superior from an environmental point of view, but has also rapidly lowered the cost of power generation. R & D on storage battery performance, price reduction, and appropriate management for distributed power systems are yielding positive results on the challenge of stable supply. The Netherlands and Germany are implementing a combination of various technologies. One example is the connection of electric vehicles to electric power grids and the use those vehicles as storage devices. While the electrification of appliances has improved the overall efficiency of energy consumption in both developed and developing countries, there are concerns over new problems arising from an increase in electric consumption in the digital society. Japan's industrial sector takes pride in being the most efficient in the world in terms of energy consumption. However, there is still room for innovation and improvement in the manufacturing process. There also remains room for further progress and penetration of energy-saving products in the civilian sector, both household and business, as well as in the transportation sector, and in improvement in energy management. In terms of resources, the most fundamental proposition is to effectively secure and utilize limited natural resources and to promote the realization of a recycling-oriented society. The perspective of urban mines illustrates that the finite nature of quantity must be overcome by promoting the efficient use and recycling of minerals, metals, petroleum, soil, and forests As the global economy and standard of living continue to improve, certain issues have become more pressing such as preventing pollution, environmental destruction, and loss of biodiversity. Another important element for a sustainable society is maintaining nature's ecosystem. The ecosystem is responsible for the long-term conservation of species and recycling of materials while cleaning up pollution.

Using the above framework, ICF has classified the problems and issues in the Energy and Environmental area into the following five categories.

(1)	Need to accelerate decarbonization in the supply side of energy	→ Promote comprehensive decarbonization measures
(2)	Addressing the large room for energy conservation and decarbonization on the demand side	→ Provide solutions to promote decarbonization in the industrial, household, and transportation sectors
(3)	Insufficient recycling and ineffective use of resources	→ Create a recycling society that makes effective use of resources
(4)	Intensifying environmental deterioration and pollution	→ Take immediate action to capture the current situation, analyze the cause, and implement countermeasures
(5)	Loss of biodiversity	→ Maintain sustainable coexistence between humans and other living creatures

Legend

Potential impact estimates

(A) The maximum impact on financial cost and future population by 2025 to 2030 if no effective countermeasures are taken

(B) The maximum impact of the worst-case scenario that can be reasonably expected to occur at present

Issues and Challenges are classified into three categories:

Japan	World	Japan	World	World	Japan
Resolved →	Unresolved	Unresolved →	Unresolved	Unresolved →	Unresolved

(1) Issues that have already been resolved in Japan, and utilizing Japanese technologies that can be of help in resolving global issues;

(2) Current issues that also exist in Japan. By becoming the first country to resolve them, Japan can lead the pack on global issues; and

(3) Early tackling of future global issues will lead to resolving them in Japan in the future.

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% in FY 2030 from the level of FY 2013. The supply side must further strive for introduction and expansion of renewable energies to accelerate decarbonization

Japan **Potential Impact estimates**	In the energy supply end, CO_2 emissions are forecast to be cut by 50 percent through initiatives such as designating a zone to promote renewable energy and proactively introducing solar power generation. An estimate shows that 103 million t-CO_2 emissions in FY 2013 will be reduced to 56 million t-CO_2 in FY 2030.[1,2] (A)

Japan **Unresolved** → World **Unresolved**

Societal Issues — Promote comprehensive decarbonization measures

Key Points for Resolving Issues

Technological Development in Production and Conversion of Energy: Expanding renewable energies, power generation with hydrogen and ammonia

- Various efforts are being made to achieve decarbonization, such as developing next-generation solar batteries, floating offshore wind power generation, carbon-neutral liquid fuels, and research on nuclear fusion power generation

- Research is underway to replace coal with hydrogen and ammonia in thermal power plants. Hydrogen and ammonia are the best possible energy source for future decarbonization. The challenge is to develop a method to produce hydrogen and ammonia without generating CO_2

Development of Energy Storage and Transportation Technologies: Improvement of performance, safety, and affordability of storage batteries

- The primary weakness of solar and wind power generation is unstable output as they depend on natural and seasonal conditions. The solution is to improve the performance, safety, and affordability of storage batteries and to lower their price. Solid electrolyte technology is attracting attention as the next-generation battery that brings a quantum leap both in safety and reliability. Practical use is expected by the second half of the 2020s. Some foreign countries are beginning to achieve grid parity, where the cost of power generation from renewable energy is equal to or lower than fossil fuels. Furthermore, within ten years, storage parity is also expected to be achieved, where the total cost of power generation, including storage, is lower than fossil fuels

Development of New Distributed Energy Systems: Virtual power stations and microgrids

- While an increasing number of operators are entering the renewable energy generation sector, there is also a growing need on the demand side to use locally generated renewable energy in the areas it was created, especially from the ESG point of view. Under such circumstance, virtual power plants (VPP) and microgrids are becoming more popular. They combine various electric power resources, such as collection of small-scale renewable energy power plants and electric vehicles utilized as storage batteries, to function as one integrated power plant and provide energy for local consumption

- Although some proof-of-concept projects have started in Japan, their application is still limited due to the high cost of building a private power line. Additionally, there is currently no precedent of a power company allowing its electric power line to be shared, and thus the system is yet to be streamlined

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Energy Suppliers

Technology development in production and conversion of energy

■ Solar power generation, which has 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, it can be easily manufactured by just its coating

2025 to 2035

■ Offshore wind power plants are being developed, mainly in Europe, on a large scale. The advantage of offshore plants is in wind conditions, i.e., the way the wind blows in a specific location, are more stable above the sea than on land, resulting in higher operating efficiency rates. In Japan, however, there are few areas where the water depth is suitable to install the power plants. Thus, the development of floating offshore wind power plants will become essential

2020 to 2025

> Example
>
> In U.K., offshore wind power generation has increased to 10% of its annual power generation in 2020, which is the highest in the world.
> The Crown Estate and Crown Estate Scotland are proactively attracting new entrants to the development of new offshore wind power plants, including auctioning new seabed from 2019.

■ Initiatives are underway to make use of otherwise wasted heat and the development of technology to tap into new energy resources, such as algae and methane hydrate. Carbon-neutral liquid fuels are seeing an increase in necessity, and the E.U. is currently home to multiple proof-of-concept experiments on bio jets

2020 to 2025

■ Hydrogen and ammonia are attracting attention as important energy sources for the future. Research is underway on power generation using hydrogen and ammonia to promote the decarbonization of thermal power plants[3]

After 2035

■ DT (deuterium and tritium) fusion and fusion power generation with helium-3 of the lunar surfaces are still high-tech dreams as of today

After 2035

> Example
>
> Condensed matter nuclear reactions are exothermic reactions that occur at the quantum level through the diffusion of hydrogen. Utilization of the reactions as clean energy, called Quantum Hydrogen Energy, is underway, aiming to be of practical use in society by 2025. Its heat generation density is more than 1,000 times that of gasoline. This research and development is being conducted by Clean Planet Inc. and Tohoku University, Japan.[4]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Energy Suppliers

Realization Timeline ▼

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 are batteries, thermal storage, and hydrogen conversion storage. Batteries are expected to be smaller in size, shorter in charging time, lower in cost, as well as being safe and easy-to-recycle. The solid-state batteries are well on the way to practical application with potential for increased safety and storage capacity

2025 to 2035

- Experiments are underway to build a consistent supply chain of storage, transportation and consumption for hydrogen production at small- and medium-sized hydro-electric power plants. This supply chain will enable a local manufacturing and local consumption model of low-carbon energy.[5]

2025 to 2035

Applications for new distributed energy systems

- With society's trend of shifting from a centralized to a distributed model, local production and consumption of electricity with dispersed power plants may prevail

2025 to 2035

- Virtual power plants, demand response, and electric vehicles (EVs) are attracting attention. A distributed energy system utilizing demand-side assets, such as connecting EVs to the electrical grid, is now in the proof-of-concept stage and is moving towards practical application testing. The future likely holds in store an off-grid self-sufficient society independent from electric power companies. Key steps involve rechargeable batteries and renewable energy sources such as solar and wind power

2020 to 2025

Example

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.).[6]

Powerpeers is a service provided in the Netherlands by Vattenfall AB, a major Swedish power company. It operates a P2P power trading marketplace on a business basis for the electricity users with individuals and corporations that own distributed energy resources such as solar power and batteries.[7]

Example

A startup company operates a smartphone app that enables users to become a solar power plant owner, starting with as little as one watt (CHANGE THE WORLD Inc., Japan).[8]

Regulatory Trends

- Carbon pricing, which will become the basis for carbon taxes and emissions trading, is now being discussed in Japan. Japan's tax rate for measures against global warming is low relative to the carbon tax rates of other countries.[9] Keeping a close eye on the future rise in the carbon tax rate is warranted

- The U.K. expects to provide more than 30% of its electricity from offshore wind turbines, a clean and environment friendly option by 2030[10]

- 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 offshore wind power plants

- The feed-in tariff (FIT) schemes are being reviewed worldwide, and Germany takes the lead in transitioning to the feed-in premium (FIP) scheme. As a post-FIT scheme, the FIP is scheduled to be rolled out in Japan. The scheme introduces competition into the renewable energy market. The FIP is market-linked and will be applied to large-scale commercial solar and wind power plants starting in FY 2022. Unlike the FIT, the FIP does not purchase electricity at a fixed price. Still, it promotes the expansion of renewable energy by adding certain premiums as an incentive to the market price. Since the market determines the selling price based on the demand and supply of electricity, and the supply becomes more efficient, the price will be better controlled than under FIT[11]

- Many countries operate using the non-fossil fuel energy certificate system. This system certifies the value of electric power derived from non-fossil energy sources such as renewable energy. The certificates are traded through electric power companies, and the electric retailers that purchase the certificates can reduce the actual amount of their CO_2 emissions by the value of the certificate. In the U.S., and major countries in Europe and Asia, systems have been put in place to incorporate attribute information, such as the location of a power generation facility, to the certificate for tracking. The verification of certificate tracking is also being tested in Japan[12]

- Stadtwerke, a municipality-owned institution in Germany, develops and operates infrastructure for public services including electricity, gas, water, and transportation. In the next ten years, Stadtwerke plans to actively invest in upgrading electricity distribution networks, ICT, renewable energy, and distributed power sources. Stadtwerke will play a major role in the energy conversion which is being promoted by the federal government[13]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (2)	Addressing the large room for energy conservation and decarbonization on the demand side

- On the energy demand side, there are three sectors: industry, civilian, and transportation, which account for 25%, 10%, and 18%, respectively, of Japan's CO_2 emissions as of 2018. Further conservation and decarbonization on the demand side of energy are imperative to realize carbon neutrality

- Japan's industrial sector, including the steel industry, has made huge progress by global standards in introducing energy-saving technologies. There may be some room left for additional energy-saving and decarbonization if it continues to rely on conventional technology. It is necessary to develop innovative technology for further energy-saving and decarbonization

- In the civilian sector of households and businesses, energy-saving housing and buildings have been introduced, as well as electric vehicles in the transportation sector. However, they are still not widely used. It is necessary to reduce CO_2 emissions not only at the product usage stage but also throughout the entire product life cycle of manufacturing, usage, recycling, and disposal

- The increase in power consumption resulting from exponential growth in use of AI in the digital sphere has become a global problem

Japan **Potential Impact estimates**	Without energy conservation measures, total electricity demand in 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 measures *are* taken, the demand in FY 2030 is estimated to be 511 billion kWh, or a 15% reduction from FY 2013. Promoting energy conservation measures as targeted will reduce consumption by 176 billion kWh and electric power cost 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.

Japan **Resolved** → World **Unresolved**

Societal Issues	Provide solutions to promote decarbonization in the industrial, household, and transportation sectors

Key Points for Resolving Issues

Industrial Sector: Decarbonization of manufacturing processes and technological innovation in CO_2 capturing and recycling

- Among the technological innovations in the manufacturing process, the steel industry is conducting research and development on hydrogen-based production which uses hydrogen instead of coke combustion to extract iron from ironstone. The process called Carbon Capture, Utilization, and Storage (CCUS) is also attracting attention. It separates, captures, stores, and utilizes the CO_2 generated in the manufacturing processes. The industrial sector generates a certain amount of CO_2 from relatively few locations, making it easier to capture CO_2 than in the civil 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 energy for 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 synthesizing into formic acid.

Civilian (Business and Household) Sector: Popularization of energy-saving houses and buildings, and energy technology innovation using IoT

- The government's targeted agenda, from the *Strategic Energy Plan*, includes the spreading of Net Zero Energy Houses (ZEH) and Net Zero Energy Buildings (ZEB).[14] To this end, it is necessary to raise consumer awareness and provide focused education to small- and medium-sized builders with low proficiency in the *Energy-Efficiency Standards*. It is also important to encourage innovation in energy-related technologies utilizing IoT together with digitization. Using data obtained through networks of wireless terminals with multiple sensors enables structures to ensure both comfortable amounts of space and the optimization of energy production and consumption simultaneously

Transportation Sector: Development of technologies in automotive batteries and FCVs, and improvement of utilization rates through sharing and joint delivery

- The transportation sector also needs to promote energy conservation and decarbonization products. Efforts in the automobile domain are especially imperative, as the industry accounts for 85% of direct CO_2 emissions. To popularize EVs for personal use, it is also imperative to advance automotive batteries particularly in the areas of driving range and safety. As vehicles emit CO_2 throughout their lifecycle, notably not only while being driven, decarbonization must be pursued at each stage of production from acquiring the components, to manufacturing, and disposal. Car sharing improves the effective utilization of resources by fueling 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. Share-ride taxis and on-demand bus services are possible measures to improve the number of passengers per vehicle and operation ratio in public transportation. Promoting the development of fuel cell vehicles (FCV) for freight trucks is effective because they have the advantage in driving range, loading capacity, and re-fueling time[15]

Technological Trends

Industrial Sector

Realization
Timeline
▼

Technological innovation in the manufacturing process

■ Steel production using electric furnaces is attracting attention. The CO_2 emissions are one-fourth of those from blast furnaces, and the recycling of scrap iron contributes to the recycling society. Production of high-grade steel by electric furnaces has been difficult in the past due to impurities such as copper and nitrogen mixed in iron scrap, but technological development is making progress to alleviate these impurities[16]

2020
to
2025

> Example
>
> NIPPON STEEL CORPORATION, using electric furnace, plans to start producing high-grade products with high purity and high-quality thin sheet metal, including magnetic steel sheets, in the first half of 2022.

■ Quicklime, the primary raw material for cement, generates CO_2 during the current manufacturing methods that depend on the decarboxylation reaction of limestone. The development of technology and proof-of-concept for practical usage are being carried out to recycle the CO_2 from the cement manufacturing process and reuse it as a resource for cement and construction material[17]

2025
to
2035

■ Production processes are the subject of recent innovation exploration because of the large amounts of energy required to produce materials in chemical manufacturing. Catalysts are also being used to promote specific chemical reactions. Through use of AI, it is possible that new type of catalysts may be discovered that will dramatically enhance the energy efficiency in the manufacturing process in a short period of time

2025
to
2035

> Example
>
> The Interdisciplinary Research Center for Catalytic Chemistry at the National Institute of Advanced Industrial Science and Technology (AIST) has developed a technology to forecast catalytic reactions with AI.[18] AIST has proposed Catalyst Informatics, which combines catalytic science and informatics, and is expected to significantly shorten the development time of catalysts.

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Industrial Sector ---

Carbon recycling technology

■ Technology is under development that separates and recovers CO_2 at its origins, such as exhaust gas emission from power plants and manufacturing plants. The current methods include chemical absorption, physical absorption, solid sorbent, and membrane separation methods. The next challenge will be to reduce cost and energy required

20**25** to 20**35**

■ The direct air capture, or 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 progressing to help realize carbon neutrality

20**25** to 20**35**

Example

Climeworks AG, a Swiss university venture company, is the first 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 recovers 4,000 metric tons of CO_2 annually. The plant uses renewable energy from a nearby geothermal power plant and stores the recovered CO_2 deep underground.[19]

Civilian (Business and Household) Sector ------------------------------------

Energy-saving houses and buildings

■ Passive houses are being developed to realize a comfortable life. They control energy consumption with solar power utilizing natural light and minimize the usage of traditional equipment or power[20]

20**20** to 20**25**

Energy management

■ Energy management services, such as HEMS, BEMS, FEMS, utilizing IoT in homes, buildings, and factories are gaining popularity

20**20** to 20**25**

■ A new process called *energy harvesting* is also attracting attention. The process converts the low-density heat and vibration energy captured in the surroundings into electric energy. Incorporating the technology into sensors also makes it possible to construct a flexible network of sensors that does not require any cost for electric power. It has already seen use in elevators, vending machines, and construction machinery, and there is a possibility it could also be applied in monitoring the deterioration of infrastructures such as tunnels and bridges[21]

20**20** to 20**25**

Example

An IoT sensor mat has been commercialized. It uses self-generated power to transmit two types of wireless IDs when the user steps on and leaves the mat, allowing tracking of activities, including time spent at the location. (soundpower corporation, Japan)[22]

Clues to Solutions

Technological Trends

Civilian (Business and Household) Sector -

Realization
Timeline
▼

Energy conservation in data centers

- ■ Data center can significantly reduce power consumption by being in a good location. Selecting a region of cold weather may help to lower the cost for electric power

20**20**
to
20**25**

> **Example**
>
> A technology has been developed in adopting a new cooling concept that does not directly draw in outside air into the data center. It achieves energy-saving and stable air environments through humidity control and dust removal in the server rooms. (KAJIMA CORPORATION, Japan)[23]
>
> However, there are cases of developing data centers that do not need cooling. (Microsoft Corp., the U.S.)[24]

Providing information and incentives to change behavior

- ■ The private sector has taken the lead in providing visual information on environmental burden

20**20**
to
20**25**

> **Example**
>
> DP, an international NGO, is encouraging companies to disclose information on their greenhouse gas emission and lists companies on the *Climate Change A List* that have demonstrated outstanding strategies and responses on climate change.[28] The list is one of the major evaluation guidelines for ESG investment and is attracting increasing attention year over year.

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

20**20**
to
20**25**

> **Example**
>
> TEPCO runs a website service called Daily Life with TEPCO Web. TEPCO users, by providing their profile, can compare their electricity usage with similar households.[25]
>
> An experimental project also encourages household to save energy by using nudges to reduce electricity bills.[26]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Transportation Sector--

Realization
Timeline
▼

Innovation in technology of batteries

■ Liquid lithium-ion batteries, which are currently the mainstream in automotive batteries, have various technical issues including safety, economy, charging time, weight, and dependence on scarce resources. Usage is expected to transition towards all-solid-state batteries around 2030. By approximately 2035, innovative products such as fluoride-ion and zinc negative electrode batteries are expected to become available

2025
to
2035

> | Example |
>
> Toyota Motor Corporation intends to promptly realize an all-solid-state battery for PHV, which solves the problems of liquid lithium-ion battery, and intends to expand it to EV in the future.[27]
>
> NEDO has initiated R&D by forming an industrial, governmental, and academic alliance on fluoride ion batteries and zinc negative electrode batteries. The innovative batteries achieve high energy density as well as increased safety while using inexpensive materials that have limited constraints on resources.[28]

Wireless power transmission to electric vehicles

■ Wireless power transmission technology has been developed to support the supplying of power to running vehicles via roadside inductors. This technology reduces the size and weight of vehicle batteries as well as energy consumption throughout their lifecycle of running, manufacturing, and disposal. With this technology, a vehicle can run indefinitely without worrying about charging, which improves its overall operation rate[29]

After
2035

Recycled carbon fuel (synthetic fuel)

■ Commercial vehicles face difficulty in electrification due to EV's short driving range, which results from its charging necessity and its high cost. Carbon neutrality of the fuel must be achieved to overcome this obstacle. It is also necessary to find catalysts with high synthetic efficiency and establish a consecutive manufacturing process for commercialization to overcome the problems of low productivity and high cost

After
2035

> | Example |
>
> n Japan, technological development is underway to produce synthetic fuel from CO_2. (Alliance among Japan Petroleum Energy Center (JPEC), ENEOS Corporation, Idemitsu Kosan Co., Ltd., and others, Japan)[30]

| Clues to Solutions |

Regulatory Trends

- Japan's *Fifth Strategic Energy Plan*, issued in 2018, stipulates a policy agenda on ZEH: more than half of the homes built by custom home builders *must* achieve ZEH by 2020. Furthermore, the average of all new homes must meet the ZEH by 2023. 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.

- Introduction of Life Cycle Assessment, or LCA, is being considered for automobiles. It evaluates not only the Tank-to-Wheel environmental impacts but also the entire life-cycle, starting from the acquisition of raw materials manufacturing and disposal. The EU plans to introduce LCA regulation mandatory on batteries in 2024. The CO_2 emission assessment may be changed from a Tank-to-Wheel basis to a LCA basis.

- A medium-term electrification policy of passenger cars is also being adopted in each country. The UK will ban sales of gasoline cars in 2030 and hybrid vehicles in 2035. France plans to ban the sale of internal-combustion engine vehicles in 2040. In Japan, all new cars sold in 2035 are planned to be electric vehicles.[31]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

- Incineration (garbage burning) without energy recovery occurs more in Japan than in other countries; Japan has room for better efficiency in the use of this resource. Incineration accounts for 77% of waste treatment in Japan, which ranks the highest in the OECD countries. At the same time, only 19% of materials are recycled as resources, placing Japan at 29th among OECD countries[32]

- Useful metals, such as rare and precious metals, are vital for next-generation vehicles and ICT equipment. They accumulate in so-called urban mines but are not 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, which are used in capacitors, and 4% of lithium, which are used in lithium-ion batteries.[33] This large accumulation reflects the low level of utilization of urban mines in Japan, since recycling is not economically feasible. The cost of recovering, separating, and refining metals is higher than that of natural resource procurement in the market

- This utilization rate is also insufficient for domestically available forest resources and organic biomass. The annual growth of forests in Japan amounts to about 70 million m^3, of which only 31 million m^3, or about 44% is utilized[34]

Japan / Potential Impact estimates	Vast amounts of metal resources have accumulated in urban mines in Japan. Gold and silver reserves amount to 6,800 metric tons, equivalent to 16% of the world's reserves, and 60,000 metric tons, equivalent to 22% of the world's reserves, respectively. 36 The 6,800 metric tons of gold are worth about JPY 50 trillion at a conversion rate of JPY 7,000 per gram. (C)
Japan / Potential Impact estimates	Japan's forests are strewn with approximately 20 million m^3 of fallen branches and timber from forest thinning.[35] If used for biomass power generation, these neglected resources would total JPY 160 billion per year. In addition, using this wood would reduce CO_2 emissions by 43.44 million metric tons per year, or 4.5% of Japan's total, rendering an additional JPY 28.3 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 possible reduction of CO_2 emission. Total fuel value = (Unused thinned timber[36] × Fuel unit price of thinned timber[37]) CO_2 credits = (Unused thinned timber ÷ Use of biomass power plant of 5,000 kW scale[38] × Annual generated electric energy of 5,000 kW scale power plant[39] × Actual emission factor[40] × CO_2 unit price[41])

Japan		World		Japan		World
Resolved	➡	Unresolved		Unresolved	➡	Unresolved

Societal Issues	Create a recycling society that makes effective use of resources

Key Points for Resolving Issues

Enhancement of Resource Utilization throughout the Product Life Cycle

- In addition to expanding the use of recycled materials, it is important to dismantle, decompose, and recreate recycled materials in order to effectively recycle the products. Manufacturers are expected to design products that are easy to recycle and reuse. Reduction of containers and packaging are also desired

- The recycling rate in Japan has not changed significantly over the past decade. It is thus necessary to re-evaluate policy positions and efforts in order to better devise changes in perception

Advanced Recycling

- It is important to promote *horizontal* recycling, which can maintain the same or similar quality of the original materials, instead of *vertical* recycling, which results in downgraded quality. The efficient segregation of resources with sensors and robots enables low-cost horizontal recycling

Advanced Utilization of Biomass Resources

- Biomass resources are roughly classified into three categories:

  (1) Waste (domestic drainage water, food waste, and others)

  (2) Unused materials (wood from tree thinning, crop residues, and others)

  (3) Agricultural production (grazing grass, algae, and others)

  Its applications range from renewable energy sources, feedstuff, fertilizer, and building materials. As waste is required to be disposed of appropriately, converting it to energy is an effective method to cut its associated costs.[42] (Reference: The annual cost necessary for local governments and municipalities to dispose of domestic waste is approximately JPY 2 trillion)

- Expertise on enhancing wood-biomass power generation is being shared, revealing techniques such as more efficient drying of raw wood and utilization of low-quality materials. Wood-biomass is derived from leftover lumber created through 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. The self-sufficiency rate is only one third of Japan's current annual timber demand of about 70 million m^3. In Lithuania, after the opening of the biomass exchange market for wood chips and pellets, numerous new entrants have entered the market, and the biomass supply business expanded quickly. Developing such trading platforms is also an effective effort to support the stable procurement of wood-biomass

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Enhancement of resource utilization throughout the product life cycle

Realization Timeline ▼

- It is essential to design products taking recycling and reuse into consideration, such as products that are easy to disassemble and repair or products made with reusable materials

  2020 to 2025

- It is desirable to advance resource utilization and environmental loading reduction throughout the entire product life cycle. Biodegradable materials, such as cellulose nanofibers and biomass-based plastics, are being developed as alternatives to plastics

  2020 to 2025

- Projects and businesses for the effective use of resources are emerging through local communities and recycling-oriented systems that emphasize design

  2020 to 2025

> Example
>
> A real estate company 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).[44]
> Electronic commerce operators, manufacturers, and retailers jointly launched a recycling business by making use of reusable, durable, and finely designed containers that are made of glass and stainless steel.@ (LOOP Global Holdings LLC, U.S.)[45]

Advanced recycling

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

  2020 to 2025

> Example
>
> The world's first waste-sorting robotic system has been developed (ZenRobotics Oy, Finland).[46] 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 uses AI and robotics to sort waste fed into conveyors (UENOTEX Co., Ltd., Japan).[47]

- There is also anticipation for technologies that identify discarded electronic devices using image recognition and low-cost/automated recycling of nonferrous and rare metals

  2025 to 2035

> Example
>
> 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).[48]

Technological Trends

Advanced recycling

■ The task of recycling using chemical reactions has also begun

2020
to
2025

> **Example**
>
> A proof-of-concept is expected to be unveiled at the end of FY 2021 to test new technologies that convert garbage otherwise incinerated, including domestic food waste, into ethanol. This technology uses microorganisms as a catalyst during the conversion. Commercialization is planned for FY 2025. (Jointly developed by SEKISUI CHEMICAL CO., LTD., INCJ Ltd., Japan, and a U.S. entrepreneur, LanzaTech)[49]
>
> A recycling business is also in development that collects clothing at retail stores, breaks apart the polyester into smaller substances, or BHET, and then reprocesses the BHET back into polyester. (JEPLAN, INC., Japan)[50]

Advanced utilization of biomass resources

■ Cost reduction is desired through the development of technology using sewage sludge, organic waste, and livestock excrement through batch treatment. Sewage sludge has been identified as the core of a recycling society; it is being used as a source for energy, building materials, fertilizer for green belts and farmland

2020
to
2025

> **Example**
>
> 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).[43]

■ A 100% biomass recycling process using houseflies and soldier flies is being developed[51]

2020
to
2025

> **Example**
>
> Technology was developed to produce larvae of American Soldier Flies using food residue - which are 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 completely recycle biomass into the feed and organic matter (MUSCA Inc., Japan).

