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BUILDING THE RESILIENCE OF JAPAN'S AGRICULTURAL SECTOR TO TYPHOONS AND HEAVY RAIN

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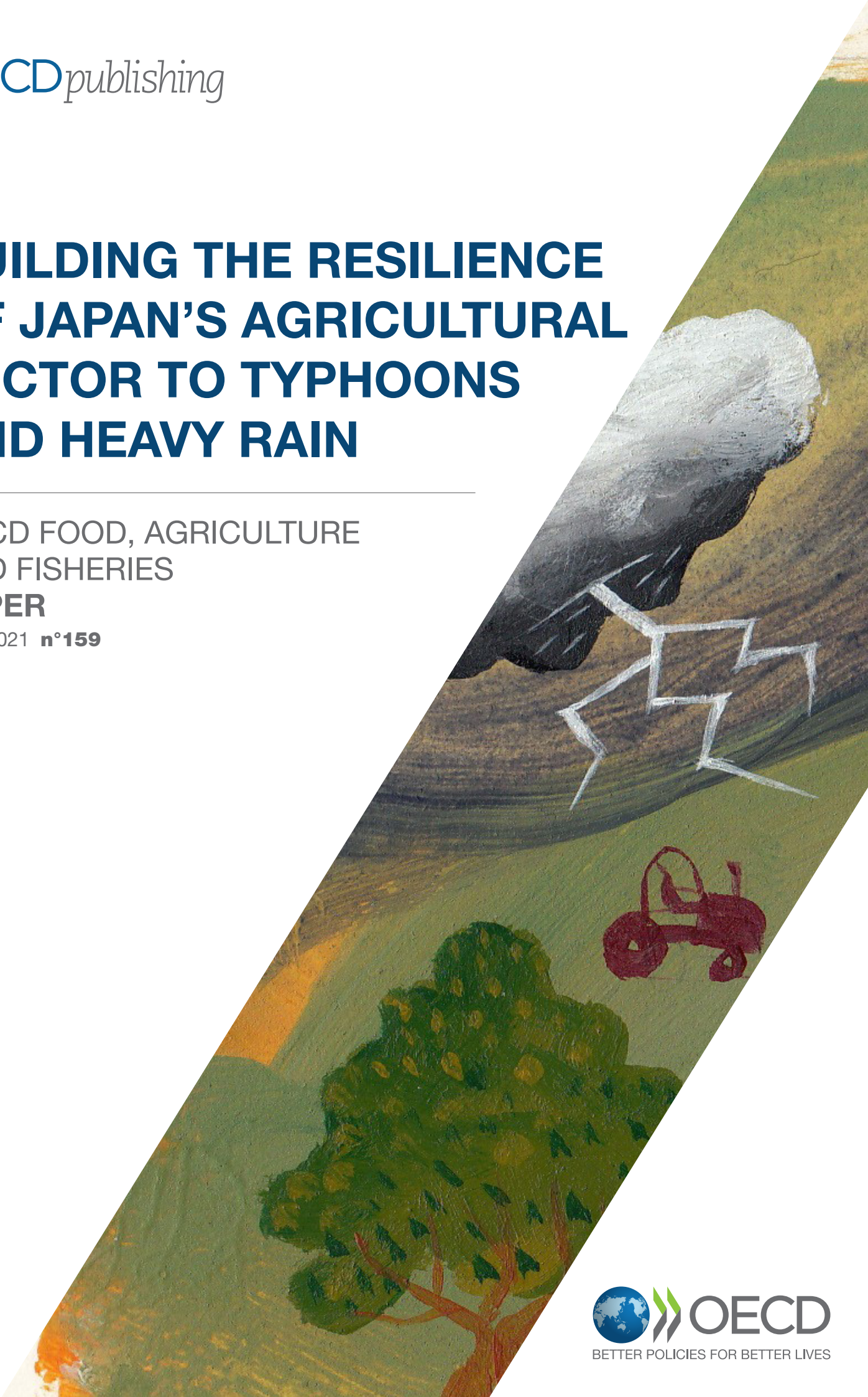

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Building the Resilience of Japan's Agricultural Sector to Typhoons and Heavy Rain

Makiko Shigemitsu and Emily Gray

Japan is highly exposed to natural hazards, and agricultural producers in Japan have significant experience in managing the risk of natural hazard-induced disasters (NHID). However, recent large-scale typhoons and heavy rain events have highlighted the importance of increasing the sector's resilience to NHID. A number of current practices build resilience. Disaster risk governance and agricultural policy frameworks are flexible and responsive to evolving NHID risks. Non-structural measures such as hazard maps are increasingly seen as complementary to infrastructure in preventing and mitigating flood risks. Innovative on-farm solutions for mitigating flood risks, such as the paddy field dam, are also increasingly used. Disaster response is rapid, and disaster assistance prioritises helping producers to resume farming. However, agricultural disaster risk management (DRM) must reflect the challenge of more frequent and intense typhoons and heavy rains in the context of ageing and depopulation in rural areas. Public DRM measures should also be complemented by greater efforts from farmers and other stakeholders, such as agricultural co-operatives, to build agricultural resilience to NHID.

Key words: Resilience; typhoons; heavy rain; agricultural risk management; natural disaster risk

JEL codes: Q54, Q18, Q15, Q16, Q25

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Table of contents

1. Introduction 5

2. Country context 7

2.1. The agricultural sector in Japan 7
2.2. Exposure to natural disasters 7

3. Natural disaster risk management in Japan 10

3.1. Disaster governance and broad policy documents 10
3.2. Risk identification and assessment 14
3.3. Disaster risk prevention and mitigation 18
3.4. Risk preparedness 22
3.5. Disaster response and crisis management 24
3.6. Recovery and reconstruction 26

4. Analysis 29

4.1. Disaster risk management frameworks in Japan are comprehensive, flexible and emphasise resilience to natural hazards, but agricultural actors' roles could be defined more clearly 29
4.2. Risk and vulnerability assessments drive disaster risk reduction activities, but data on agricultural losses could be used more extensively 30
4.3. A combination of structural and non-structural measures help to mitigate flood risks, but on-farm efforts could be strengthened 31
4.4. Japan's policies support rapid response and recovery from NHID, but may discourage farmers from taking steps to reduce their vulnerability to future risks 32

5. Conclusion 33

References 35

Tables

Table 1. Main resilience building policy frameworks and functions 12
Table 2. Causes and key revisions in 2020 Basic Disaster Management Plan 15
Table 3. Lists of emergency assessments and inspections conducted for the agricultural sector 16
Table 4. Agricultural damage and losses 18
Table 5. Agricultural measures in the support package for 2019 typhoons and heavy rains 26
Table 6. Types of agricultural recovery and reconstruction support for damage caused by typhoons and heavy rains in Japan, 2019 28

Figures

Figure 1. Relative frequency of natural hazards in Japan, 1985-2018 8
Figure 2. Frequency of heavy rainfall events, 1976-2019 8
Figure 3. Damage and losses to Japan's agricultural sector as a result of water-related events and earthquakes, 2010-19 9
Figure 4. Disaster risk management governance in Japan 11
Figure 5. The organisational structure of national resilience building policies in Japan 12
Figure 6. The national subscription rate for agricultural insurance, by commodity, 2018 22

Boxes

Box 1. Principles for effective disaster risk management for resilience 5
Box 2. Risk identification and revisions of DRM 15

Box 3. Emergency risk assessments and inspections in the agricultural sector 15
Box 4. Risk assessments on agricultural reservoirs 16
Box 5. Collecting data on farm damage and losses following a natural hazard-induced disaster 17
Box 6. The Act on Agricultural Reservoir Management and Conservation 20
Box 7. Paddy field dams 21

Key messages

What is the issue and why is it important?

- Japan's agricultural sector faces a range of natural hazards but the scale and impacts of typhoons and heavy rains in 2018-19 were unprecedented. Typhoons and heavy rains are expected to become more intense and frequent due to climate change.
- The agricultural sector has experience in managing natural disaster risk, but an ageing population and depopulation in rural areas suggest that the sector will be more vulnerable in the future. Increasing resilience to typhoons and heavy rains will require policies that balance safeguarding farmers' livelihoods with providing incentives for on-farm strategies that increase preparedness, prevent and mitigate risks, and support a more resilient recovery.

What did we learn?

- Disaster risk governance and agricultural policy frameworks explicitly recognise that improving resilience is critical for agriculture, and emphasise the importance of preparedness and recovery efforts for managing natural disaster risk in the sector.
- Japan's disaster risk management frameworks are flexible and responsive to evolving hazard risks. Vulnerability assessments inform revisions to policy frameworks, and guide investments for maintaining critical infrastructure, such as irrigation facilities.
- Current frameworks emphasise grey infrastructure such as dams and reservoirs, but non-structural measures such as hazard maps are increasingly seen as complementary for preventing and mitigating flood risks. There are also innovative on-farm solutions, such as the paddy field dam.
- Japan's disaster response is rapid, with comprehensive financial safety nets to help producers return to farming as quickly as possible. Effective communication between stakeholders also helps ensure that *ex post* assistance is provided smoothly.

Key recommendations

- Disaster risk management (DRM) in agriculture must reflect the challenge of more frequent and intense typhoons and heavy rains in the context of ageing and depopulation in rural areas. Government-led disaster risk reduction efforts are effective but should be complemented by greater efforts from farmers and other stakeholders. This could be encouraged by:
    - Clarifying farmer's responsibilities and options for DRM through comprehensive communication on natural disaster risks. This could be led by public extension agents, given their knowledge of national policies and local conditions.
    - Incorporating agricultural co-operatives, specifically JA's trusted, tight-knit and nation-wide network, into *ex ante* disaster risk management activities.
- Finally, the government's generous *ex post* assistance may reduce farmers' incentives to adapt or transform in response to the changing risk landscape. Defining the triggering criteria and types and level of government support in advance would provide farmers with a clearer incentive to invest *ex ante* in preparedness capacities, risk prevention and mitigation measures. In addition, there may be an opportunity to increase farmer uptake of *ex ante* risk management tools such as insurance through improving policy design.

1. Introduction

Japan frequently experiences natural hazards such as earthquakes, tsunamis, typhoons and heavy rains. Given the high frequency with which natural hazards occur in Japan, the nation has ample experience with reconstructing (building back) and thriving after these events. However, the scale of recent typhoons and heavy rains has been unprecedented, causing a major setback to the economy and society, and to the agricultural sector specifically. In 2018-19, natural hazards caused more than JPY 1.1 trillion (USD 10 billion) in agricultural damage and losses (MAFF, 2020[1]).

This case study examines how governance arrangements and policy measures help to build the resilience of Japanese farmers and the agricultural sector to natural hazard-induced disasters (NHID). It is one of seven case studies[1] prepared for the joint OECD-FAO project on *Building Agricultural Resilience to Natural Hazard-Induced Disasters: Insights from Country Case Studies* (OECD-FAO, 2021[2]). This project examines Disaster Risk Management[2] (DRM) frameworks in selected OECD and developing countries to identify what governments and agricultural sector stakeholders can do to build resilience to NHID – defined here as the ability of farmers to prepare and plan for, absorb, respond, recover from, and more successfully adapt and transform in response to natural hazards (OECD, 2020[3]). The project identifies good practices for building resilience at each stage of the DRM cycle – risk identification, assessment and awareness; prevention and mitigation; preparedness; response and crisis management; and recovery and reconstruction – where good practices are identified according to four principles for effective disaster risk management for resilience (Box 1).

Each of the country case studies in this project focuses on a particular type of natural hazard in order to explore how different policy measures, governance arrangements, on-farm strategies and other initiatives contribute to building resilience. The Japan case study focuses on typhoons and heavy rains, which have caused significant agricultural damage and losses in recent years.[3] Japan has invested in both infrastructure and other measures in order to better manage the natural hazard risk landscape and increase the resilience of Japanese agriculture to these natural events. However, typhoons and heavy rains are expected to intensify and occur more frequently as a result of climate change, increasing flood and landslide risks and threatening agricultural sustainability and productivity. Accordingly, the focus on typhoons and heavy rain events is highly relevant.

Box 1. Principles for effective disaster risk management for resilience

In 2017, G7 Agriculture Ministers in Bergamo recognised the effects of natural hazards on farmers' lives, agro-food systems, agricultural production and productivity in regions all over the world, and that climate change is projected to amplify many of these impacts. Ministers also noted the importance of strengthening the resilience of farmers to natural hazards (G7 Agriculture Ministers, 2017[4]).

Responding to this imperative, the joint OECD-FAO project on *Building Agricultural Resilience to Natural Hazard-Induced Disasters: Insights from Country Case Studies* identifies good practices for building agricultural resilience at each stage of the DRM cycle. Good practices in the case study countries are identified according to principles and recommendations from key international frameworks for managing the risks posed by disasters and other critical shocks, including OECD recommendations and the Sendai Framework.[1] Based on these frameworks, each case study

[1] The seven case study countries are Chile, Italy, Japan, Namibia, New Zealand, Turkey and the United States.

[2] UNISDR (2015[79]) defines disaster risk management as the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.

[3] "Damage" refers to the total or partial destruction of physical assets and infrastructure in disaster-affected areas, expressed as replacement or repair costs. "Losses" refer to the changes in economic flows or revenues arising from the disaster (FAO, 2016[78]).

assesses their country-specific situation according to the following four *Principles for Effective DRM for Resilience*:

- An inclusive, holistic and all-hazards approach to natural disaster risk governance for resilience.
- A shared understanding of natural disaster risk based on the identification, assessment and communication of risk, vulnerability and resilience capacities.
- An *ex ante* approach to natural disaster risk management.
- An approach emphasising preparedness and planning for effective crisis management, disaster response, and to "build back better" to increase resilience to future natural hazards.

Good practices encompass policy measures and governance arrangements that encourage public and private stakeholders to address gaps in their resilience levels. This can be done by helping stakeholders understand the risks that they face from natural hazards and their responsibilities for managing the risks they pose to their assets. For example, while rarer catastrophic risks such as NHID may require public intervention, on-farm strategies and the individual farmer's overall capacity to manage risk also play a critical role in reducing risk exposure to catastrophic events, particularly over the long term (OECD, 2020[3]; OECD Publishing, 2009[5]). Specifically, good practices that build agricultural resilience to natural hazards are policies and governance arrangements that:

- Encourage public and private actors to consider the risk landscape over the long term, including to take into account the potential future effects of climate change on the agricultural sector, and to place a greater emphasis on what can be done *ex ante* to reduce risk exposure and increase preparedness.
- Provide incentives and support the capacity of farmers to prevent, mitigate, prepare and plan for, absorb, respond, recover from, and more successfully adapt and transform in response to natural hazards.
- Consider a wide range of future scenarios, including expected environmental, economic and social structural change, and contribute to agricultural productivity and sustainability, even in the absence of a shock or stress.
- Take into account the trade-offs inherent in natural disaster risk management, including between measures to build the capacities of the sector to absorb, adapt, or transform in response to natural disaster risk, and between investing in risk prevention and mitigation ex ante and providing ex post disaster assistance.
- Are developed with the participation of a wide range of actors, to ensure that all relevant stakeholders are equally involved in the design, planning, implementation, monitoring and evaluation of interventions; and share a common understanding of the risk landscape and their respective responsibilities for managing natural disaster risk.

