As the world’s population continues to rise, particularly in emerging economies, the problem of food shortages is becoming extremely serious. The latest available estimates from the food assistance branch of the United Nations, the UNWFP (United Nations World Food Program), indicate that about 795 million people in the world—just over one in nine—are not receiving enough nourishment to live a healthy, active lifestyle. And yet, every day in developed economies and emerging economies alike, large amounts of food are going to waste. Food production requires not only massive consumption of our precious water resources, but releases large amounts of greenhouse gasses. The fact that an enormous amount of resources are wasted through the production of food that is not eaten is a problem that we cannot ignore if we hope to protect this planet. The areas we should focus on as sources of these issues are food reduction (food loss) at their respective steps in the value chain and the disposal that occurs at the time of retail and consumption. Resolving these issues is a matter of urgency, and there is talk of regulating food loss and waste in the same way that CO₂ emissions are regulated.

As time moves forward, various businesses are working in collaboration to address the issues of food loss and waste, and there is a demand for new innovations concerning the entire value chain. This report overviews NEC’s various cutting edge technologies and efforts to resolve issues in the processes leading from food production to consumption.
With the exception of some developed countries, the world as a whole is experiencing a rise in population, with no end in sight. According to the latest UN reports, the world population will rise to an estimated 9.7 billion people by 2050. Compared to the roughly 7.3 billion population of 2015, that’s about 1.3 times more people. Naturally, as the population increases, the amount of necessary food resources will also rise. However, food production requires large amounts of water, and the process results in the emission of greenhouse gasses. Thus, food production is linked to the wasting of our precious global resources.

An important approach to resolving this issue is to reduce food loss and waste. According to a study by the FAO (Food and Agriculture Organization of the United Nations), roughly one-third of the food produced for human consumption gets lost or wasted globally, which totals to about 1.3 billion tons of food per year. The food that is produced and not eaten results in an estimated 3.3 Gigatonnes of greenhouse gas emissions and about 250 km$^3$ of fresh water consumption. If we could produce an appropriate amount of food and to deliver it to consumers without any waste, the resulting reduction in wasted global resources would surely bring us closer to achieving a sustainable society.

In an agenda adopted by the UN in 2015 titled "Transforming our world: the 2030 Agenda for Sustainable Development," a set of SDGs (Sustainable Development Goals) were established. In a description of "Our world today," the document notes that "billions of our citizens continue to live in poverty and are denied a life of dignity" and warns that "the survival of many societies, and of the biological support systems of the planet, is at risk."

These SDGs focus on food loss and waste. Specifically, one of the listed goals is "by 2030, [to] 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." Now is the time for us as a society to earnestly pursue the reduction of food loss and waste.

### Impact of Food Waste on the Global Environment

<table>
<thead>
<tr>
<th>Resource</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh water</td>
<td>250 Km$^3$</td>
</tr>
<tr>
<td>Utilized land mass</td>
<td>Approx. 1.4 billion ha (37 times the area of Japan)</td>
</tr>
<tr>
<td>Greenhouse gas emissions</td>
<td>Approx. 3.3 Gtonnes</td>
</tr>
</tbody>
</table>

* Based on "Food wastage footprint impacts on natural resources"
Global Call to Prevent Annual Food Loss and Waste of 1.3 Billion Tons

1.3 billion tons of the food produced globally over the course of a year is lost or wasted, costing the economy an estimated 7.6 trillion yen, as calculated by the FAO. Not even Japan can ignore the issues of food loss and waste, as the Ministry of Agriculture, Forestry and Fisheries of Japan has estimated that 20 percent of all domestic production, a total of around 17 million tons of food a year, is disposed of, and 5 to 8 million tons of this yearly food loss is thrown away despite being essentially edible. This is equal to the amount of rice produced in Japan (about 8.5 million tons) and more than twice the amount of food aid provided world-wide (about 4 million tons).

To improve this type of situation, international initiatives dealing with food loss and waste are currently underway. In 2011, the FAO launched a global initiative called “SAVE FOOD,” cooperating with international organizations and private businesses to reduce food waste. This initiative grew to include the Asia-Pacific region in 2013. In addition, the European Parliament designated 2014 as “European year against food waste,” and obliged participating nations to optimize their resources and pursue counter-measures in order to halve food waste by 2020. Europe, as a whole, has really begun addressing this issue.