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Advanced utilization of biomass resources

■ Efficient forest management methods are being developed that collect and analyze forest data using drones and satellites along with aerial surveying technologies[52]

20**20**
to
20**25**

■ Some issues are already being overcome through such measures as the sharing of expertise in wood drying, the introduction of dryers for low-quality wood, and a primary diagnostic tool for woody biomass power

20**20**
to
20**25**

■ Developing sound and competitive wood-biomass trading platforms is also effective for the stable procurement of biomass products such as wood chips and pellets

20**25**
to
20**35**

Example

Following the introduction of a biomass trading platform in 2012, Lithuania saw an 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 charge for heat supply by district.[53]

Regulatory Trends

■ The Ministry of the Environment (MOE) has been advocating the creation of a Revolving and Co-existence Community Zone. They aim to create a society where each region achieves independence, becomes self-supporting, and remain dispersed yet complementary to each other. MOE provides various projects in support of the realization of its proposed plan. The *Plastic Resource Circulation Strategy* was published [in 2019], mandating to reduce the cumulative emission of disposable plastics by 25% by 2030. Various recycling laws and regulations now require recycling and waste measures for each field

■ The introduction of the feed-in tariff 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 the owners cannot manage themselves. According to the *Act on Forest Environment Tax and Subsidy* enacted in March 2019, JPY 1,000 per capita every year will be collected as a national tax starting FY 2024. The amount 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

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (4) Intensifying environmental deterioration and pollution

- Ninety percent of the world's population lives under polluted air. Air pollution is caused mainly by factories, automobile gas emission, and coal and charcoal burning. Pollution is causing illnesses such as stroke, heart attack, and lung cancer[54,55]

World | **Potential Impact estimates** | More than 7 million people around the world have died early due to air pollution. This results in an estimated economic loss of about JPY 530 trillion a year.[56] (B)

- 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

World | **Potential Impact estimates** | The oceans contain 150 million metric tons of plastic waste, 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.[57]

- There has been rapid deforestation, mainly in tropical forests, in recent years. The amount of natural forests has been shrinking in addition to a deterioration of quality in the remaining forest lands. The situation has resulted in devastating conditions with the loss of various wildlife species and severely negative impacts on the lives of those who depend on the forests. In addition, large-scale flooding and forest fires are occurring with increasing frequency due to the aggravation of global warming[58]

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, the remaining rainforests are expected to disappear completely within 100 years.[59]

Japan		World		Japan		World
Resolved	⇒	Unresolved		Unresolved	⇒	Unresolved

Societal Issues Take immediate action to capture the current situation, analyze the cause, and implement countermeasures

Key Points for Resolving Issues

Measures to Control Pollution: Preventing and cleaning new and existing contamination

- It is essential to develop systems to monitor current pollution conditions, as well as effective regulations to prevent pollution in the air, water, and soil. In terms of preventive technologies, it is imperative to use renewable energy to develop lower-polluting automobiles and alternatives to plastic materials. Special

attention will be given to technologies that restore water and soil quality where contamination has already taken place. A technology called bioremediation is also attracting attention and cleans up polluted water and soil utilizing microorganisms and plants. Technology to recover maritime plastic wastes is also being developed

Countermeasures against Deforestation: Enhancing respective measures by regions and coordinated effort on a global scale

- 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 the causes 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[60]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Realization Timeline ▼

Measures against air pollution

- Air pollution in large cities is caused almost entirely by automobiles and factories, including power plants. Initiatives against air pollution are progressing as the development of lower-polluting automobiles and the utilization of electric energy generated from renewable energy. Proof-of-concept research is also being conducted on a service that encourages charging EVs and PHVs with renewable electricity and provides coupons for local area circulation. The service promotes measures against global warming while reducing the economic burden of adaption[61]

2020 to 2025

- For households in the 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 to 2025

> Example
>
> In Ulaanbaatar, the capital of Mongolia, a Japanese company has developed a technology that produces smoke-free coal to solve the air pollution problem caused by the coal-burning used for heating and cooking. (MEIWA CO., LTD., Japan)[62]

Measures against soil and water pollution

- Utilization of restoration technology, such as bioremediation and phytoremediation derived from microorganisms and plants will also become necessary in the near future. Future issues include securing safety without affecting ecosystems while finding and applying microorganisms and plants that can decontaminate pollutants

2025 to 2035

Prevention of plastic outflow 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. Biomass materials such as starch and paper are often used to develop materials to replace plastic. Biodegradable materials have been developed using corn and cassava

2020 to 2025

> Example
>
> SHIELDPLUS is a barrier material and is used as an alternative to plastic. It is paper, but it does not let oxygen and smells penetrate (Nippon Paper Industries Co., Ltd.).[63]

- **Follow-up measures:** The reuse of plastics instead of discarding them is being promoted. The development and wide spread use of easy-to-recycle plastics is desirable considering materials, colors, and forms the products will take

2025 to 2035

> Example
>
> A company is aiming to thoroughly recycle PET bottles, made from a combination of recycled PET resin and plant-derived materials, and thereby to completely recycle plastic resources by 2030 (Suntory Holdings Limited, Japan).[64]

Technological Trends

Prevention of plastic outflow into the ocean

■ **Ex-post measures:** The development of decomposition technology for plastics is also advancing. 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 PETase, a plastic degradative enzyme, obtained from PET-eating bacteria (ideonella sakaiensis)[65]

2025 to 2035

Measures against plastic in the ocean

■ **Causal countermeasures:** The development of plastics with biodegradational characteristics is advancing. Those plastics decompose into inorganic substances by the work of microorganism

2025 to 2035

Example

The biodegradable polymer (PHBH) developed by Kaneka is 100% plant-derived and can be decomposed into inorganic substances even in seawater by microorganisms.
PHBH can be processed into drinking straws and plastic bags, making it a promising alternative to plastic. (KANEKA CORPORATION, Japan)[66]

■ **Post-contamination measures:** Technological development is progressing for monitoring, collecting, and reusing the plastic waste in the ocean. However, technology to collect microplastics is yet to be realized

2025 to 2035

Example

An organization is developing a system to collect marine plastic using tidal currents (The Ocean Cleanup, the Netherlands).[67]

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 to 2035

Example

A U.S. company is developing synthetic palm oil that can be used as an alternative to palm oil produced from palm trees in tropical rainforests (C16 Biosciences, the U.S.).[68]

■ The use of IoT, AI, and drones to promote integration of the agricultural and livestock industry could help contribute to mitigate deforestation

2020 to 2025

Technological Trends

Forest conservation technology

■ Technology is being developed to promptly detect environmental damages such as deforestation, wildfires, and floods

20**25**
to
20**35**

Example

Huawei, together with Rainforest Connection, a U.S. non-profit organization, is conducting a project to prevent illegal logging and poaching in Southeast Asia, utilizing the voice monitoring system and AI. (Huawei Technologies, Co. Ltd.)[69]

Example

Fireball, 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.[70]

Forest regreening technology

■ A public-private partnership is operating a proof-of-concept and technological development in depleted land in developing countries where tree planting is difficult. The database of the technologies is open to the public

20**25**
to
20**35**

Example

Japan International Forestry Promotion and Cooperation Center (JIFPRO) is conducting a project to export reforestation technology to developing countries. In FY 2020, they conducted a technological verification 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*.[71]

Business models for forest protection

■ A business model has been released that contributes to sustainable forest management and improvement of the living in forest areas

20**25**
to
20**35**

Example

Japan International Forestry Promotion and Cooperation Center (JIFPRO) released the *Forest Business Database of Developing Countries (BFPRO)* online. The database includes new business models that make use of forest resources such as African blackwood, cacao beans, and beeswax.[72]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Regulatory Trends

- China has strengthened its air pollution control measures, and an amendment of the Environmental Protection Law (2014) has tightened penalties for violators.[73] During the 13th Five-Year Plan (2016 – 2020), significant progress was made in establishing the emission standards for pollutants

- China is also moving forward with 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, and other scraps would be gradually phased out. In response to these regulations, Japan also implemented emergency subsidies for waste plastic sophistication facilities in 2017, but also revised and enforced 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[74]

- International regulations on marine debris are being tightened. At the G7 Summit held in June 2018, the *Ocean Plastics Charter* was proposed. The E.U. is tightening the rules 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[75]

- 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. Japan has also launched the *MARINE Initiative* to promote measures against marine plastic waste worldwide and to ban free plastic bags at stores and supermarkets

- 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 started strengthening regulations, and, in 2019, it established detailed operating rules in the *Forest Land Development Permit Standards* for solar power plants. Increasing number of local governments have enacted their ordinances to regulate clearing for solar power development[76]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (5)	Loss of biodiversity

- In recent years, biodiversity has been damaged by deforestation and invasion by non-native species. Biodiversity is the existence of a wide variety of species and ecosystems on the earth that plays an essential role in maintaining lives and natural systems. The International Union for Conservation of Nature (IUCN) has published a list of endangered species as the Red List, stating that 40,000 of the 2.13 million species known to exist on the earth are in danger of extinction. There are concerns that the loss of biodiversity could lead to a negative chain reaction of global warming, food shortages, and an increase in risk of infectious diseases[77]

World **Potential Impact estimates** | The economic value the functions provide to the earth and humankind is estimated at USD 33 trillion per year.[78]
Note: A diverse ecosystem provides four functions:
(1) Provisioning services (food and water supply)
(2) Regulating services (purification of air and water in coordination with disaster prevention)
(3) Cultural services (a culture that enriches human life)
(4) Supporting services (a foundation for green plant photosynthesis and soil formation).

- However, recent efforts intended to conserve and protect the environment have instead at times resulted in adverse effects on general biodiversity[79]

- 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 organisms in the ecosystems

- Experts are concerned that the practice of dosing livestock with substantial amounts of antibiotics could lead to life-threatening infections. There is also the possibility that antibiotics from livestock can contaminate soil and water in addition to producing new bacteria that are antibiotic-resistant

World
Unresolved ➡ Japan
Unresolved

Societal Issues	Maintain sustainable coexistence between humans and other living creatures

Key Points for Resolving Issues

Visualization: Understanding the actual state of the ecosystem and practice of segregation

- Although living creatures and organisms on earth have coexisted for a long time, it has become clear that human activities have often lead to the loss of biodiversity and to environmental destruction. This has resulted in a loud and clear call for conservation of ecosystems. Ecosystems, however, cannot be conserved just through a human refusal to interact with nature. It requires active participation in the protection and upkeep of the environment. For example,

deterioration is observed in farming villages and other rural areas due mainly to aging and declining population. Those changes are resulting in an imbalance in biodiversity, where certain organisms face extinction while others increase to excess. Therefore, after analyzing the living status and interdependence of various organisms that initially inhabited the area, it is critical to develop 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 the ecosystem by accessing and learning about the reality of the ecosystem. Expectations are high for a system to raise awareness of ecosystems by utilizing advanced technologies

Commercialization: Securing conservation funds through the utilization of ecosystems

- In the past, conservation measures were limited to conservation initiatives, such as banning entry to areas inhabited by rare organisms. In recent years, proactive efforts are becoming more common, like inviting tourists to the destination to increase awareness of rare organisms and utilizing their spending as a source of funds for conservation activities. Establishing a system to secure conservation funds acquired through the business of utilizing biodiversity will enable sustainable coexistence between humans and other organisms

Technological Trends

Visualization

■ Most recent 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 to 20**35**

> Example
>
> In the area around Nishinoshima Island in the Ogasawara Islands, research is being conducted to unveil the primitive ecosystems of terrestrial and marine organisms. Drones and unmanned underwater vehicles, such as AUV and ROV, are used for the research.[80]

> Example
>
> University of Georgia in the U.S. provides 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.[81]

> Example
>
> A Japanese company, Biome, has developed an app, also named "Biome", to help collect data on living creatures. The company collects and compiles the data of posted images, locations, and time on the app to visualize the distribution and impact of each organism. (Biome Inc., Japan)[82]

■ Opportunities to learn about biodiversity are becoming more accessible through exhibitions and art with advanced technologies

2020 to 20**25**

> Example
>
> 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 been installed in *Graffiti Nature - High Mountains and Deep Valleys, Red List*.[83]

■ More tools are becoming available for children to both enjoy and learn about biodiversity

2020 to 20**25**

> Example
>
> The smartphone app LINNÉ LENS instantly identifies creatures in aquariums and zoos when users hold up their smartphone. Users can enjoy learning about the species through the collected and categorized data.[84]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Commercialization

■ Business models are being developed to conserve and utilize rare organisms, mainly in tourism and agriculture sectors

2025 to 2035

> Example
>
> Honeybees play an essential role in developing pharmaceuticals and in growing vegetables and fruits. Efforts to cultivate and conserve honeybees on building rooftops are gaining popularity in many cities nationwide. This initiative is helpful not only for urban greening and ecosystem conservation but also for creating local communities, dietary education for children, and environmental lessons. Companies are also experimenting in attempts to create a viable business model by selling honey from beekeeping.[85]

> Example
>
> 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. It preserves storks and provides economic benefits such as income for the farmers and ecotourism.[86]

■ Companies are promoting biodiversity offsets, mainly overseas

2020 to 2025

> Example
>
> In 2005, Walmart Inc., in coordination with the National Fish and Wildlife Foundation (NFWF), started 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.

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Regulatory Trends

- The first part of the 15th meeting of the Conference of the Parties (COP 15) regarding the Convention on Biological Diversity (CBD), was held in Kunming, China, from October 11th-15th, 2021. There are about 200 countries that are signatories to the CBD. Discussion was held based on the Post-2020 Biodiversity Framework which will replace the Aichi Biodiversity Targets set in 2010 that were not achieved. Twenty-one practical targets for 2030 were proposed and discussed, resulting in four directions which were adopted as the following Kunming Declaration:

  (1) national strategies to protect biodiversity

  (2) increase support for developing countries

  (3) enhance the One Health approach (a holistic approach to protect the health of people, animals, and ecosystems by treating them as one system that is intertwined and interconnected)

  (4) consider the sharing of benefits from digital sequencing information.

  The targets will be set during the second part of the meeting starting in April 2022[87]

- 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 providing habitats for living organisms, forming desirable landscapes, and controlling temperature rise. It will also contribute to ecosystem conservation, as well as disaster prevention and mitigation. Additionally, these changes will increase the attractiveness of the cities and living environments. Currently, a public-private partnership platform is being formed across ministries and agencies[88]

- The Ministry of the Environment (MOE) released two publications with the objective of enhancing biodiversity conservation as a business of the private sector so that loans and investments will become available. They are the "*Casebook on Biodiversity Engagements by Private Sector*" and "*the Good Practices in Corporate Disclosure Related to Biodiversity and Natural Capital*"[89]

- The Ministry of the Environment (MOE) is also promoting the Project to Fully Enjoy National Park. By enhancing the brand value of the National Parks and increasing foreign visitors to Japan, the project aims not only to promote regional development but also to raise awareness of ecosystem conservation[90]

Problems	Issues
(1) Need to accelerate decarbonization in the supply side of energy	**Promote comprehensive decarbonization measures**
	Targets in UN 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 support
(2) Addressing the large room for energy conservation and decarbonization on the demand side	**Provide solutions to promote decarbonization in the industrial, household, and transportation sectors**
	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
(3) Insufficient recycling and ineffective use of resources	**Create a recycling society that makes effective use of resources**
	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
(4) Intensifying environmental deterioration and pollution	**Take immediate action to capture the current situation, analyze the cause, and implement countermeasures**
	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
(5) Loss of biodiversity	**Maintain sustainable coexistence between humans and other living creatures**
	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

Notes and References

All URLs were viewed on September 1st, 2021.

1 Agency for Natural Resources and Energy, Japan, FY 2019 *Energy Supply and Demand Record (Revised Report)*, p. 28, 2021. (in Japanese)
https://www.enecho.meti.go.jp/statistics/total_energy/pdf/honbun2019fyr2.pdf

2 Agency for Natural Resources and Energy, Japan, "Energy Supply and Demand Outlook for FY 2030 (A supplemental material)" *the Sixth Strategic Energy Plan*, 2021. (in Japanese)
https://www.enecho.meti.go.jp/category/others/basic_plan/pdf/20211022_03.pdf

3 Yoshida, T. (Mitsubishi Power Ltd.), "Hydrogen power generation for carbon neutrality by 2050," the 21st Council for a Strategy for Hydrogen and Fuel Cells, 2021. (in Japanese)
https://www.meti.go.jp/shingikai/energy_environment/suiso_nenryo/pdf/020_04_00.pdf

4 Clean Planet Inc.
https://www.cleanplanet.co.jp/en/

5 Nagamachi, M., Smart Japan Micro-Hydro Power Plant Produces Hydrogen, First Demonstration in Japan Begins in Hokkaido, Smart Japan, May 29, 2018. (in Japanese)
https://www.itmedia.co.jp/smartjapan/articles/1805/29/news032.html

6 Google Wind Power
https://www.blog.google/technology/ai/machine-learning-can-boost-value-wind-energy/

7 PowerPeers
https://www.powerpeers.nl/

8 CHANGE THE WORLD Inc. (in Japanese)
https://ctws.jp/business/change

9 Ministry of the Environment, Japan "Introduction of carbon taxes in other countries," July 2017.
https://vitality.sumitomolife.co.jp/

10 Department for Business, Energy & Industrial Strategy, Offshore wind Sector Deal, 4 March 2020
https://www.gov.uk/government/publications/offshore-wind-sector-deal/offshore-wind-sector-deal

11 Agency for Natural Resources and Energy, Japan, "Renewable energy as Japan's major energy source! The FIP (feed-in premium) scheme will launch in April 2022," 2021. (in Japanese)
https://www.enecho.meti.go.jp/about/special/johoteikyo/fip.html

12 Agency for Natural Resources and Energy, Japan, "Commencement of the tracking demonstration experiment for the 1st Non-FIT Non-Fossil Fuel Energy Certificate Auction FY 2021," *Call for proposal*, 2021. (in Japanese)
https://www.enecho.meti.go.jp/category/electricity_and_gas/electric/nonfossil/page/20210726.html

13 New Energy Development Organization (NEDO), the latest trends in distributed energy systems, and examples of their introduction
https://www.hkd.meti.go.jp/hokpp/20191219/data01.pdf#page=34

14 ZEH and ZEB: Short for net-zero energy houses and buildings. They achieve the net-zero annual primary energy consumption with energy-saving measures, such as highly efficient air conditioners, boilers and lightings, and building materials with high thermal insulation performance. Introducing generators for solar and other renewable energy sources are also an approach.

15 Mori, D. (TOYOTA MOTR CORPORATION), "FCV development and creation of the next-generation vehicle market: Towards Hydrogen Society," the 7th *Energy System Integration Symposium*, The University of Tokyo, August 4, 2020. (in Japanese)
https://www.esisyab.iis.u-tokyo.ac.jp/symposium/20200804/20200804-03.pdf

16 NIPPON STEEL CORPORATION, *Nippon Steel Carbon Neutral Vision 2050*, pp. 17-21, March 30, 2021.
https://www.nipponsteel.com/en/ir/library/pdf/20210330_ZC.pdf

17 Agency for Natural Resources and Energy, Japan, "Study for achieving carbon neutrality in 2050," *the 36th Comitee for the Basic Policies of the Advisory Committee for Natural Resources and Energy*, January 27, 2021. (in Japanese)
https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/036/036_005.pdf

18 National Institute of Advanced Industrial Science and Technology, "AI predicts catalytic yield," *Research Achievements*, January 31, 2018. (in Japanese)
https://www.aist.go.jp/aist_j/press_release/pr2018/pr20180131/pr20180131.html

19 Abe, H., "Recovering carbon dioxide from the atmosphere!? A surprising new technology," Energy and Environment Vo. 27, *Energy Frontline*, June 15, 2021. (in Japanese)
https://ene-fro.com/article/ef203_a1/

20 Passive House Japan (in Japanese)
https://passivehouse-japan.org/ja/

21 Shimizu, A., "Energy harvesting realizes the world of IoT," *MRI Economic Review*, January 20, 2017. (in Japanese)
https://www.mri.co.jp/knowledge/insight/20170120.html

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Notes and References

All URLs were viewed on September 1st, 2021.

22 ENERGY HARVESTING (ENVIRONMENTAL POWER GENERATION) SOUND POWER CO., INC. (in Japanese)
https://www.soundpower.co.jp/work/vibration.html

23 Kajima Corporation, "Development of new energy-saving technology for data centers: An air conditioning that uses outside air for cooling," *Press Release*, July 29, 2021. (in Japanese)
https://www.kajima.co.jp/news/press/202107/29a1-j.htm

24 Josefsberg, A., "Dublin data center celebrates grand opening," Microsoft Datacenters Blog, September 23, 2009.
https://docs.microsoft.com/ja-jp/archive/blogs/msdatacenters/dublin-data-center-celebrates-grand-opening

25 TEPCO Energy Partner Life TEPCO (in Japanese)
https://www.kurashi.tepco.co.jp/pf/ja/pc/pub/hub/charge-amount-confirm.page

26 Oracle Corporation Japan, "Oracle helps utility customers reduce 47,000 tons of CO_2 with Ministry of Environment Japan program to realize decarbonized society," *Press Release*, June 29, 2021.
https://www.oracle.com/news/announcement/oracle-helps-utility-customers-reduce-co2-with-ministry-of-environment-japan-program-2021-06-29/

27 Maeda, M. (TOYOTA MOTOR CORPORATION), "Towards carbon neutrality: TMC's development and supply of batteries," *A Briefing on Batteries and Carbon Neutrality*, September 7, 2021. (in Japanese)
https://global.toyota/pages/news/images/2021/09/battery/battery_01_jp.pdf

28 New Energy and Industrial Technology Development Organization, "NEDO launches a research and development project for an innovative rechargeable battery that exceeds the lithium-ion cells' performance and production cost" *News Release*, June 3, 2021. (in Japanese)
https://www.nedo.go.jp/news/press/AA5_101435.html

29 Fujimoto, H., "Future society opened by direct dynamic wireless power transfer to EV," *JST-Mirai Program*.
https://www.jst.go.jp/mirai/en/program/lowcarbon/JPMJMI21E2.html

30 New Energy and Industrial Technology Development Organization, "NEDO launches a research and development project of an integrated manufacturing process to produce liquid fuels from carbon dioxide," *News Release*, February 22, 2021. (in Japanese)
https://www.nedo.go.jp/news/press/AA5_101410.html

31 Agency for Natural Resources and Energy, Japan, "Study for achieving carbon neutrality in 2050," *the 36th Comitee for the Basic Policies of the Advisory Committee for Natural Resources and Energy*, January 27, 2021. (in Japanese)
https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/036/036_005.pdf

32 Organisation for Economic Co-operation and Development , *Environment at a Glance 2015: OECD* Indicators, OECD Publishing, 2015.
https://doi.org/10.1787/9789264235199-en

33 United Nations Environment Programme, *International Resource Panel, Recycling Rates of Metals: A Status Report*, 2011.
https://www.unep.org/resources/report/recycling-rates-metals-status-report

34 Forestry Agency, Japan, *Timber Products Supply and Demand Tables*, 2020. (in Japanese)
https://www.rinya.maff.go.jp/j/press/kikaku/200930_30.html

35 Forestry Agency, Japan. (in Japanese)
https://www.rinya.maff.go.jp/j/mokusan/saisei/pdf/kokusan_shiryou4-4.pdf

36 Unutilized thinned wood = approx. 20 million m3/year Forest Agency, promotion of utilization of woody biomass, December 2014.

37 Fuel unit price of thinned wood = JPY 5,000 to 8,000/m3

38 A 5,000 kW biomass power plant annually consumes 10,000 m3 of thinned woods. Source: Ministry of Agriculture, Forestry and Fisheries, "Promoting small-scale woody power plants," No. 1, the 17th Calculation Committee for Procurement Prices*, January 28, 2015.
https://www.meti.go.jp/shingikai/santeii/pdf/017_01_00.pdf

39 Annual power generation at 5,000 kW power plants 23 = 5,700 kW × 24 hours × 365 days × 87% = 43,440,840 kWh Source: Working Group for Power Generation Cost Validation at Advisory Committee for Natural Resources and Energy, "Power generation cost review sheet," *Report for the Power Generation Cost Validation in Response to the Committee for the Basic Policies,* Agency for Natural Resources and Energy, September 14, 2021. (in Japanese)
https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/#cost_wg

40 Utility Actual Emission Factor = 0.000500 (t-CO_2/kWh)

41 Unit price of CO_2 = EUR 5 = JPY 651.4 (JPY 130.28 to EUR 1, as of July 2018)

42 New Energy and Industrial Technology Development Organization, "Biomass energy," Chapter 4, *NEDO Renewable Energy Technology White Paper -- Challenges and Prescriptions to Be Overcome for Dissemination*, 2nd Edition, 2014. (in Japanese)
https://www.nedo.go.jp/content/100544819.pdf

Notes and References

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

All URLs were viewed on September 1st, 2021.