Note: 1. OECD's Approach to Risk Management for Resilience (OECD Publishing, 2009[5]; OECD, 2020[3]; OECD, 2011[6]); the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015[7]); the OECD Recommendation on the Governance of Critical Risks (OECD, 2014[8]); and the Joint Framework for Strengthening resilience for food security and nutrition of the Rome-based Agencies (FAO, IFAD, WFP, 2019[9]).

2. Country context

2.1. The agricultural sector in Japan

Japan is the world's third largest economy after the United States and the People's Republic of China. Although primary agriculture contributes only 1.2% of GDP and 3.2% of employment (OECD, 2020[10]), the sector accounts for 10% of GDP if all food-related industries are considered,[4] such that natural hazards can have profound economic impacts on agri-food value chains (MAFF, 2019[11]). Disruptions to agricultural production because of natural hazards have also often affected domestic prices for some commodities, such as vegetables and fruits, impacting consumers.

The country's geography contributes to a variety of landscapes and climatic patterns, leading to diverse agricultural production. Today, livestock accounts for more than one-third of total agricultural output, followed by vegetables (26%), rice (18%) and fruits (9%) (OECD, 2019[12]). Overall, the agricultural sector accounts for 12% of the total land area, which is relatively high given that two-thirds of the land is covered by mountains (OECD, 2019[12]). However, the limited land available also means that farms are relatively small: average farm size in Japan was 2.5 hectares in 2019, which is small compared to other OECD countries (OECD, 2020[10]). In terms of agricultural land use, rice paddy fields make up more than half of the country's agricultural land (Box 7**)**.

The agricultural workforce has declined by almost half since 2015 to 2.1 million, with an accelerated pace of decline in the last decade (OECD, 2019[12]). The average age of farmers in Japan is 66.8 years, and more than 80% of farmers are over 60 years old (OECD, 2020[10]). Finally, as average farm size is small, the majority of farmers rely on income sources other than agriculture (OECD, 2019[12]).

2.2. Exposure to natural disasters

Japan is one of the most exposed countries to natural hazards, with natural hazard-related damages experienced by Japan accounting for 14.3% of total global damage over the period 1985 to 2018 (SMEA, 2019[13]). Its location at the intersection of four tectonic plates[5] exposes Japan to earthquake, tsunami, and volcanic eruption risks, with around 7% of the world's active volcanoes situated in the country (JMA, 2015[14]). Japan's location in the Pacific also exposes the country to significant typhoon risk – the Western Pacific is one of the world's largest sites of tropical storms (NASA, 2013[15]). Moreover, Japan's climate is also characterised by high precipitation – average annual precipitation is about two times higher than the OECD average (OECD, 2019[12]). While the amount of precipitation varies by region due to the country's mountainous topography, it is concentrated in the rainy (June-July) and typhoon (July-October) seasons. Furthermore, with mountains occupying two-thirds of the country and short rivers running steeply down mountain ranges, the country is susceptible to floods and landslides.

Typhoons are the most frequent natural hazard in Japan (Figure 1). Climate studies suggest that Japan could experience more frequent and stronger typhoons in the future, due in large part to warming of the Pacific Ocean, which allows powerful storms to form more frequently (Knutson et al., 2019[16]; Yoshida et al., 2017[17]).[6] Another study shows that the trend of translation speed of typhoons is slowing down (Yamaguchi et al., 2020[18]) – implying that more damaging impacts can be foreseen. Climate change may also change the path of typhoons and send typhoons into areas of Japan that typically do not experience them (Yokoi, Takayabu and Murakami, 2013[19]). In terms of precipitation, the average annual frequency of heavy rainfall (exceeding 80 mm per hour) has increased over time, with the average annual number of such events during 2010-19 around 1.7 times higher than in the period 1976-85 (Figure 2). Similar to typhoons, Japan projects that the frequency of heavy precipitation events will likely more than double by

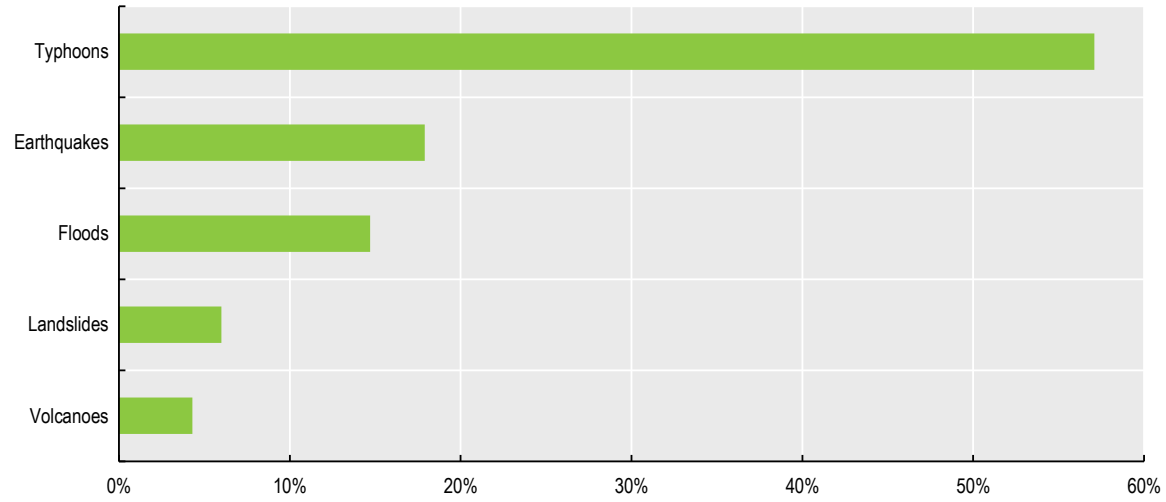
[4] Food related industry here includes agriculture, forestry and fisheries, agricultural material supply, food manufacturing, food related distribution and merchandising, and food service.

[5] The Pacific, North American, Eurasian and Filipino plates.

[6] Evidence shows that tropical cyclones in the Northwest Pacific Ocean Basin are reaching their maximum intensities farther north than they used to (Knutson et al., 2019[16]).

the end of the century compared with the end of the 20th century, under a high greenhouse gas emissions scenario[7] (JMA, 2020[20]; JMA, 2017[21]).

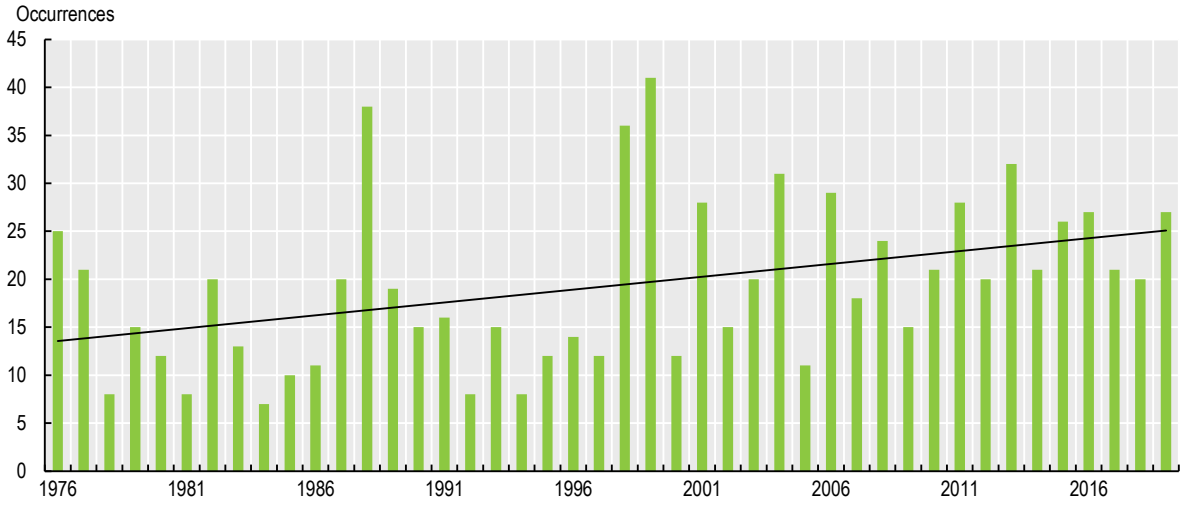
Figure 1. Relative frequency of natural hazards in Japan, 1985-2018



Source: SMEA (2019[13]).

Figure 2. Frequency of heavy rainfall events, 1976-2019

Number of rainfall events exceeding 80 mm per hour



Note: The bars indicate the annual number of rainfall events at 1 300 AMeDAS stations for each year across Japan, and the straight line indicates the long-term linear trend.
Source: JMA (2020[22]).

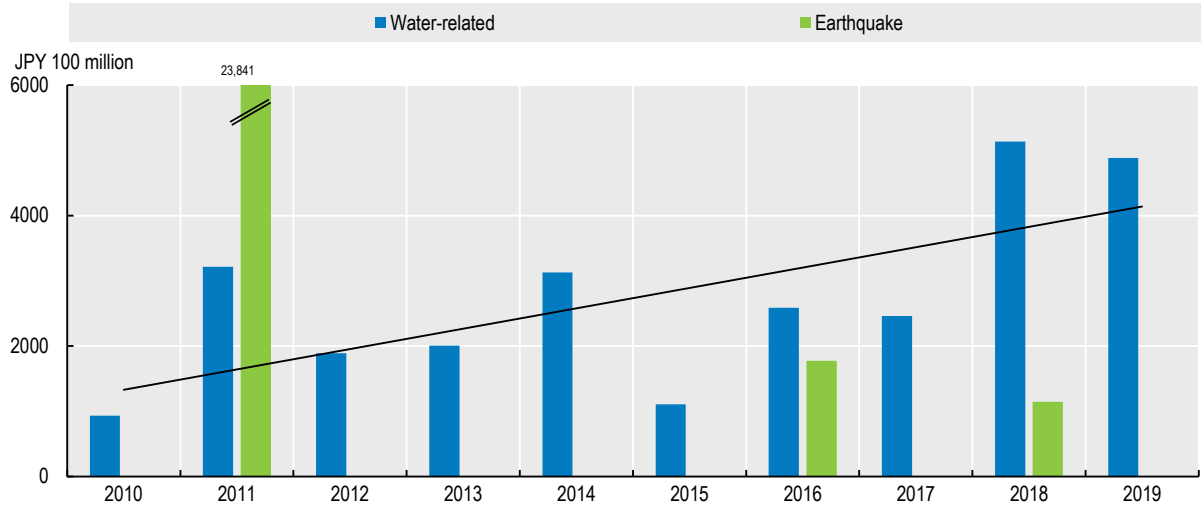
[7] Based on the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change Representative Concentration Pathway (RCP) 8.5 scenario.

In 2018 and 2019 alone, Japan experienced several catastrophic typhoons and heavy rain events.[8] Extreme wind and rainfall resulted in flooding and landslides that caused many human fatalities, river and infrastructure collapses, transportation disruptions and electricity outages. Indeed, the number of landslide-related disasters experienced in 2018 was twice the number in 2017 and was the highest on record (Cabinet Office, 2019[23]). The top four most damaging typhoons since 1950 in Japan have occurred since 2018, with typhoon Hagibis in October 2019 causing over USD 15 billion in damages, making it the world's most expensive weather-related disaster of 2019 (EMDAT, 2020[24]).

The agricultural sector can experience significant damage and losses from typhoons and heavy rain. Heavy rain events normally occur in the early summer to autumn, and most typhoons land in Japan between July and October, with August and September being the peak season. However, this is also the peak production period for a number of key agricultural commodities, such as rice and a large variety of vegetables and fruits, meaning that the agricultural sector is particularly exposed to these risks. For instance, typhoon Hagibis caused landfall in October 2019, damaging apple orchards in Nagano Prefecture just before the harvest, and inundated rice paddy fields across the country (MAFF, 2020[1]).

The rising frequency and intensity of large-scale typhoons and heavy rain events has become increasingly damaging for the Japanese agricultural sector, particularly in recent years. Although one individual earthquake can have severe impacts on the region where it hits, the cumulative effects of typhoons and heavy rain-related disasters are greater for the agricultural sector. In 2018, the damage and losses to the agricultural sector caused by typhoons and heavy rains accounted for JPY 514 billion (USD 4.7 billion) – the highest in the last ten years – and JPY 488 billion (USD 4.5 billion) in 2019 (Figure 3) (MAFF, 2020[1]). Effective risk management for large-scale typhoons and heavy rain events is therefore ever more important for Japan's agricultural sector. The following section outlines the current state of disaster risk management related to the agricultural sector, highlighting examples of good practices while also indicating possible challenges.

Figure 3. Damage and losses to Japan's agricultural sector as a result of water-related events and earthquakes, 2010-19



Note: As of April 2020. The data includes damage and losses of agriculture, forestry and fisheries.
Source: author based on MAFF (2020[1]).

[8] In 2018, heavy rains occurred all over the country including large scale July 2018 Heavy Rain. In 2019, Japan's average annual temperature was the second highest since the start of statistics in 1898 (2020 was the highest). Record storms and heavy rains occurred in northern and eastern Japan due to the landing of typhoon Faxai and Hagibis. In addition, there were record heavy rainfalls from summer to autumn, including the northern part of Kyushu in late August and the Kanto Koshin and Tohoku regions in late October. The number of days with daily rainfall of 400 mm or more was the second highest after 2011 (JMA, 2021[81]).

3. Natural disaster risk management in Japan

One way to reduce the impacts of natural hazards such as typhoons and heavy rains is to invest in enhancing resilience. A resilience approach encourages stakeholders to anticipate and plan for natural hazards in order to reduce damage and losses, rather than waiting for an event to occur and paying for it afterward (OECD, 2020[3]). A variety of measures can be implemented by different actors, with some measures more effective at managing the impacts of risks of different magnitudes, while other measures contribute to building resilience to all events more broadly (OECD, 2020[3]).