The U.S. also perceives food loss and waste as a large problem. The nation’s Environmental Protection Agency and Department of Agriculture have set a national goal to reduce food waste by 50%. To achieve this, the states and public foundations, NGOs (nongovernmental organizations), and other various groups have stated their intentions to pursue cooperative initiatives.

At the 2016 World Economic Forum held in the Swiss municipality of Davos, the issues of food loss and waste were addressed. 30 people from the UNEP (United Nations Environment Programme), NGOs, representatives from various agencies, key figures from chief enterprises, cabinet ministers, and others came together to initiate “Champions 12.3,” a coalition dedicated to reducing the world’s food loss and waste. The mission of this group is to achieve the landmarks set by the SDGs regarding food loss and waste, to take action in their own organizations, and to convey the importance of this issue to other companies while urging them to take action as well.

By pursuing these types of international activities, even more enterprises are recognizing that food loss and waste are serious problems. As was mentioned earlier, these issues have a negative impact on the global environment and are very likely to cause grave concern for the large populations to come. We should also be conscious of the likelihood that when it comes to food purchases and eating out, customers will be swayed by initiatives against food loss and waste.

Global initiatives to reduce food loss and waste

- **USA**: Set national goal to reduce food waste by 50%
- **European Parliament**: Requires that EU member countries improve resource efficiency in order to halve food waste by 2020
- **UN**: Set goal to halve the amount of food waste by 2030

*According to press releases related to the UN, European Parliament, and USA*
Food loss and waste from production through consumption occurs at every step of the value chain, but we should take care to acknowledge the differences in timing between developed and emerging economies.

In developed countries, a lot of food waste occurs from post-processing through the consumer phase. For example, when new items go on sale or when the standard stock shifts, existing items are removed from the storefront and discarded. Common business practices and the perceptions that people have regarding food safety also lead to an increase in the amount of food waste. And, it is worth noting the sizeable amount of food that is leftover at the dinner table or left to expire after purchase and is summarily thrown out.

In contrast, the food in emerging economies is being wasted at the production and distribution stages. Starting with underdeveloped harvesting technologies, large amounts of food are being wasted at their production sites, and because there is a lack of reliable transportation infrastructure and packing techniques are still low grade, a lot of food is cast out over the course of distribution as well.

At present, the per capita food loss in Europe and North-America is 280 to 300 kg/year, with each consumer wasting somewhere between 95 to 115 kg of food. In sub-Saharan Africa and South/Southeast Asia, the per capita food loss is 120 to 170 kg/year, but only 6 to 11 kg are thrown out by consumers.

To solve this problem, it will be necessary to plan countermeasures that deal with developed and emerging economies separately. For developed countries with a big appetite for food consumption, we must cooperate with the operators of each step in the value chain to identify deficiencies and guide consumers in how to adjust their food wasting habits. Due to consumers’ tendency to seek quality and to reject food that contains outward imperfections, merchants will recall items that are nearing their best-by dates and dispose of them of their own volition, generating a large amount of waste.

On the other hand, in emerging economies which require strengthened initiatives, we consider implementation of the “cold chain system”. The cold chain system is a structure to keep agricultural harvests and marine products at low temperatures throughout every step of processing and delivery, to the point of consumption. In developed countries, where this system has been enabled, the ratio of foods damaged over the course of distribution has been reduced. However, in emerging economies the necessary infrastructure is not yet in place, so much food is wasted before it reaches processing.

In order to halve food loss and waste, it is necessary to reevaluate each step of the value chain based on the circumstances of each country and region. At present, in anticipation of future regulations, the movement of enterprises and organizations, including large-scale producers and retailers, is actively accelerating. Approximately 400 food companies, distributors, etc., including Coca-Cola and Nestle, Kirin, Ajinomoto, and others, have joined the CGF (Consumer Goods Forum), which has settled on a plan to halve the food waste resulting from production and sales by 2025. Already, many corporations and industry groups have initiated voluntary actions against food loss and waste.

* Source: Global Food Losses and Food Waste
To reduce food loss and waste, it is important to thoroughly expose weak points in each stage of the value chain—from production in the agriculture, dairy, fishing and other industries (primary industries) to production (secondary industries), where the bulk of processing occurs, as well as in retail and consumption—and to apply specific countermeasures.

As mentioned earlier, developed countries experience a large amount of food loss and waste at the retail and consumer phases, but new companies addressing this problem via IT have begun to appear. For example, a 16-year-old boy from the U.S. started “Waste No Food,” a service which offers to collect the food that would be discarded by restaurants and supermarkets and distribute it to charitable organizations and homeless shelters. This initiative has amassed many supporters, and many stores, including some restaurants that have appeared in the Michelin Guide, are participants and contribute food.