43   4Nature Inc., *1.2-mile community compost*. (in Japanese)
      https://www.4nature.tokyo/community-compost

44   NIPPON STEEL KOWA REAL ESTATE CO., LTD., "The sharing economy tool for apartment residents, sharecome, launches in Tokyo*," News Release*, March 30, 2021. (in Japanese)
      https://www.nskre.co.jp/company/news/2021/03/20210330.pdf

45   Loop Japan (in Japanese)
      https://loopstore.jp/

46   ZenRobotics
      https://zenrobotics.com/

47   Ministry of Economy, Trade and Industry, Japan, "Promotion of the three Rs by manufacturing and developing Japan's first automated waste sorting system equipped with the in-house AI, URANOS, and other environmental equipment," FY 2021 Achievement Awards for 3Rs Promotion*, News Release*, October 22, 2021. (in Japanese)
      https://www.meti.go.jp/press/2021/10/20211022001/20211022001-1.pdf

48   AIST News (June 20, 2018) (in Japanese)
      https://www.aist.go.jp/aist_j/news/pr20180620.html

49   SEKISUI CHEMICAL CO., LTD., "SEKISUI CHEMICAL established a joint venture for generating ethanol from burnable waste," News Release, April 16, 2020. (in Japanese)
      https://www.sekisui.co.jp/news/2020/1348992_36493.html

50   JEPLAN, INC., "What is BRING™ clothing recovery?"
      https://www.jeplan.co.jp/en/service/bring/

51   MUSCA Inc.
      https://musca.info/en/

52   Shimada, H., "Understanding of forest resource information using aerial photographic images by drone," Mie Prefecture. (in Japanese)
      https://www.pref.mie.lg.jp/ringi/hp/000232832.htm

53   "Growing woody biomass trading platform in Scandinavia: Baltpool Biomass Exchange," *LRI Newsletter*, June 30, 2020. (in Japanese)
      https://londonresearchinternational.com/wp-content/uploads/2020/12/LRIEC300620.pdf

54   World Health Organization Western Pacific Region, "Air pollution."
      https://www.who.int/westernpacific/health-topics/air-pollution

55   Gardiner, B., "Air pollution kills millions every year, like a 'pandemic in slow motion,'" *National Geographic Magazine*, April 2021 issue, March 16, 2021.
      https://www.nationalgeographic.com/magazine/article/air-pollution-kills-millions-every-year-like-a-pandemic-in-slow-motion-feature

56   The World Bank and Institute for Health Metrics and Evaluation University of Washington, Seattle, *The Cost of Air Pollution: Strengthening the Economic Case for Action*, 2016.
      http://documents1.worldbank.org/curated/en/781521473177013155/pdf/108141-REVISED-Cost-of-PollutionWebCORRECTEDfile.pdf

57   World Wildlife Fund, "Marine plastics," October 26, 2018. (in Japanese)
      https://www.wwf.or.jp/activities/basicinfo/3776.html

58   World Wildlife Fund, "What you can do today to stop deforestation." (in Japanese)
      https://www.wwf.or.jp/campaign/forest/

59   Vidal, J., "We are destroying rainforests so quickly they may be gone in 100 years," *The Guardian*, January 23, 2017.
      https://www.theguardian.com/global-development-professionals-network/2017/jan/23/destroying-rainforests-quickly-gone-100-years-deforestation

60   Pacheco, P., Mo, K., Dudley, N., Shapiro, A., Aguilar-Amuchastegui, N., Ling, P.Y., Anderson, C. and Marx, A., *Deforestation Fronts: Drivers and Responses in a Changing World – Summary* -, World Wildlife Fund, 2021.
      https://www.wwf.or.jp/activities/data/deforestation_fronts_summary_english.pdf

61   CHUBU Electric Power Co., Inc., "Demonstration experiment on EV and PHV charging service with carbon dioxide free electricity," *Press Release*, November 15, 2018. (in Japanese)
      https://www.chuden.co.jp/publicity/press/3269410_21432.html

62   Journal of Industry-Academia-Government Collaboration, Vol. 12, No. 1, 2016. (in Japanese)
      https://sangakukan.jst.go.jp/journal/journal_contents/2016/01/articles/1601-02-2/1601-02-2_article.html

63   Nippon Paper Industries Co., Ltd., "SHIELDPLUS – Paper-based barrier material," *Products*.
      https://www.nipponpapergroup.com/english/products/shieldplus/

64   Suntory Group, *Suntory Group Plastic Policy.*
      https://www.suntory.com/csr/activity/environment/reduce/plastic/

Notes and References

All URLs were viewed on September 1st, 2021.

65   Kyoto Institute of Technology, "Discovery of a bacterium that degrades and assimilates PET," News, March 11, 2016. (in Japanese)
https://www.kit.ac.jp/2016/03/topics160311/

66   KANEKA CORPORATION, "KANEKA Biodegradable Polymer Green Planet ™."
https://www.kaneka.co.jp/en/solutions/phbh/

67   The Ocean Cleanup
https://theoceancleanup.com/

68   C16 Biosciences, "C16 Biosciences raises $20 million Series A to produce bio-based palm oil alternative for consumer products," Press Release, March 2, 2020.
https://www.c16bio.com/c16-biosciences-raises-20-million-series-a-to-produce-bio-based-palm-oil-alternative-for-consumer-products

69   Huawei Technologies Co., Ltd., "Rainforest connection and Huawei's 'Nature Guardian' Project wins GSMA GLOMO for outstanding mobile contribution to the UN SDGs," News, June 30, 2021.
https://www.huawei.com/en/news/2021/6/tech4all-nature-guardian-glomo

70   exci Pty Ltd.
https://www.exci.ai

71   Japan International Forestry Promotion and Cooperation Center, *FY 2020 Report on the Promotion of Forest Regeneration Technology in Developing Countries,* 2021. (in Japanese)
https://www.maff.go.jp/j/kokusai/kokkyo/yosan/pdf/R2_17_001.pdf
Japan International Forestry Promotion and Cooperation Center, "Technical Note for Tree Planting Practices."
https://jifpro.or.jp/tpps/en/

72   Japan International Forestry Promotion and Cooperation Center, "Business of Forest Products (BFPRO)."
https://jifpro.or.jp/bfpro/english/

73   Ministry of the Environment, Japan, "Development and enforcement of legal systems," China's Current State of Environmental Pollution, Countermeasures, and Technical Needs for Environmental Measures, *Implementing Japanese Environmental Technologies in Asia*, April 1, 2016. (in Japanese)
https://www.env.go.jp/air/tech/ine/asia/china/SeidoCH.html

74   Kashiwase, A., "G20 energy ministers agreed on reducing oceanic plastics*," JETRO Business News*, June 18, 2019. (in Japanese)
https://www.jetro.go.jp/biznews/2019/06/805b0ce1a2ecaecb.html

75   Japan Management Association, *FY 2019 Commissioned Survey Report on New JAS Standards*, March 2020. (in Japanese)
https://www.maff.go.jp/j/jas/attach/pdf/yosan-28.pdf

76   Forestry Agency, Japan, "Forest Agency's efforts against forest land development for photovoltaic power stations*," the 15th Task Force Meeting for Reviewing Regulations on Renewable Energies,* September 7, 2021. (in Japanese)
https://www8.cao.go.jp/kisei-kaikaku/kisei/conference/energy/20210907/210907energy11.pdf

77   World Wildlife Fund Japan, "The Red List: A list of the world's endangered wildlife," December 10, 2020. (in Japanese)
https://www.wwf.or.jp/activities/basicinfo/3559.html

78   World Wildlife Fund Japan, "What is Biodiversity? Its importance and conservation," October 21, 2019. (in Japanese)
https://www.wwf.or.jp/activities/basicinfo/3517.html

79   Sugiyama, T., "Can wind power generation survive increasing environmental costs*?" International Environment and Economy Institute*, September 25, 2019. (in Japanese)
https://ieei.or.jp/2019/09/sugiyama190925/

80   Ministry of the Environment, Japan, "Implementation of the FY 2021 Nishinoshima Comprehensive Scientific Research," *Press Release*, July 5, 2021. (in Japanese)
http://www.env.go.jp/press/109764-print.html

81   Early Detection and Distribution Mapping System (EDDMapS)
https://www.eddmaps.org/

82   Biome Inc. (in Japanese)
https://biome.co.jp/about/

83   *teamLab Borderless: MORI Building DIGITAL ART MUSEUM*
https://borderless.teamlab.art

84   LINNÉ LENS, *Scannable AI encyclopedia*
https://lens.linne.ai/en/

85   Yamamoto, M., "Honeybees connect cities, people and the nature. Creating a prosperous society through urban beekeeping: The Honeybee Project by the National Urban Beekeeping Network," an interview with Kazuhiro Komaru, *JAMMIN*, November 23, 2020. (in Japanese)
https://jammin.co.jp/charity_list/201123-mitsubachi/

Notes and References

All URLs were viewed on September 1st, 2021.

86 Ministry of the Environment, Japan, "Restoring rice paddy habitats to reintroduce the oriental white stork in Toyooka City," An introduction of good practices in Japan, *Payments for Ecosystem Services (PES),* 2010.
https://www.biodic.go.jp/biodiversity/shiraberu/policy/pes/en/satotisatoyama/satotisatoyama02.html

87 Tsuchiya, T., "What will happen in biodiversity? – Commentary on everyday life," *Commentary Archives*, NHK, October 19, 2021. (in Japanese)
https://www.nhk.or.jp/kaisetsu-blog/700/455764.html

88 Ministry of Land, Infrastructure, Transport and Tourism, Japan, *The Portal Site for Green Infrastructure*. (in Japanese)
https://www.mlit.go.jp/sogoseisaku/environment/sosei_environment_tk_000015.html

89 Ministry of the Environment, *Japan, Casebook on Biodiversity Engagements by Private Sector*, March 2021.
https://www.env.go.jp/nature/biodic/act_promo/pamph/jireisyu_en.pdf
Ministry of the Environment, *Japan, Good Practices in Corporate Disclosure Related to Biodiversity and Natural Capital*, March 2021.
https://www.env.go.jp/nature/biodic/act_promo/pamph/good_practice_en.pdf

90 Ministry of the Environment, Japan, *Project to Fully Enjoy National Parks.*
https://www.env.go.jp/en/nature/enjoy-project/index.html

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

4. MOBILITY

A SOCIETY WHERE ALL CAN SATISFY THEIR MOBILITY NEEDS IN A CLEAN, FREE, AND SAFE MANNER

Automobiles and railroads have enabled people to increase their range and means of travelling. On the other hand, the prevalence of automobiles has created environmental problems such as air pollution and contributed to larger issues like global warming, as well as economic losses due to traffic congestion. The sustainability of public transportation and the logistics services using these means is also being questioned. Public transportation services are being shrunk or terminated in areas where, because of declining birth rates, overall commutes to work and school are decreasing. Concerns are increasing over securing transportation for residents in those areas. The shortage of truck drivers remains a problem as the delivery traffic grows from the spreading of e-commerce.

New technologies and services must be developed to resolve these problems. As for automobiles, manufacturers are introducing new technologies for safety measures and electrification. Ride-sharing could be an effective initiative to address traffic congestion and adverse environmental impact by effectively utilizing automobiles. In response to the reduction or termination of public transportation services, there is a movement to improve the convenience of on-demand transportation by using AI. Autonomous driving is also being deployed to achieve better efficiency of bus operation. To better sustain logistics services, drone delivery and new services have begun to emerge in order to match empty trucks with packages for improved loading efficiency.

Furthermore, the progress of digitization and online operation has expanded the possibility of new types of activities and communication. In addition to simply commuting to work, going shopping, or transporting goods, new value for mobility itself is being created that enhances enjoyment and affluence to consumers. Examples include sharing services of electric kickboards and services that use remote-controlled robots to give users virtual experiences as if they have actually travelled in-person. Also, as a result of the increasing popularity of autonomous driving, many are considering and developing technologies to transform the vehicle's interior into a space for entertainment. Developing services to make better use of travel time can additionally bring new business opportunities.

From the perspective above, ICF has classified the problems and issues in the mobility field into the following four categories.

(1)	Adverse effects of vehicle-centric transportation systems	→ Optimizing traffic flow and promoting the use of safe and comfortable mobility services
(2)	Deficiency of logistics capacity for increased demand	→ Building a sustainable logistics network
(3)	Expansion of areas where transportation is restrained	→ Providing mobility services to maintain quality of life
(4)	Rapid changes in means of transportation and opportunities utilizing digital technologies	→ Providing wider variety of customer experiences in response to the changes in the configuration of transportation

Legend

Potential impact estimates

(A) The maximum impact on financial cost and future population by 2025 to 2030 if no effective countermeasures are taken

(B) The maximum impact of the worst-case scenario that can be reasonably expected to occur at present

Issues and Challenges are classified into three categories:

Japan	World	Japan	World	World	Japan
Resolved ➡	Unresolved	Unresolved ➡	Unresolved	Unresolved ➡	Unresolved

(1) Issues that have already been resolved in Japan, and utilizing Japanese technologies that can be of help in resolving global issues;

(2) Current issues that also exist in Japan. By becoming the first country to resolve them, Japan can lead the pack on global issues; and

(3) Early tackling of future global issues will lead to resolving them in Japan in the future.

Societal Problem (1)	Adverse effects of vehicle-centric transportation systems
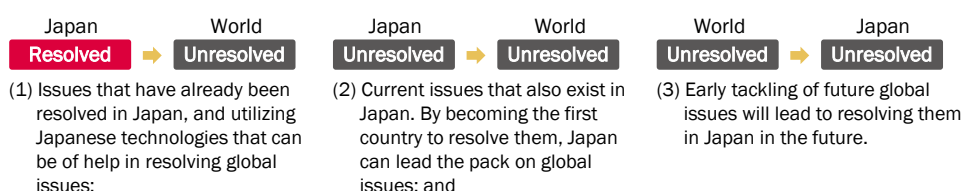
- Traffic congestions are frequently seen within and between cities worldwide, and are the cause of enormous economic losses. Thanks to the measures taken both in hardware and software, congestion is on the decline. Even in the developed countries, however, where the population is decreasing and cities are becoming more compact, congestion is causing substantial economic losses

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]

- Given the popularity of automobiles, cars were often prioritized in construction of roads and urban planning. Unregulated urban expansion in the suburbs caused so-called urban sprawl based on the assumption that most people use cars. In recent years, fatal traffic accidents occur frequently where older people are either victims or perpetrators

Japan **Potential Impact estimates**

Though the number of traffic fatalities decreased by 44% in 2021 compared to 2011, the rate of decease in older generations, aged 65 and over, was limited to 34%.[3] The number of accidents also decreased by 58% in 2020 compared to 2010. However, the accidents caused by elderly drivers were reduced by only 36%.[4]

- Automobiles are a major cause of environmental problems. The exhaust gases cause air pollution, CO_2 emissions accelerate global warming, and noise is a nuisance to the neighborhood

World **Potential Impact estimates**

Electric vehicles and renewable-energy power generation systems could replace automobiles; in this scenario, an estimate has shown that it could reduce the CO_2 emissions by approximately 20% compared to a scenario where no policy initiatives were implemented.[5](C)

Japan		World		Japan		World
Resolved	➡	Unresolved		Unresolved	➡	Unresolved

Societal Issues	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

- Demand-side management and controlling technologies and mechanisms are effective in solving traffic congestion. By dispersing the congested area and hours, the demand for automobile can be leveled. Examples include a system to control

traffic signals in an area where traffic jams occur and a sophisticated navigation system to guide cars to less congested roads. Mechanisms that encourage behavioral change on the demand side, such as promoting staggered commuting hours and work from home, also reduce morning and evening rush hours in cities. Although some proof-of-concept projects have started in Japan, their application is still limited due to the high cost of building a private power line. Additionally, there is currently no precedent of a power company allowing its electric power line to be shared, and thus the system is yet to be streamlined

Accident Prevention: Enhancement of safety support functions for vehicles and roads

- Many new vehicles sold in Japan have already installed systems to support safe driving. If autonomous driving prevails in the future, most of traffic accidents caused by human error can be avoided. Safety can further improve through the instillation of sensors on vehicles and roads to detect pedestrians and moving vehicles

Reducing Environmental Impact: Popularization and promotion of transportation with low environmental impact

- It is necessary to expand the use of eco-friendly cars with high performance to reduce the environmental impact caused by vehicles. Convenient, safe, and comfortable models with reasonable pricing are in high demand. Encouraging ride-sharing, improving load factors, and shifting to public transportation from driving will also reduce the negative impact on the environment

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Optimization

Route control and adjustment synchronization

■ Controlling traffic with quantum computing is becoming popular. The technology enables each vehicle to be adaptively guided to an optimal route. It also manages and controls the traffic lights in groups in a particular area. Experiments are also underway for urban air mobility, (including flying cars and drones) controlling their routes and schedules on a real-time basis

20**25**
to
20**35**

> Example
>
> TOYOTA CENTRAL R&D LABS., INC. and the University of Tokyo (JAPAN) have developed a control method using quantum computing to adapt urban traffic lights to operate in sync with the traffic conditions.[6]

> Example
>
> SUMITOMO CORPORATION, Tohoku University, and a system development company, OneSky Systems, Inc. (Japan), embarked on a proof-of-concept experiment aiming for future society with urban air mobility.
> The experiment seeks real-time management of multiple aircrafts to provide an optimal route and schedule using quantum computing.[7]

■ Systems utilizing GPS's high-precision location information have been introduced, with new capacities such as providing an efficient route or charging tolls for vehicles entering cities during busy hours[8,9]

20**20**
to
20**25**

Behavioral modification on demand side

■ The application of big data to predict congestions is becoming popular. It induces drivers to avoid traffic jams

20**25**
to
20**35**

> Example
>
> 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. The experiment aims to reduce traffic jams by providing tourism information and using nudges. It is also expected to heavily reduce CO_2 emission.[10]

■ Ride-sharing for people heading in the same direction reduces the total volume of traffic

20**20**
to
20**25**

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Avoiding Accidents

Realization Timeline ▼

Safe driving technology

- A technology has been developed which utilizes facial image analysis and vital sign monitoring sensors, to constantly monitor drivers' health condition. System development is 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[11]

  2025 to 2035

- Technology is also emerging to detect hazardous road conditions when it is difficult for drivers to visually identify them. It will prevent accidents caused by poor visibility or pedestrians unexpectedly jumping out into the street. The technology uses optical remote sensing called Light Detection and Ranging (LiDAR), millimeter-wave radar, and edge computing that processes data close to the sensing device terminal

  2025 to 2035

Ensuring the safety of pedestrians

- A system has been introduced that automatically displays a crosswalk when a pedestrian is about to cross the road

  2025 to 2035

  > Example
  >
  > A U.K. company, Umbrellium Ltd., has developed and is conducting a pilot run of a road sign control system that dynamically displays crosswalks. The system displays crosswalks and stop lines on pavement in response to the movements of pedestrians and bicycles.[12]

Reduction of Environmental Impact

Reducing environmental impact by vehicles

- There is a movement for decarbonization of vehicles, not just during driving but throught their product life-cycle, starting from raw material to manufacturing process

  2025 to 2035

  > Example
  >
  > The World Business Council for Sustainable Development (WBCSD) and the World Economic Forum (WEF) has launched the Circular Cars Initiative (CCI) in January 2021. It aims to minimize carbon dioxide emissions during the automotive manufacturing process and to achieve the 1.5°C scenario stated in the Paris Agreement.[13]

Human-centric urban development

- Efforts are being made around the world to create livable, walkable cities.[14] The walkable cities limit automobiles entering the cities while introducing single rider mobility devices and the ShopMobility scheme in which stores have the mobility to provide services[15]

  2025 to 2035

135

Technological Trends

Reduction of Environmental Impact

Realization Timeline ▼

Promotion of public transportation

- Efforts are being promoted to achieve the concept of Mobility as a Service (MaaS). MaaS provides optimal personalized mobility services combining public and other transportation means. Reduction of environmental impacts and traffic congestions are two significant results[16]

  2025 to 2035

- Many tourist destinations are offering transportation as part of their entertainment activity packages. Sightseeing trains and Green Slow Mobility are also being introduced. The latter is a small-scale mobility services using electric vehicles that can travel on public roads at speeds under 20 km/h

  2020 to 2025

> Example
>
> Onomichi City and JR West Railway Company (JR-West) have been conducting an experimental project to introduce Green Slow Mobility service since 2019. The service is operated mainly on weekends and national holidays, where users can check the bus location and number of passengers in real-time using smartphones.[17]

Clues to Solutions

Regulatory Trends

- The Ministry of the Environment, Japan (MOE) and the Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) are jointly working to promote Green Slow Mobility which also attempts to address various regional transportation challenges. Support is being provided for demonstrations of experimental projects and the promotion of major decarbonization in regional transportation, securing the last one mile, promoting tourism, and revitalizing central urban areas[18]

- The MLIT and the Ministry of Economy, Trade and Industry, Japan (METI) started temporary tax reduction measures in 2019 to promote the purchase of eco-friendly cars[19]

- 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[20]

- The MLIT has introduced a dynamic road pricing system to reduce traffic congestion on the Metropolitan Expressway during the 2022 Tokyo Olympic and Paralympic Games. It was Japan's first implementation of such kind

- In November 2021, the MLIT made it mandatory for all new passenger vehicles produced in Japan to be equipped with an automatic braking system. Automakers are encouraged to further develop such technology

- Emission regulations in Japan are being tightened every year. Globally, the sale of fossil fuel-based vehicles has started to be restricted for better emission control. The U.K. government announced a plan for complete ban in 2035 on selling new gasoline and diesel vehicles in the country[21]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Deficiency of logistics capacity for increased demand

- Total volume of freight transportation in Japan has been decreasing over the long term. Due to the rapid increase of demand of home delivery services, the frequency of small-lot, high-frequency deliveries has been increasing. As a result, truck loading rates are declining and delivery efficiency is deteriorating[22]

- The trucking industry faces a shortage of drivers mainly due to low wages and long working hours

- If decreasing delivery efficiency and the shortage of truck drivers continue, the demand for smaller lots and more frequent deliveries cannot be satisfied. As a result, Japan's logistics service may not maintain its quick and reliable delivery

Japan **Potential Impact estimates** | One estimate suggests that the shortage of drivers will continue to rise to 591 thousand to meet the total domestic freight transportation demand of 3.17 billion metric tons in 2030. If the driver's per capita delivery efficiency does not exceed the record maximum of the past, 1.14 billion metric tons of cargo will not satisfied.[23] (A)

Japan **Unresolved** ➡ World **Unresolved**

Building a sustainable logistics network

Key Points for Resolving Issues

Improving Delivery Efficiency: Coordinating supply chain, matching shippers and trucks, and offering optimal route

- To improve operational efficiency, it is necessary to improve the utilization of existing resources by increasing truck loading rates and reducing waiting times

- In order to improve operational efficiency, the logistics industry needs to coordinate throughout the supply chain in transporting goods or levelling the shipment volume. Measuring the loading situation with sensors and cameras or matching shippers with trucks can improve the loading rate

- It is also necessary to minimize the driving distance and time by configuring optimal routes. There is a service being developed that detects recipients away from home and provides drivers with optimal routes to avoid redelivery

Labor-saving Measures and Automation: autonomous driving, utilization of delivery robots and drones

- Autonomous driving can be an efficient solution to fill the shortage of drivers in an environment where demand continues to increase. Semi-autonomous truck platooning technology is one technology in this field that is being developed. Multiple trucks in the convoy are wirelessly connected, and a crewed leading truck tows the rest of the unmanned vehicles

- Practical application of logistics robots and drones are also gaining popularity to enable automatic delivery operations

> **New Delivery Service:** Delivery by proprietary business drivers and mixed loading of freight and-passengers
>
> - Creating a non-conventional delivery mechanism may be the solution to cope with the increase in smaller-lot but higher-frequency type of domestic demand
>
> - Some companies offer services in which proprietary business drivers promptly deliver meals, perishable food, and groceries
>
> - Some transportation service providers started making better use of their buses and taxis for cargo delivery or mixed-loading with passengers

Clues to Solutions

Technological Trends

Improving Delivery Efficiency

Realization Timeline ▼

Coordinating supply chains

- Efforts to realize efficient logistics have started to take place not just among logistics companies but across the entire supply chain. R&D is underway to build and utilize a database that collects, centrally manages, and visualizes the information of distribution and commercial flow of the whole supply chain[24]

  2020 to 2025

  > Example
  >
  > The Strategic Innovation Promotion Program (SIP) of the Cabinet Office promotes R&D of elemental technologies for extensive utilization of logistic and commercial data platforms. The element technology includes (1) access control, (2) anti-tamper security, (3) extraction and conversion of individually managed data, (4) high-speed input-output processing, and (5) collaboration with other platforms.[25]

- Dynamic pricing is being introduced in the logistics industry as a mechanism for leveling the volume of deliveries and efficiently utilizing the delivery resources

  2020 to 2025

  > Example
  >
  > Seino Information Services, Co., Ltd. (Japan) has developed a system to level the delivery volume. The system uses AI to predict the demand and applies a discount rate for an early delivery reservation.

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Improving Delivery Efficiency

Realization Timeline ▼

Matching shippers and trucks

■ A service is being implemented to match shippers' demand with trucks which results in a reduction in inefficient truck operation. R&D is conducted to monitor the trucks' loading status using sensors and cameras

2020 to 2025

> Example
>
> a-xross corp. (Japan) operates "Trakuru Go", a delivery matching service that connects shippers and carriers. A shipper can compare fares of multiple carriers and simplify the process of arrangements. The carriers can search across the country for shipments that match the trucks' load availability.