The management of natural hazard risks in the agricultural sector in Japan includes emergency responses for immediate and catastrophic events, and agricultural policies aimed at both short-term risk coping and long-term planning. It involves activities across actors at local and national levels. The following sections outline the main actors and activities for DRM in Japan related to typhoon and heavy rain events, and how they contribute to building resilience in the agricultural sector. Each stage of the disaster risk management cycle is considered, including key governance frameworks; risk identification, assessment and awareness; prevention and mitigation; preparedness; response and crisis management; and recovery and reconstruction.

3.1. Disaster governance and broad policy documents

Japan's national DRM governance is highly structured and institutionalised. The *Disaster Countermeasures Basic Act*[9]and the Basic Act for National Resilience Contributing to Preventing and Mitigating Disasters for Developing Resilience in the Lives of the Citizenry[10] (hereafter the *Basic Act for National Resilience*) are the two main pillars that advance Japan's DRM activities. The two disaster governance frameworks address typhoon and heavy rain events as national risks, and assign roles and responsibilities to each sector, including agriculture. DRM activities in agriculture are programmed based on the directions of these national frameworks. In addition, Japan's chief economic policy document communicates natural hazard measures as a priority for the policy agenda. A key focus of the 2019[11] and 2020[12] economic policy plans (the *Basic Policies for Economic and Fiscal Management and Structural Reform*) was natural disaster prevention and mitigation, recovery and resilience building, particularly in response to typhoons and heavy rains. Japan also announced a key pillar that targets natural disaster measures in its emergency economic stimulus packages in both 2019 and 2020 (Cabinet Office, 2019[25]; Cabinet Office, 2020[26]).

The *Disaster Countermeasures Basic Act* is the national management framework for catastrophic events, and aims to ensure basic security and quality of life against both human-made and natural hazards. The Act provides a coherent institutional framework for all-hazard risk management: it defines the roles and responsibilities of national, prefectural, and municipal governments[13] as well as public institutions and citizens involved in risk management activities for each step of the DRM cycle. This includes the responsibility at the national and local levels to elaborate DRM plans and to carry out preventative, emergency and recovery measures. Importantly, the Act assigns municipalities a primary responsibility for natural disaster response, such as for issuing evacuation directions and warning areas, and at the municipalities' expense, except when the scale of the disaster is catastrophic[14] (Section 3.5).

[9] Disaster Countermeasures Basic Act, Act No. 223 of 1961, and revised in 2019.

[10] Basic Act for National Resilience Contributing to Preventing and Mitigating Disasters for Developing Resilience in the Lives of the Citizenry, Act No. 95 of 2013.

[11] Cabinet decision 21 June 2019.

[12] Cabinet decision 17 July 2020.

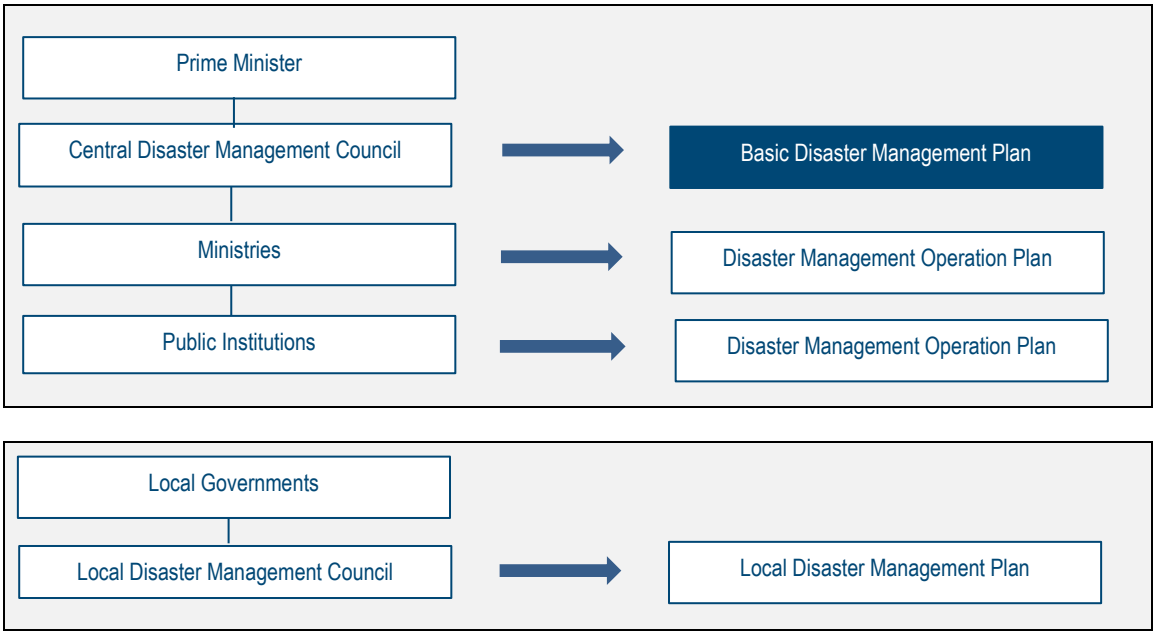
[13] Japan has a three-level governance structure.

[14] Based on the Act on Special Financial Support to Deal with the Designated Disaster of Extreme Severity (Act No. 150 of 1962).

The Disaster Countermeasures Basic Act also streamlines national DRM governance by mandating the Central Disaster Management Council,[15] which is chaired by the prime minister and composed of relevant ministers, organisations and experts. The Council ensures that national DRM planning and policies are formulated in a consistent manner, including by establishing an umbrella plan of all DRM activities in Japan – the *Basic Disaster Management Plan.*[16] The Basic Disaster Management Plan describes the sequence of countermeasures from preparation, damage mitigation, emergency response, recovery, and reconstruction for identified disasters, and defines the roles and responsibilities of stakeholders, including in agriculture. For flood and storm related disasters,[17] the Plan stipulates that the Ministry of Agriculture, Forestry and Fisheries (MAFF) is mainly responsible for developing structural defences, responses and recovery projects, and collecting necessary information on floods, inundations and storms.

Figure 4. Disaster risk management governance in Japan

The structure of the Disaster Countermeasures Basic Act



The second pillar of Japanese disaster governance, the *Basic Act for National Resilience*, was enacted after the country experienced the 2011 Great East Japan Earthquake, and aims to reorient how Japan manages natural disaster risk. It shifts the policy focus toward *ex ante* disaster preparedness in order to withstand large-scale natural disasters, as opposed to conventional disaster management measures focused on *ex post* assistance. The Act defines what national resilience means to Japan and outlines the main constraints and barriers to increasing resilience in Japan. It prioritises strengthening resilience to large-scale natural hazards, including by investing in physical infrastructure, but also emphasises the importance of social and economic systems for coping with natural hazard impacts. A combination of structural and non-structural measures and cross-sectoral government-wide efforts are emphasised in the Act.[18] The Act requires that the public cost of implementing these measures be reduced by making effective use of existing social capital. In addition, measures should contribute to efficient and effective maintenance

[15] Articles 11 and 12 of the Disaster Countermeasures Basic Act.

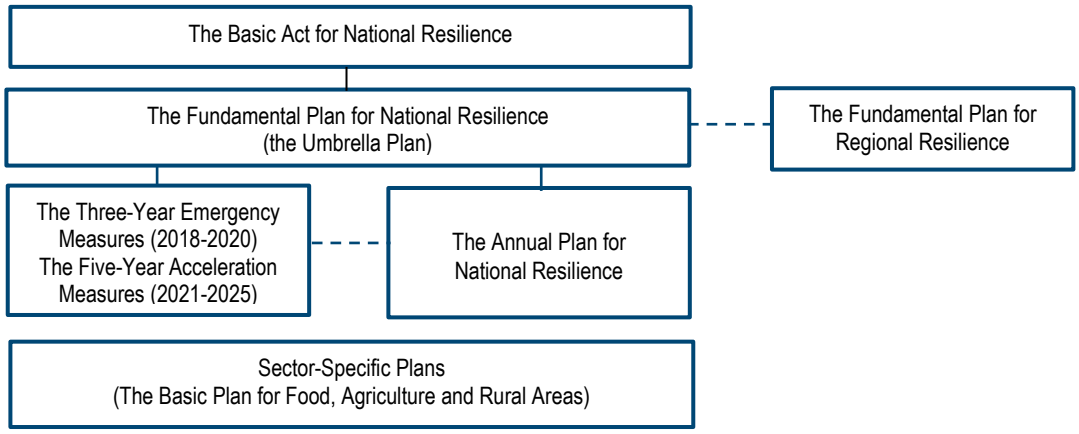
[16] Section 1 of Article 34 of the Disaster Countermeasures Basic Act.

[17] Section 5 of the Disaster Countermeasures Basic Act.

[18] Articles 6 and 8.

and management of facilities and equipment.[19] Recognising the importance of building resilience in local communities, the government also provides guidance to prefectures and municipalities to develop their own regional resilience plans. To co-ordinate the various resilience plans, outlined in Figure 5 and Table 1, Japan established the National Resilience Promotion Headquarters under the Cabinet as the Secretariat for planning and programming resilience building policies and activities. The leadership provided by the Headquarters plays a key role in clarifying priority areas and responsibilities among actors.

Figure 5. The organisational structure of national resilience building policies in Japan



Source: Authors, based on Cabinet Secretariat (2019[27]).

Table 1. Main resilience building policy frameworks and functions

Resilience Policy Frameworks	Description
The Basic Act for National Resilience	Sets goals to promote Japan's resilience to large-scale natural disasters.
The Fundamental Plan for National Resilience	Serves as the overall guidelines for policies concerning building resilience. It identifies targets and measures (15 prioritised policy areas) to achieve the set goals. The Plan is reviewed approximately every five years, but changes can be made earlier if necessary.
The Three-Year Emergency Measures	Outline 160 emergency measures to be implemented in 3 years (Fiscal Year (FY) 2018-20) to prevent critical damages caused by large-scale natural disaster. The measures indicates achievement targets, implementation details and project costs.
The Five-Year Acceleration Measures	Address 123 projects to be implemented in 5 years (2021-26) to increase resilience of critical infrastructure.
The Annual Plan for National Resilience	Used to manage progress of implementation and to assess direction for projects under the Fundamental Plan for National Resilience and Three-Year Emergency Measures.
The Fundamental Plan for Regional Resilience	A voluntary regional plan which can be established at prefectural or municipal level as a guideline for implementing regional resilience programmes. The concepts are based on the Fundamental Plan for National Resilience.

Source: Authors, based on Cabinet Secretariat (2019[27]).

The Basic Act for National Resilience requires the government to develop a national plan to guide resilience building activities. Accordingly, the *Fundamental Plan for National Resilience*, adopted by the Cabinet in 2014 and revised in 2018, serves as a master plan to guide each policy domain and conduct necessary resilience building activities. The Plan addresses the following resilience building objectives for agriculture:

- Strengthen the disaster response capabilities of agricultural supply chains.
- Undertake adequate operations of food reserves.

[19] Article 9 (1), (2).

- Manage agricultural infrastructure using both structural and non-structural measures, including: extending the service life of agricultural irrigation facilities; decommissioning high risk agricultural reservoirs; and creating hazard maps and contingency plans for agriculture-related facilities.
- Leverage the land conservation function of agricultural land by maintaining agricultural activities in rural areas.
- Maintain rural collaborative disaster prevention and restoration activities such as joint agricultural land and irrigation facility management.

Facing unprecedented levels of damage and loss caused by typhoons and heavy rain events in recent years, the government also released the Three-Year Emergency Measures for Disaster Prevention, Mitigation and Building Resilience 2018-2020 (hereafter the *Three-Year Emergency Measures*) in 2018. The Three-Year Emergency Measures aimed to expedite resilience-building efforts in areas identified as most in need, to address vulnerabilities and prepare for foreseen large-scale natural disasters by 2020. The Measures provided specific targets and baseline conditions, and the government budgeted JPY 7 trillion (USD 64 billion) over three years to fix vulnerabilities in key infrastructure such as river embankments, roads and bridges, airports and power facilities. (Cabinet Secretariat, 2019[28]). To manage the risks to the agricultural sector from typhoons and heavy rain, the Three-Year Emergency Measures budgeted JPY 315 billion (USD 2.9 billion) (Section 3.3).

The progress of projects in both the Fundamental Plan for National Resilience and the Three-Year Emergency Measures are measured and assessed in the Annual Plan for National Resilience. The performance of the projects and extent to which the projects' targets are achieved are assessed quantitatively using indexes. In addition, in December 2020, the government formulated the Five-Year Acceleration Measures for Disaster Prevention, Mitigation and Building Resilience 2021-25 (hereafter the *Five-Year Acceleration Measures)*. The projects in the Five-Year Acceleration Measures now focus on investing in resilience measures against increasingly severe typhoons and heavy rains, in addition to large-scale earthquakes. The Five-Year Acceleration Measures emphasis the management of ageing infrastructure, including the maintenance of irrigation and agricultural reservoirs, since many municipalities are unable to repair their aged infrastructure due to a lack of financial resources. The Measures also specify the need for digitalisation in DRM, such as forecasting, collection and dissemination of disaster-related information. The Five-Year Acceleration Measures address 123 projects worth JPY 15 trillion (USD 138 billion) (Cabinet Office, 2020[29]).

The agricultural sector's capacity to manage natural hazard risk is also influenced by the country's agricultural policy frameworks. For example, the Cabinet led a national agricultural reform plan in 2013 (revised in December 2020), called the *Plan for Creating Dynamism through Agriculture, Forestry and Fishery Industries and Local Communities*. The plan emphasised the need for improved irrigation facility maintenance, combining both structural and non-structural measures, among other targets. This includes increasing efforts on water facility improvements and flood damage prevention, strengthening irrigation management systems, and creating hazard maps for agricultural reservoirs.

Japan's ten-year agricultural policy agenda is outlined in the *Basic Plan for Food, Agriculture and Rural Areas*, as mandated by the *Food, Agriculture and Rural Areas Basic Act.*[20] The plan was revised in March 2020, and now incorporates natural disaster risk management as one of the eight focus priorities of the Japanese agricultural policy agenda.[21] Specifically, the plan emphasises preparedness and recovery from large-scale disasters as the two main objectives for managing natural disaster risks in the agricultural sector:

- Prepare for large-scale natural disasters:
  - Incorporate disaster preparation into farmers' business management
  - Develop and disseminate risk-reducing technologies

[20] Food, Agriculture and Rural Areas Basic Act (Act No. 106 of 1999).

[21] Policy Priority 6: Strengthen risk management to natural disasters, livestock infectious diseases, and climate change.

  - Promote the sector's natural disaster prevention and mitigation measures
  - Strengthen the natural disaster response system
  - Prepare for a stable food supply during unforeseen circumstances
- Recover from large-scale natural disasters.