When it comes to developing services which address the environmental issues related to food production, there is the Swiss-made “Eaternity.” This enterprise offers a solution to reduce the environmental burden that comes with food by providing restaurants with suggested menu items that are more environmentally friendly.

And, there is a growing initiative in the retail industry to focus on the reduction of food loss and waste throughout the value chain. Starting the 2013, the large-scale British supermarket chain “Tesco” launched a unique investigation. Estimating that 56,850 tons of food was wasted from their stores and delivery centers, the company investigated the disposal of each item at every step and began to release the results publicly on their website.

Retail stores that are pursuing the reduction of food loss and waste by actively planning to revise their existing procedures are also appearing. For example, a Swedish retailer with more than 300 shops has eliminated unnecessary losses spotted throughout the processes that span from planning and stocking through purchasing and disposal, by reimagining the value chain used until now. Thanks to this, not only have costs gone down, the number of sales and customer satisfaction have also risen.

In Japan, the ”Foodloss Challenge Project” has been put into effect. This joint-development project, which focused on the issues of food loss and waste, brought together people from various backgrounds, such as agriculture/seafood production, manufacturers, distributors, retailers, and others in the business and organization of the “food value chain,” as well as administrative food specialists, NPOs, and researchers. It has become incredibly essential to conceive of countermeasures against food loss and waste throughout the value chain by considering the occurrences of lost and wasted food at each step from production to consumption in this way.

### Problems facing the value chain for food and agriculture

<table>
<thead>
<tr>
<th>Stage</th>
<th>Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production (primary industry)</td>
<td>Disposal according to production regulations</td>
</tr>
<tr>
<td>Transport</td>
<td></td>
</tr>
<tr>
<td>Production (secondary industry)</td>
<td></td>
</tr>
<tr>
<td>Wholesale</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td></td>
</tr>
<tr>
<td>Retail</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td></td>
</tr>
<tr>
<td>Consumer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unsold items</td>
</tr>
</tbody>
</table>

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**Industry Eco-System**

Problems facing the value chain for food and agriculture

- Screening/ removal of non-standard goods
- Disposal according to production regulations
- Replacement of goods/ Manufacturing errors
- Unsold items
- Leftovers
- Not yet equipped for cold chain
Applying AI to Commodity Demand Forecasting to Help Reduce Food Loss and Waste

For reducing food loss and waste, we will not be able to achieve basic solutions without addressing a number of problems that span each process from production to logistics and retail. This monumental role has been assigned to demand forecasting, which makes use of artificial intelligence (AI) technology. NEC believes in practically applying demand forecasts to each process and approaches value chain innovation by linking the processes of “MAKE” (manufacturing), “CARRY” (logistics), and “SELL” (retail/services).

One of the reasons that food loss and waste occurs is an excessive mismatch between supply and demand. Pertinent estimations are not easy to attain, because the demands of consumers fluctuate based on a variety of factors, including the weather, the temperature, and the day of the week. The difficulties of demand forecasting are further affected by the recent increase in the number of commodities and the shortening of product cycles. In response, NEC offers a commodity demand forecasting solution which uses heterogeneous mixture learning powered by AI.

Heterogeneous mixture learning technology automatically groups a large variety of data in high volume, and then automatically and identifies trends within those groups with great accuracy. The sorting of data, which used to take specialists a long time to do by hand, can now be performed automatically, which makes it possible to handle the enormous task of forecasting demands for separate commodities daily. Participating food manufacturers can calculate predictions based on an array of data that factors in the outbound shipping results of demand forecasting, calendar information, POS data and weather information, comparisons and other business negotiations, advertising promotions, and so on. In practice, 70% of the target commodities received highly accurate results. Furthermore, we are challenging ourselves to apply this system to commodities for which demand is difficult to forecast.

In regards to orders placed by retail stores, the number of disposed items was reduced by about 40% compared to when the previous personnel was in charge, thanks to the demand forecasts attained through analysis of the sales results and disposals for that time period, stockout information, weather information, and other interrelated issues via heterogeneous mixture learning technology. Even new store branches, which do not have any past data and have always been hard to predict, can implement demand forecasts, based on data learned through the sales trends of several similar past store openings.