> Example
>
> Nippon Express Company, Ltd., SoftBank Corp., Sharp Corporation, and Wireless City Planning Inc., conducted a proof-of-concept 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.[26]

Offering optimal routes

■ Technology has been developed to determine the optimal route derived from truck driving records and in-car sensors

2020 to 2025

> Example
>
> Groovenauts, Inc. (Japan) started a service to optimize logistics and distribution operations using quantum computing. The service automatically calculates and indicates an optimal delivery route with the shortest driving distance and time based on various information. The variables include trucks' loading and operating status, drivers' skills and working conditions, destination and designated delivery time, and customer-specific requirements.[27]

Avoiding redelivery

■ An AI-assisted system for selecting delivery routes is in development. The system detects the recipients' being away via smart meters for household electricity and optimizes delivery routes aiming to reduce possible redeliveries

2020 to 2025

> Example
>
> 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 absence 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%.[28,29]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Labor-saving and Automation -

Realization Timeline ▼

Autonomous driving

■ Unattended truck platooning technology is being developed to cope with the truck drivers' shortage and improve operational efficiency. Techniques for safe driving while maintaining a distance between vehicles by automatic control and semi-autonomous truck platooning technology is under development. A crewed leading truck tows a convoy of autonomous vehicles[30]

2020 to 2025

> Example
>
> 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 it on highways by the end of FY 2020. The two ministries commissioned Toyota Tsucho Corporation to experiment in February 2021. Three large trucks drove at 80 km/hour in a platoon with a nine-meter distance between each vehicle.[31]

Home delivery robots and drones

■ A proof-of-concept experiment of an unmanned delivery service is being conducted using micro-mobility, drones, and vertical takeoff and landing aircraft (VTOL). Practical use of drones is being pursued for small-lot delivery to sparsely populated areas and remote islands[32,33]

2020 to 2025

> Example
>
> In October 2021, Kawasaki Heavy Industries, Ltd. conducted two proof-of-concept experiments of an unmanned VTOL for delivery in Ina City, Nagano Prefecture, in 2021.
> In October, the delivery was made to a mountainous area. In November, a coordinated delivery test between VTOL and a logistic robot was conducted.The experiment confirmed the feasibility of a complete unmanned cargo transport conducted through the following three procedures: (1) the delivery robot with a load of parcels boards the unmanned VTOL unassisted, (2) the VTOL autonomously takeoffs, flies, and lands, (3) the delivery robot autonomously disembarks the VTOL and delivers the parcels.[34]

New Delivery Service -

Delivery by proprietary business drivers

■ A new business for small-lot delivery has also started. The business provides a service to match senders with independent delivery workers

2020 to 2025

> Example
>
> SAROUTE Co., Ltd. (Japan), a company engaged in the motorcycle courier business, operates a cloud service that matches senders with individual drivers. The app enables both parties to conduct all the procedures, from orders through payments.[35] The drivers deliver goods by bicycles or motorcycles on their free time. SAROUTE, together with a pharmacy, started a proof-of-concept experiment of a prescription drug delivery scheduled for six months from February 1st, 2022.[36]

Technological Trends

New Delivery Service -

Mixed loading of freight and passengers transport

Realization
Timeline
▼

■ Transportation service providers started mixed loading in which they carry both cargo simultaneously and passengers on an on-demand vehicle

20**20**
to
20**25**

> Example
>
> 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.[37]

Regulatory Trends

■ The Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) has been implementing measures to support efforts to improve the efficiency of distribution operations through the *Act on Advancement of Integration and Streamlining of Distribution Business*. They support efforts to reduce stress on the environment and contribute to labor-saving through collaboration between two or more companies[38]

■ The MLIT has allowed paid deliveries by private vehicles during designated busy seasons such as year-end, new year holidays and summertime. The approved carriers are required to provide safety guidance such as operation and labor management[39]

■ In 2020, the National Police Agency (NPA) clarified the procedures of proof-of-concept experiments for autonomous delivery robots on public roads. The NPA requires the 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 such specific requirements are met, such as when an automated delivery robot has 240 hours or more of driving record[40,41]

■ Since 2020, the government has been studying ways to improve the system to fly remotely controlled UAVs and drones in inhabited areas. As a countermeasure against frequent accidents and unauthorized flights, registration of UAVs will become mandatory from June 2022, and flights of unregistered aerial vehicles will be prohibited[42,43]

■ Starting April of 2024, based on *The Work Style Reform Act*, a ceiling on overtime for truck drivers will be enforced and the violators will be penalized

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (3) Expansion of areas where transportation is restrained

- In depopulated areas and suburbs, the decline of users affects the transportation operators' business. The central and local governments subsidize operating and vehicle expenses to maintain local transportation. However, the subsidy cannot cover the total costs, resulting in service level reduction or service discontinuation. Consequently, the benefits of the residents have been impaired, and depopulation has accelerated

- As the number of areas increases where the service level of public transportation is reduced or service is 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 thousand in 2010 to 1.09 million in 2040.[44] * 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 per hour.
Japan	**Potential Impact estimates**	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 those who live 500 meters or more from the nearest grocery store and do not have a car.[45]

Japan **Unresolved** ➡ World **Unresolved**

Societal Issues Providing mobility services to maintain quality of life

Key Points for Resolving Issues

Transportation to Fill the Demand/Supply Gap: On-demand and last-mile transportation

- Convenient and inexpensive transportation services are necessary to maintain the quality of life of residents where public transportation has been reduced or abolished

- On-demand transportation is available in some areas as an alternative to public transportation. The challenge is to eliminate the trouble of calling and making reservations that would otherwise reduce the convenience of these services. There is great demand for the operators to provide services that anyone can use easily, with special consideration regarding the people who do not use computers or smartphones

- It is vital to provide the last-one-mile transportation between the stations or bus stops and their final destinations to assist seniors or people who have difficulty walking

Transportation Services to Fulfill Users' Objectives: Collaboration and integration of transportation business with merchandise and service providers

- Transportation operators are not the only ones capable of providing this service

- Merchandise, medical, and tourism operators can also provide transportation as part of their services to help meet users' needs who live in areas without convenient transportation. Collaboration between transportation operators and service providers is becoming increasingly popular at certain destinations to provide transportation to and from stores in addition to home deliveries

- Conversely, another effective way to eliminate inconveniences is for the service providers to come within the proximity of the residences, such as through mobile retail and house call services

Small-scale Service to Meet Diverse Needs: Improving operational and network efficiency

- Transportation means must be maintained for residents in areas where total demand for transportation is expected to decrease due to the declining birthrates. In those areas, it is important to move from a centralized transportation system to a small-scale, dispersed system to meet users' diverse needs. Improving the operational efficiency of the existing network can be achieved with AI-assisted demand forecasting, efficient operation of autonomous driving, and mixed transportation of freight and passenger

Technological Trends

Highly Convenient Transportation Means - Realization Timeline ▼

On-demand transportation

■ On-Demand transportation has already seen much practical application. The benefits are also on full display, whereby using no fixed timetable or routes, the service is fully in line with the demands of its users. However, the inconvenience of making reservations remains a large impediment in expanding its usage. User-friendly apps and reservation kiosks are being developed for users who do not use smartphones or personal computers

20**20** to 20**25**

> | Example |
>
> Dai Nippon Printing Co., Ltd. and Mirai Share Co., Ltd. (Japan) conducted a proof-of-concept experiment in Odai Town, Mie Prefecture. The companies have developed an AI-assisted system that optimizes vehicle dispatching based on on-demand reservations and the locations of taxis and buses. They have also placed reservation kiosks at roadside stations and local clinics so that seniors without smartphones can easily use them. The kiosk employs digital signage with a touch screen allowing users to book transportation for home.[46]

Last-one-mile transportation to the final destination

■ Personal mobility and ultra-small mobility are attracting attention as means of realizing the goal of smooth transportation from railroad stations and bus stops to users' final destinations. Autonomous driving experiments are also being conducted in sparsely populated areas and tourist spots

20**20** to 20**25**

> | Example |
>
> Tsukuba City and KDDI CORPORATION (Japan) conducted a proof-of-concept experiment by linking an autonomous vehicle and an electric wheelchair in efforts to test the efficiency of low-speed personal mobility. By using a remote control device, these autonomous wheelchairs support the transportation from the users' residence to a hospital as well as the mobility of the wheelchair within the hospital facility.[47]

> | Example |
>
> Toyota Transportation Research Institute (Japan) conducted an experiment on public roads of Toyota's self-balancing two-wheeled personal mobility vehicles. The experiment was designed to support senior users who have difficulty walking long distance. Because users stand on the vehicle and move slowly, it is possible to hold a conversation with a pedestrian.[48]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Transportation Services to Fulfill Users' Objectives -

Collaboration of transportation operators and service providers

■ Demand for highly convenient services, including activities at the destination, has been increasing in recent years. Through collaboration between transportation operators and service providers at the commercial facilities, a response is being crafted through intense experimentation.

2020
to
2025

> Example
>
> MONET Technologies and IZUMI Co., Ltd., a shopping center operator, are conducting a proof-of-concept experiment of MaaS for retail business by linking mobile services with retail stores. MONET Technologies provides an on-demand bus to pick up and drop off customers at supermarkets. It also provides a shopping support service that allows customers to order items in advance over the phone and pick them up directly at the store front. The buses are operated as mixed freight-passenger transportation and the services include delivery of commercial merchandise.[49]

Mobile retailers and services

■ Automakers and retailers such as supermarkets and convenience stores are collaborating to develop unmanned mobile retail stores with autonomous driving technology. The technology is expected to help resolve problems not just in urban areas but also in more depleted areas where shopping is difficult, like sparsely populated rural zones

2020
to
2025

> Example
>
> A U.S. supermarket chain, Stop & Shop Supermarket Company, partnered with Robomart, Inc. (U.S.) to launch a mobile grocery service of perishable food with autonomous driving vehicles, Robomarts, in 2019.[50]

■ Vehicles equipped to provide nursing and medical care combined with 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
to
2025

> Example
>
> Ina City in Nagano Prefecture has conducted a proof-of-concept experiment on mobile medical care. The multi-purpose medical vehicle visits the users and provides online medical care via a medical doctor from a remote location. The service aims to kill two birds with one stone by resolving the shortage of physicians in rural areas and helping maintain the health of residents who have mobility difficulties. A nurse will board the vehicle mounted with medical equipment, help the patients, and support the doctor. In FY 2022, the city plans to provide mobile administrative service utilizing local community buses during their idle time.[51]

Technological Trends

Meeting Small-scale Service Diverse Needs

Streamlining of operations

■ AI enables demand forecasting, congestion prediction, and the ability to search for optimal routes. Practical application of AI based on-demand transportation services with high level of convenience and efficiency is seeing great success

2020 to 2025

> Example
>
> Nissan Motor Co., Ltd., and NTT DOCOMO, INC. have conducted a proof-of-concept experiment in Yokohama City of an autonomous driving service that optimizes allocation of vehicles and routes by using AI to respond in real-time to passengers' boarding requests.[52]

■ Autonomous buses are seeing practical application on public roads to help reduce the negative impacts of decreasing access to traditional bus routes.

2020 to 2025

Improving the efficiency of existing networks

■ The mixed freight-passenger loading for railroad, bus, taxi and on-demand transportation is spreading to maintain regional transportation and improve logistics efficiency

2020 to 2025

■ On-Demand transportation and home delivery services in areas with low population density improve user convenience, operator utilization rate, and transportation efficiency

2020 to 2025

> Example
>
> Nissan Motor Co., Ltd., and Toppan Inc., together with 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 provides a new shopping experience with a VR-enabled shopping support service for users who cannot come to stores by themselves. At the same time, it improves delivery efficiency by utilizing on-demand transportation.[53]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

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. A mixed passenger and freight transportation is currently permitted for scheduled local buses nationwide and for chartered buses, taxis, and trucks in sparsely populated areas[54]

- The government is looking into revising transportation regulations to enable the safe use of new technologies, such as personal mobility and electric scooters with an emphasis on consistent 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 the new transportation regulations and the classification of vehicles under *the Road Traffic Act*[55]

- The MLIT simplified the notification process of fare setting in 2020 to promote flexible fare arrangements among multiple operators and collaboration among stakeholders at the destination. A special provision was put in place requiring only one representative entity to submit the fare application[56]

- 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. Today, municipalities and NPOs can operate the service for residents and tourists or welfare-related deliveries only in areas without public transportation[57,58]

- In November 2021, the Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT) partially lifted the ban on ride-sharing taxi services nationwide. The taxi operators are required to match passengers with similar destinations through an app and provide a shared ride[59]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (4)	Rapid changes in means of transportation and opportunities utilizing digital technologies

- Remarkable progress in the digitization and proliferation of online services is expanding the possibilities for new activities and communication. New technologies are under the spotlight as a means to create diverse opportunities for activity, especially through better mobility services in the new normal

Japan Potential Impact estimates	Changes in working styles, such as work-from-home, could lead to bigger spending on e-learning and other services that enhance the quality of life. Its potential market size is estimated to increase by 33%, from JPY 247.2 billion in 2021 to JPY 327.9 billion in 2030. (A)

Estimation Method

Potential market size = (Number of employees) multiplied by (The percentage of employees who take e-learning classes) multiplied by (The monthly tuition per person engaged in a work).

・Number of employees: 66.59 million in 2021 (*Labour Force Survey* in December 2021), 54.49 million in 2030 (Estimated by the Ministry of Health, Labour and Welfare, Japan (MLIT))

・The percentage of employees who take e-learning classes:

The MRI Market Intelligence and Forecasting System estimated the rate of change in 2030 as 16.4%, based on 4.4% in 2012 and 11.6% in 2021.

・The monthly tuition per person:

JPY 2,667 in 2021. Based on the monthly tuition in the *Estimated from the Family Income and Expenditure Survey* in 2021, assuming it will stay the same in 2030.

Japan Potential Impact estimates	The popularity of work-from-home will encourage people to move from Tokyo Metropolitan Area to provincial areas. This demographic is substantial with potentially 230 thousand able to move including work-from-home candidates, their families, and those in the service industry. By one estimate, the positive effect on the local consumption is JPY 500 billion[60] (C)

World Unresolved → Japan Unresolved

Societal Issues	Providing wider variety of customer experiences in response to the changes in the configuration of transportation

Key Points for Resolving Issues

Diversifying Work Styles: Improving efficiency in work and creating a better work-life balance

- Work-from-home has spread rapidly in light of the COVID-19 pandemic. Along with the trend toward work-life balance reform, the digitalization of office work is expected to accelerate. People started to shift from offices within cities to more regional areas

- Online services that can effectively use the spare time created by streamlining 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 and health promotion services

149

New Tourism: Providing diverse experiences to meet customer needs in tourism

- Online tourism, a new form of travel, is attracting attention. Tours in the virtual sphere, such as space travel, can provide an experience that would otherwise be difficult to achieve in real life. It also makes it possible to create a travel experience without putting a burden on the environment or dealing with the constraints of travelling

- As people transfer or migrate to provincial areas, the recreational value of meeting people and experiencing culture in person is being reassessed to place greater emphasis on the connections rooted in the local communities. Through in-person experiences, these new recreational activities will also help regional revitalization

Next-generation Mobility: New mobility and development of associated services

- The means of transportation are also changing. The latest changes include the expansion of ride-sharing, mobility as an entertainment, and the spread of remote-controlled robots that reduce the need for 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 people to pay attention to the time spent in vehicles as ways to experience the sphere of mobility. As the travel time grows, services to make better use will lead to an enormous business opportunity

Clues to Solutions

Technological Trends

Diversification of Work Styles --- Realization Timeline ▼

Improving office environment

- In the wake of the COVID-19 pandemic, hotels have experienced a drastic decrease in demand. Some hotels are even remodeling into office spaces

  2020 to 2025

  | Example |

  The Osaka City Shinkin Bank has started operating its Yodoyabash Office in the BizMiix Yodoyabashi, a rental office which was remodeled from a bankrupt hotel. The bank intends to utilize the office to provide consultation services for the occupants and make it a development center for seminars.[61]

Technological Trends

Diversification of Work Styles --

Realization Timeline ▼

Integrating office and house in provincial Areas

- The prevalence of work-from-home has shifted people's housing needs toward increased interest in relocation to areas. As a result, the need for satellite offices in provincial areas is expected to increase

  2020 to 2025

- Attention has been drawn to efforts to utilize work-from-home to create a better work-life balance and to enjoy personal travelling after business trips[62]

  2020 to 2025

> **Example**
>
> MRI is promoting the idea of a temporary work-from-home system in provincial areas for office workers in large cities. To achieve this concept of simultaneously realizing work style reform and regional revitalization, MRI implemented the program in cooperation with nine municipalities.

Use of spare time

- Various skill-sharing services that offer and share expert knowledge and experience online are gaining popularity to utilize spare time and improve the quality of life

  2020 to 2025

New Tourism --

Utilizing various digitization

- Metaverse tourism, which enables tourists to visit a city in a virtual sphere, is becoming popular as an alternative to in-person traveling. The city is a recreation of an actual city using location information technology such as GPS and GIS[63]

  2020 to 2025

- Metaverse tourism is expected to contribute to regional revitalization by visualizing the multifaceted attractiveness of each region and providing opportunities to enjoy the new value of the area

  2020 to 2025

> **Example**
>
> Tourist destinations in Sumida Ward tend to be concentrated around the Tokyo Skytree. The ward is attempting to disperse the concentrated area by visualizing diverse cultural resources and attractions by creating a metaverse tourism map. The ward also develops human resources for the metaverse tourism.[64]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

New Tourism

Realization
Timeline
▼

Tourism as means of regional revitalization

■ The value of the real world is being re-evaluated, especially the parts that cannot be satisfied directly by the online experience. There is a movement to utilize renovated antique traditional Japanese homes or vacant houses for lodging places where a region-specific experience is provided[65]

| 2020 to 2025 |

Example

NOTE, Inc. (Japan) aims to support regional revitalization by creating a renaissance of historic buildings forgotten in the region and 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.[66]

Example

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 the antique traditional houses along the villages of the railroad lines as guest rooms. It utilizes station buildings and railroad facilities as the hotel's front desk. They build the concept, "Transferring the Whole Railroad and Vicinity Hotel," by collaborating with residents to provide customer service and management.[67]

■ Attention is being paid to new ways for tourists not just to temporarily visit local areas, but to enjoy new ways of tourism by participating directly in resolving local problems and deeply interacting with residents.

| 2020 to 2025 |

Example

OTETSUTABI (JAPAN) runs a Web platform that matches farmers, local inns, and other business operators facing short-term and seasonal labor shortages with young people interested in the region. The participants, while enjoying the trip, can also reduce travel expenses and interact with local businesses by helping farmers and inns.[68]

Mobility of Next Generation

Shared mobility

■ An expansion has been seen in the use of electric kick scooters and electric bikes for the last-one-mile transportation[69]

| 2020 to 2025 |

■ Matching apps for the shared taxis are being developed and its proof-of-concept experiments are taking place in various locations. It is expected to be used for short-distance travel and solve the taxi driver shortage problem

| 2025 to 2035 |

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Mobility of Next Generation

Realization Timeline ▼

Remotely operated robots

- There is a growing service that intends to provide a travel experience comparable to in-person tourism by combining avatars and remote-controlled robots

2020 to 2025

> Example
>
> avatarin, Inc. (Japan), a startup launched from ANA HOLDINGS, has developed "avatarin," which allows users to instantly move to a place where the avatar or remote-controlled robot is located.[79]

- New technologies, such as telexistence and haptics, are being put into practical use. They enable users to maneuver remote robots with senses and body functions similar to that of humans

2025 to 2035

Entertainment in transportation

- The prevalence of autonomous driving has prompted the creation of services offering new mobility experiences

2025 to 2035

> Example
>
> Sony Corporation unveiled a concept car, Vision-S, and announced the inauguration of Sony Mobility Inc. scheduled in the spring of 2022. The company aims to provide a new sphere of mobility that includes entertainment experiences enabled with novel technologies.[71]

> Example
>
> Gekidaniino, G.K., a group company of the Kansai Electric Power Co., Inc., has developed "iino," a transportation device that runs autonomously at a low speed of 5 km/hour. It can move side-by-side with walking pedestrians and provide an enjoyable mobility experience.[72]

Regulatory Trends

- The Cabinet Office, Government of Japan (CAO) promotes work from home that contributes to regional revitalization. Subsidies are provided to support projects to create a flow of people to regions through the construction and operation of satellite offices[73]

- In cooperation with other ministries and agencies, the CAO engages to create and expand the number of non-residents that connect, contribute, and interact with another local community. They promote it by disseminating information through its portal site and allocating local tax grants for model projects[74,75]

- The Japan Tourism Agency (JTA) launched the "Project to Discover My Second Hometown" to promote relationships with new people and revitalize the local economy[76]

- With the increased popularity of electric kick scooters, the National Police Agency (NPA) is considering relaxing regulation set for electric bikes. Current regulation requires kick scooter users to obtain a driver's license, drive on vehicle lanes, and wear helmets

ICF issues with targets in UN SDGs

Problems	Issues
(1) Adverse effects of vehicle-centric transportation systems	**Optimizing traffic flow and promoting the use of safe and comfortable mobility services**
	Targets in UN SDGs
	3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents
(2) Deficiency of logistics capacity for increased demand	**Building a sustainable logistics network**
	—
(3) Expansion of areas where transportation is restrained	**Providing mobility services to maintain quality of life**
	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
(4) Rapid changes in means of transportation and opportunities utilizing digital technologies	**Providing wider variety of customer experiences in response to the changes in the configuration of transportation**
	—

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Notes and References

All URLs were viewed on September 1st, 2021.

1   Economic loss per driver from Pishue, B., 2021 INRIX Global Traffic Scorecard, December 2021.
     https://lesvoitures.fr/wp-content/uploads/2021/12/2021_INRIX_Scorecard_Report-Paris-embouteilages-2021.pdf

2   Population estimates by countries as of July 1, 2021, listed in Statistics Bureau, Ministry of Internal Affairs and
     Communications, Japan, World Statistics 2021, March 2021. (in Japanese) https://www.stat.go.jp/data/sekai/notes.html

3   *Traffic Planning Division, Traffic Bureau, National Police Agency, Japan, Traffic Fatalities in FY2021, January 26, 2022. (in
     Japanese)*
     *https://www.e-stat.go.jp/stat-
     search/files?page=1&layout=datalist&toukei=00130002&tstat=000001032793&cycle=7&year=20210&month=0&tclas
     s1val=0*

4   Traffic Bureau, National Police Agency, Japan, "Trends in the number of traffic accidents by motorists as a primary party by
     age group," Traffic Accidents in 2020, p. 23, February 18, 2021. (in Japanese)
     https://www.npa.go.jp/publications/statistics/koutsuu/index_jiko.html

5   Zhang, R, and Fujimori, S., "The role of transport electrification in global climate change mitigation scenarios,"
     Environmental Research Letter, Vol. 15, 034029, 2020.
     https://iopscience.iop.org/article/10.1088/1748-9326/ab6658

6   TOYOTA CENTRAL R&D LABS., INC., "TOYOTA CENTRAL R&D LABS developed an optimization technology to control large-
     scale traffic signal clusters using quantum computing," News Release, February 10, 2021. (in Japanese)
     https://www.tytlabs.co.jp/cms/news/news-20210210-1834.html
     https://doi.org/10.1038/s41598-021-82740-0

7   Sumitomo Corporation, "Commencement of pilot experiment for developing flight routes for numerous air mobility vehicles
     by quantum computing," News, June 02, 2021.
     https://www.sumitomocorp.com/en/jp/news/release/2021/group/14850

8   Cabinet Office, Japan, "Mitsubishi Heavy Industries (MHI) Group to win the contract for Next-generation Electronic Road
     Pricing system using positioning satellites in Singapore," Related News, Quasi-Zenith Satellite System (QZSS), March 18,
     2016. (in Japanese)
     https://qzss.go.jp/info/archive/singapore_160318.html

9   Cabinet Office, Japan, "Toyota Tsusho Corporation to conduct a practical demonstration of route-guidance system with the
     Quasi-Zenith Satellite System (QZSS) in Bangkok in March," Related News, Quasi-Zenith Satellite System (QZSS), February
     6, 2018. (in Japanese)
     https://qzss.go.jp/info/archive/toyota-tsusho_180206.html/

10   Central Nippon Expressway Co., Ltd., "Demonstration experiment started aiming at CO_2 emission reduction through
     behavioral changes near Gotemba Premium Outlets," News Release, November 5, 2021. (in Japanese)
     https://www.c-nexco.co.jp/corporate/pressroom/news_release/5289.html

11   Fujiwara, A., "Mazda's autonomous driving system to stop the autonomous driving vehicle when catching abnormalities,"
     The Nikkei, online edition, December 21, 2021. (in Japanese)
     https://www.nikkei.com/article/DGXZQOUC173S20X11C21A2000000/

12   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "Revision of the Production Green Land Act." (in Japanese)
     https://www.mlit.go.jp/common/001198169.pdf

13   World Economic Forum, "The circular cars initiative."
     https://www.weforum.org/projects/the-circular-cars-initiative

14   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "'Comfortable and walkable streets' are spreading ~ Come
     to Kobe to think about a walkable city! ~" (in Japanese)
     https://www.mlit.go.jp/report/press/toshi09_hh_000058.html

15   akippa Inc., "akippa Inc. partners with Mellow Inc. for mobility business platform development," PR TIMES, February 2,
     2021. (in Japanese)
     https://prtimes.jp/main/html/rd/p/000000287.000016205.html

16   "Japan Radio Co., Ltd. and NEDO to launch a joint research project on an integrated traffic signal management enabled
     with AI," News Release, The Nikkei, online edition, September 6, 2018. (in Japanese)
     https://www.nikkei.com/article/DGXLRSP489844_W8A900C1000000/

17   Onomichi City, "The operation schedule in Fall 2021 as a part of Demonstration Project for the Effective Introduction of
     Green Slow Mobility Using IoT Technology," October 8, 2021. (in
     Japanese)https://www.city.onomichi.hiroshima.jp/soshiki/2/43356.html

18   The Ministry of the Environment, Japan, "Green Slow Mobility." (in Japanese)
     https://www.env.go.jp/earth/earth/ondanka/green_slow_mobility/index.html

Notes and References

All URLs were viewed on September 1st, 2021.