Climate change policies also describe agricultural sector measures for resilience to typhoons and heavy rains. The *Basic Environmental Plan of 2012*, which orients current environmental and climate change policies in Japan, anticipates an increase in flood risk and calls for adaptation measures in agriculture. The *National Climate Change Adaptation Plan*, approved by the Cabinet in 2018, also projects an increase in heavy rain and water-related disasters, and considers measures to mitigate the risks to the agricultural production base (e.g. through maintaining irrigation facilitates and creating hazard maps). The *Climate Change Adaptation Plan* of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) outlines measures to strengthen flood defences; improve monitoring and forecasting of disasters; provide more accessible information about climate-related disasters to the public; encourage the use of disaster resilient construction techniques; and promote land use practices that increase resilience. The MAFF *Climate Change Adaptation Plan*, released in August 2015, addresses improving disaster prevention and mitigation functions in rural areas by appropriately combining structural and non-structural measures – in particular, for agricultural water management. This includes developing drainage pump stations and drainage channels; identifying and assessing highly vulnerable agricultural facilities and areas through research and development; and promoting the establishment of business continuity plans for irrigation facilities.[22]

3.2. Risk identification and assessment

Risk identification is the critical first step for more effective disaster preparedness, risk reduction, response and recovery measures (OECD, 2020[3]). Japan's Basic Disaster Management Plan identifies 13 hazards that pose a threat to national security, including storms and floods,[23] and includes chapters on each hazard that describe specific DRM measures. The plan is reviewed every year and revised when necessary by the Central Disaster Management Council to reflect any newly identified risks and more effective measures (Box 2). These amendments have contributed to sustained enhancement of resilience over the long-term (Jimee, Meguro and Dixit, 2019[30]).

Vulnerability assessments allow areas of critical concern to be identified and can help to guide risk mitigation efforts (UNISDR, 2015[7]; Fuchs, Birkmann and Glade, 2012[31]). Japan has increasingly focused on incorporating vulnerability assessments into the policy planning process, to help identify the level of risks in various sectors. The Basic Act for National Resilience requires the government to conduct a vulnerability assessment before formulating the Fundamental Plan for National Resilience, which takes place approximately every five years. The vulnerability assessment for the Fundamental Plan for National Resilience focuses on the risk that certain impacts occur regardless of the type of hazard that causes them; however, natural hazards are considered to pose the greatest risk to the country. The latest vulnerability assessment conducted in 2018 simulated 45 "worst-case scenarios that should be avoided", employing flow chart analysis to organise the causal relationships and cascading effects that lead to the worst case. Based on the scenarios, countermeasures[24] were formulated and addressed in the Fundamental Plan for National Resilience, including for agriculture.

[22] Chapter 2, Section 4 Agricultural Production Base.

[23] The 13 hazards include natural hazards (earthquake, tsunami, storm and flood, volcano, snow) and human-made hazards (maritime, aviation, railroad, road, nuclear, hazardous materials, large scale fire, and forest fire).

[24] Countermeasures include for twelve sectors and three cross-cutting areas.

Box 2. Risk identification and revisions of DRM

Japan aims to continuously identify risks and assess its disaster response, and any issues that arise during disasters are analysed and addressed through amendments to existing legal provisions, policies and guidelines. Since its first enactment in 1963, the Basic Disaster Management Plan has been amended 22 times (as of 2020). The latest revision of the plan, which took place in May 2020 following Typhoons Faxai and Hagibis in 2019, enhanced provision of river and weather information and support for local governments that are not accustomed to dealing with large-scale storms.

Table 2. Causes and key revisions in 2020 Basic Disaster Management Plan

Typhoon Hagibis	Typhoon Faxai	Other social changes
Foster understanding of disaster risks and actions to be taken before and during the disaster	Enhancement of support for local governments unaccustomed to natural disasters	Development of infectious disease countermeasures at disaster evacuation centres including new coronavirus infections
Enhancement of provisions of river and weather information	Strengthening response to long-term power outages and communication network disturbance	Gathering information using unmanned aircraft (drone)
Improvement of disaster waste treatment system	Enhancement of relief supplies for victims of natural disasters	Providing training to coordinators who assist foreigners in the event of disaster
Systematisation of holding government meetings for natural disaster response and reconstruction support		

Source: Cabinet Office (2020[32]).

The Three-Year Emergency Measures resulted from recognition that accelerating investment in prevention and mitigation measures is critical to avoid future damage, given increasing occurrence of natural hazards (Section 3.1). The formation of the Three-Year Emergency Measures required twelve ministries and agencies to carry out “emergency risk assessments and inspections” on 132 infrastructure facilities and systems that are critical to Japan, with the aim of identifying areas particularly vulnerable to large scale natural disasters (Box 3 and Box 4).

Box 3. Emergency risk assessments and inspections in the agricultural sector

In 2018, the government conducted emergency risk assessments and inspections based on the Three-Year Emergency Measures for Disaster Prevention, Mitigation and Building Resilience 2018-2020, including on high-risk agricultural infrastructure and facilities. The assessment and inspection revealed the extent to which many facilities were vulnerable to natural hazards, motivating a number of remediation actions. For example, one of the emergency assessments was conducted on agricultural greenhouse facilities. The emergency inspection detected deterioration and insufficient resistance to typhoons, heavy rain and heavy snowfall in approximately 9 000 hectares of agricultural greenhouse facilities, around 19% of the total area (MAFF, 2018[33]; MAFF, 2020[34]). Another emergency assessment and inspection determined that emergency power sources were not secured in some large-scale agricultural wholesale markets, which could hinder their operation in the event of power outages, and in turn could affect the entire supply chain (Section 3.3).

Table 3. Lists of emergency assessments and inspections conducted for the agricultural sector

Emergency assessments
Conditions of mountainous disaster risk areas (including agricultural and forestry facilities in those areas)
Conditions of disaster prevention forests in the coastal areas
Conditions of forests on and surrounding mountainous disaster risk areas
Functions and conditions of agricultural dams and irrigation facilities
Functions and conditions of agricultural irrigation facilities (Water wall, drainage pump station, water gates, aqueduct and water canals, and water pumping stations)
Availability of emergency power supplies in large-scale wholesale markets
Availability of response plan at dairy facilities in the case of power outages
Availability of response plan at milk storage facilities (cooling station) in the case of power outages
Availability of response plan on dairy farms (including agricultural cooperatives, etc.) who ship raw milk to designated raw milk producer groups in the case of power outages
Availability of response plan at slaughterhouse facilities in the case of power outages
Sufficient weather resistance of agricultural greenhouse facilities (to typhoons, heavy rains and heavy snowfall)

Source: Cabinet Secretariat (2018[35]).

Box 4. Risk assessments on agricultural reservoirs

Agricultural reservoirs in Japan are artificially constructed ponds used to store and withdraw water for agriculture, and there are approximately 160 000 agricultural reservoirs nationwide (MAFF, 2021[36]). Aside from their primary function, agricultural reservoirs can mitigate flood impacts by temporarily storing water at times of high rainfall, and preventing sediment outflow from the mountains. However, these disaster mitigation functions are only performed when agricultural reservoirs are properly managed.

The vulnerability of agricultural reservoirs to typhoons and heavy rains poses a critical risk to the agricultural sector. Agricultural reservoirs were mainly built before the Edo period (1603-1868), and some are deteriorating and improperly maintained, due in part to ageing and depopulation in rural areas. In 2009-18, 77% of damage to agricultural reservoirs was caused by heavy rains (MAFF, 2018[37]; MAFF, 2021[38]).

Based on inspections conducted by prefectures and municipalities in 2013-15, MAFF designated about 6% of agricultural reservoirs as “disaster prevention priority agricultural reservoirs” to call for appropriate maintenance. However, a number of undesignated small-scale agricultural reservoirs in the mountainous regions collapsed following heavy rain in 2018, thereby exacerbating flood damages in the downstream areas during and after the rain. In response, emergency inspections of agricultural reservoirs took place again during the summer of 2018, in co-operation with prefectures and municipalities. Based on this inspection, MAFF identified 1 540 agricultural reservoirs that required emergency measures, out of a total of 88 133 agricultural reservoirs that were identified as having the potential to damage houses and public facilities in downstream areas. Following these risk identification exercises, prefectures and municipalities implemented temporary measures such as lowering water levels and removing sediment.

MAFF also initiated a taskforce composed of policymakers, specialists, researchers from the National Agriculture and Food Research Organization (NARO), and prefectures impacted by heavy rain in 2018 to identify effective measures for preventing further damages in areas downstream from agricultural reservoirs. One of the main tasks focused on identifying and assessing the conditions of agricultural reservoirs damaged by the heavy rain. This exercise included conducting a field survey and analysis on reservoir conditions (e.g. scale, year of construction, soil conditions) and the

potential impact to downstream areas in the event of a collapse. The taskforce also highlighted the complex nature of managing the agricultural reservoirs. For example, most agricultural reservoirs are privately owned and are often managed by villagers or water users associations (MAFF, 2020[39]). However, the ageing and declining agricultural population is rapidly changing the demography of Japanese rural communities, which reduces the use and care of agricultural reservoirs and has increased the number of agricultural reservoirs owned by unknown rights holders and left without adequate maintenance. Given the results, MAFF revised the designation criteria of the disaster prevention priority agricultural reservoirs in November 2018. These were redefined as: reservoirs that are located nearby housing or public facilities, and may flood downstream area in the event of collapse. Based on this criteria, prefectures have identified 63 522 reservoirs as disaster prevention priority agricultural reservoirs (as of March 2020), more than 5.5 times higher than the number confirmed at the end of FY 2017 (see Box 6 for disaster prevention and mitigation measure for agricultural reservoirs).

Disaster damage and loss data are a critical input into planning current and future disaster preparedness activities. Japan has a longstanding programme for collecting quantitative and qualitative information on agricultural damage and losses caused by natural disasters. With records dating back to 1964, data and related information are gathered by MAFF and shared with the public. These data are very detailed and are categorised by number (scale), cost, region, and types of damage and losses, and covering agricultural products, orchard trees, livestock, livestock products, agricultural machinery, agricultural land, and a range of agricultural facilities and infrastructure. Information collection and reporting begins immediately after natural hazards occur, with the data collection undertaken by municipalities through on-site visits (Box 5). Similarly, agricultural co-operatives – that is, Japan Agricultural Co-operatives[25] (JA) – assess damage experienced by their members and to their own facilities (e.g. warehouses) to determine if support is needed, and regional JAs report damage estimates to JA Headquarters. Local governments and JA also use this information to request relevant recovery support from the national government. Finally, MAFF also sends its staff to affected areas in order to assess the actual damage swiftly and formulate assistance programmes (Sections 3.5 and 3.6).

Box 5. Collecting data on farm damage and losses following a natural hazard-induced disaster

Both national and local governments are important actors for collecting information on farm damage and losses caused by natural hazard-induced disasters in Japan. Based on the Disaster Countermeasures Basic Act,[1] prefectures – usually in co-operation with municipalities – investigate on-farm damage and losses and create a damage report for agriculture, forestry and fisheries, which is provided to MAFF and becomes the basis for planning and implementing national disaster responses and emergency measures, including allocating support and funding to local governments. The reporting includes four phases: disaster occurrence notification, preliminary damage report, damage overview report, and damage confirmation report. The disaster occurrence notification needs to be reported to the government immediately after the occurrence of a disaster and should contain information at least (1) the cause of the disaster; (2) the date and time of the occurrence; (3) the location or area; (4) the degree of damage; and (5) measures taken against the disaster. The damage overview report must be submitted within two weeks after the occurrence of the damage.[2]

[25] The agricultural co-operatives in Japan (Japan Agricultural Co-operative – JA) are mutual aid organisations established voluntarily by farmers and non-farm members to improve members' agricultural income. In 2017, the JA operated local services in 679 municipalities. It also has regional headquarters in each prefecture as well as national headquarters that administers the entire group (JA Zenchu), a marketing body that is responsible for wholesale business and supply of production inputs (JA Zen-Noh), a finance body (Norinchukin Bank), and an insurance body (JA Zen-kyoren). Due to this wide range of services and well-developed network, almost all farmers in Japan are members of the JA. Each regional JA usually has farm advisors (total of 13 750 in 2016) to provide technical farming and marketing support to farmers (OECD, 2019[12]).

Finally, the damage confirmation report needs to be reported within one month of the end of the disaster. Updated information is posted on MAFF's website.

The report covers agricultural damage and losses caused by storms, heavy rain, floods, storm surges, earthquakes, tsunamis, low temperatures, drought, frost, hailstorms, and other abnormal natural phenomena. It also includes large-scale fire and other disasters caused by a large-scale accident, or due to significantly increased pests and diseases. The amount of damage and losses for agricultural facilities is calculated based on the replacement value or the recovery cost, and the amount of damage and losses of agricultural products is calculated according to the current market price[3] or multiplying the quantity of damage by the official price if one can be obtained. Losses and damage are reported according to the categories below.

Table 4. Agricultural damage and losses

Facility	Agricultural products	Other
Communal use agricultural facilities	Crops	Inventories of agricultural cooperatives
Agricultural greenhouse	Orchard tree	
Agricultural warehouses, processing facilities, etc.	Livestock animal	
Livestock facility	Silkworm cocoon	
Agricultural and livestock machinery		
Other		

Note: The reporting document also contains sections for forestry and fisheries damage and losses.

Besides this reporting system, damage to farmland and agricultural facilities, including irrigation infrastructure, is reported to the government separately. Japan gives weight to on-site visits for assessing agricultural damage and losses as this allows damage to be captured more precisely (e.g. satellite imagery cannot detect precise damage and some damage and losses may take a while to become apparent). The data collection efforts rely heavily on the experience of municipality staff, making sharing technical knowledge crucial e.g. through training.

Notes:
1. Article 51(1).
2. However, in the case of long-term damage such as cold temperature and drought, the reporting continues until the disaster ends.
3 After subtracting the sales commission and other production costs from the wholesale price.
Source: MAFF (2019[40]).

Disaster research is considered to be critically important for improving understanding of natural hazard risks and advancing Japan's risk reduction activities in agriculture and rural areas. The Institute for Rural Engineering, NARO (NIRE) conducts applied research on disaster-prone agricultural infrastructure (irrigation facilities, agricultural land and embankments). Given the recent focus on non-structural measures in DRM frameworks, NARO has now increased its research emphasis on hydrological modelling to assess climate change's impact on agricultural water resources, and flood damage analysis on paddy fields in relation to increasing heavy rain trends. The research outcomes are used when MAFF invests in drainage facilities, for example.