In this way, heterogeneous mixture learning technology can learn from large array of data and produce large benefits through the demand forecasts given to food producers and retail stores. Moreover, if food producers and retailers can use the data from these demand forecasts to build a cooperative value chain, they can optimize the balance of supply and demand and attain more big results.

Commodity demand forecasting solution

- **Wide range of data**
  - Meteorological data
  - Calendar data
  - POS data
  - Warehouse-out data
  - Shipment data
  - Promotional information
  - SNS information
  - Event information

- **Advanced forecasting from the AI**
  - Demand forecasting
  - Order forecasting
  - Production forecasting

AI: Heterogeneous mixture learning engine

Etc.
The NEC is leveraging use of the world’s leading AI and the IoT* to tackle various social issues and carry out Value Chain Innovation, which creates new value that connects people, things, and processes in the entire value chain of “MAKE,” “CARRY,” and “SELL.” This section introduces the NEC’s push for demand forecasting using the aforementioned AI, and gives examples for each process.

First, in the process of “MAKE,” the “NEC Industrial IoT” is being offered as a next-generation manufacturing solution for manufacturing industries using the IoT. According to “Visualization Solution for Manufacturing,” based on demonstrative experiments conducted by this company using manufacturing innovation and the IoT, collection and visualization of data at the production site lead to improvements in productivity, the flow of the value chain, and quality. By applying these initiatives to places where food is manufactured, inefficiency is removed, production is optimized, quality is improved, and the issue of food loss and waste at the “MAKE” stage can be handled.

On the topic of “CARRY,” NEC is offering the “Logistics Visualization System” to visualize the logistics at points throughout the globe. By proving information on “what, where, and how much” in real time, inventory control can be optimized, and distribution can be efficiently managed. For the distribution of food, if issues that would lead to food loss through distribution channels can be visualized, the problems can be largely resolved.

Finally, the “SELL” process relies heavily on stabilizers for a range of equipment used in retail stores. This reliability is especially important for retail businesses that have many stores throughout the globe and require stable operation 24 hours a day, 365 days a year. NEC’s “IT-LCM service” uses sensing and cloud technology to monitor the condition of each type of machinery in real time, to anticipate potential malfunctions, and to support the store management. This not only prevents the decline in store services that would have occurred in the event of a failure, it combats the social problems of food loss and waste by reducing the waste that would have resulted from a broken fixture.

In this way, greater efficacy and optimization of the value chain is realized, and full-time enterprises can run safely and securely, hopefully leading to the reduction of food loss and waste in a way that moves beyond individual enterprises.

While respecting the essential values pursued by society and by their customers, NEC wishes to work together with everyone and use the ICT to design new social values for the sake of a brighter world. If you have any questions concerning the contents of this report or NEC initiatives, please do not hesitate to contact us.

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* Internet of Things

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**NEC’s Goal to Create Social Value through Value Chain Innovation**

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**Creating new value through “Value Chain Innovation”**

[Diagram illustrating Value Chain Innovation with various processes and technologies]
NEC Group is focusing its efforts on providing “Solutions for Society” by upgrading the social infrastructure with ICT. NEC defined six megatrends based on a structural observation of the global economy and social trends. Based on the six megatrends, NEC formulated seven themes for social value creation as its mission.

### Sustainable Earth
Establish a sustainable lifestyle base by utilizing limited resources effectively and taking measures to prevent damage to the global environment in order to live in harmony with the Earth.

### Safer Cities & Public Services
Help emerging countries build safe and secure cities, and help developed countries mature their societies. Establish a "global" administrative service platform through joint initiatives between the public and private sectors.

### Lifeline Infrastructure
Establish ICT systems that resolve disparities of area and delivery time, and build safe and efficient lines for travel, utilities, etc. that can support around-the-clock activities in society.

### Communication
Build a platform for information and communications to support the distribution of information and knowledge, which becomes more important as society advances.

### Industry Eco-System
Innovate a new industrial ecosystem including connection of industrial machinery with the Internet, 3D printers, crowdsourcing and reverse innovation.

### Work Style
Create new work style and relationship with society in which people work together with communities and robots regardless of gender and generation.

### Quality of Life
Build a diversified and equal society to support people’s enriched and active lives through contributions to education, healthcare and medicine.

This Social Value Creation Report is issued for each of the seven themes listed above and summarizes NEC’s concepts, efforts, and proposals, in addition to social issues and global trends. NEC hopes that this report can be the first step in establishing cooperative creative partnerships with customers.