19 *Ministry of Land, Infrastructure, Transport and Tourism, Japan, "Tax system related to automobiles." (in Japanese)*
https://www.mlit.go.jp/jidosha/jidosha_fr1_000028.html

20 The Ministry of Land, Infrastructure, Transport and Tourism, Japan, "Efforts to rebuild and use street spaces: Creating comfortable and walkable streets." (in Japanese)
https://www.mlit.go.jp/toshi/toshi_gairo_tk_000081.html

21 Gov.UK, "Consulting on ending the sale of new petrol, diesel, and hybrid cars and vans," July 14, 2021.https://www.gov.uk/government/consultations/consulting-on-ending-the-sale-of-new-petrol-diesel-and-hybrid-cars-and-vans/consulting-on-ending-the-sale-of-new-petrol-diesel-and-hybrid-cars-and-vans

22 Automobile Division, Manufacturing Industries Bureau, the Ministry of Economy, Trade and Industry, Japan, Report by Study Group on New Mobility Services in the Field of Distributions (Study Group on Distribution MaaS), pp. 9-10, April 20, 2020. (in Japanese)
https://www.meti.go.jp/press/2020/04/20200420005/20200420005-3.pdf

23 Japan Institute of Logistics Systems, Logistics Concept 2030, pp. 15 – 16, February 7, 2020. (in Japanese)
http://www.logistics.or.jp/2030/%E3%83%AD%E3%82%B8%E3%82%B9%E3%83%86%E3%82%A3%E3%82%AF%E3%82%B9%E3%82%B3%E3%83%B3%E3%82%BB%E3%83%97%E3%83%882030.pdf

24 Ministry of Land, Infrastructure, Transport and Tourism, Japan, Summary of the Recommendations for Sustainable Logistics through Collaboration – Learnings from the Case Examples to Improve Logistics Productivity, June 21, 2019. (in Japanese)
https://www.mlit.go.jp/common/001294318.pdf

25 Secretariat of Science, Technology and Innovation Policy, Cabinet Office, Japan, The R&D Plan for Smart Logistics Service for Strategic Innovation Promotion Program (SIP), May 26, 2021. (in Japanese)
https://www8.cao.go.jp/cstp/gaiyo/sip/keikaku2/11_logistics.pdf

26 SoftBank Corp., "3D visualization of trucks' loading status: A demonstration experiment to improve truck delivery operations efficiency using 5G," SoftBank News, March 9, 2020. (in Japanese)
https://www.softbank.jp/sbnews/entry/20200309_02

27 Groovenauts, Inc., "Groovenauts validated the 50% reduction in delivery trucks driving distance! Launch of the Logistics Optimized Solution Set utilizing quantum computing," press release, September 1, 2020. (in Japanese)
https://www.magellanic-clouds.com/blocks/wp-content/uploads/2020/09/20200901.pdf

28 SAGAWA EXPRESS CO., LTD., "Using AI and power consumption data to resolve redelivery due to absence," presentation at the 6th Growth Strategy Working Group, Council for Regulatory Reform, February 21, 2020. (in Japanese)
https://www8.cao.go.jp/kisei-kaikaku/kisei/meeting/wg/seicho/20200221/200221seicho03.pdf

29 SAGAWA EXPRESS CO., LTD., "Using AI and power consumption data to resolve redelivery due to absence," presentation at the 6th Growth Strategy Working Group, Council for Regulatory Reform, February 21, 2020. (in Japanese)
https://www8.cao.go.jp/kisei-kaikaku/kisei/meeting/wg/seicho/20200221/200221seicho03.pdf

30 Ogawa, H. (Technical Planning and Review Committee for Trucks Lead, Japan Automobile Manufacturers Association, Inc. (JAMA); Executive Technical Advisor, Hino Motors, Ltd.), "The state and issues of truck platooning," presented at MLIT's Second Road Spaces for Autonomous Driving Committee, p. 14, August 28, 2019. (in Japanese)
https://www.mlit.go.jp/road/ir/ir-council/road_space/pdf02/02.pdf

31 Ministry of Economy, Trade and Industry, Japan, "Successful autonomous driving technology tests for truck platooning," news release, March 3, 2021.
https://www.meti.go.jp/english/press/2021/0305_003.html

32 Kawasaki Heavy Industries, Ltd., "Agreed on the joint development of and demonstration experiment for service construction of autonomous robots for last-mile deliveries," press release, August 31, 2021. (in Japanese)https://www.khi.co.jp/pressrelease/news_210831-1.pdf

33 "VTOL aircraft to transport supplies to mountain huts to become practical in FY 2026," Nagano Nippo, December 2, 2021. (in Japanese)
http://www.nagano-np.co.jp/articles/86455

34 Kawasaki Heavy Industries, Ltd., "Kawasaki completes proof-of-concept testing for unmanned cargo transport by cooperation of unmanned VTOL aircraft and delivery robot," November 29, 2021.
https://global.kawasaki.com/en/corp/newsroom/news/detail/?f=20211129_7602

35 SAROUTE Co., Ltd., "DIAq." (in Japanese) https://www.dia-9.com/

36 SAROUTE Co., Ltd., "SOKUYAKU, a DIAq API integrated service become available in Osaka City," announcement, September 2, 2021. (in Japanese) https://www.saroute.co.jp/inf_doc/inf38002.html.

37 Mirai Share Co., Ltd., "Mirai Share starts a home delivery service of mixed loading of freight-passenger with AI taxi, Kappi Noriai," news, May 26, 2020. (in Japanese)
https://www.miraishare.co.jp/202005kappidelivery/

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Notes and References

All URLs were viewed on September 1st, 2021.

38   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Guidance in Applying Approval of the Comprehensive Efficiency Plan of the Act on Advancement of Integration and Streamlining of Distribution Business, May 2021 revision. (in Japanese)
https://www.mlit.go.jp/common/001403258.pdf

39   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Document No. 3 for the Third Investment Working Group, Council for Regulatory Reform, November 6, 2020. (in Japanese)
https://www8.cao.go.jp/kisei-kaikaku/kisei/meeting/wg/toushi/20201106/201106toushi03.pdf

40   National Police Agency, Japan, "Procedures for demonstration experiments of automated delivery robots on public roads for proximity monitoring with the operation and remote monitoring with operation types." (in Japanese)
https://www.npa.go.jp/bureau/traffic/selfdriving/202009robotjikkentejun.pdf

41   National Police Agency, Japan, "Police initiatives to realize autonomous driving." (in Japanese)
https://www.npa.go.jp/bureau/traffic/selfdriving/NPA-initiative.pdf

42   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "Executive summary for the Interim Report by Subcommittee for Realization of Level 4 UAV Flights (Beyond Visual Line of Sight) above Inhabited Areas," Technology and Safety Subgroup, Aviation Group, Council of Transportation Policy and the Panel on Infrastructure Development, March 8, 2021. (in Japanese)
https://www.mlit.go.jp/policy/shingikai/content/001389495.pdf

43   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "Unmanned aircraft registration web portal."
https://www.mlit.go.jp/koku/drone/en/

44   "Column 5: The elderly vulnerable transportation users," Regional issues related to population distribution (2), NIES Research Booklet, Vol. 71, National Institute for Environmental Studies, December 27, 2018. (in Japanese)
https://www.nies.go.jp/kanko/kankyogi/71/column5.html

45   Yakushiji, T. (Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries), "Executive summary for 'Food access issues and health of the seniors,'" October 21, 2014. (in Japanese)
https://www.maff.go.jp/primaff/koho/seminar/2014/attach/pdf/141021_02.pdf

46   Dai Nippon Printing Co., Ltd., "DNP and Mirai Share to conduct an on-site experiment of an AI-assisted on-demand transportation service in Odai Town, Mie Prefecture," news, November 2, 2021. (in Japanese)
https://www.dnp.co.jp/news/detail/10161637_1587.html

47   Tsukuba Smart City Council, "The Council conducted an on-site experiment of the Smart Community Mobility to support commuting to hospitals with autonomous vehicles and personal mobilities," March 9, 2021. (in Japanese)
https://www.sompo-japan.co.jp/-/media/SJNK/files/topics/2020/20210309_1.pdf?la=ja-JP

48   Toyota City, "Toyota City to conduct a demonstration deregulation experiment for self-balancing two-wheeled personal EV in public roads," press release, July 7, 2021. (in Japanese)
https://www.city.toyota.aichi.jp/pressrelease/1044523/1044588.html

49   MONET Technologies Inc., "MONET launches a practical application for the Autono-MaaS, a MaaS for a retail business with an autonomous vehicle," press release, December 4, 2020. (in Japanese)
https://www.monet-technologies.com/news/press/2020/20201204_01

50   Stop & Shop, press release.
https://stopandshop.com/news-and-media/article-01-16-19

51   Ina City, MONET Technologies Inc., "Ina City and MONET concluded business partnership agreement for a next-generation mobility service," May 14, 2019. (in Japanese)
https://www.inacity.jp/shisei/inashiseisakusesaku/shinsangyougijutu/osirase/teiketu.files/mobileclinic.pdf

52   NTT DOCOMO, INC., "Nissan and DOCOMO test an on-demand dentist service using autonomous vehicles," topics, July 19, 2021. (in Japanese)
https://www.nttdocomo.co.jp/binary/pdf/info/news_release/topics_210719_01.pdf

53   Toppan Inc., "Toppan, NoMA Lab, and Minamisoma City to begin a demonstration experiment of VR shopping support service," March 24, 2021. (in Japanese)
https://www.toppan.co.jp/news/2021/03/newsrelease210324_3.html

54   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "MLIT to enhance the productivity of the automobile transportation industry through the mixed freight-passenger transport – Allowing road transport operators to carry both human and cargo in dispersed areas -," press release, June 30, 2017. (in Japanese)
https://www.mlit.go.jp/common/001190936.pdf

55   National Police Agency, Japan, "The purpose of the Expert Committee for Transportation Regulation for Diverse Stakeholders," July. 2020. (in Japanese)
https://www.npa.go.jp/bureau/traffic/council/mobility/0702-4.pdf

56   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "(3) Promotion of new mobility services such as MaaS," Section 4, Chapter 2, White Paper on Land, Infrastructure, Transport and Tourism in Japan, p. 164, 2021. (in Japanese)
https://www.mlit.go.jp/hakusyo/mlit/r02/hakusho/r03/pdf/kokudo.pdf

Notes and References

All URLs were viewed on September 1st, 2021.

57   Passenger Transport Division, Road Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan, Handbook on Profit Transportation of Passengers and Freight with Private Vehicles, April 2018 (revised in November 2020). (in Japanese)
https://www.mlit.go.jp/common/001374819.pdf

58   Road Transport Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan, "Revision of laws and regulations pertaining to profit transportation of passengers and freight with private vehicles," January 22, 2021. (in Japanese)
https://zenkoku-ido.net/_laws/201127kaisei_syorei_tsutatsu/210122tokyoHC_seminar_shiryo.pdf

59   Director-General, Road Transport Bureau, the Ministry of Land, Infrastructure, Transport and Tourism, Japan, "Handling of carpooling passengers in general passenger vehicle transportation business," circular notice, October 29, 2021. (in Japanese)
https://www.mlit.go.jp/jidosha/content/001429619.pdf

60   The Osaka City Shinkin Bank, "Osaka City Shinkin Bank establishes Yodoyabashi Office to expand consultation functions for start-ups and existing customers," news release, March 10, 2021. (in Japanese)
https://www.osaka-city-shinkin.co.jp/news/2020/20210310yodoyabashi.pdf

61   BizMiiX (in Japanese) https://bizmiix.jp/

62   Japan Tourism Agency, A New Travel Style: Workation & Bleisure - Brochure for Companies, March 2021. (in Japanese)
https://www.mlit.go.jp/kankocho/workation-bleisure/img/wb_pamphlet_corporate.pdf

63   Ashibi Company Co., Ltd., Virtual OKINAWA. (in Japanese)
https://virtualokinawa.jp/

64   META Tourism, Sumida Meta Tourism Festival - September to December 2021. (in Japanese)
https://www.sumida.metatourism.jp/

65   "NIPPONIA: The key to building communities after the COVID-19 pandemic is to make use of the increasing number of vacant houses (Part 1)," Yamato-gokoro .jp, November 19, 2020. (in Japanese)
https://yamatogokoro.jp/inbound_case/40905

66   NIPPONIA. (in Japanese) https://team.nipponia.or.jp/

67   East Japan Railway Company, SATOYUME CO., LTD., "JR East and SATOYUME to establish a joint venture, Ensen Marugoto Co., Ltd. – Human-centered development of high value-added regional businesses – ," JR East News, November 19, 2021. (in Japanese)
https://www.jreast.co.jp/press/2021/hachioji/20211119_hc004.pdf

68   OTETSUTABI. (in Japanese) https://otetsutabi.com/

69   LUUP. (in Japanese) https://luup.sc/

70   avatarin, Inc., avatarin. (in Japanese)
https://avatarin.com/concept

71   Sony Corporation, "Sony unveils Vision-S 02 at CES 2022," news, January 4, 2022. (in Japanese)
https://www.sony.com/ja/SonyInfo/vision-s/news.html#entry13

72   Gekidaniino G.K., "Gekidaniino released a 5 km/h new mobility, 'iino' Type-S and Type-R," news, October 2, 2020. (in Japanese) https://gekidaniino.co.jp/news/

73   Office for Promotion of Regional Revitalization, Cabinet Office, Japan, Subsidy for Telework in Aiming Regional Revitalization, May 10, 2021. (in Japanese)
https://www.chisou.go.jp/sousei/about/mirai/pdf/teleworkkouhukin_gaiyou210510.pdf

74   Office for Promotion of Regional Revitalization, Cabinet Office, Japan, Convection Promotion Project for Creation and Expansion of Relevant Population. (in Japanese)
https://www.mlit.go.jp/kokudoseisaku/content/001396632.pdf

75   Ministry of Internal Affairs and Communications, Japan, "The portal for Relevant Population." (in Japanese)
https://www.soumu.go.jp/kankeijinkou/form/index.html

76   Japan Tourism Agency, "Advisory council for Creating Second Hometown Project," December 28, 2021. (in Japanese)
https://www.mlit.go.jp/kankocho/dai2nofurusato.html

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

5. Disaster Prevention and Infrastructure

A RESILIENT SOCIETY WHERE ALL ARE ASSURED THE SAFETY AND SECURITY

In considering the field of disaster prevention & infrastructure, ICF defines the ideal future society as a resilient society where the safety and security of all are assured.

Many of the UN's SDGs include items on resilience and disaster, and it has become a common global issue. In the event of a natural disaster such as an earthquake, typhoon, heavy rain, or tsunami, the preparedness of society determines the extent of damage and the time needed to recover. As a disaster-prone country, Japan should take the lead in disaster resilience spanning its promotion and implementation. Preventative measures include technologies for prediction, techniques for mitigation, and education for disaster preparedness. Measures to be taken after a disaster are the transportation of relief supplies and repairing of malfunctions that surfaced in long-term infrastructure. Global warming is the cause behind the year by year growth in the frequency and intensity of natural disasters; Japan is no exception to the resulting loss in human lives and damages to critical infrastructure. Japan is merely halfway in achieving its goal of becoming a resilient society.

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. Targets must be set higher than utilizing AI to improve efficiency in infrastructure maintenance; 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. Key solutions can be derived from new technologies and innovations.

From the viewpoints above, ICF has identified the following four problems and issues in the disaster prevention and infrastructure fields.

(1) Insufficient preparation and response to natural disasters	→ Strengthening of disaster response capabilities through innovative technologies and societal infrastructure
(2) Poor management of societal infrastructure	→ Improvements to efficient management of infrastructure through aggregated and centralized control, and better utilization
(3) Urban decay caused by an increasing number of vacant houses	→ Revitalization of local communities by making use of vacant houses
(4) Larger number and harsher types of cyberattack	→ Security measures based on a *Society 5.0* world

Legend

Potential impact estimates

(A) The maximum impact on financial cost and future population by 2025 to 2030 if no effective countermeasures are taken

(B) The maximum impact of the worst-case scenario that can be reasonably expected to occur at present

Issues and Challenges are classified into three categories:

Japan	World		Japan	World		World	Japan
Resolved ⇒	Unresolved		Unresolved ⇒	Unresolved		Unresolved ⇒	Unresolved

(1) Issues that have already been resolved in Japan, and utilizing Japanese technologies that can be of help in resolving global issues;

(2) Current issues that also exist in Japan. By becoming the first country to resolve them, Japan can lead the pack on global issues; and

(3) Early tackling of future global issues will lead to resolving them in Japan in the future.

Insufficient preparation and response to natural disasters
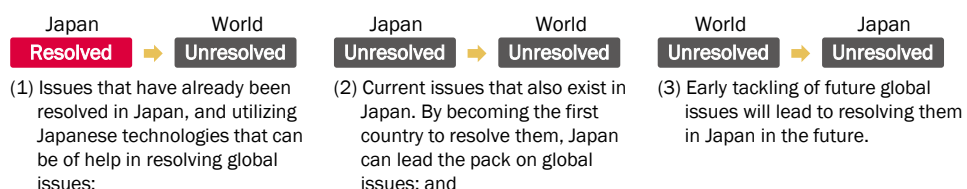
- Natural disasters have increased both in frequency and severity due to climate change leading to large losses in human life and severe damage to infrastructure. As a result, more time is required for the recovery and reconstruction of infrastructure

- 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, only local and passive responses are taken during large-scale disasters, and which is often followed by secondary disasters. Especially for small and medium-size rivers, hazard maps are not sufficiently compiled, resulting in the frequent occurrence of unforeseen damage[1]

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).[2] (B)

- 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

Japan **Potential Impact estimates**	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.[3](A)

Japan **Unresolved** ➡ World **Unresolved**

Societal 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. They offer opportunity to be better prepared as opposed to 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

Normal Times and During Disasters: Prediction and assessment of disasters via public-private sharing of information establishing an operating framework

- 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

Emergency Response: Assisted and un-assisted evacuation of local residents

- The swift evacuation of residents in the event of a disaster requires more than conveying information; it must be translated, residents must be instilled with a sense of urgency, and response must provide the complete transportation of evacuees and supplies . 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

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

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Normal Times -   Realization Timeline ▼

Disaster prediction

- 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. NIED is conducting research to upgrade MOWLAS[4]   **2020 to 2025**

- 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[5]   **2020 to 2025**

- 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[6]   **2020 to 2025**

- 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[7]   **2020 to 2025**

- 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 to 2035**

> **Example**
>
> 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.[8]

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[9]   **2020 to 2025**

> **Example**
>
> 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.[10]

Technological Trends

Normal Times
- Realization Timeline ▼

Strengthening infrastructural resilience

■ Projects are being promoted to prevent water disasters, in which sensor technology, drones, and image analysis technology for surveillance cameras are used in rivers[11]

2020 to 2025

■ Seismic isolation technology has been developed to protect buildings from sinking by soil liquefaction after an earthquake[12]

2025 to 2035

■ 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[13]

2025 to 2035

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 to 2025

> Example
>
> 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.[14]

> Example
>
> 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.[15]

■ 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[16]

2020 to 2025

■ 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 to 2025

■ 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 to 2025

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Emergency Response   Realization Timeline ▼

Identifying damages during disaster

- 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[17]

  2020 to 2025

- 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[18]

  2020 to 2025

- New technologies will enable the immediate implementation of initial and emergency responses, and include those that utilize digital twin and chatbot technologies. The system captures changing disaster dynamics.[19] 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 to 2035

Evacuation order

- 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 to 2025

- Research is being conducted using quantum computing to quickly identify appropriate evacuation routes[20]

  2025 to 2035

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[21]

  2020 to 2025

- Search and rescue is a recent subject of development where GPS information is combined with data from mobile phones and drones[22]

  2020 to 2025

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 to 2025

- 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[23]

  2020 to 2025

- 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[24]

  2025 to 2035

Technological Trends

During Disaster

Realization Timeline ▼

Balancing with and incorporating into daily life

■ 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 to 2025

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 to 2025

> **Example**
>
> 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.[25]

■ 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 to 2025

> **Example**
>
> 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.[26]

> **Example**
>
> 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[27]

2020 to 2025

■ 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 to 2035

> **Example**
>
> ICON Technology, Inc., a U.S. startup, has produced low-cost, 3D-printed homes and is providing them to people, including the homeless.[28]

1. WELLNESS
2. WATER AND FOOD
3. ENERGY AND ENVIRONMENT
4. MOBILITY
5. DISASTER PREVENTION AND INFRASTRUCTURE
6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Regulatory Trends

- In response to natural disasters becoming more frequent and severe, the Cabinet approved the *Three-Year Emergency Measures for Disaster Prevention, Mitigation, and Homeland Resilience* in FY 2018. The entire country is working to meet emergency measures[29]

- In response to recent extensive damage by floods, MLIT's Panel on Infrastructure Development introduced a policy entitled *River Basin Disaster Resilience and Sustainability by All.* This policy proposes that everyone in a river basin cooperate and implement sustainable flood control measures through means such as storage facilities, urban planning, and disaster-prepared households[30, 31]

- 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[32]

- 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*[33]

- 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[34]

- 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[35]

- 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[36]

- 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

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (2) — 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 in mass at the same time. As national and local governments face financial difficulties, the monetary burden associated with maintenance and management has become a significant problem

- The aging water supply system for consumers and industry also needs to be dealt with and renewed. Especially in rural areas where the population is decreasing, financial constraint is resulting from maintaining infrastructure that does not match the current size of the population. In the future, regional disparities are expected to widen in the quantity and quality of infrastructure services. Therefore, it is necessary to devise measures to efficiently update and rebuild infrastructure[37]

Japan — Potential Impact estimates	Maintenance and renewal costs for domestic infrastructure will continue to increase in the medium term. The future level is expected to be about 1.2-1.3 times that of the JPY 5.2 trillion total in 2018. Cumulative costs over the next 30 years are estimated to reach around JPY 176.5-194.6 trillion.[38] (A)
Japan — Potential Impact estimates	If we were to replace all drinking-water- related facilities according to their stipulated service lifespan, the replacement cost per year would average JPY 1.4 trillion.[39] (B)

- The societal infrastructure is the basis of economic activity, and the dilemma of low profitability in its operations 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

- 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	World	Japan	World
Resolved →	Unresolved	Unresolved →	Unresolved

Societal Issues — Improvements to efficient management of infrastructure through, aggregated and centralized control, and better utilization

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 take the following three points into consideration: (1) to reduce cost and increase efficiency in maintenance, (2) to prioritize and determine the necessity of repair and reconstruction, and (3) to upgrade infrastructure by utilizing new technologies. It is essential to build, sustain, and develop a maintenance cycle based on effective preventive maintenance by adopting IoT. The cycle consists of inspection and diagnosis, evaluation, and repair or reconstruction phases. Reconstruction must be conducted using the latest forms of next-generation infrastructure technology, which enables safe and resilient preparation for disasters

169

Consolidating Infrastructure: **Compact cities and concentrated and efficient use over a wide area**

- In reviewing less frequently used infrastructure, it is necessary to pay attention to the current situation of cities where residents are spread out across low-density areas. For sustainable urban management, it is essential to form cities and societies that use limited resources intensively and efficiently. The key is to consolidate and abolish infrastructure in wide areas, rather than maintaining and managing existing infrastructure

- Virtual power plants use IoT to manage and control multiple power sources scattered 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 result in unused facilities and land. It will be important to effectively utilize these assets

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 high-level use of infrastructure; this achieves the advantages from multifaceted perspectives such as profitability, energy efficiency, societal needs, and improvements to quality of life

- 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

- Dynamic pricing according to demand is expected to become popular in light of improvements in AI

- This 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

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Efficient Infrastructure Management
- -
Realization Timeline ▼

Efficient monitoring and inspection

- Digital twin technology is realized through sensors and can be effective in infrastructure maintenance. The technology can diagnose degradation due to aging and immediately identify damage to bridges during disasters **2020 to 2025**

- Technology is under development to understand road surface conditions via vehicle tires. The technology uses tires as sensing devices and enables effective data acquisition **2020 to 2025**

> **Example**
>
> In 2015, Bridgestone Corporation became the first company in the world to succeed in practical application of a sensing technology, CAISTM, that analyzes road surface information from data collected via sensors installed inside tires.[40]

- Improvements in camera and sensing technology, and advancement in AI analysis have led to inexpensive and real-time identification of degradation and damage on bridges, tunnels, and road paving. These advancements enable repair and reconstruction at appropriate times **2020 to 2025**

> **Example**
>
> UrbanX Technologies, Inc. has developed Road Inspection AI, enabling real-time quantitative road inspections to detect road damage using smartphones with AI.[41]

- A service is under development to diagnose deterioration in building inspections using image analysis technology with drones and AI. Expectations are high for the service's potential to resolve issues related to workforce shortage, reduction of load, and improvements in safety in inspection work at high heights.[42] Improved sensing technology will lead to the development of a diagnosis method of long-term deterioration in buildings and structures affected by earthquakes and temperature changes[43] **2020 to 2025**

Efficient infrastructure maintenance and management by utilizing new materials

- 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 its 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 to strengthen heavy load-bearing infrastructure[44] **2025 to 2035**

Efficient design

- The concept of *design without rework* is becoming popular as a means of promoting step-by-step modifications and changes based on the assumption that external forces will increase in the future due to climate change **2020 to 2025**

> **Example**
>
> The U.K.'s *Thames Estuary* TE 2100 provides responses 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.

Clues to Solutions

Technological Trends

Efficient Infrastructure Management

Holistic urban planning centered on proximity to infrastructure

- To rationalize the maintenance and management of infrastructure and to improve the efficiency of administrative services, urban development is being promoted under the Compact City + Network concept. The concept gradually guides the construction of residential areas along public transportation routes and close to everyday activities

  `2020 to 2025`

Utilizing 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 to 2025`

  > Example
  >
  > 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.[45]

Supply-demand adjustment: Demand side management (DSM)

- To optimize the utilization rate of infrastructure, dynamic pricing has been introduced worldwide. Dynamic pricing is expected to become popular in Japan as well as an analytical tool using big data and AI

  `2025 to 2035`

  > Example
  >
  > 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.[46]

Multiple purpose utilization of infrastructure

- Introduction and installation of solar photovoltaic power generation are being promoted, utilizing vast public infrastructure such as ports, airports, and road facilities. Solar cell modules are being developed in various forms for installation[47]

  `2020 to 2025`

  > Example
  >
  > NIPPO CORPORATION and MIRAI-LABO are developing a photovoltaic pavement called Solar Mobiway to install them on roads.[48]

- 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[49]

  `2020 to 2025`

- 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[50]

  `2025 to 2035`

  > Example
  >
  > The Flowell system developed by Colas, U.K., embeds LED light signals in roads to flexibly change driving lanes and shared spaces in town.[51]

Technological Trends

Consolidating Infrastructure

Realization
Timeline
▼

Multiple functions: Multi-purpose utilization of infrastructure

- 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
to
2025

> **Example**
>
> 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.