3.3. Disaster risk prevention and mitigation

Ex ante investments in measures to prevent or mitigate natural disaster risk can reduce the cost of disaster response and recovery, by addressing underlying vulnerabilities and reducing natural hazard exposure. Government policies and programmes can also encourage stakeholders to identify disaster risks to their own assets, address gaps in their resilience levels, and take steps to mitigate the impacts of natural hazards, including on agricultural production.

In Japan, the risks identified in the national DRM frameworks (the National Basic Disaster Management Plan and the Fundamental Plan for National Resilience) are the basis of agricultural prevention and

mitigation measures for natural hazard risks. Under the Three-Year Emergency Measures, the government set the following targets for the agricultural sector based on its risk identification exercises (Section 3.2):

- Secure the operation and installation of standby power generators in case of power supply shortages (20 floodgates)
- Secure dikes and improving wave-dissipation facilities to protect against storm surges and tsunamis (130 locations)
- Implement erosion and disaster control in mountainous disaster hazard areas (600 areas)
- Manage coastal forests planted to prevent and mitigate storm and tsunami risks (50 km)
- Implement preventive measures for damage caused by wood debris in mudslides(700 areas)
- Restore devastated forests (2 000 areas)
- Maintain agricultural irrigation facilities (1 000 areas)
- Maintain disaster prevention priority agricultural reservoirs (1 000 reservoirs)
- Create business contingency plans for wholesale markets (100 markets) and secure emergency power in some markets where operations could be hindered by a power outage
- Formulate a response plan in case of power outages and install emergency power (dairy facilities – ten regions)
- Formulate a response plan in the case power outages and install emergency power (40 slaughterhouse facilities)
- Reinforce and formulate damage prevention plans for horticultural facilities (9 000 hectares)

As natural disaster damage in rural areas is often the result of infrastructure failure, building and maintaining structural defences is considered to be of critical importance for the agricultural sector. In particular, improving river flows, strengthening dams, and improving embankments and sewage systems play an important role in preventing and mitigating damage caused by typhoons and heavy rains. On agriculture specific infrastructure, the government invested around JPY 333 billion (USD 3.1 billion) in 2019 to increase agricultural structural defences (agricultural irrigation and drainage facilities, reservoirs and roads) against natural hazards. In addition, given the recent intensification of flood damage, since June 2020, the government has maximised the effective storage capacity of dams utilised for water use for flood control,[26] including agricultural dams. This increased the water storage capacity of these dams, resulting in 20% reduction in the water flow of the Kiso River in Nagano Prefecture during the heavy rain in July 2020, preventing flooding. Further, the Five-Year Acceleration Measures also included infrastructure maintenance for prioritised mountainous areas and rural community sewerage facilities to prevent mudflows and landslides, as well as to renew and repair irrigation facilities that mitigate and prevent flood risks to approximately 210 000 hectares of agricultural land and surrounding areas (Cabinet Secretariat, 2021[41]).

Japan has constructed extensive agricultural irrigation and drainage systems nationwide. Total canal length is estimated to be 400 000 km, and around 2 000 large-scale public agricultural dams[27] exist nationwide (Japan Dam Foundation, 2018[42]). However, around 25% of the nation's basic agricultural irrigation facilities have already exceeded their depreciation period – equivalent to JPY 4.6 trillion (USD 42 billion) in renewal costs – and 40% of the total will be depreciated in the next ten years (OECD, 2019[12]; MAFF, 2020[43]). In the context of more frequent typhoons and heavy rain events, these conditions mean that there is a higher risk of severe infrastructure failure. To prolong the life of existing facilities and reduce national government expenditures, the government had earlier formulated the *Basic Plan for Extending the Service Life of Infrastructure* in November 2013, encouraging national and local governments to work together to promote strategic maintenance and renewal of infrastructure (MLIT, 2019[44]). Further, to improve the situation, the Five-Year Acceleration Measures included a target for

[26] There are also dams in Japan that are solely built for the purpose of controlling and adjusting water flow.

[27] Public agricultural dams are different from agricultural reservoirs.

renewing the main agricultural irrigation facilities that had exceeded their life-cycle (in total, 1 200 km of waterways and around 260 facilities) (Cabinet Secretariat, 2021[41]). However, regular rehabilitation and construction work on agricultural infrastructure predominantly emphasises enhancing the provision of irrigation services to agriculture, rather than disaster prevention.

Based on the risk assessments activities on agricultural reservoirs (Section 3.2), information on all agricultural reservoirs that have been re-designated as a priority for disaster prevention must be included in an agricultural reservoir map created and published by municipalities. In addition, information on those responsible for managing the designated agricultural reservoir is also included in an emergency contact list system. However, the Five-Year Acceleration Measures point out that disaster prevention measures have been implemented at only 19% of designated disaster prevention priority agricultural reservoirs. As a result, the Five-Year Acceleration Measures include support for implementing disaster prevention and mitigation measures to all the disaster prevention priority agricultural reservoirs (approximately 37 000 locations) (Cabinet Secretariat, 2021[41]). This includes evaluating the extent of deterioration and capacity to resist heavy rain, and consolidating and demolishing reservoirs if necessary. In addition, the government has recently clarified the responsibility of reservoir owners and local authorities to manage local agricultural reservoirs (Box 6).

Box 6. The Act on Agricultural Reservoir Management and Conservation

The responsibilities of reservoir owners and governments to manage and maintain agricultural reservoirs are outlined in the *Act on Agricultural Reservoir Management and Conservation*, enacted in April 2019 (Act No. 17 of 2018). In particular, the Act requires owners of agricultural reservoirs to report their reservoir information to the prefecture. The prefecture then publishes this information in a database for agricultural reservoirs. To support these efforts, NARO developed a database that includes real time data and projects water levels, spill, and inundation areas in case of agricultural reservoir failures. This facilitates damage status reporting by local governments while inspecting the reservoirs, enabling the rapid sharing of disaster information (NARO, 2020[45]). Moreover, prefectures can designate agricultural reservoirs that may impact residential areas if they collapse, requiring owners of agricultural reservoirs to obtain permission from the prefecture before carrying out disaster prevention work on designated agricultural reservoirs. The Act also gives prefectures the right to conduct a walk-in inspection, and the ability to order the owner to carry out (or execute by proxy) disaster prevention measures if necessary. If municipalities have designated reservoirs in their area, they are required to develop hazard maps with the name and location of these agricultural reservoirs and make those maps publically available so that the municipalities can provide local residents with the information necessary for making evacuation decisions. Municipalities may also acquire rights to manage the agricultural reservoir if necessary.

Japan also implements non-structural measures to prevent and mitigate damages caused by typhoons and heavy rains. Based on *the Flood Control Act* [28] and the *Sediment Disaster Prevention Act*,[29] 417 rivers are covered by the flood warning system; 1 555 rivers are subject to water-level notifications; and 1 931 rivers are designated as inundation risk areas (as of March 2014). Municipalities in such areas are encouraged to prepare flood hazard maps indicating areas likely to be damaged, along with evacuation routes and sites, and disseminate these maps among their communities; 83% of those municipalities had published these maps as of March 2014 (MLIT, 2018[46]). These maps are not specifically for the agricultural sector, but farmers may use the maps for land-use decisions and evacuations, and they are available through a MLIT website that consolidates information collected from municipal governments. In addition, Japan amended the Flood Control Act in 2017 to apply the same rules for informing residents about flood risk to medium and small rivers (i.e. information on areas that are expected to be inundated and water depth) when municipalities consider it relevant to do so based on past flood data.

[28] Act No. 193 of 1949.

[29] Act No. 57 of 2000.

Farm-level initiatives and private actions also contribute to flood risk prevention and mitigation. Many of the traditional prevention and mitigation activities used in rural communities for flood and landslide are nature-based solutions: for example, maintaining forests to prevent soil erosion, planting pine trees along the coast to mitigate wind and sand blow, and planting bamboo trees along river banks to reduce flooding. Certain types of agricultural production systems can also act as physical barriers against typhoons and heavy rains, reducing the impact on, and vulnerability of, communities. In particular, rice paddy fields can be effective in flood reduction and mitigation because they can retain rainwater, lower the peak flow of rivers, and increase groundwater recharge, with research finding that more than 40% of rainfall received in an extreme event[30] could be stored in paddy fields (Matsuno et al., 2006[47]; MLIT, 2018[48]; OECD, 2015[49]; Sujono, 2010[50]). Currently, several prefectures are promoting on-farm measures to maximise paddy field water storage potential for flood control (Box 7).

Box 7. Paddy field dams

Rice paddy fields can naturally help to reduce flood risks by retaining and slowing the flow of water. In addition, farmers can further increase the natural water storage capacity of their paddy fields – and contribute to flood mitigation – by installing a simple runoff control device (an adjustment plate with a hole smaller than a drain pipe) to control the drainage of the paddy field. With this plate, paddy fields serve as dams. Rainwater is temporarily stored in the paddy field during and after heavy rainfall, and the water is slowly drained over time, preventing a rapid rise in water levels in rivers and drainage canals. These initiatives can reduce the flood risks to downstream communities, especially as residential areas and farmland are often located next to each other in Japan.

The paddy field dams offer a physically effective and cost-efficient option to manage flood risk and mitigate the impact. The maintenance cost is equivalent to JPY 875 (USD 8) for 5 000 m^2 per year, or 30 minutes or less for the labour requirement (Niigata Prefecture, 2020[51]). In Niigata Prefecture, the area known for rice production, the paddy field dam measure has been expanded and implemented on 14 640 hectares (in 15 municipalities) as of FY 2018 (Niigata Prefecture, 2020[52]), and similar efforts have been carried out across the country to mitigate flooding (OECD, 2015[53]). The Science Council of Japan estimates that activities to improve the water storage function of paddy fields, such as the paddy field dam, could increase water storage to almost 19 000 thousand m^3. In contrast, achieving a similar level of water storage with grey infrastructure – such as a flood prevention dam – was estimated to cost around JPY 6.3 billion (USD 58 million) per year (MAFF, 2017[54]). Now supported by the Five-Year Acceleration Measures, the government aims to increase the areas of paddy field dams through using payments for non-commodity outputs (multi-functionality) (Cabinet Secretariat, 2021[41]).

Risk transfer is another strategy that can be used to mitigate the financial impact of risks and limit the natural disaster liability of farmers. Insurance helps transfer risk to a larger market, which can absorb small farm losses more easily than individual farmers. MAFF offers two types of insurance programmes for farmers and subsidises the premiums to make insurance more accessible. The commodity insurance programme[31] offers insurance for yield losses and production equipment damaged by natural hazards. It is available for a range of commodities (rice, wheat, barley, livestock, fruit, and field crops), and crop quality losses are also insured for some commodities (rice, wheat, barley, and fruits). Government support covers around 50% of the insurance premium. The revenue insurance programme, launched in 2019, compensates farmers for revenue losses stemming from various factors – including natural hazards – relative to a benchmark based on the previous five years' revenue. The government supports 50% of the insurance premium and 75% of the reserve fund. To avoid duplicated payments by the government

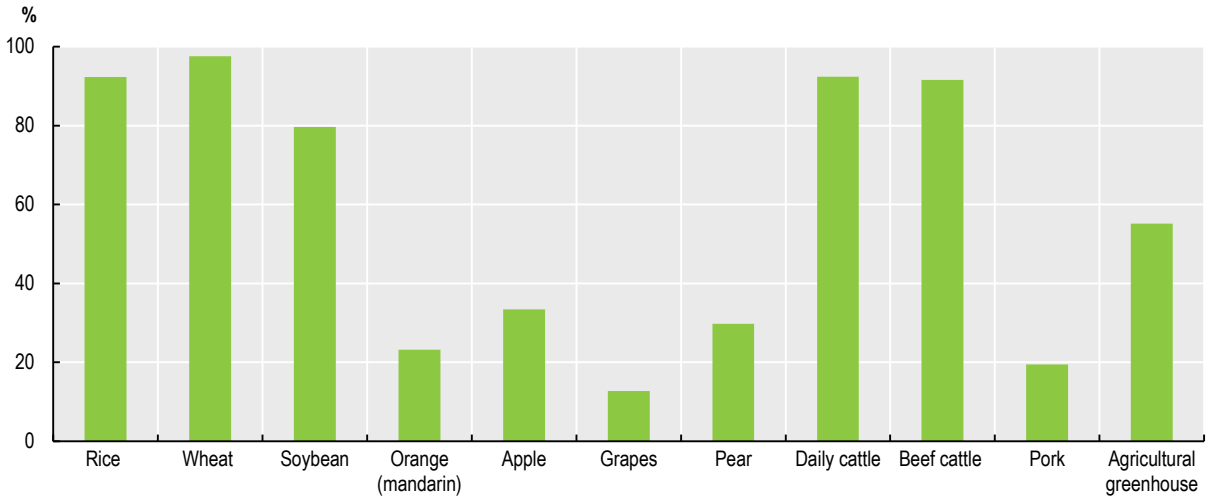
[30] Based on an experiment simulating this event. Four water irrigation techniques were applied in the research, and the amount of water and when it should be irrigated vary among the techniques.

[31] Agricultural Insurance Act, Act No. 185 of 1947.

programmes, farmers can in principle participate in either commodity insurance or the revenue insurance programme, but not both (OECD, 2020[10]).

Around 20% of eligible farmers subscribed to the revenue insurance programme in 2019, which may be partially explained by the fact that the programme is still relatively new. In contrast, subscription to the commodity insurance programme had in the past been mandated for some commodities, such as rice, and therefore such commodities have high subscription rates. However, even given the subsidised premiums, some producers do not purchase insurance, with coverage very heavily concentrated by commodity (Figure 6). The government is encouraging producers to subscribe to insurance, and in some cases requires farmers to have insurance in order to qualify for *ex post* disaster support. In 2019 for example, MAFF required producers to carry either commodity insurance or revenue insurance in order to receive recovery assistance for orchards.[32] MAFF has also introduced a new discount package for the commodity insurance programme (for agricultural facilities) for group subscriptions, as well as several options that reduce the insurance premiums for the revenue insurance programme by up to 40% compared with the regular premium in 2019.[33] Moreover, because the revenue insurance programme uses the tax system, indemnities are received after the end of the fiscal year (after March), while typhoons and heavy rain usually occur in June to October. In response to financial constraints that may arise because of this delay, the government also offers a zero interest bridging loan for the period before indemnities are paid (MAFF, 2020[55]).

Figure 6. The national subscription rate for agricultural insurance, by commodity, 2018



Source: MAFF (2020[56]).