> **Example**
>
> 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

- To help realize biomass stations, practical use is underway of unused organic materials generated locally and received at sewage treatment plants such as food waste and human excrement.[52] Progress has also been made on research on infectious diseases using sewage

2025
to
2035

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

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 principle 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. Discussions are taking place for a technology catalog to promote new technologies as well as flexibility in inspection methods and frequency[53,54]

- Japan has been promoting infrastructure development based on the concept of a *civil minimum* that sets the amount of infrastructure as small as possible to maintain citizens' daily lives. In the future, it is required to introduce the concept of asset management and provide infrastructure services that maximize the satisfaction of residents with limited financial resources[55,56]

- 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[57,58]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (3) — 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.[59] Vacancy is due to declining population and birthrate, aging population as well as changes in social needs. Unmanaged vacant houses cause societal problems that harm people's living environment in areas such as 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[60]

Japan — Potential Impact estimates

The national rate of vacancy will reach 28.5% in 2033 if current levels stay the same for the number of housing starts and demolitions,.[61] (B)

Japan — Potential Impact estimates

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.[62] (C)

Japan **Unresolved** ➡ World **Unresolved**

Societal Issues — 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

- 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.[63] 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

Promotion of Effective Use and Repurposing: Remodeling and renovation

- Some vacant houses are worth remodeling or renovating to promote effective use. Good-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 incentives to individual owners and private businesses to use vacant houses—the result, the revitalization of the local economy

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Confirm the Current Situation -- Realization Timeline ▼

Use of advanced technologies

- Changes can be detected in vacant houses and land through the development of AI-assisted analysis of space data observed via positioning and observation satellites.[64] **2020 to 2025**

- 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.[65] **2020 to 2025**

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.[66] **2020 to 2025**

- 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 to 2025**

- 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 to 2025**

Make Effective Use of Stock --

Use of advanced technologies

- MR (mixed reality) technology is used to remotely control construction work. The technology ensures the 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 labor-hours of supervisors spent traveling between sites.[67] **2020 to 2025**

Utilization of regional expertise

- By establishing a coordination system with local craftsmen and holding workshops on DIY and self-renovation, efforts are being made to resolve funding issues for renovation and to popularize renovation techniques.[68] **2020 to 2025**

177

Technological Trends

Make Effective Use of Stock ---

Realization
Timeline
▼

Renovation

■ Renovation is gaining popularity (prevailing) 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
to
2025

> Example
>
> 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.[69]

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.[70,71]

2020
to
2025

■ VR and 3D cameras are being introduced to make it easier to preview vacant houses in remote areas.

2020
to
2025

> Example
>
> GA technologies Co., Ltd. has partnered with PropTech, Beike, a Chinese company, to launch a 3D walk-through preview service.[72]

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[73]

- 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[74]

- The Cabinet approved the *Basic Land Policy* based on the *Basic Act for Land* 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)[75, 76]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

- 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

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.[77] (B) 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.
World	Potential Impact estimates	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.[78] (A)

Japan **Unresolved** ➡ World **Unresolved**

| Societal 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

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

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

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Control Systems
Realization Timeline ▼

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 to 2025

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[79]

2025 to 2035

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 to 2025

> Example
>
> 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.[80]
.
- There is an increasing need for technical solutions that prevent the remote-control hacking of autonomous vehicles

2025 to 2035

> Example
>
> 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.[81]

- 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 to 2025

> Example
>
> 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.[82]

- 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[83]

2025 to 2035

Technological Trends

Automated Equipment - Realization Timeline ▼

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 to 2035`

Access to Web Sites -

Technology to prevent damages from fraudulent access

- With the expansion of money transfer services using smartphones, security technologies have emerged to detect unauthorized access and to prevent fraudulent purchases

  `2020 to 2025`

- 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[84]

  `2020 to 2025`

- 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 to 2025`

  > **Example**
  >
  > 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.[85]

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 to 2025`

  > **Example**
  >
  > 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.

  > **Example**
  >
  > 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.[86]

- There is a need for online elections. The challenge is how to ensure identity verification and at the same time to secure anonymity

  `2025 to 2035`

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

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[87]

- METI formulated the *Cyber/Physical Security Framework (CPSF),* which summarizes the overall picture of the security measures required for industries[88]

- 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*[89]

ICF issues with targets in UN SDGs

Problems	Issues
(1) Insufficient preparation and response to natural disasters	**Strengthening of disaster response capabilities through innovative technologies and societal infrastructure**
	Targets in UN 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
(2) Poor management of societal infrastructure	**Improvements to efficient management of infrastructure through, aggregated and centralized control, and better utilization**
	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 transborder 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
(3) Urban decay caused by an increasing number of vacant houses	**Revitalization of local communities by making use of vacant houses**
	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
(4) Larger number and harsher types of cyberattack	**Security measures based on a Society 5.0 world**
	9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Notes and References

All URLs were viewed on September 1st, 2021.

1   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Technical Committee on Flood Risk Assessment of Small and Medium Rivers (in Japanese)
     https://www.mlit.go.jp/river/shinngikai_blog/tyusyokasen/index.html

2   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "the Estimated Flood Damage in 2019," press release, March 31, 2021. (in Japanese)
     https://www.mlit.go.jp/report/press/mizukokudo03_hh_001056.html

3   Working Group on Countermeasures against Tokyo Inland Earthquake, Committee for Policy Planning on Disaster Management, Central Disaster Management Council, Cabinet Office, Japan, "Summary for Final Report by Working Group on Countermeasures against Tokyo Inland Earthquake," December 19th, 2013 (in Japanese)
     http://www.bousai.go.jp/jishin/syuto/taisaku_wg/pdf/syuto_wg_gaiyou.pdf

4   National Research Institute for Earth Science and Disaster Resilience, "Strategic integrated research project of earthquake and tsunami prediction technologies" (in Japanese)
     https://www.mowlas.bosai.go.jp/project/?LANG=ja

5   "Development of linear precipitation zones observation and prediction system," Section V, Strengthening National Resilience (Disaster Prevention and Mitigation) (in Japanese)
     https://www.nied-sip2.bosai.go.jp/research-and-development/theme_5.html

6   "Development of super typhoon damage prediction system," Section VI, Strengthening National Resilience (Disaster Prevention and Mitigation) (in Japanese)
     https://www.nied-sip2.bosai.go.jp/research-and-development/theme_6.html

7   Waseda University, "Real-time urban inundation forecasts becomes possible," topics, May 20, 2019 (in Japanese)
     https://www.waseda.jp/top/news/64900

8   One Concern, "Resilience to weather any storm"
     https://www.oneconcern.com/jp/platform/

9   "New earthquake-resistant technology," The Sankei Shimbun (in Japanese)
     https://www.sankei.com/premium/news/201205/prm2012050002-n1.html

10   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Green infrastructure, Towards a Better Relationship between People and the Natural Environment (in Japanese)}
     https://www.mlit.go.jp/common/001179745.pdf

11   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Climate Change Adaptation Measures in the Netherlands (in Japanese)
     https://www.hkd.mlit.go.jp/ky/kn/kawa_kei/splaat000001weys-att/splaat000001wf69.pdf

12   Ministry of Land, Infrastructure, Transport and Tourism, Japan, The Framework for the Development and Introduction of New Technologies (in Japanese)
     https://www.mlit.go.jp/river/shinngikai_blog/shaseishin/kasenbunkakai/shouiinkai/kikouhendou_suigai/4/pdf/04_shingijutu.pdf

13   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Efforts to Strengthen Electric Power Resilience in Light of Disasters (in Japanese)
     https://www.meti.go.jp/shingikai/enecho/denryoku_gas/datsu_tansoka/pdf/004_03_00.pdf

14   Weathernews Inc., "Weathernews to launch the AR Inundation Simulator, an app enabling pseudo experience of flooding," press release, August 20, 2020. (in Japanese)
     https://jp.weathernews.com/news/32399/

15   iDEACLOUD inc., "Developed a free VR game in the U.S. to support disaster management for people with disabilities," June 30, 2020 (in Japanese)
     https://bousai-vr.com/blog/vr-game-on-disaster-preparedness.html

16   Ministry of Land, Infrastructure, Transport and Tourism, Japan, The 3D Displayed Disaster Risk Information
     https://www.mlit.go.jp/toshi/city_plan/content/001348705.pdf

17   "Development of the disaster situation analysis and sharing system," Section II, Strengthening National Resilience (Disaster prevention and mitigation) (in Japanese)
     https://www.nied-sip2.bosai.go.jp/research-and-development/theme_2.html

18   National Institute of Advanced Industrial Science and Technology, "Mudslide detection sensor system enabled with an AI"
     https://www.aist.go.jp/aist_j/press_release/pr2018/pr20181010_2/pr20181010_2.html

19   "Development of an integrated system for supporting evacuation and emergency operations," Section I, Strengthening National Resilience (Disaster prevention and mitigation) (in Japanese)
     https://www.nied-sip2.bosai.go.jp/research-and-development/theme_1.html

20   Quantum Annealing Research and Development Center, Tohoku University (T-QARD), Possibility of Utilization of Quantum Annealing in Disaster Evacuation such as Tsunami (in Japanese)
     https://www.youtube.com/watch?v=RX1FGURde4g

Notes and References

All URLs were viewed on September 1st, 2021.

21   Ministry of Economy, Trade and Industry, Japan, Effective Use of Electricity Data (in Japanese)
      https://www8.cao.go.jp/kisei-kaikaku/kisei/meeting/wg/seicho/20200319/200319seicho02.pdf

22   KDDI CORPORATION, "KDDI Developed the mobile phone location estimation technology using drone base transceiver station in disaster response" (in Japanese)
      https://news.kddi.com/kddi/corporate/newsrelease/2019/03/01/3645.html

23   "Development of a groundwater utilization system in disaster response," Section IV, Strengthening National Resilience (Disaster Prevention and Mitigation) (in Japanese)
      https://www.nied-sip2.bosai.go.jp/research-and-development/theme_4.html

24   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Concrete Actions in Telecommunication Technology Vision 3, 2018 (in Japanese)
      https://www.mlit.go.jp/tec/it/vision/vision3_torikumi.pdf

25   Hacobu (in Japanese)
      https://movo.co.jp/

26   Weathernews Inc., "With eleven cities, Ibaraki Prefecture collaborate to use disaster prevention chatbots for the initial action and decision making," News (in Japanese)
      https://jp.weathernews.com/news/28658/

27   "Development of a support system for early recovery of the wide-area of economy," Section III, Strengthening National Resilience (Disaster prevention and mitigation) (in Japanese)
      https://www.nied-sip2.bosai.go.jp/research-and-development/theme_3.html

28   ICON Technology, Inc., "Printing homes for the homeless in Austin"
      https://www.iconbuild.com/updates/printing-homes-for-the-homeless-in-austin

29   Cabinet Secretariat, Japan, "Special featured website on the three-year emergency measures for disaster prevention, disaster mitigation, and national resilience" (in Japanese)
      https://www.cas.go.jp/jp/seisaku/kokudo_kyoujinka/3kanentokusetsu/index.html#3)

30   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Approaches to Water Disaster Countermeasures in Response to Climate Change: Conversion to Sustainable Basin Water Control with All the Stakeholders, a report by the Panel on Infrastructure Development, July 2020. (in Japanese)
      https://www.mlit.go.jp/river/shinngikai_blog/shaseishin/kasenbunkakai/shouiinkai/kikouhendou_suigai/pdf/03_honbun.pdf

31   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Executive Summary for the Approaches to Water Disaster Countermeasures in Response to Climate Change: Conversion to Sustainable Basin Water Control with All the Stakeholders, a report by the Panel on Infrastructure Development, July 2020. (in Japanese)
      https://www.mlit.go.jp/river/shinngikai_blog/shaseishin/kasenbunkakai/shouiinkai/kikouhendou_suigai/pdf/02_gaiyo.pdf

32   Kobayashi, K., "Infrastructure Resilience: A U.S.-Japan Joint Research," Message from the JSCE president No. 48, JSCE Magazine Civil Engineering, Vol. 104, No. 6, pp. 2-3, June 2019. (in Japanese)
      https://www.jsce.or.jp/journal/message/201906.pdf

33   Meteorological Service in 2030, considering the development of science and technologies (Recommendations), p. 12 (in Japanese)
      https://www.jma.go.jp/jma/press/1808/20a/bunkakai_teigen.pdf

34   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "Revision of Regulations for Enforcement of the Act on Real Estate Brokerage" (in Japanese)
      https://www.mlit.go.jp/totikensangyo/const/sosei_const_fr3_000074.html

35   Cabinet Office, Japan, "Evacuation Information (Revised Version) Guidelines Revised in May 2021."
      http://www.bousai.go.jp/oukyu/hinanjouhou/r3_hinanjouhou_guideline/evacuation_en.html

36   Ministry of Economy, Trade and Industry, Japan, Effective Use of Electricity Data (in Japanese)
      https://www8.cao.go.jp/kisei-kaikaku/kisei/meeting/wg/seicho/20200319/200319seicho02.pdf

37   Cabinet Office, Japan, "The platform for infrastructure development," Section 3, FY 2013 Annual Report on the Japanese Economy and Public Finance (in Japanese)
      https://www5.cao.go.jp/j-j/wp/wp-je13/h03_03.html

38   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Estimation of Future Maintenance, Management and Renewal Costs of Social Capital in Areas under the Jurisdiction of MLIT (in Japanese)
      https://www.mlit.go.jp/sogoseisaku/maintenance/_pdf/research01_02_pdf02.pdf

39   Water Supply Division, Health Service Bureau, Ministry of Health, Labour and Welfare, Japan, For Future Renewal of Water Supply Facilities, October 29, 2012 (in Japanese)
      https://www.mlit.go.jp/common/000228597.pdf

40   Bridgestone Corporation, "World's first practical application of the technology based on the CAISTM concept, that identifies the condition of the road surface" (in Japanese)
      https: :// www.bridgestone.co.jp/english/corporate/news/2015112502 .html

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Notes and References

All URLs were viewed on September 1st, 2021.

41   UrbanX Technologies, Inc., "Road Inspection AI" (in Japanese)
      https://www.urbanx-tech.com/

42   "Drone Pilot Agency raises JPY 100 million to diagnose degradation of structures using drones with an AI for image
      analysis," PRTIMES (in Japanese)
      https://prtimes.jp/main/html/rd/p/000000007.000030651.html

43   New Energy and Industrial Technology Development Organization, "Research and development of infrastructure monitoring
      systems with highly reliable sensors," Infrastructure Monitoring Technologies, February 2019 (in Japanese)
      https://www.nedo.go.jp/content/100887966.pdf

44   Mitsubishi Research Institute, Inc., "Development trends and outlook on self-healing materials" (in Japanese)
      https://www.mri.co.jp/knowledge/column/20200713.html

45   Aichi Road Concession Co., Ltd., "Commenced operation of Aichi Accelerated Field, a new technology verification system for
      businesses such as the operation of Aichi Prefecture Toll Road" (in Japanese)
      https://www.maeda.co.jp/select/blog_assets/attachments/495/arcpressrelease20180806.pdf

46   The Kansai Electric Power Company Incorporated, "KEPCO launched an on-site experiment of remote charge/discharge
      electric vehicle control with dynamic electricity pricing based on wholesale electricity market prices, as part of the
      demonstration project for the virtual power plant construction" (in Japanese)
      https://www.kepco.co.jp/corporate/pr/2020/0601_2j.html

47   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Promoting the Renewable Energy Utilizing Social
      Infrastructure (in Japanese)
      https://www.mlit.go.jp/common/001018146.pdf

48   MIRAI-LABO CO., Ltd., "Photovoltaic power generation pavement" (in Japanese)
      https://mirai-lab.com/solarmobiway

49   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Green infrastructure --Towards a Better Relationship
      between People and the Natural Environment (in Japanese)
      https://www.mlit.go.jp/common/001179745.pdf

50   Ministry of Land, Infrastructure, Transport and Tourism, Japan, The Scene on Roads will Changes in 2040 (in Japanese)
      https://www.mlit.go.jp/road/vision/pdf/01.pdf

51   The Colas Group
      https://www.colas.co.uk/expertise/innovation/

52   Ministry of Land, Infrastructure, Transport and Tourism, Japan, New Sewerage Vision Acceleration Strategies (in Japanese)
      https://www.mlit.go.jp/common/001197678.pdf

53   Council for Regulatory Reform, "Opinions on the utilization of new technologies and data in infrastructure maintenance" (in
      Japanese)
      https://www8.cao.go.jp/kisei-kaikaku/kisei/meeting/committee/20200413/200413honkaigi09.pdf

54   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Periodic Inspection Procedure for Road Bridge, February
      2019 (in Japanese)
      https://www.mlit.go.jp/road/sisaku/yobohozen/tenken/yobo4_1.pdf

55   Ministry of Land, Infrastructure, Transport and Tourism, Japan, The Ideal Form of Urban Area Planning, Development and
      Management System, 2008 (in Japanese)
      https://www.mlit.go.jp/crd/city/sigaiti/information/council/arikata/02/data/2-shiryou2.pdf

56   Ministry of Land, Infrastructure, Transport and Tourism, Japan, The Basics of Asset Management, 2017 (in Japanese)
      https://www.mlit.go.jp/common/001184712.pdf

57   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Guidelines for Facilitating Regional Activities Utilizing Roads,
      revised edition (in Japanese)
      https://www.mlit.go.jp/road/senyo/pdf/280331guide.pdf

58   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "MLIT's procedures on the road occupancy permits in times
      of COVID-19 pandemic"
      https://www.mlit.go.jp/road/senyo/03.html

59   Statistics Bureau, Ministry of Internal Affairs and Communications, Japan, "Special aggregation of the 2018 Housing and
      Land Survey" (in Japanese)
      https://www.stat.go.jp/data/jyutaku/2018/tokubetsu.html

60   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Measures to Sponge Cities (in Japanese)
      https://www.mlit.go.jp/common/001258292.pdf

Notes and References

All URLs were viewed on September 1st, 2021.

61   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Measures to Sponge Cities (in Japanese)
        https://www.fujitsu.com/jp/group/fri/column/opinion/201503/2015-3-1.html

62   Development Bank of Japan Inc., Revitalization of Local Communities Resulting from the Economic Value Created through
        the Use of Old Folk Houses, April 2015 (in Japanese)
        https://www.dbj.jp/pdf/investigate/etc/pdf/book1504_01.pdf

63   Ministry of Land, Infrastructure, Transport and Tourism, Japan, Executive Summary of Research on the Mechanism of
        Generation and Distribution of Vacant Houses (Part 2) (in Japanese)
        https://www.mlit.go.jp/pri/shiryou/press/pdf/shiryou180628_2.pdf

64   Ministry of Internal Affairs and Communications, Japan, Final Report of the Task Force on the Utilization of 4-Dimensional
        Cyber cities (in Japanese)
        https://www.soumu.go.jp/main_content/000562537.pdf

65   Grid Databank Lab. LLP, "Verification of the possibility of utilizing electricity data to cope with vacant houses" (in Japanese)
        https://www.gdb-lab.jp/wp-
        content/uploads/2019/10/%E5%88%A5%E7%B4%992.%E5%A0%B1%E5%91%8A%E6%9B%B8%E3%82%B5%E3%83%9
        E%E3%83%AA%E3%80%90%E4%BD%8F%E5%AE%85%E8%A8%B2%E3%80%91.pdf

66   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "FY 2020 model project to strengthen vacant house
        countermeasures' key actors" (in Japanese)
        https://www.mlit.go.jp/report/press/content/001354805.pdf

67   Renoveru, Inc., "On-site experiment and implementation cases of remote construction management using the Mixed Reality
        technology" (in Japanese)
        https://renoveru.co.jp/news/3942/

68   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "FY 2020 Model project to strengthen and collaborate key
        actors in countermeasures for vacant houses" (in Japanese)
        https://www.mlit.go.jp/report/press/content/001354805.pdf

69   ADDress, Co., Ltd., "Unlimited fixed price platform for living in multiple locations." (in Japanese)
        https://address.love/

70   Sumave, "Demand for government-sponsored 'Vacant House Tech'—Can it be the solution for the vacant house issue?" (in
        Japanese)
        https://www.sumave.com/20190716_11920/

71   HowMa (in Japanese)
        https://www.how-ma.com/

72   GA technologies Co., Ltd., "GA technologies will become the first Japanese alliance to introduce 3D property preview service
        of Beike, a PropTech unicorn with five million 3D property data," Press Release (in Japanese)
        https://www.ga-tech.co.jp/news/5760/

73   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "MLIT selected 58 projects for the model project to
        strengthen and collaborate key actors in countermeasures for vacant houses-- Selected projects will receive supports for
        establishing human resource development and consultation systems, and efforts to resolve common issues--" (in
        Japanese)
        https://www.mlit.go.jp/report/press/house03_hh_000125.html

74   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "Revision of Regulations of the Real Estate Brokerage Act"
        (in Japanese)
        https://www.mlit.go.jp/totikensangyo/const/sosei_const_fr3_000074.html

75   Ministry of Land, Infrastructure, Transport and Tourism, Japan, "The Cabinet approval of the new Basic Land Policy and
        MLIT's PR on land policies," press release, May 28, 2021. (in Japanese)
        https://www.mlit.go.jp/report/press/content/001406368.pdf

76   Civil Affairs Bureau, Ministry of Justice, Japan, "Revision of the civil law system to resolve unclaimed lots," May 2021. (in
        Japanese)
        http://www.moj.go.jp/content/001347356.pdf

77   *McAfee Corp., "New McAfee report estimates global cybercrime losses to exceed $1trillion," press release, December 7,*
        2020. https://www.mcafee.com/enterprise/en-us/about/newsroom/press-releases/press-
        release.html?news_id=6859bd8c-9304-4147-bdab-32b35457e629

78   Furudate, W., "Global Market Survey on Drones (UAV/UAS) (2019)," Summary, Yano ICT, Yano Research Institute Ltd.,
        February 25, 2020. (in Japanese)
        https://www.yanoict.com/summary/show/id/585

79   Trend Micro Incorporated, "Publishing the verification test results for cyber security risks hidden in smart industrial control
        systems," press release, October 13, 2020. (in Japanese)
        https://www.trendmicro.com/ja_jp/about/press-release/2020/pr-20201013-01.html

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Notes and References

All URLs were viewed on September 1st, 2021.

80   SafeRide Technologies Ltd
      https://www.saferide.io/cybersecurity/

81   Panasonic Corporation, "Panasonic Corporation with Mori Building Co., Ltd. began a demonstration experiment on AI-based
      security technology for building automation systems, accelerating technology development," press release, February 20,
      2019. (in Japanese)
      https://news.panasonic.com/jp/press/data/2019/02/jn190220-1/jn190220-1.pdf

82   Robust Intelligence, Inc.
      https://www.robustintelligence.com/

83   ENABLER Ltd., "About GNSS Security," Future, March 25, 2021. (in Japanese)
      https://www.enabler.co.jp/blog/gnss-secure

84   Digital Solutions Corporation, "Quantum key distribution."
      https://www.toshiba.co.jp/qkd/en/what.htm

85   Truepic Inc.
      https://truepic.com/

86   Dtto (in Japanese)
      https://intro.dtto.com/

87   Information system Security Management and Assessment Program (ISMAP) (in Japanese)
      https://www.ismap.go.jp/csm

88   Ministry of Economy, Trade and Industry, Japan, "Cyber/Physical Security Framework (CPSF) Formulated," press release,
      April 18, 2019.
      https://www.meti.go.jp/english/press/2019/0418_001.html

89   Yuasa, H., "Trends in the U.S. election laws for deep-fake regulations," International Information Network Analysis (IINA),
      The Sasakawa Peace Foundation, March 19, 2021. (in Japanese)
      https://www.spf.org/iina/articles/harumichi_yuasa_01.html

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

A SOCIETY WHERE ALL ARE EMPOWERED TO CONTRIBUTE TO THE SOCIETY

In considering the field of education and human resource development, ICF defines the future society as "A society where all are empowered to contribute to the society."

As progress in science and technology, along with societal change, intensifies, 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, compulsory and higher education, to recurrent education to establish the foundational skills and knowledge essential later in life. This education must be provided in accordance with the individual's interests, focus, and characteristics. It will be essential to utilize EdTech to develop new avenues for learning as there is a limit on the range of content that an individual teacher can offer. While the pervasive popularity of the Internet brought easy access to a wide range of information, it has also created problems such as information flooding and the proliferation of biased information which may result in further social divisions. Hopefully, digital technologies can be used to create cordial and friendly spaces, where people with common interests and values can enjoy free interaction.

Differences in geographic area and economic conditions often create disparities in opportunities for appropriate education and in the motivation to continue voluntary learning. Motivation to learn can be encouraged by fostering personal responsibility and ambition combined with a scientific measuring of educational effectiveness.

Providing appropriate and fair employment opportunities coupled with psychological safety in the workplace is essential in order to empower people to play active and fulfilling roles in the society, regardless of their various backgrounds. Diversity & Inclusion are indispensable components for realizing a society where everyone is empowered to contribute to the society.

ICF has identified the following four aspects of problems and issues in the fields of education and human resource development.

(1) Insufficient skill development in terms of mastering new technologies and processes → Provide learning opportunities to all children

(2) Few people in adulthood return to school (between different job opportunities) → Provide continuous opportunities for learning suited to modernizing skillsets

(3) Filter bubbles (i.e. Information flooding and bias) → Ensure free and open speech

(4) Lack of diversity in human resources → Develop an environment that accepts and empowers all individuals (= diversity management)

Legend

Potential impact estimates

(A) The maximum impact on financial cost and future population by 2025 to 2030 if no effective countermeasures are taken.