3.4. Risk preparedness

Ex ante disaster preparedness and planning are crucial for effective crisis management – by public and private stakeholders with a role in disaster response, and on farms. Preparedness activities are an important and necessary complement to risk prevention and mitigation efforts, such that when natural hazards inevitably occur and disrupt agricultural activities, stakeholders have the networks, capacities and resources in place to manage a crisis effectively, minimise the disruptions to agricultural activities, and ensure a quicker and more resilient recovery (UNISDR, 2015[7]). Risk preparedness requires public and private actors to undertake a wide range of activities, such as developing and improving risk monitoring systems, risk education, and risk information and drill exercises.

[32] Producers were required to subscribe the insurance before the disaster event to qualify for disaster assistance. Producers without the insurance received lower rate of the orchard assistance.

[33] The final amount of compensation is reduced by choosing these options.

In general, the overall preparedness for natural disasters in Japan is co-ordinated systematically across the country. For example, National Disaster Prevention Day is observed on the first day of September. Educational events and drills are conducted nationally at schools and workplaces every year on what to do when a major natural hazard strikes, raising awareness of disaster preparedness.

With timely access to disaster information, farmers and agricultural policy makers can better understand the potential impacts of natural hazards and prepare before a disaster strikes, by carrying out risk-sensitive planning and investments. Unlike earthquakes, the magnitude and location of typhoons and heavy rain events can be predicted in advance to some extent. The Japan Meteorological Agency (JMA) gathers, reports and forecasts weather data and also monitors weather-related risks. For example, JMA utilises their Automated Meteorological Data Acquisition System, which collects automated measures of rainfall, air temperature and wind direction and speed, for observing meteorological phenomena that cause storm and flood disasters (JMA, 2020[57]). These forecasts are broadcast widely, helping to keep all citizens informed about conditions before typhoons and heavy rains arrive.

JMA also hosts a web portal with weather information tailored to the needs of farmers (JMA, 2020[58]). The portal provides advice on preparedness and other activities that farmers can undertake, tailored for specific commodities, weather events and regions. Specifically, farmers can choose the type of weather event,[34] a time period,[35] and a commodity,[36] and the portal provides information on how to prepare for the hazard. Additionally, JMA publishes a handbook of meteorological information specifically for the agricultural sector, which is tailored to 11 regions in Japan, to help each region prepare for weather events, including typhoons and heavy rains (JMA, 2020[59]).

Before a severe weather event occurs, MAFF issues technical guidance for farmers in a timely manner based on JMA's weather information, to help prevent damage (mainly) to agricultural products. The technical guidance includes safety instructions for farmers during the storm; measures to protect against pests and insects; and advice on seeding, harvest and facility maintenance. This guidance was originally issued to MAFF's regional bureaus (nine locations in total) to help them provide technical guidance to the prefectures under their jurisdiction, but technical guidance is now also accessible to farmers through JMA and MAFF's web portal[37] (MAFF, 2020[60]).

Disaster preparedness in the horticultural sector is supported by several initiatives. Under the Three-Year Emergency Measures, the government reinforced approximately 9 000 hectares of existing greenhouse facilities against storms over the period 2018-20 (Section 3.2, Box 3, and Section 3.3) with the government funding 50% of the cost, and assisted prefectures to formulate a damage prevention plan for these horticultural facilities (which could include facility reinforcement planning, workshops and promotion of agricultural insurance). Aside from financial support, guidance on improving the resilience of horticultural facilities to typhoons is available from several sources. For example, since 2018, MAFF has appointed June (before typhoon season) and November (before snow season) as Disaster Resilient Horticulture Months. During these periods, MAFF conducts awareness campaigns, including providing technical guidance for installing weatherproof greenhouses and promoting agricultural insurance programmes (MAFF, 2018[61]). JA has created an instruction book on building horticultural facilities that are more resilient to typhoons and heavy rains, which can serve as a reference for farmers and prefectures. Several prefectures (e.g. Kyoto Prefecture, Shizuoka Prefecture) also prepare greenhouse building manuals for prefectural advisers and in some cases for farmers, but the content and focus vary widely by prefecture. In the Five-Year Acceleration Measures, MAFF supports groups of horticultural farmers who aim to establish business contingency plans (MAFF, 2021[62])

The level of preparedness on farms is uneven across the country. Regions in which typhoons frequently land have accumulated significant knowledge on how best to prepare for typhoons and storms. For example, Mie prefecture issues a letter to agricultural facility managers to conduct a facility check well before and after the arrival of typhoons and heavy rain events. In contrast, areas with relatively less experience of typhoons and heavy rainfall have low awareness of the risk and their responsibilities for

[34] Low temperature, high temperature, hours of sunlight (drought), rainfall, snowfall, hail, frost, wind, volcanic ash.

[35] Up to next two weeks.

[36] Rice, bean, potato, vegetables, fruit, flower, livestock, forage crop.

[37] The MAFF web-portal is called Technical Guidance to Prevent Agricultural Damage.

managing them, which tends to result in a greater reliance on government support for recovery activities. However, recent typhoons and heavy rain have affected a wider area and the overall exposure to natural disaster risks is spreading across the country. This changing situation calls for increased farmers' awareness and preparedness in some regions.

To increase farmers' preparedness, in 2020, MAFF created a new natural disaster information page on its website focused on typhoons and heavy rains and summarising priorities for preparing for extreme events (MAFF, 2020[63]). Through the Three-Year Emergency Measures and Five-Year Acceleration Measures, the government has encouraged the agricultural sector to establish contingency plans (Cabinet Secretariat, 2019[28]; MAFF, 2021[62]; MAFF, 2021[64]). MAFF has created a checklist to prepare for natural disasters and an example of an agricultural business contingency plan, with the goal of raising awareness among farmers about the need for preparedness and contingency planning (MAFF, 2021[64]). Further, to facilitate natural hazard preparedness and make natural hazard information more accessible, MAFF also launched the smartphone application "MAFF appli" in May 2020 containing natural hazard information and preparation advice for farmers.

Japan's farmers also have access to public extension services. However, it is not clear if advisors provide advice on how to prepare for typhoons and heavy rain. Agricultural extension services are co-managed by MAFF and prefectures under the Agricultural Improvement Promotion Law. [38] Approximately 7 000 prefectural extension advisors nationwide provide face-to-face technical and managerial guidance to solve challenges specific to the region. Advisors provide support on diverse topics, including on adoption of new technologies and good practices through on-site consultation and small group activities. Given the importance of extension services as a source of information for farmers, it is important that advisors have an up-to-date understanding of natural disaster risks and DRM policy programmes, and that they be equipped with technical guidance and mitigation practices that are tailored to the region.

3.5. Disaster response and crisis management

Effective crisis management and response hinge on all actors knowing their responsibilities in the event of an emergency and communicating effectively, with the public sector taking a leadership role when the private sector is unable to cope. In crisis situations in Japan, public sector actors play an active role from risk notification through to the response and co-ordination.

Alerts and real-time information on imminent hazards are important to help farmers take action ahead of typhoons and heavy rains. JMA uses six types of emergency warnings, seven types of warnings, and sixteen types of advisories based on the level of force (JMA, 2020[20]). "Emergency warnings" are issued if there is significant likelihood that a natural phenomenon[39] will have catastrophic impacts of a scale that will far exceed the criteria level of indices, such as for precipitation and wind.[40] "Warnings" are issued if there is a chance that weather conditions[41] will meet relevant warning criteria. "Advisory warnings" are issued if there is the possibility that serious adverse weather conditions[42] will develop that meet advisory criteria but remain below the warning criteria.

[38] Act No. 165 of 1948.

[39] Heavy rain, storm, storm surge, high waves, snow storm and heavy snow.

[40] JMA issues Heavy Rain (landslide) Emergency Warnings and Heavy Rain (inundation) Emergency Warnings for municipalities where extreme risk (the highest level) appears on Real-time Risk Maps when observed conditions (indexes) are expected to persist and rainfall is expected to continue. For typhoons, JMA issues Emergency Warnings when a typhoon with a central pressure of 930 hPa or lower or a maximum wind speed of 50 m/s or higher typhoon), or a comparable extratropical cyclone hits Japan. For Okinawa, Amami and Ogasawara, JMA issues Emergency Warnings when a typhoon with a central pressure of 910 hPa or lower or a maximum wind speed of 60 m/s or higher is expected. This is equivalent to "a level of exceptional risk of a magnitude observed only once every few decades" (JMA, 2021[80]).

[41] Storm, storm surge, snow storm, high waves, heavy rain, flood, and heavy snow.

[42] Gale and snow, gale, heavy rain, heavy snow, dense fog, thunderstorm, dry air, avalanche, ice accretion, frost, low temperature, snow-melting, storm surge, high waves and flood.

These announcements are usually region-based and are issued according to the level of risk associated with the weather event. JMA communicates with the national, prefectural and municipal governments as well as broadcasting organisations to discuss the timing of the announcement, in order to support effective disaster preparation activities. In addition, press conferences are frequently held before and concurrent with the issuing of warnings to explain the situation to the public. JMA also announces flood forecasts for the designated large-scale rivers in collaboration with river management authorities (MLIT or prefectural organisations) which indicate the water level or discharge, and also issues landslide warnings jointly with prefectures. Farmers generally acquire warning information through regular media (e.g. TV, radio, newspaper) and announcements made by the municipal governments. Based on the revision of the Guidelines for evacuation advisories, in 2019 JMA introduced a new five-level disaster alert scale, in order to clarify the type of actions to be taken and speed up evacuations.

Crisis governance involves a well-defined and yet flexible distribution of responsibilities. The Disaster Countermeasures Basic Act gives municipal governments the primary role for responding to natural disasters. The head of a municipality is responsible for emergency operations in its jurisdiction, including designating the warning zone, issuing evacuation orders, and providing necessary assistance. Prefectural governments assist municipal governments and take over the role of conducting response and relief activities when the scale of a natural disaster exceeds the capacity of the municipality to carry out its primary functions. In turn, the national government takes the lead if the capacity of the prefecture is short of the needs.

If the scale of a disaster is large enough, the national government implements emergency measures immediately. In the case of large-scale disasters that exceed the response capabilities of affected municipal governments, the national government mobilises emergency resources by setting up an emergency response team composed of senior-level officials from each ministry and agency that participates in the Crisis Management Centre of the Prime Minister's Office. The team analyses the situation using the collected information, and reports the results to the prime minister. Depending on the scale of the disaster, the government also may establish the Extreme Disaster Management Headquarters (headed by the prime minister) or the Headquarters for Major Disaster Management (headed by the Minister of State for Disaster Management) to co-ordinate emergency activities taken by stakeholders and to swiftly respond to the disaster.

MAFF also aims to minimise the vulnerability of farming communities during a crisis. To ensure an effective response against typhoons and heavy rain, MAFF establishes its own Emergency Headquarters for Natural Disaster Countermeasures if directed by the Minister of Agriculture, Forestry and Fisheries, or in some cases, a Headquarters for Major Disaster Management is established in the Prime Minister's Office. The role of MAFF's emergency headquarters is to co-ordinate the disaster response for the agricultural and agro-food sectors; this includes information gathering, posting staff to where they are needed, food assistance, and formulating a policy package with key actors (e.g. with different departments within MAFF, other ministries, local governments and JA). During this period, priority is given to collecting information from the affected areas to identify the needed assistance. Therefore, two-way communication between the agricultural sector (JA, prefectures and specific agricultural industries depending on the area affected) and the government is frequent and encouraged. In addition to the above actors, MAFF also communicates with its regional bureaus through video conferences in order to understand conditions in affected areas. Farmers communicate with municipalities, prefectures (extension advisors) or JA regarding the damage they sustained. In the livestock sector for example, milk collectors and livestock feed vendors who visit livestock farmers on a daily basis, voluntarily check the damage situation of livestock farmers and report information to local governments and the national government. As a part of this information gathering activity, MAFF also dispatches staff to liaise with affected local governments during or immediately after the disaster. Sending national staff to the affected area has become increasingly important as the frequent occurrence of severe typhoons and heavy rains has caused personnel shortages in the affected local governments, sometimes preventing timely information reporting to national policy makers. It also helps strengthen the link between staff at the ministry and local authorities, which may enhance co-operation in the long term.

Another core responsibility of MAFF during a natural disaster is to provide emergency relief food and water supplies to the affected regions since the preservation of life is a priority. To avoid a higher fatality rate, MAFF sends nutrient balanced food and beverages to victims and shelters without waiting for the request from the local governments, based on the number of people evacuated in each prefecture. Approximately

one million items were shipped in total during the heavy rains of July 2018 and during typhoons Faxai and Hagibis in 2019 (MAFF, 2020[1]).

3.6. Recovery and reconstruction

Recovery and reconstruction efforts also offer an opportunity for public and private stakeholders to "build back better" by addressing underlying gaps in resilience, and building the capacities needed to manage natural hazards in the future (FAO, IFAD, WFP, 2019[9]). This requires all stakeholders – including producers – to learn from natural disasters in order to adjust DRM frameworks, policy measures and on-farm strategies with a view towards long-term resilience (OECD, 2014[8]; OECD, 2020[3]).

Within one to two months after a natural disaster, the government announces all-sector support packages to ensure a smooth recovery. In November 2019 for example, in response to the damage caused by typhoon Faxai in September and typhoon Hagibis in October of the same year, the government designated approximately JPY 132 billion (USD 1.2 billion) for a reserve fund to finance restoration activities. The programme included ad hoc support for early recovery of flooded orchards and rice paddy fields, as well as to restore agricultural machinery. In particular, support was provided for farmers to replant and manage young orchard trees and farm in alternative fields until the newly planted trees bore fruit. Support for rice farmers aimed to restart production for the next crop year cycle, all aiming for production continuity (Table 5) (Cabinet Office, 2019[65]).

Table 5. Agricultural measures in the support package for 2019 typhoons and heavy rains

Type	Support
Orchards	Replanting damaged trees (apples and peaches): JPY 170 000/1 000 m², in case of replanting labour saving type trees, apple trees: JPY 530 000/1 000 m² Managing young trees: JPY 220 000/1 000 m² Securing alternative farmland when conducting large-scale replanting: JPY 520 000/1 000 m² Efforts towards maturing orchard trees rapidly: JPY 200 000/1 000 m² Protection and recovery of existing orchard trees for the next harvest seasons (in case of not replanting): JPY 74 000/1 000 m²
Rice farmers	Expenses required for removal of rice straw and sediments from paddy fields due to flooding: JPY 5 000/m³ Expenses for soil diagnosis and soil preparation for resuming farming: JPY 70 000/1 000 m² (for farmers whose rice stored in the warehouse after harvest was damaged) Additional soil preparation for the continuation of rice farming that has suffered large-scale flood damage due to the collapse of river dikes: JPY 10 000/1 000 m²
Machinery, facilities	Support the reconstruction and repair of damaged agricultural houses and agricultural machinery Support for renting agricultural machinery necessary for early restart of farming Support restoration of damage to farmland/agricultural waterways, joint use facilities such as fruit sorting stations and country elevators, and other agricultural facilities
Others	Support for purchasing additional pesticides, fertilisers, seeds and seedlings Support for purchasing livestock and feed, mastitis treatment/prevention, and recovering/reinforcing barns

Source: Cabinet Office (2019[65]).

When a natural disaster is considered to be extremely severe, the national government provides support to reduce the financial burden on municipal governments. To do so, the government designates a natural disaster as "extremely severe" pursuant to the Act on Special Financial Support to Deal with Extremely Severe Disasters.[43] In order to receive support for restoring damaged agricultural land and agricultural facilities:

- The estimated the cost of disaster recovery projects must exceed approximately 0.5% of the estimated national agricultural income of Japan; or
- The estimated cost of disaster recovery projects must exceed approximately 0.15% of estimated national agricultural income for the relevant fiscal year, and the cost of disaster recovery projects

[43] Act No. 150 of 1962.

must exceed 4% of estimated agricultural income for the prefecture in a relevant year, or exceed more than JPY 1 billion (USD 9 million).

Affected local governments regard important that the national government designate an extremely severe disaster when large-scale natural disasters occur, to facilitate more rapid recovery and reconstruction efforts. To designate a disaster as an extremely severe disaster, the affected local government is required to investigate damage and report the results to the national government. Based on the reported information, the national government considers whether the conditions meet the criteria for an extremely severe disaster. The designation decision also takes into account the opinions of the Central Disaster Management Council, which considers whether it is particularly necessary to reduce the burden on local finances or to provide special assistance to victims. To facilitate the procedure, the government provides local governments with assistance for damage investigations required for the designation process. Specifically, relevant ministries and agencies such as MAFF and MLIT are instructed to actively support damage investigations and provide a summary report of the investigation results to the Cabinet Office.

Local governments have also consistently requested that the process for designating extremely severe disasters be accelerated, noting that it can take several months. Understanding the importance of timing in a successful disaster relief intervention, the national government changed the system in 2017 and can now announce the prospects for a designation ("potential designation") as early as a week after the termination of the natural hazard event. This allows affected local governments to start recovery and reconstruction – including recovery projects for agricultural land and facilities – promptly without concerns over financial uncertainties. Given this change in procedures, the government announced the potential designation four days after typhoon Hagibis landed in 2019.

Recovery activities often begin while emergency response activities are still in progress (Lin Moe et al., 2007[66]). MAFF safeguards and rebuilds agricultural and rural livelihoods as quickly as possible, particularly when the post-disaster coping capacity of communities is exceeded. In addition to the all-sector national support package, MAFF announces its own ad hoc support programmes to facilitate continuation of farming operations. Recovery and reconstruction measures for the agricultural sector can include infrastructure reconstruction, repair or replacement of production equipment, asset recovery and rebuilding of farmer livelihoods, and support programmes are adjusted to suit the conditions of each disaster. Programme formulation depends on the scale of damage in the agricultural sector and thus, programme triggers remain flexible (i.e. there are no specific criteria). Funding for ad hoc support programmes comes from MAFF's initial budget as well as the national supplementary budget and budget reserve.

Payments provided in the ad hoc support packages developed in response to damage caused by typhoons and heavy rains in 2019 were very high, particularly in those municipalities which received an 'extremely severe' disaster designation. The national government covered more than 90% of indemnities for damage to agricultural land, agricultural irrigation channels and agricultural warehouses for areas with the extremely severe designation,[44] such that costs incurred by farmers were nearly fully covered. The coverage and menu of support programmes has also been expanded in recent years (Table 6).

[44] The support rate was 50-60% if the damage occurred outside of area designated as experiencing an extremely severe disaster.

Table 6. Types of agricultural recovery and reconstruction support for damage caused by typhoons and heavy rains in Japan, 2019

Support package for the agricultural sector
Infrastructure recovery and reconstruction (agricultural land, water canal, storage facility)
Technical advisory and staff were dispatched to provide assistance
Waste removal (rice straw and damaged greenhouse and agricultural facility removal)
Repair and installation of greenhouse and agricultural facility
Acquisition of agricultural machinery
Business restoration
Loan without interest, guarantee charge and mortgage, raising lending limit
Early payment of commodity insurance, support programmes for subscribers
Special measures for fruit producers (flooded orchards)
Special measures for rice farmers
Measures for livestock farmers
Employment for those impacted by farm damage
Support for damage caused by electric outages
Oil removal from agricultural land

Note: The package covered damages by heavy rains in August-September and typhoon Krosa, Lingling, Faxai, Tapah, and Hagibis.
Source: Based on MAFF (2019[67]).

Accelerating reconstruction through measures such as contingent reconstruction plans, and pre-approved contracts and financial arrangements, can reduce disaster impacts in the long term, particularly in countries that experience frequent events (GFDRR, 2018[68]). MAFF emphasises the swiftness of recovery and reconstruction. For example, in order to support early recovery of damaged agricultural land and facilities (e.g. agricultural irrigation systems), MAFF promoted the use of a system that allows reconstruction work to start without first conducting a disaster assessment, if doing so would help restart farming operations in the next cropping cycle. Moreover, to better ensure the effectiveness of recovery activities, MAFF held meetings in affected regions for local governments and related stakeholders, such as JA and crop and livestock farmers, to explain the current recovery status and available support programmes, and offered case-specific consultations soon after the support measures were announced during 2019.

Due to the increased frequency of large-scale typhoons and heavy rains, personnel shortages in the affected local governments have become a chronic problem, to the point that they can impede swift recovery. In response, MAFF dispatches its technical staff (agricultural civil engineers and experts from NARO) to local governments to guide disaster recovery projects, as well as to areas where technical guidance for early restoration is needed – such as for removing sediment from rice fields and orchards. Usually, matters related to local governments are co-ordinated by the Ministry of Internal Affairs and Communications,[45] but MAFF also encourages and co-ordinates with unaffected local governments to send their staff to affected local governments, by providing 80% of salaries, allowances, and travel expenses.

Nevertheless, affected areas often struggle to repair infrastructure damage, as activities such as removing mud, debris and driftwood from agricultural fields require substantial physical labour. One feature of Japan's recovery and reconstruction process is that a wide range of actors take part. In particular, volunteer work has become essential to the swift recovery from disasters. For example, in response to typhoons Faxai and Hagibis, the government asked for volunteers to help with the recovery effort in order to speed up the process. Prefectural governments also co-ordinate among themselves to help affected prefectures. Prefectures created a system to pair up prefectures, and help the partner prefecture in case of a large-scale natural disaster. This structured system proved particularly helpful in 2018-19 because typhoons and heavy rains in those years landed in areas with less historical exposure to such events. This meant that more experienced and unaffected prefectures could help affected regions by providing reconstruction knowledge and expertise to guide the recovery process. Drawing on its vast network, JA also sends

[45] The Ministry of Internal Affairs and Communications is responsible for policies concerning local administrations.

volunteers to affected farm regions. For example, JA formed the "JA Group Support Team" consisting of JA Group executives and employees, which provided assistance to remove and dismantle damaged horticulture facilities after Faxai in 2019. In Nagano Prefecture, the major area for the production of apples and peaches, farmers struggled to recover their orchards from massive flooding caused by typhoon Hagibis. The regional JA, farmers, non-profit organisations and the prefectural and municipal governments collaborated to organise volunteers to assist in cleaning up the disaster debris and the mud from around the roots of the fruit trees. Through the vast network of JA and these collaborative efforts, affected areas received 6 508 volunteers (Shinshu Agriculture Recovery Volunteer Project Executive Committee, 2019[69]).

JA focuses its efforts on the recovery and reconstruction phase of the risk management cycle. JA's post disaster activities are diverse, but the bulk of their efforts are focused on two initiatives: supporting the restart of farming operations, and maintaining members' livelihoods. The Central Union of Agricultural Co-operatives (JA Zenchu, headquarters) sets up the central emergency task force to co-ordinate recovery efforts, including communicating with the government on damage and the assistance needed. Affected prefectural JAs also set up emergency response headquarters to co-ordinate regional recovery work. Following the typhoons in 2019, the regional JA in the affected area (Tohoku JA) supported farmers by purchasing damaged rice, offering compensation for price drops, and providing rental agricultural machinery to help restart farm activities. For livelihood support, Regional JAs in the affected areas started delivering relief supplies (e.g. food and beverages) to those affected. JA Bank (the financial section of agricultural co-operatives) also supports affected members by providing special loans for rebuilding houses and livelihoods and allowing deposits to be withdrawn without fees. JA Kyosai (the insurance section of JA) are committed to providing prompt pay-outs, including through the simplification of procedures to members in affected communities and by extending the date of premium payment.

In the time of a disaster, agricultural extension services can also support recovery by working side-by-side with farmers (Cathey et al., 2007[70]; Boteler, 2007[71]). Agricultural extension advisors conduct on-site visits to evaluate the damages and loss and assess conditions in farming communities, including the extent of damage to land, infrastructure, machinery and cultivated products. Advisors then deliver those identified needs to the prefectural authorities. In addition, this direct two-way interaction, which is often overlooked, also serves as an important element to help alleviate farmers' psychological distress and the sense of isolation stemming from income and agricultural asset loss.

4. Analysis

4.1. Disaster risk management frameworks in Japan are comprehensive, flexible and emphasise resilience to natural hazards, but agricultural actors' roles could be defined more clearly

Strong and effective governance arrangements are crucial for building agricultural resilience to NHID (OECD, 2011[6]; OECD, 2014[8]; OECD, 2020[3]). Policy frameworks for managing the risks to the Japanese agricultural sector from typhoons, heavy rain events and other natural hazards stem chiefly from two national DRM frameworks – the *Disaster Countermeasures Basic Act*, which focuses on hazard-specific *ex ante* and *ex post* countermeasures; and the *Basic Act for National Resilience*, which focuses on building the resilience of critical infrastructure. The agricultural sector is fully integrated into these overarching frameworks for governing disaster risks, which include specific goals and measures for building the agricultural sector's resilience to natural hazards. For instance, the Disaster Countermeasures Basic Plan mandates structural defences to protect the agricultural sector from floods, inundations and storms, as well as measures to facilitate the response and recovery. Further, DRM priorities are explicitly integrated into Japan's key agricultural policies. The *Basic Plan for Food, Agriculture and Rural Areas* – Japan's ten-year agricultural policy agenda – now explicitly recognises the need for *ex ante* efforts to reduce the risks to the agricultural sector from large-scale natural hazards. By emphasising measures to increase disaster preparedness and support recovery, agricultural policies signal the importance of disaster risk management and resilience-building for the sector.

Japan's risk governance structure also sets an example of multi-level governance, by showing how different ministries and jurisdictions can work together before, during and after NHID. The institutional

arrangements defined in the Disaster Countermeasures Basic Act and the Basic Disaster Management Plan assign roles and responsibilities to each public sector actor – and among ministries in particular – and leave little space for areas where responsibility is unclear within governments. This clear assignment of responsibilities also facilitates co-operation between different national and local jurisdictions during typhoons and heavy rain events. The specific policy targets in the Fundamental Plan for National Resilience and the Three-Year Emergency Measures also set out responsibilities and targets for MAFF.

A strength of Japan's disaster risk governance is its flexibility, responsiveness and adaptability, and the emphasis placed on improving DRM. Japan revises and updates its national DRM frameworks (i.e. the National Basic Disaster Management Plan, the Fundamental Plan for National Resilience, and measures in the Basic Plan for Food, Agriculture and Rural Areas) periodically based on identified risks and policy assessments. Reviews take into account the effectiveness of measures in existing plans and policies, and revise or develop new measures based on identified gaps. The government also takes steps to implement revisions after any major disaster. Focusing on *ex ante* and *ex post* measures for agriculture, MAFF considers feedback from JA and farmers, as well as prefectures and municipalities, and adjusts policies when necessary.

Japan's agricultural DRM is consistent with cross-sectoral frameworks. However, the roles and responsibilities of agricultural stakeholders at all stages of the DRM cycle could be more clearly defined, as current policy documents do not define the responsibilities of private actors, including farmers, to prevent, mitigate and prepare for natural hazards. The Basic Plan for Food, Agriculture and Rural Areas outlines general, broad objectives for managing natural disaster risk but does not define the specific responsibilities and roles for stakeholders (e.g. farmers, JA, and other actors), making sectoral efforts rather segmented and results in the burden of disaster risk management falling mainly to the government. Clarifying the responsibilities of agricultural actors to prevent and mitigate the risks and impacts of natural hazards would also encourage farmers to undertake additional risk management activities, with *ex post* assistance provided only when a particular disaster event is beyond their capacity to manage (OECD Publishing, 2009[5]). For instance, most of JA's current activities are centred on *ex post* support, but given the JA's vast national network, trusted strong connections with rural areas, and significant financial and marketing capacities, agricultural DRM would benefit from leveraging JA's reach and expertise to build the agricultural sector's and rural communities' resilience and preparedness capacities.

4.2. Risk and vulnerability assessments drive disaster risk reduction activities, but data on agricultural losses could be used more extensively

Information on hazard risks and vulnerabilities is important to guide investments in risk prevention and mitigation (OECD, 2014[8]; OECD, 2020[3]). Japan regularly reviews hazard risks and vulnerabilities, and uses that information as an essential input when developing and revising DRM frameworks and systems. This helps ensure that DRM is responsive to a changing risk landscape, focuses attention on the most significant risks, and guides resource allocation (OECD, 2014[8]; OECD, 2020[3]). For example, more frequent vulnerability assessments conducted on agricultural reservoirs and horticultural facilities identified at-risk infrastructure and have meant that key vulnerabilities could be prioritised and addressed.

Japan has comprehensive time series data on damage and losses caused by natural hazards in both qualitative and quantitative terms, in part because sector stakeholders – the local authorities, JA and farmers – collaborate with the national government to provide and develop the data. Currently, the collection and analysis of on-farm damage and losses are a critical component of marshalling *ex post* support for farmers and local authorities and paying out insurance claims, while local authorities and JA use the data to request financial assistance from the ministries. But information on commodity losses and damage to perennial crops and infrastructure can also be used to raise awareness of the exposure and vulnerability of agricultural production, infrastructure and facilities in different localities. Moreover, national and local governments could also use these rich data resources more rigorously to analyse the effectiveness of their programme investments, identify where changes in DRM policy are necessary and identify the most cost-effective measures to prevent and mitigate hazard impacts in the long term. By revealing the extent to which natural hazards affect the agricultural sector, these data are also an important input into on-farm decision-making, including on where and how to prioritise resilience investments.