(B) The maximum impact of the worst-case scenario that can be reasonably expected to occur at present

Issues and Challenges are classified into three categories:

Japan	World	Japan	World	World	Japan
Resolved ⇒ Unresolved		Unresolved ⇒ Unresolved		Unresolved ⇒ Unresolved	

(1) Issues that have already been resolved in Japan, and utilizing Japanese technologies that can be of help in resolving global issues;

(2) Current issues that also exist in Japan. By becoming the first country to resolve them, Japan can lead the pack on global issues; and

(3) Early tackling of future global issues will lead to resolving them in Japan in the future.

| Societal Problem (1) | Insufficient skill development in terms of mastering new technologies and processes |

- Reading comprehension is becoming increasingly important as a skill that is difficult to replace by AI. However, the average scores of reading comprehension of students in Japan declined under the study conducted by the OECD's Programme for International Student Assessment (PISA). The number of students categorized in the Proficiency Level 1 or lower is increasing both in Japan and OECD average[1]

- Education is wrought with inequality due to differences in geographic, residential, and economic conditions. Specifically, the lack of educational opportunities is observed most clearly in preschool- age children in low-income groups

| World Potential Impact estimates | In 2030, 1 billion school-aged children will not be enrolled in 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 preschool- age children in low-income group directly and significantly improves non-cognitive skills and psychological measurements such as the motivation to voluntarily learn. The return on investment of this support is expected to 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 the age of 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 left unchanged. The shortage of lifetime income for these youth will result in a JPY 1.1 trillion loss in tax and social security premium.[4] (A) |

Japan Unresolved ➡ World Unresolved

| Societal Issues | Provide learning opportunities to all children |

Key Points for Resolving Issues

Defining the Essential Education: Clarifying the educational contents required to keep up with the times

- In preschool, elementary, and secondary educations, the targeted qualities and abilities to foster differ depending on the physical and mental developmental stage of each child. 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 necessary to clearly define the knowledge and skills required for children 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,

skills for teaching others, and problem-setting skills, as well as non-cognitive abilities

Individually Optimized Learning: Providing education tailored for children's characteristics and backgrounds

- Each person has different cognitive characteristics. They are roughly divided into visual dominance and auditory dominance. The former implies a preference for processing information seen by the eyes, and the latter implies a preference for information heard by the ears. It is necessary to implement both personalized teaching and personalized learning at same time. Personalized teaching flexibly utilizes teaching methods according to each child's characteristics and attainment level, while personalized learning deepens learning by aligning lesson methodology with the interests of the child. Advancing educational ICT and EdTech, a combined use of technology and educational theory and practice, can provide individualized and optimized education for all children through collaboration between schools and business operators. It is even possible to provide interactive and high-quality education to children who live in sparsely populated areas or cannot attend school for a variety of reasons. During the COVID-19 pandemic, learning from home and e-learning became widespread, utilizing digital textbooks and course materials. It is thus important to promote digital technologies to enhance the resilience of the educational system. By utilizing the learning records and the logs of digital materials, it is also possible to teach according to each individual's comprehension level; this technique is called adaptive learning. The development, introduction, and establishment of new educational services will be realized through cooperation between schools and business operators, using educational ICT, EdTech, and AI[5]

Clues to Solutions

Technological Trends

Education for Young Children

Realization Timeline ▼

Preschool education

- In addition to cognitive skills, children need to develop non-cognitive skills, such as emotional attachment, self-motivation, and self-control, in order to understand fundamental pieces of knowledge and language

2020 to 2025

Example

In Missouri, U.S.A., the state government provides home visits and educational programs by educational professionals, free of charge, under its Educare program for child-care providers of children under the age of 6.[6]

1. WELLNESS
2. WATER AND FOOD
3. ENERGY AND ENVIRONMENT
4. MOBILITY
5. DISASTER PREVENTION AND INFRASTRUCTURE
6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Primary and Secondary School Education -   Realization Timeline ▼

Learning supported by ICT

■ Schools are increasingly using e-learning apps as supplementary teaching material that was primarily employed only for personal use in the past[7, 8]   2020 to 2025

> Example
>
> Apple proposes ideas for using iPads in classrooms to introduce augmented reality in education.[9] They intend to provide students with opportunities to see life-size artifacts in history classes, measure objects around them in math classes, and learn anatomy by virtual frog dissection in science classes.

■ Programming with robots, 3D printers, and drones, are also gaining popularity as educational materials for STEM/STEAM[10]   2020 to 2025

■ There are various examples of development of fab labs or fabrication laboratories, through which users can experience digital manufacturing in person. In the future, fab labs must be built in places close to home such as school and childcare facilities   2020 to 2025

■ There is currently a study attempting to study the movement of students' pupils in the eyes during lectures to see where they have shown interest. This study will enable objective assessment of the students' interest to create attractive educational content[11]   2020 to 2025

■ Tablet computers are being used for ESL (English as a Second Language) education where students receive pronunciation lessons from native English speakers overseas. These schemes help to improve the quality of education while also reducing the schoolteachers' burden[12]   2020 to 2025

■ Some schools are experimenting with a flipped classroom model, where students prepare at home for classroom learning using tablet computers, increasing the amount of time available for Q&A and problem solving. Reducing the burden on teachers is required for the flipped classroom model to take hold[13]   2020 to 2025

■ Services have emerged that provide proficiency assessment and personalized teaching through AI. There is a hope for development of carefully crafted teaching functions for individual students that identify causes of errors in their thought processes and set students on the right track[14]   2025 to 2035

> Example
>
> Qubena offers AI-assisted learning material on tablets, which 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 the assignment to be solved.[15] A U.K. EdTech startup, Atom Learning Ltd., offers a paid service to fill the learning disparities that are often overlooked in standard education.[16]

■ This system is another service used to reduce the burden on teachers to create and share better teaching materials   2020 to 2025

> Example
>
> Teachers Pay Teachers (U.S.) provides a platform for teachers worldwide to buy and sell teaching materials.[17] More than two-thirds of U.S. teachers reportedly use this platform.

Technological Trends

Secondary and High School Education
Realization Timeline ▼

Education Tailored to cognitive characteristics

- The progress in research of cognitive characteristics has helped integrate individually tailored learning methods into standardized education

  2020 to 2025

  > **Example**
  >
  > 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 that was used was tailored to the selected cognitive characteristic.[18]

Education that fosters continuous self-motivated learning through problem-solving

- Some schools have introduced PBL (problem-based learning) as an approach to resolving familiar yet remaining societal problems in local communities.[19] To this end, in order to encourage creativity, proactivity, and interactivity among students in these communities, down-to-earth mentors who can provide direct and clear advice are vital in the application of this approach

  2020 to 2025

  > **Example**
  >
  > In a proof-of-concept project as part of METI's Future Classroom, a PBL field-study was attempted in which high school students hoping to go to university could intern at a local company (Mynavi Corporation).[20]

- There has been an increase in the number of PBL offered through collaborations between schools and companies. Students can experience real jobs, as if they had entered the work-force, and companies can use the opportunity as part of their employee training

  2020 to 2025

- The role of education providers, even excluding teachers, 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 university students, homemakers, and seniors to the appropriate human resources and contacts[21]

  2020 to 2025

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Regulatory Trends

- While the restriction on remote high school classes was lifted in April 2015, students can acquire only 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 applicable from remote classes, as has the lifting of a restriction at the compulsory education level (*Council for the Regulatory Reform of the Cabinet Office*).[22,23] Deregulation is also occurring in other areas of education; starting in 2019, digital textbooks have been permitted for use in the classroom setting[24]

- METI is in the process of verifying the *Future Classroom 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, etc. However, it is essential to develop services on the premise that the burden on teachers will not increase

- The Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT) published a report called *Human Resource Development for Society 5.0 - Changes to Society, Changes to Learning* and describes its educational policy for the coming era. The policy directions include:
  1) Fair and individually-optimized learning
  2) The intent for all students to acquire fundamental abilities, such as basic reading comprehension and mathematical thinking, along with information competency
  3) A break from the divide between liberal arts and technical science

- The METI has set up an advisory panel on education reform called the Future Classroom and EdTech Study Group. The panel states three goals:
  (1) The application of STEAM Learning that enables the exciting cycle of knowledge acquisition, inquiry, and project-based learning,
  (2) Autonomous and individually-optimized learning to realize a method that suits students' cognitive characteristics and achievement levels
  (3) The establishment of new learning platforms to create schools that are digitalized and seamlessly connected with the society

- Student loan debt has become a significant issue in the U.S. during the COVID-19 pandemic. Starting in March 2020, the federal government has frozen interest rate hikes and placed a moratorium on repayment until August 31st, 2022

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Societal Problem (2)	Few people in adulthood return to school (between different job opportunities)

- As Lifespans are getting longer than in the past, a shift must take place from the typical life plan. The old pattern of learning at school, working for a company, and spending many years in retirement should be changed to a wider variety of ways to work and live

- The advent of new technologies like AI has brought about significant changes in the supply-demand balance in human resources among job opportunities. This trend requires most workers to acquire new skills midway through their careers

Japan Potential Impact estimates	Given the spread of digital technologies in response to the COVID-19 pandemic, the supply-demand balance of human resource is expected to shift from an excess of demand to equilibrium or even an excess of supply in FY 2022 Mismatches are forecasted 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.
Japan Potential Impact estimates	In Japan, educational institutions provide training programs for workers in their 20s to 60s. However, the participation rate among the courses has been only 20% in the last three years. Despite the low participation rate, 44.2% of adults have in fact still reported an interest in learning.[25]

Japan **Unresolved** ➡ World **Unresolved**

Societal Issues	Provide continuous opportunities for learning suited to modernizing skillsets

Key Points for Resolving Issues

Workers: Fostering and supporting career ownership

- The qualities and abilities required of workers have changed rapidly. Under such circumstances, individual workers need to continue proactive learning throughout their life in order to modernize their work-related qualities and abilities in a timely manner

- To resolve this challenge, workers need to practice good habits, such as setting their own career goals, handling inventory of their knowledge, skill, and experience, as well as defining and acquiring the qualities and abilities needed to fill the gap between the ideal goals and current circumstances. These practices must be conducted with the idea of career ownership (an intent to proactively build one's career) as a focal point. In light of these emerging factors, there is increasing demand for a service that can assist proactive career development in addition to the conventional support already provided by career consultants

Companies: Active participation and investment in human resource development

- For workers to effectively and efficiently obtain the qualities and abilities demanded by society, employers must articulate the career-related requirements and present them to the employees and the training program providers

- It is also necessary for companies to proactively invest in human capital while at the same time creating a system to reward employees who develop their capabilities

Educational Program Provider: 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 provided by private education and training businesses

- 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 as an overall lifelong learning, performed on a timely and spontaneous basis, after graduating from school to continuously refine abilities required for work. This definition by the Ministry of Health, Labour and Welfare, Japan (MHLW)[26] is broader than that of other countries.

Clues to Solutions

Technological Trends

Workers - Realization Timeline ▼

Career development supporting 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 things to study

    2020 to 2025

    Example

    A U.S. database O*NET OnLine stores quantitative and qualitative data on approximately 1,000 job categories, including job descriptions, required experience, education, and training. Utilizing this database, Mitsubishi Research Institute, Inc. (MRI) provides a service of matching job seekers and recruiting companies within and outside specific sectors. Both parties search the database of shared information for work experience and employment requirements.

Technological Trends

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 job openings and to present skills to educational institutions

20**25**
to
20**35**

Educational Program Provider ---

Educational services to meet new needs

- A variety of educational programs are now being provided online. E-learning elevates classroom lectures and off-the-job training by including project-based learning (PBL) programs

20**20**
to
20**25**

> Example
>
> In response to the growing digital needs of companies, the Ministry of Economy, Trade and Industry, Japan (METI) has created a program to educate personnel who can use AI and data to help resolve issues facing the corporations.
> The ministry provides practical learning opportunities through online project-based learning programs.[27]

- A matching service is emerging through which employees from large and mid-sized companies are seconded to venture companies to gain practical skills in innovation[28]

20**20**
to
20**25**

> Example
>
> LoneDEAL (JAPAN) created a platform to facilitate the seconding of employees from large and mid-size companies to startups.

- Some industries require training for workers to acquire specific technical skills in order to advance. In these industries, there are movements emerging to enable effective and efficient acquisition of skills by analyzing the differences between the beginner and the skilled worker through data collection of the skilled worker's movements and other variables

20**20**
to
20**25**

> Example
>
> The University of Aizu in Japan is quantifying and compiling the perspectives and teaching methods of experienced kindergarten and nursery teachers into a database. The database then transforms the data into a VR experience, aiming to promote acquisition of technical skills for inexperienced teachers.[29]

Scientific measurement of educational effectiveness

- New methods are expected to emerge that can measure training and education effectiveness using techniques such as cerebral blood flow measurement and computer vision[30,31]

20**25**
to
20**35**

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Regulatory Trends

- The Cabinet Office, Japan (CAO) published the *Emergency Proposal Toward the Launch of a New Form of Capitalism that Carves Out the Future*. The proposal highlights the need to study the enhancement of disclosures of non-financial information in the annual securities reports. It also refers to the promotion of companies' human capital investment efforts, support for job training, employment on probation basis, and labor mobility[32]

- In the *Basic Policies on Economic and Fiscal Management and Reform 2019,* there is a provision named the *Human Resource Development Reinforcement as Recurrent Education*. It endorses the promotion of educational training benefit plan, consideration of specific incentives for companies, students, universities, and others, and support of non-full time workers who left jobs to acquire technical skills that will help satisfy market demand[33]

- The *Report of the Study Group on Improvement of Sustainable Corporate Value and Human Capital* indicates the so-called 3P/5F Model with three viewpoints and five common elements required for human resources strategy.[34] Learning new skills and going through re-education are one of the five common elements. It is pointed out that companies need to support individuals' proactive development in order to respond to the rapid changes in the business environment and to the diversification of individual values

- The Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT) has set up a portal site called Manapass[35] where users can search for educational programs designed specifically for working adults. On this site, users can specify and inquire about various conditions such as the field of lectures, qualifications, availability of support, and lecture schedules

Societal Problem (3)	**Filter bubbles (i.e. Information flooding and bias)**

- As the time and rate of people using social media expands, internet defamation has become a more serious problem, resulting in bullying, job loss, and even suicide. The number of online human rights violations cases in Japan has tripled in the past ten years[36]

- Internet users receive most information filtered according to their personal data such as browsing and location histories. This type of algorithmic filtering creates what is 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, or lack of diversity, in information is a problem

- There is also concern over the echo chamber effect that limits communication to only within a community of like-minded individuals. This effect tends to amplify and reinforce one's own beliefs at the cost of consistent rejection of contrasting beliefs

World **Potential Impact estimates**	Anyone who uses the internet is said to be, whether consciously or not, caught in some form of filter bubble (4.57 billion).[37] In the U.S., 18.2% of adults collect political information primarily from social media. They may be more affected by filter bubbles.[38]
World **Potential Impact estimates**	A study estimated that if 95% of people had worn masks in public spaces, 33,000 lives in the COVID-19 outbreak could have been saved. It was also estimated that 27% more people who are open-minded to various reports tend to wear masks than those who have limited their sources of information. A significant number of lives could be saved by accepting a wider variety of information.[39]
Japan **Potential Impact estimates**	The number of junior high and high school students who have symptoms resembling internet addiction has reached 930,000 nationwide in Japan. This number has doubled in the last five years.[40] * As many as 10.6% of boys and 14.3% of girls in junior high school have been diagnosed with internet addiction, compared to 4.4% and 7.7% respectively in the previous survey. In high school, the diagnoses increase to 13.2% of boys and 18.9% of girls, which were 7.6% and 11.2% respectively five years ago.

Japan Unresolved ➡ World Unresolved

Societal Issues	**Ensure free and open speech**

Key Points for Resolving Issues

Clarifying and Correcting Information Flooding and Bias: Complete elimination of incorrect information is difficult

- Removing incorrect or biased information is an effective countermeasure to better control information flooding and the proliferation of biased information on the internet. However, completely eliminating false data is difficult in liberal countries. The second-best measure is to explicitly identify information that is misleading or biased. To cope with the enormous amount of data, one idea is to

have a system that can automatically score data using search engines and AI to provide various recommendations. 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 towards the internet. Offline communication may also mitigate the harmful impact of biased information flooding. It may be possible to resolve this issue by creating a system where people with different ideas can meet offline and exchange opinions and reward them with community points

Education on Communication: Understanding the characteristics of internet world

- Given the prevalence and influence of social media, it is becoming more important to disseminate information and education materials in order to improve the "internet literacy rate" for communication online. The first step in mitigating the harmful effects of unsafe internet usage on individual users is to recognize the existence of filter bubbles and to understand how they work. Individuals can take the following measures:
  (1) using different search engines, to avoid the impact of the filtering
  (2) deleting cookies, and
  (3) adding extensions to browsers.
  Furthermore, users' behavioral changes, such as viewing news sites that provide a variety of perspectives, accessing websites that offer multiple political views, and using and accepting critical thinking, also serve to mitigate the filter bubbles. A system that incentivizes these changes will be much more effective in combating filter bubbles and their negative effects

- 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, the voice of the majority becomes louder than the true picture in shaping public opinion while that of the minority is underestimated.
  • 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 usage of offensive language. Studies indicate that less than even a small percentage of internet users participate in flaming

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Technological Trends

Diversification of Information Sources

Realization Timeline ▼

Internet education

■ Ideas for education at school include teaching students about the existence and mechanism of filter bubbles, as well as giving lessons to parents about internet safety. Educating employees at companies is another avenue for mitigating filter bubbles. It is also effective to incorporate filter bubble education into unconscious bias training courses

2020 to 2025

> **Example**
>
> 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 available to measure users' level of unconscious bias.[41] Microsoft has disclosed the unconscious bias training methodology of its employees to the public.

> **Example**
>
> A's Child Inc., a Japanese IT startup, provides a social media network monitoring service that protects children and provides moral literacy seminars for local municipalities, schools, and NPOs.[42]

Changing the internet environment

■ Concerns surrounding filter bubbles have led to the creation of various search engines that do not provide information based on personalized search data

2020 to 2025

> **Example**
>
> Search engines that do not personalize search results include YaCy, DuckDuckGo, Qwant, Startpage.com, and Searx.

■ Other startups are working to improve the Internet's information reliability by using blockchain technology to provide avenues to combat fake news and to promote a scoring system on the reliability of online content

2020 to 2025

> **Example**
>
> An Italian startup, TrueInChain, 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 receive. EscapeYourBubble, a U.S. startup, provides a browser extension service to highlight articles that show opposite viewpoints in users' Facebook News Feed.

Clues to Solutions

Technological Trends

Diversification of Information Sources

Realization Timeline ▼

Measures against defamation

- In addition to human surveillance, AI is also used as measure against defamation

  2020 to 2025

  Example

  The operator of Yahoo News 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)

Take advantage of being offline

- Filter bubbles may be eliminated by providing people with opportunities to meet offline with others who possess differing ideas

  2025 to 2035

  Example

  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.

  Example

  Dutch beer company, Heineken N.V., provided opportunities to work and talk together as a pair with people with opposing ideas, such as feminists with anti-feminists, environmental activists with global warming skeptics, and transgender supporters with those who disagree. It was broadcasted as a commercial film under the concept "Open Your World."

204

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Clues to Solutions

Regulatory Trends

- In October, 2019, the *Filter Bubble Transparency Act* was introduced in the U.S. 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. 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 protecting user data, election management rules, and guidelines which was 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

- The Ministry of Internal Affairs and Communication, Japan (MIC) revised its ordinance on *the Provider Liability Limitation Act* in August 2020. In the case of defamation accusations, the sender 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 awareness of users to improve information use 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[43]

- There is an argument that addiction of social media network use should be defined as a formal psychiatric disorder in *the International Classification of Diseases (ICD)* and diagnostic criteria for mental disorders

Societal Problem (4)	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 the way of thinking, such as values and lifestyles

World	Potential Impact estimates	A study found that one standard deviation increase of the employees' average racial diversity increases productivity by more than 25% in the legal, finance, or health industries.[44] Other research has shown that there is a positive correlation between diversity of members and innovation.[45] (C)

- The World Economic Forum ranks Japan the 120th out of 156 countries in the Global Gender Gap Index, the lowest among developed countries. The Japanese government originally targeted 2020 as its target year to achieve a proportion of 30% of leadership positions being filled by women. However, the government postponed this target year to the soonest possible year before 2030. More than half of the companies involved responded that it would be difficult to achieve this goal any earlier than the deadline[46]

- Though companies are hiring an increasing number of people with disability, their retention rate is low after one year of employment

Japan	Potential Impact estimates	According to a survey by Ministry of Health, Labour and Welfare, Japan (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 disorder leave the workplace within one year after starting work.[47]

Japan **Unresolved** ⇒ World **Unresolved**

Societal Issues	Develop an environment that accepts and empowers all individuals (= diversity management)

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 not just public education but also new educational opportunities and environments. These include private educational organizations, experiential learning activities, and a virtual learning process utilizing ICT

- A mechanism for objectively assessing of diversity is also in need. In 2016, the PRIDE Index was established as the first of its kind in Japan. It evaluates institutions' efforts to accept LGBTQ and other sexual minorities in the workplace.[48] The Ministry of Economy, Trade and Industry, Japan (METI) released *the Revised Diversity Management Diagnostic Toolkit* in 2021. The tool helps companies visualize the status of their diversity management level.[49] There are high hopes that the assessments with these indexes and toolkit to improve the personnel system and workplace environment

Make the Most of Diverse Human Resource Potential to Achieve Organizational Objectives: Reform of work practices, human asset matching, and psychological safety

- Creating a comfortable work environment for individuals under various circumstances, such as a requirement for childcare, nursing care, or relearning, will provide opportunities for diverse human resources to be utilized effectively. Efforts to accept diverse human resources into business are progressing, such as support for the second career development of athletes[50] and placement services for people with disabilities

- It is necessary not only to bring together diverse human resources but to make the most of each individual's various abilities and characteristics. To this end, it is essential to (1) raise the percentage of employed minorities above a certain level, and (2) ensure psychological safety in the workplace

Clues to Solutions

Technological Trends

Realization Timeline ▼

Promoting diverse human resource employment

- The use of satellite offices and work-from-home policies are becoming popular to employ workers who have difficulty commuting

  2020 to 2025

  | Example |

  Activatelab Co, Ltd. (Japan) provides a service to assess whether institutions are ready to employ candidates with disabilities by compiling a report on the constraints of hiring. They support each institution in identifying types of work that can be done at home or through work-from-home.[51]

- Some companies are featuring the art of those with mental disabilities in their branding efforts

  2020 to 2025

  | Example |

  HERALBONY Co., Ltd. (Japan) solicits artworks created by artists with mental disability at their website. The company utilizes high-resolution digital scanning to create and distribute high-quality fashion products and interior goods.

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Technological Trends

Learning diversity & inclusion

■ It is possible to understand and empathize with others' feelings through experiencing the views of people with different attributes and in different situations

20**20**
to
20**25**

> Example
>
> Jolly Good Inc. (Japan) developed a VR system called Yourside for a training course in the prevention of workplace harassments. It provides an experience to the executives and management from the perspective of the employees reporting to them.[52]

■ Including diverse characters in movies and educational TV programs contributes to promoting diversity and inclusion in society[53]

20**20**
to
20**25**

> Example
>
> Sesame Street, a U.S. educational TV program for children, has introduced various characters 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.[54]

Cross-cultural understanding through collaborative learning environments

■ Some schools in remote areas are connected to enable online collaborative learning

20**20**
to
20**25**

> Example
>
> Kizuna Across Cultures, a non-profit organization based in Washington, D.C., couples 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. It gives an opportunity for Japanese students to use the English language skills they learned in the classroom with native English speakers of the same generation. At the same time, the program promotes cross-cultural understanding and motivated both students to study abroad.[55]

Psychological safety

■ To encourage diverse human resources to work effectively, it is important to secure psychological safety in the workplace free from fear of others' reactions. Services are being developed that support building teams with high psychological safety

20**20**
to
20**25**

> Example
>
> 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 style manner.[56]

Clues to Solutions

Regulatory Trends

- On March 1st, 2021, the Japanese government raised the statutory employment rate for persons with disabilities for companies from 2.2% to 2.3%

- In December 2020, the Nasdaq Stock Market announced its new policy that companies applying for a listing on the exchange must have a diverse board representation of women, blacks and other minorities, as well as LGBTQ. Goldman Sachs, as an underwriter of company IPOs, also made it clear that it would require U.S. and European companies seeking to go public to appoint at least one diverse board member, strongly emphasizing women[57]

- 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) promote young and senior workers also to play active roles,
  (3) reform work practices,
  (4) invite highly skilled foreign human resources,
  (5) realize a society accessible without constraints, and
  (6) promote a society that embraces the LGBT community[58]

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Problems	Issues
(1) Insufficient skill development in terms of mastering new technologies and processes 4 QUALITY EDUCATION	**Provide learning opportunities to all children** **Targets in UN 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
(2) Few people in adulthood return to school (between different job opportunities) 4 QUALITY EDUCATION 5 GENDER EQUALITY	**Provide continuous opportunities for learning suited to modernizing skillsets** 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 women
(3) Filter bubbles (i.e. Information flooding and bias)	**Ensure free and open speech** —
(4) Lack of diversity in human resources 4 QUALITY EDUCATION 5 GENDER EQUALITY	**Develop an environment that accepts and empowers all individuals (= diversity management)** 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 women

Notes and References

All URLs were viewed on September 1st, 2021.

1 National Institute for Educational Policy Research, the Ministry of Education, Culture, Sports, Science and Technology, Japan, "Summary of OECD's *Programme for International Student Assessment 2018 (PISA 2018),*" December 3, 2019. (in Japanese)
https://www.nier.go.jp/kokusai/pisa/pdf/2018/01_point.pdfl

2 The International Commission on Financing Global Education Opportunity, *The Learning Generation*, September 2016.
http://report.educationcommission.org/report/

3 *Ohtake, F., "Economic effects and poverty alleviation by education," The fifth meeting of the Third Group in the Education Rebuilding Council, March 23, 2015. (in Japanese)*
https://www.kantei.go.jp/jp/singi/kyouikusaisei/bunka/dai3/dai5/siryou3.pdf

4 The Nippon Foundation and Mitsubishi UFJ Research and Consulting Co., Ltd., *Report on the Estimates of Societal Loss Caused by Child Poverty,* December 2015. (in Japanese)

5 An example of an adaptive learning service is shown in "Knewton."
https://japan.knewton.com/

6 Area Resources for Community and Human Services, "About Educare."
https://www.stleducare.org/about-us/educare.html/

7 Recruit Co., Ltd., "Studysapuri." (in Japanese)
https://studysapuri.jp//

8 Udemy https://www.udemy.com

9 Apple, "Augmented reality in education – Lesson ideas," November 2018.
https://www.apple.com/education/docs/ar-in-edu-lesson-ideas.pdf

10 mBot <https://www.embot.jp/> sold by KEINIS, Ltd. < https://www.kenis.co.jp/mbot/> (in Japanese)and the educational version of LEGO® MINDSTORMS®
https://education.lego.com/ja-jp/product/mindstorms-ev3
etc.