Effective risk communication with agricultural and rural stakeholders is important to enhance stakeholders' understanding of their specific risk exposure, and thus promote self and mutual-help mechanisms. At

present, detailed and well advanced warning systems, flood hazard maps, and regional evacuation plans are all available in Japan. The recent government effort to establish agricultural reservoir hazard maps also helps farming communities and local governments take appropriate action when an unprecedented typhoon and heavy rain event approaches. The development of agricultural reservoir hazard maps, as required by the Act on Agricultural Reservoirs Management, is a key step forward to increase awareness among farming communities of the importance of agricultural facility management and how it affects the risk landscape in these areas.

At the same time, information on natural hazards needs to be accessible to farmers and tailored to their specific needs. The Japanese agricultural sector and rural communities face progressive ageing and depopulation, and risk is at its highest where a high level of exposure to natural hazards coincides with vulnerable societies (United Nations, 2016[72]). Farmers may not understand how the risks of typhoons and heavy rain are evolving because of climate change, due to the complexity or technicality of information, resulting in unpreparedness. Extension service advisors could play a role in communicating information specific to NHID and ensuring that constraints raised by farmers are understood and addressed by government officials formulating response plans. Extension advisors can also break down the technical risk knowledge and information for farmers and make sure that they understand the extent of impacts and the consequences of increasing typhoon and heavy rain risk – building the capacity of farmers to manage natural hazard risks, and improving awareness of the importance of preparedness.

4.3. A combination of structural and non-structural measures help to mitigate flood risks, but on-farm efforts could be strengthened

Japan aims to mitigate the impacts of natural hazards by reducing vulnerabilities. As identified in Japan's Fundamental Plan for National Resilience, infrastructure plays a critical role in minimising damage caused by natural hazards. The underlying challenge for the Japanese agricultural sector is how best to manage agricultural infrastructure, given the social and economic structural changes in the sector. Both agriculture-related water infrastructure and the farmers who manage them are ageing (OECD, 2019[12]; OECD, 2020[10]), and local governments face financial constraints that may curtail needed maintenance. As large-scale typhoons and heavy rain events are expected to occur more frequently, the sector needs to improve planning for agricultural infrastructure management. Currently, decisions on regular agricultural infrastructure maintenance are made based on how well facilities perform, in terms of agricultural service provision. However, given fiscal constraints, funding for renewal and repair could focus on where the rehabilitation is most needed from the standpoint of NHID risks. The government could also explore innovative financing approaches to leverage private funding sources. In this sense, the government's recent reform of agricultural reservoir management (Box 6) took a balanced approach by mixing structural and non-structural measures, namely physical rehabilitation of reservoirs as well as establishing hazard maps and clarifying the responsibilities of the owners and local authorities. Greater attention should be also paid to opportunities for nature-based solutions such as the paddy field dams, as nature-based solutions can be a physically effective and cost-efficient alternative to grey infrastructure (OECD, 2020[73]). The national resilience building frameworks also ensure that progress is monitored and evaluated. In addition, given challenging trends, various infrastructural R&D at NARO tailored towards disaster prevention could be encouraged and further supported.

Farmers have access to risk management tools such as commodity and revenue insurance programmes that can help them to mitigate the financial impacts of natural hazards, and their use has increased. In particular, the government is promoting a revenue insurance programme as a more cost-effective product to yield insurance (loss evaluation is based on the tax form instead of sight-visit). However, the proportion of farmers subscribing to insurance – the revenue insurance programme in particular – remains low despite generous premium subsidies and promotion. The main justifications for subsidising agricultural insurance programmes as an *ex ante* risk management measure is to make disaster assistance more targeted and efficient as compared to *ex post* assistance, while also requiring farmers to participate financially (OECD, 2011[6]). Current low subscription rates may reflect farmers' low understanding of NHID risks and their responsibility to manage those risks. In the case of the revenue insurance programme, losses are evaluated via the 'blue' income declaration form, which not all farmers use and thus farmers may need guidance to complete the form. In this respect, it is important to understand why farmers do not subscribe to insurance in order to improve the programme design rather than further encourage participation using subsidies. Finally, it is also essential to ensure that subsidised insurance does not blunt farmers' incentives

to adapt to and mitigate the risks they face from natural hazards such as typhoons and heavy rain in the long term.

More generally, the country has significant experience in managing natural hazard risk, and farmers in many agricultural regions have substantial experience with managing storms. The experience of certain farmers and regions could be an asset for building resilience more widely. But the sector faces demographic challenges that may reduce the capacity of the sector to manage natural disaster risk. While older farmers can have significant experience, the sector's ageing demography may also mean that farmers have a limited drive for modernisation and innovation, and lower capacity to manage risk (OECD, 2020[3]). In particular, these farmers may be less inclined to utilise new risk management tools or make use of technical information, and may not have the incentive to make investments for managing risk in the long term. Finally, average farm size is small, with the majority of farmers relying on income sources other than agriculture (OECD, 2019[12]). The financial buffer provided by off-farm income may reduce the incentive to use on-farm risk management tools. Nonetheless building on its extensive experience with natural hazards and with the right tools, the agricultural sector can increase its resilience to typhoons and heavy rains.

It is worthwhile to highlight that Japan's agricultural extension service can assist agricultural and rural communities to manage natural disaster risk. In general, extension services tend to have local credibility, capacity, and mission to address the depth and breadth of community needs (Kerr et al., 2018[74]). Extension can provide farmers with advice on preparedness and available support in the event of extreme events. In particular, advisors can provide technical and operational guidance and assistance tailored for each region and farmer, often developed collaboratively with the national and prefectural governments. Considering that the role of agricultural extension advisors is embedded in farming communities, along with partnerships with both national and local government authorities, public research institutions, and other agricultural organisations such as JA, they can serve as more effective participants in community-based *ex ante* efforts. This can include promoting disaster resilient practices, educating farmers on risk awareness, helping business contingency planning, and providing tailored and accessible technical and policy programme information adapted to the needs of agricultural communities. The extension service could also help provide information on how farmers can use existing resources and capacities to increase their preparedness, and technical support to help them implement activities such as paddy field dams on a wider scale. Moreover, leveraging JA's influential network of farmers and facilitating them to participate in more *ex ante* activities is also important. The government needs to further incorporate the role of the extension service into the agricultural DRM system and develop the capacities of extension advisors through education and training specifically on DRM, including by providing comprehensive knowledge on natural disaster risks and impacts to agriculture, and practical disaster management techniques that directly address community needs. Increasing the knowledge of extension advisors on potential regional impacts and adaptation strategies with regard to climate change is also critical.

4.4. Japan's policies support rapid response and recovery from NHID, but may discourage farmers from taking steps to reduce their vulnerability to future risks

Under the leadership of the Cabinet and the Prime Minister's Office, Japan's natural disaster response during a crisis is well co-ordinated across government ministries and agencies, local authorities and public institutions. Disaster efforts also benefit substantially from the involvement of a large number of volunteers in the response, recovery and reconstruction processes. But the assignment of responsibilities for disaster response and recovery among national, prefectural and municipal governments may need to be reviewed. In particular, extreme weather conditions frequently overwhelm the capacity of many (largely small) municipalities despite their efforts to deal with disasters, as they are not well equipped to manage the situation. Moreover, many major disasters affect extensive areas and one single local authority may be ill-equipped to manage the response. Government actors could consider how the arrangement could be adjusted and examine whether co-ordination between the national and local governments could be improved, to better manage large-scale typhoon and heavy rain events.

Japan was the first country to bring the concept of "Building Back Better" to the UN World Conference on Disaster Risk Reduction in 2015. Building back better as both a policy goal and practice is an integral part of the post disaster reconstruction approaches in Japan (Cabinet Office, 2018[75]; Cabinet Office, 2018[76]). There is also a recognition across ministries of the importance of building back better after a natural disaster. However, current policies for the agricultural sector mainly focus on the swiftness of the recovery

and reconstruction rather than decreasing future vulnerability of the sector. Given generous support to farmers, a significant policy challenge concerns how to support farmers to rebuild farm infrastructure and facilities, while ensuring that they face incentives to make proactive resilience enhancing improvements to their facilities. Japan explicitly defines the designation for "extremely severe disaster", which sets boundaries for catastrophic risks and a framework that determines when and how *ex post* disaster assistance will be provided. However, the criteria for when the government provides agricultural disaster assistance are not clearly defined, which encourages farmers to rely on *ex post* government assistance, particularly as these programmes are offered for most disasters.

Japan's recent approach also prioritises faster recovery of the agricultural sector and ensuring business continuity, which can minimise labour exit from the sector in the wake of a natural hazard event, and sustain production. Revisions that allowed the government to fast track the announcement that a given incident would be designated an "extremely severe disaster", and announce disaster recovery policy packages more quickly (including prompt pay-out of commodity insurance and interest free bridging loans linked to revenue insurance) help to minimise the financial impact of disasters by helping farmers return to normal operations as quickly as possible. Japan's approach can provide valuable insights, as a faster recovery and reconstruction process can restore the income and assets of affected farmers earlier, reducing the cumulative income losses and minimising the disaster's impact on economic growth (World Bank, 2017[77]).

Nevertheless, recovery and reconstruction process are typically the longest and most costly phase of DRM. MAFF's longer-term interventions focus on recovery, rehabilitation and reconstruction to increase the resilience of rural communities and agricultural infrastructural to future hazards and facilitate the continuation of agricultural operations. The government prepares generous and flexible assistance packages for the agricultural sector, including strong financial protection to cover reconstruction costs, access to borrowing to finance the reconstruction, with both all-sector and agriculture specific special recovery measures created on an ad hoc basis. For instance, the national and local governments together covered almost all the costs for flooded agricultural land in 2019. The flexible approach to adjust the support to each disaster condition has some advantages. Nonetheless, the current policy challenge for Japan lies in encouraging farmers to take responsibility for building their resilience, while ensuring that any support reflects build back better principles. In particular, high rates of assistance provide farmers with little incentive to conduct their own natural hazard risk prevention and mitigation activities – including purchasing of insurance products – and reduce resources available for investments in natural disaster risk prevention and mitigation, or indeed, investments in building the capacities of farmers to manage those risks.

Japan's agricultural sector has significant experience with a range of natural hazards, and some regions have accumulated expertise to cope with typhoon and heavy rain risks. However, the regions affected by typhoons and heavy rains have gradually shifted and become less predictable than in the past. Areas with less experience in managing natural hazards are more vulnerable, and therefore establishing networks to share the information and capabilities of more experienced regions is becoming progressively more important. There are several networks and processes in place (e.g. Prefectural Council and groups, JA platforms) to ensure that experience is shared and used. But more frequent discussions and information sharing on measures and strategies to build preparedness and recover more quickly among agricultural actors (including farmers, JA, local and national government) could help encourage agricultural stakeholders in the less experienced regions to allocate more resources to DRM activities. Also, providing opportunities for sharing experiences on DRM among local government officials would help communities to better understand their risks and learn what they can do to protect themselves, which would lead to reducing risk exposure, loss and damage, and ultimately raise resilience of the sector and regions.

5. Conclusion

Japan's disaster risk management systems for agriculture offer many examples of good practices for building the sector's resilience to typhoons and heavy rains. Governance arrangements and national frameworks are comprehensive, and explicitly recognise the imperative of improving the agricultural sector's resilience, confirming the government's clear commitment to this objective. Explicitly stated targets and priorities for managing hazard risks and building resilience in these national frameworks facilitate

investments and the implementation of an array of agricultural DRM and resilience building programmes. Moreover, Japan's DRM systems are flexible and responsive to evolving hazard risks and to resilience gaps identified through vulnerability assessments and detailed data on damage and losses. Furthermore, a variety of structural and non-structural measures target improved risk prevention and mitigation, including the use of innovative and cost-effective nature-based solutions like paddy field dams. Finally, rapid recovery and swift provision of *ex post* support are a hallmark of Japan's DRM system, with comprehensive financial safety nets to help producers return to farming as quickly as possible.

Despite these good practices, the evolving risk landscape and structural changes occurring in the sector – namely rapid ageing and depopulation – suggest that agriculture will be increasingly vulnerable to typhoons and heavy rains in the future. A number of actions would help to ensure that the sector can continue to cope with or adapt to these events. First, these socioeconomic and demographic changes of rural communities need to be urgently addressed in Japan's agricultural DRM policy frameworks. This includes recognising that some farmers may have different objectives – for example, because of the financial buffer provided by off-farm income – or need additional support in order to build their resilience capacities and increase their preparedness for natural hazards. In this respect, it may be useful to co-produce programmes and tools with farmers, including extension services, in order to be sure that they meet the needs of all farmers, and older farmers in particular. The policies should acknowledge the current condition of infrastructure and the capacity of rural communities and individual farmers to make improvements. More frequent infrastructure evaluation, changes in management processes and reconfigured institutional arrangements are all possibilities to be considered. Second, natural defences such as paddy field dams are an economically viable flood control option that should be promoted more widely. Third, it is necessary that the government takes advantage of the extensive data on damage and losses to inform investments in risk prevention and preparedness by all stakeholders, including farmers.

Finally, a key issue concerns the extent to which farmers and other private sector actors are responsible for their own DRM, including preventing and mitigating the risks and impacts of typhoons and heavy rains on their farm operations and assets. At present, resilience-building efforts appear to be driven by government mandates, and the extent to which farmers themselves undertake proactive on-farm disaster risk prevention and mitigation activities is not clear. In particular, generous disaster assistance may make farmers over reliant on *ex post* assistance, such that the incentive to adapt or transform in response to the changing risk landscape is blunted. Defining the triggering criteria and types and level of government support in advance would provide farmers with a clearer incentive to invest *ex ante* in preparedness capacities, risk prevention and mitigation measures.

Government-led efforts to build the agricultural sector's resilience to natural hazards will be effective only if farmers and the agricultural sector stakeholders also take responsibility for their own DRM. As a first step, farmers' roles in and responsibilities for DRM could be clarified through comprehensive communication on natural disaster risks to farmers. Public extension services are particularly well placed for this outreach, as they understand both national policies and local conditions. In addition, proactive engagement with other agricultural stakeholders such as JA and the private sector are needed and should be integrated into resilience-building efforts across the DRM cycle. In particular, incorporating the JA's trusted, tight-knit and nation-wide network into DRM activities would support a more cohesive sectoral response. Finally, some regions and farming communities have substantial experience in coping with typhoon and heavy rain events. This knowledge needs to be widely shared within the sector to enhance its DRM capacity.

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