11 Leave a Nest Co., Ltd., "FY 2018 Interim Report for the Future Classroom Demonstration Project." (in Japanese)
https://www.learning-innovation.go.jp/verify/a0001/

12 A METI Demonstration Project, "World-standard English education through coaching and feedback." (in Japanese)
https://www.learning-innovation.go.jp/verify/z0048/

13 ICT Education at Kindai University Higher School, "ICT in Education." (in Japanese)
https://www.jsh.kindai.ac.jp/hs/education/ict/

14 Turnitin, LLC, "Gradescope."
https://www.gradescope.com/pricing

15 Qubena
https://qubena.com/

16 Atom Learning US, Inc., "Atom Learning."
https://atomlearning.com/

17 "Teachers Pay Teachers"
https://www.teacherspayteachers.com/

18 Kamioka, S., Kitaoka, T.., Suzuki, K., "The study of training for children with specific difficulties in learning English," Journal of Inclusive Education, Vol. 5, pp. 77-78, 2018. (in Japanese)
https://doi.org/10.20744/incleedu.5.0_77

19 Shimane Prefectural Oki-Dozen High School (in Japanese)
https://shimane-ryugaku.jp/dozen/

20 A METI Demonstration Project, "Creation of a movement for local SMEs and education by promoting internships for high school students." (in Japanese)
https://www.learning-innovation.go.jp/verify/z0050/

21 Such as a volunteer opportunity information website, "active." (in Japanese)
https://activo.jp/children/senior

22 Japan Association of New Economy, prepared for the hearing at the Working Group on Investment, etc., Council for Regulatory Reform, October 26th, 2018.
https://www8.cao.go.jp/kisei-kaikaku/suishin/meeting/wg/toushi/20181026/181026toushi01.pdf

23 "The Council for Regulatory Reform to recommend online classes in junior high schools in FY 2019*," The Nikkei*, November 8, 2018. (in Japanese)
https://www.nikkei.com/article/DGXMZO37510030Y8A101C1PP8000/

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Notes and References

All URLs were viewed on September 1st, 2021.

24 Ministry of Education, Culture, Sports, Science and Technology, Japan, "About digital textbooks for learners." (in Japanese)
https://www.mext.go.jp/a_menu/shotou/kyoukasho/gaiyou/04060901/1349317.htm

25 Mitsubishi Research Institute, Inc., *FY 2020 Evaluation Report on the Recurrent Education Programs Management Model under the Comprehensive Promotion Project of Recurrent Education at Specialized Training Colleges*, March 2021. (in Japanese)
https://www.mri.co.jp/knowledge/pjt_related/senshuugakkou/dia6ou0000020y31-att/2020_edu01_01.pdf

26 Ministry of Health, Labour and Welfare, Japan, "Recurrent Education." (in Japanese)

27 Ministry of Economy, Trade and Industry, Japan, "AI Quest," a WARP archive, National Diet Library, November 1, 2021. (in Japanese)
https://warp.da.ndl.go.jp/info:ndljp/pid/11875095/aiquest.meti.go.jp/2021

28 A personnel rental transfer platform, "LoanDEAL" (in Japanese): https://loandeal.jp/

29 "VR for improving childcare service quality: Senior Associate Professor Nakazawa at the University of Aizu in Fukushima starts developing teaching materials*," Fukushima Minpo News*, January 3, 2011. (in Japanese)
https://www.minpo.jp/news/moredetail/2022010393294

30 NeU Corporation, "Neuro marketing and kansei evaluation." (in Japanese)
https://neu-brains.co.jp/service/neuro-marketing/

31 GAIA
http://engagement.style/#news

32 ecretariat of New Form of Capitalism Realization Headquarters, Cabinet Secretariat, Japan, *"Outline of Emergency Proposal Toward the Launch of a 'New Form of Capitalism' that Carves Out the Future,"* November 8, 2021.
https://japan.kantei.go.jp/ongoingtopics/_00001.html

33 Cabinet Office, Japan, *Basic Policies on Economic and Fiscal Management and Reform 2021*, Cabinet Decision, provisional translation, June 18, 2021.
https://www5.cao.go.jp/keizai-shimon/kaigi/cabinet/2021/2021_basicpolicies_en.pdf

34 Ministry of Economy, Trade and Industry, *Japan, Report of the Study Group on Improvement of Sustainable Corporate Value and Human Capital*, provisional translation, September 2020.
https://www.meti.go.jp/shingikai/economy/kigyo_kachi_kojo/pdf/20200930_1e.pdf

35 "Manapas - A website that supports workers' studies at universities." (in Japanese) https://manapass.jp//

36 "Human rights violation cases tripled in ten years," *The Nikkei*, February 8, 2021. (in Japanese)
https://www.nikkei.com/article/DGKKZO68909140X00C21A2CR8000/

37 Johnson, J., "Global digital population as of January 2021," statista, September 10,2021.
https://www.statista.com/statistics/617136/digital-population-worldwide/

38 Mitchel, A., Jurkowitz, M. Baxter Oliphant, J. and Shearer E., "Americans who mainly get their news on social media are less engaged, less knowledgeable," report, Pew Research Center, July 30, 2020.
https://www.journalism.org/2020/07/30/americans-who-mainly-get-their-news-on-social-media-are-less-engaged-less-knowledgeable/

39 Bird, R. and Ritter, Z., "Is the media creating division on COVID-19 health practices?" Gallup, June 23rd, 2020.
https://news.gallup.com/poll/312749/media-creating-division-covid-health-practices.aspx.

40 "Survey on alcohol consumption and smoking, and the development of effective intervention methods for reducing alcohol consumption to prevent lifestyle-related diseases," *MHLW Grant System*. (in Japanese)
https://mhlw-grants.niph.go.jp/project/26503

41 "Preliminary Information," Project Implicit.
https://implicit.harvard.edu/implicit/takeatest.html

42 A's Child Inc. (in Japanese)
https://www.as-child.com/

43 Ministry of Internal Affairs and Communications, Japan, *Policy Package for Response to Internet Defamation*, September 2020. (in Japanese)
https://www.soumu.go.jp/main_content/000704625.pdf

44 Sparber, C., "Racial diversity and aggregate productivity in U.S. industries: 1980–2000*," Economic Faculty Working Papers*, Colgate University Libraries, 2007.https://core.ac.uk/download/pdf/229475359.pdf

45 Florida, R., Gates, G. "Technology and tolerance: The importance of diversity to high-technology growth," *The Brookings Institution Survey Series*, pp. 1-12, June 2001.
https://www.brookings.edu/wp-content/uploads/2016/06/techtol.pdf

Notes and References

All URLs were viewed on September 1st, 2021.

46   "Japan gov't to push back 30% target for women in leadership positions by up to 10 years," *The Mainichi*, June 26, 2020.
       https://mainichi.jp/english/articles/20200626/p2a/00m/0fp/014000c

47   "Over half of Japan's major companies are skeptical about achieving the 30% target for women in leadership positions in early years, a questionnaire survey for 100 enterprises revealed," *NHK News Web*, January 31, 2022. (in Japanese)
       https://www3.nhk.or.jp/news/html/20220131/k10013458071000.html

48   work with Pride, "What is the PRIDE INDEX," 2021. (in Japanese)
       https://workwithpride.jp/pride-i/

49   Ministry of Economy, Trade and Industry, Japan, "Promotion of diversity management." (in Japanese)
       https://www.meti.go.jp/policy/economy/jinzai/diversity/index.html

50   Mitsubishi Research Institute, Inc., "Key to the career success of retired athletes." (in Japanese)
       https://www.mri.co.jp/knowledge/wisdom/legacy/column/index.html

51   Activatelab Co., Ltd. (in Japanese)
       https://activatelab.co.jp/

52   Jolly Good Inc., "Jolly Good developed a VR counter harassment training system under the supervision of a psychosomatic medicine doctor, partnering with PEACEMIND EAP," press release, May 29, 2019. (in Japanese)
       https://jollygood.co.jp/news/1046

53   Sesame Workshop, "Diversity and Inclusion." (in Japanese)
       https://www.sesamestreetjapan.org/schedule/index.html

54   Bechdel, A., "Bechdel Test Movie List."
       https://bechdeltest.com/

55   Kizuna Across Cultures
       https://kacultures.org/

56   Murata Manufacturing Co., Ltd., "NAONA 1 on 1." (in Japanese)
       https://solution.murata.com/ja-jp/service/naona-meeting/1on1/

57   McEnery, T., "Goldman Sachs will no longer do IPOs for companies with all-male boards, *New York Post*, January 23, 2020.
       https://nypost.com/2020/01/23/goldman-sachs-will-no-longer-do-ipos-for-companies-with-all-male-boards/?utm_source=twitter_sitebuttons&utm_medium=site%20buttons&utm_campaign=site%20buttons

58   KEIDANREN (Japan Business Federation), "Toward a diverse and inclusive society," May 16, 2017. (in Japanese)
       https://www.keidanren.or.jp/policy/2017/039_honbun.pdf

1. WELLNESS

2. WATER AND FOOD

3. ENERGY AND ENVIRONMENT

4. MOBILITY

5. DISASTER PREVENTION AND INFRASTRUCTURE

6. EDUCATION AND HUMAN RESOURCE DEVELOPMENT

Problem	Issues
(1) Rising medical costs due to lifestyle-related diseases	**Improvements in technology and measures to detect early signs of disease and prevent them from becoming severe**
	Key Points for Resolving Issues
	People at Risk for Lifestyle-Related Diseases: The key is to sustain lifestyle behavioral changes
	Patients with Lifestyle-Related Diseases: Promoting behavioral change to prevent diseases from worsening
(2) Insufficient access to medical and nursing services	**Securing services and improving quality regardless of patients' location or distance**
	Key Points for Resolving Issues
	Developed Countries: Realizing efficient utilization of resources by healthcare professionals
	Developing Countries: How to prevent neonatal mortality
(3) Intensifying shortage of care workers	**Expanding science-based nursing care to enhance productivity while ensuring quality**
	Key Points for Resolving Issues
	People at Risk for Dementia: Early detection of symptoms and the development of effective countermeasures are key
	Care Workers: Ensuring autonomy and motivation, reducing physical and mental burdens of care workers
(4) Increase in the number of people suffering from mental illness	**Support ranging from prevention and detection of early signals to treatment and rehabilitation**
	Key Points for Resolving Issues
	Mental Health Monitoring: Everyday measures for prevention and early detection
	Appropriate Intervention: From preventing mental deterioration to promoting inclusion and re-entry to the society
(5) Increasing health risks for women	**Development of products focused on women's health and social systems to support women's participation in society**
	Key Points for Resolving Issues
	Medical Perspective: Product development that considers health issues unique to women
	The Perspective of Equality in Society: Reducing the burden of caregiving work and developing products that consider gender differences

Problem	Issues
(6) Worsening harm caused by loneliness and isolation	Early detection of potential victims, implementation of preventive measures, and reduction of adverse effects
	Key Points for Resolving Issues
	Early Detection of Potential Victims (Patients) and Implementation of Preventive Measures: Support to prevent unwanted loneliness
	Mitigating Adverse Effects: Maintaining the physical and mental health of people in loneliness
(7) Frequent and severe pandemics	Preventive measures against the spread of the virus to improve resilience against infectious diseases
	Key Points for Resolving Issues
	Developed Countries: The key is balancing information-based prevention, control of outbreak, medical resources, and economic activities
	Developing Countries: Improving sanitation in developing countries, where pandemics may hit more severely

Problem	Issues
(1) Decline in food supply capacity	**Improve productivity through industrialization of food production and securing manpower**
	Key Points for Resolving Issues
	（Japan）Elderly Farmers and Fishery Workers: Mechanization, large-scale, and high value-added
	（Japan）New Members Engaging in Agriculture: Industrialization and expansion of opportunities coupled with smooth transfer of expertise
	（Global）Countermeasures for Climate change, Farmland Conservation, and Prevention of Overfishing
(2) Difficulties in food procurement due to population growth	**Secure ample food supply to meet the rise in 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 resource	**Securing and improving water infrastructure and better functionalities**
	Key Points for Resolving Issues
	Countries and Regions That Lack Clean Water: Securing the absolute quantity of water and improving the quality of water are key
	Water Infrastructure Operators: How to manage to meet demand
(4) Increase in food loss and waste	**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 that remains in prosperous societies	**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

Problem	Issues
(6) The shift toward greater respect for food diversity	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 reduction of burden
(7) Lack of communication through food	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: New experiences with food

Problem	Issues
(1) Need to accelerate decarbonization in the supply side of energy	**Promote comprehensive decarbonization measures** Key Points for Resolving Issues **Technological Development in Production and Conversion of Energy:** Expanding renewable energies, power generation with hydrogen and ammonia **Development of Energy Storage and Transportation Technologies:** Improvement of performance, safety, and affordability of storage batteries **Development of New Distributed Energy Systems:** Virtual power stations and microgrids
(2) Addressing the large room for energy conservation and decarbonization on the demand side	**Provide solutions to promote decarbonization in the industrial, household, and transportation sectors** Key Points for Resolving Issues **Industrial Sector:** Decarbonization of manufacturing processes and technological innovation in CO_2 capturing and recycling **Civilian (Business and Household) Sector:** Popularization of energy-saving houses and buildings, and energy technology innovation using IoT **Transportation Sector:** Development of technologies in automotive batteries and FCVs, and improvement of utilization rates through sharing and joint delivery
(3) Insufficient recycling and ineffective use of resources	**Create a recycling society that makes effective use of resources** Key Points for Resolving Issues **Enhancement of Resource Utilization throughout the Product Life Cycle** **Advanced Recycling** **Advanced Utilization of Biomass Resources**
(4) Intensifying environmental deterioration and pollution	**Take immediate action to capture the current situation, analyze the cause, and implement countermeasures** Key Points for Resolving Issues **Measures to Control Pollution:** Preventing and cleaning new and existing contamination **Countermeasures against Deforestation:** Enhancing respective measures by regions and coordinated effort on a global scale

Problem	Issues
(5) Loss of biodiversity	**Maintain sustainable coexistence between humans and other living creatures**
	Key Points for Resolving Issues
	Visualization: Understanding the actual state of the ecosystem and practice of segregation
	Commercialization: Securing conservation funds through the utilization of ecosystems

Problem	Issues
(1) Adverse Effects of Vehicle-centric Transportation Systems	**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: Popularization and Promotion of Transportation with Low Environmental Impact
(2) Deficiency of logistics capacity for increased demand	**Building a sustainable logistics network** Key Points for Resolving Issues Improving Delivery Efficiency: Coordinating Supply Chain, Matching Shippers and Trucks, and Offering Optimal Route Labor-saving Measures and Automation: Autonomous Driving, Utilization of Delivery Robots and Drones New Delivery Service: Delivery by Proprietary Business Drivers and Mixed Loading of Freight and-Passengers
(3) Expansion of areas where transportation is restrained	**Providing mobility services to maintain quality of life** Key Points for Resolving Issues Transportation to Fill the Demand/Supply Gap: On-Demand and Last-Mile Transportation Transportation Services to Fulfill Users' Objectives: Collaboration and Integration of Transportation Business with Merchandise and Service Providers Small-scale Service to Meet Diverse Needs: Improving Operational and Network Efficiency
(4) Rapid changes in means of transportation and opportunities utilizing digital technologies	**Providing wider variety of customer experiences in response to the changes in the configuration of transportation** Key Points for Resolving Issues Diversifying Work Styles: Improving Efficiency in Work and Creating a Better Work-Life Balance New Tourism: Providing Diverse Experiences to Meet Customer Needs in Tourism Next-generation Mobility: New Mobility and Development of Associated Services

DISASTER PREVENTION AND
INFRASTRUCTURE

Problem	Issues
(1) Insufficient preparation and response to natural disasters	**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	**Improvements to efficient management of infrastructure through, aggregated and centralized control, and better utilization** 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 and efficient use over a wide area **Utilization of Infrastructure:** Multifaceted perspectives for effective use
(3) Urban Decay Caused by an Increasing Number of Vacant Houses	**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	**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
RESOURCE DEVELOPMENT

Problem	Issues
(1) Insufficient skill development in terms of mastering new technologies and processes	**Provide learning opportunities to all children**
	Key Points for Resolving Issues
	Defining the Essential Education: Clarifying the Educational Contents Required to Keep Up with the Times
	Individually Optimized Learning: Providing Education Tailored for Children's Characteristics and Backgrounds
(2) Few people in adulthood return to school (between different job opportunities)	**Provide continuous opportunities for learning suited to modernizing skillsets**
	Key Points for Resolving Issues
	Workers: Fostering and Supporting Career Ownership
	Companies: Active Participation and Investment in Human Resource Development
	Educational Program Provider: Providing Quality Educational Programs That Reflect Rapidly Changing Needs
(3) Filter bubbles (i.e. Information flooding and bias)	**Ensure free and open speech**
	Key Points for Resolving Issues
	Clarifying and Correcting Information Flooding and Bias: Complete Elimination of Incorrect Information is Difficult
	Education on Communication: Understanding the Characteristics of Internet World
(4) Lack of diversity in human resources	**Develop an environment that accepts and empowers all individuals (= diversity management)**
	Key Points for Resolving Issues
	Pursuing Equity: Education and Assessment
	Make the Most of Diverse Human Resource Potential to Achieve Organizational Objectives: Reform of Work Practices, Human Asset Matching, and Psychological Safety

1. NO POVERTY	**Societal Problems** : Insufficient preparation and response to natural disasters (DISASTER PREVENTION AND INFRASTRUCTURE)
	Societal Issues : Strengthening of disaster response capabilities through innovative technologies and societal infrastructure
	Societal Problems : Poor Management of Societal Infrastructure (DISASTER PREVENTION AND INFRASTRUCTURE)
	Societal Issues : Improvements to efficient management of infrastructure through, aggregated and centralized control, and better utilization
2. ZERO HUNGER	**Societal Problems** : Decline in food supply capacity (WATER AND FOOD)
	Societal Issues : Improve productivity through industrialization of food production and securing manpower
	Societal Problems : Difficulties in food procurement due to population growth (WATER AND FOOD)
	Societal Issues : Secure ample food supply to meet the rise in global demand
	Societal Problems : Unhealthy food that remains in prosperous societies (WATER AND FOOD)
	Societal Issues : Providing and improving access to healthy meals
3. GOOD HEALTH AND WELL-BEING	**Societal Problems** : Rising medical costs due to lifestyle-related diseases (WELLNESS)
	Societal Issues : Improvements in technology and measures to detect early signs of disease and prevent them from becoming severe
	Societal Problems : Insufficient access to medical and nursing services (WELLNESS)
	Societal Issues : Securing services and improving quality regardless of patients' location or distance
	Societal Problems : Intensifying shortage of care workers (WELLNESS)
	Societal Issues : Expanding science-based nursing care to enhance productivity while ensuring quality
	Societal Problems : Increase in the number of people suffering from mental illness (WELLNESS)
	Societal Issues : Support ranging from prevention and detection of early signals to treatment and rehabilitation
	Societal Problems : Increasing health risks for women (WELLNESS)
	Societal Issues : Development of products focused on women's health and social systems to support women's participation in society

3. GOOD HEALTH AND WELL-BEING	**Societal Problems** : Frequent and severe pandemics (WELLNESS)
	Societal Issues : Preventive measures against the spread of the virus to improve resilience against infectious diseases
	Societal Problems : Intensifying environmental deterioration and pollution (ENERGY・ENVIRONMENT)
	Societal Issues : Take immediate action to capture the current situation, analyze the cause, and implement countermeasures
	Societal Problems : Adverse effects of vehicle-centric transportation systems (MOBILITY)
	Societal Issues : Optimizing traffic flow and promoting the use of safe and comfortable mobility services
4. QUALITY EDUCATION	**Societal Problems** : Insufficient skill development in terms of mastering new technologies and processes (EDUCATION AND HUMANRESOURCE DEVELOPMENT)
	Societal Issues : Provide learning opportunities to all children
	Societal Problems : Few people in adulthood return to school (between different job opportunities) (EDUCATION AND HUMANRESOURCE DEVELOPMENT)
	Societal Issues : Provide continuous opportunities for learning suited to modernizing skillsets
	Societal Problems : Lack of diversity in human resources (EDUCATION AND HUMANRESOURCE DEVELOPMENT)
	Societal Issues : Develop an environment that accepts and empowers all individuals (= diversity management)
5. GENDER EQUALITY	**Societal Problems** : Increasing health risks for women (WELLNESS)
	Societal Issues : Development of products focused on women's health and social systems to support women's participation in society
	Societal Problems : Few people in adulthood return to school (between different job opportunities) (EDUCATION AND HUMANRESOURCE DEVELOPMENT)
	Societal Issues : Provide continuous opportunities for learning suited to modernizing skillsets
	Societal Problems : Lack of diversity in human resources (EDUCATION AND HUMANRESOURCE DEVELOPMENT)
	Societal Issues : Develop an environment that accepts and empowers all individuals (= diversity management)

6. CLEAN WATER AND SANITATION	**Societal Problems :** Frequent and severe pandemics (WELLNESS)
	Societal Issues : Preventive measures against the spread of the virus to improve resilience against infectious diseases
	Societal Problems : Insufficient usable water resource (WATER AND FOOD)
	Societal Issues : Securing and improving water infrastructure and better functionalities
	Societal Problems : Loss of biodiversity (ENERGY・ENVIRONMENT)
	Societal Issues : Maintain sustainable coexistence between humans and other living creatures
7. AFFORDABLE AND CLEAN ENERGY	**Societal Problems :** Need to accelerate decarbonization in the supply side of energy (ENERGY・ENVIRONMENT)
	Societal Issues : Promote comprehensive decarbonization measures
	Societal Problems : Addressing the large room for energy conservation and decarbonization on the demand side (ENERGY・ENVIRONMENT)
	Societal Issues : Provide solutions to promote decarbonization in the industrial, household, and transportation sectors
8. DECENT WORK ECONOMIC GROWTH	**Societal Problems :** Increasing health risks for women (WELLNESS)
	Societal Issues : Development of products focused on women's health and social systems to support women's participation in society
	Societal Problems : Insufficient recycling and ineffective use of resources (ENERGY・ENVIRONMENT)
	Societal Issues : Create a recycling society that makes effective use of resources
9. INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Societal Problems :** Insufficient recycling and ineffective use of resources (ENERGY・ENVIRONMENT)
	Societal Issues : Create a recycling society that makes effective use of resources
	Societal Problems : Poor Management of Societal Infrastructure (DISASTER PREVENTION AND INFRASTRUCTURE)
	Societal Issues : Improvements to efficient management of infrastructure through, aggregated and centralized control, and better utilization
	Societal Problems: Larger number and harsher types of cyberattack (DISASTER PREVENTION AND INFRASTRUCTURE)
	Societal Issues : Security measures based on a Society 5.0 world

10.REDUCED INEQUALITIE	**Societal Problems :** The shift toward greater respect for food diversity (WATER AND FOOD)
	Societal Issues : Improving the diversity and quality of food to conform to the needs of individuals
11.SASTAINABLE CITIES AND COMMUNITIES	**Societal Problems :** Worsening harm caused by loneliness and isolation (WELLNESS)
	Societal Issues : Early detection of potential victims, implementation of preventive measures, and reduction of adverse effects
	Societal Problems : Intensifying environmental deterioration and pollution (ENERGY・ENVIRONMENT)
	Societal Issues : Take immediate action to capture the current situation, analyze the cause, and implement countermeasures
	Societal Problems : Expansion of areas where transportation is restrained (MOBILITY)
	Societal Issues : Providing Mobility Services to Maintain Quality of Life
	Societal Problems : Poor management of societal infrastructure (DISASTER PREVENTION AND INFRASTRUCTURE)
	Societal Issues : Improvements to efficient management of infrastructure through, aggregated and centralized control, and better utilization
	Societal Problems : Urban Decay Caused by an Increasing Number of Vacant Houses (DISASTER PREVENTION AND INFRASTRUCTURE)
	Societal Issues : Revitalization of local communities by making use of vacant houses
12.RESPONSIBLE CONSUMPTION AND PRODUCTION	**Societal Problems :** Increase in food loss and waste (WATER AND FOOD)
	Societal Issues : Streamlining food supply chain across all stages from production to supply and consumption; reducing food waste
	Societal Problems : Insufficient recycling and ineffective use of resources (ENERGY・ENVIRONMENT)
	Societal Issues : Create a recycling society that makes effective use of resources
	Societal Problems : Intensifying environmental deterioration and pollution (ENERGY・ENVIRONMENT)
	Societal Issues : Take immediate action to capture the current situation, analyze the cause, and implement countermeasures
	Societal Problems : Poor management of societal infrastructure (DISASTER PREVENTION AND INFRASTRUCTURE)
	Societal Issues : Improvements to efficient management of infrastructure through, aggregated and centralized control, and better utilization

13. CLIMATE ACTION	**Societal Problems：** Poor management of societal infrastructure (DISASTER PREVENTION AND INFRASTRUCTURE)
	Societal Issues：Improvements to efficient management of infrastructure through, aggregated and centralized control, and better utilization
14. LIFE BELOW WATER	**Societal Problems**：Intensifying environmental deterioration and pollution (ENERGY・ENVIRONMENT)
	Societal Issues：Take immediate action to capture the current situation, analyze the cause, and implement countermeasures
	Societal Problems： Loss of biodiversity (ENERGY・ENVIRONMENT)
	Societal Issues：Maintain sustainable coexistence between humans and other living creatures
15. LIFE ON LAND	**Societal Problems**：Intensifying environmental deterioration and pollution (ENERGY・ENVIRONMENT)
	Societal Issues：Take immediate action to capture the current situation, analyze the cause, and implement countermeasures
16. PEACE, JUSTICE AND STRONG INSTITUTION	**Societal Problems：** -
	Societal Issues：-
17. PARTNER-SHIPS FORTHE GOALS	**Societal Problems：** -
	Societal Issues：-

Appendix 3 – Technological Index

Appendix 3 – Technological Index

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

Resolving Societal Issues Through Innovation
---2021 Listings of Societal Issues

Issue：May.2022.Ver.1