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Building the resilience of Italy's agricultural sector to drought

Katherine Baldwin and Francesca Casalini

Increasingly frequent and severe droughts are threatening Italy's agricultural sector. With climate change forecast to accelerate these trends, the sector must build long-term resilience. This will require better planning and preparing for, absorbing the impact of, and recovering from droughts, as well as more successfully adapting and transforming in response to these events. Recent positive developments include improved data collection on water supplies and agricultural damage and loss from natural hazards to better inform water management and investment decisions; strengthened commitment to *ex ante* risk management frameworks; and more participatory approaches for water management. Nevertheless, the agricultural policy portfolio currently underemphasises investments in on-farm preparedness and adaptation, in favour of coping tools such as insurance. Further efforts to build agricultural resilience could benefit from a holistic, long-term sectoral risk management strategy; an evaluation of the trade-offs between spending on risk coping tools versus investments in natural hazard preparedness and measures to mitigate their impacts; and more explicit consideration of farmer demographics and capacities in policy design.

Key words: Resilience; drought; water governance; agricultural risk management

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

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What is the issue and why is it important?

- Drought has become a particular concern in Italy over the past decade, and will continue to threaten the country's agricultural sector under climate change. Better management of water resources will be required to confront more frequent and more severe droughts.
- Italian farmers and other agricultural sector stakeholders must increase their overall resilience to drought. This means actions across the full value chain to strengthen their ability to prepare and plan for, absorb the impact of, and recover from drought, and more successfully adapt and transform in response to these events.

What did we learn?

- Recent initiatives are positioning Italy for improved resilience to natural hazards:
  - Awareness of the risk environment is improving, ensuring stakeholders are better prepared for adverse events and can respond quickly when they occur.
  - Italian stakeholders are also improving data collection on water supplies and agricultural damage and loss from natural hazards to better inform water management and investment decisions.
  - Policy makers recognise the advantages of prevention and *ex ante* approaches.
  - Response processes are in place and prioritise business continuity.
- Nevertheless, the policy portfolio for managing drought currently underemphasises investments in on-farm preparedness and adaptation (which supports future preparedness) in favour of coping tools such as insurance.

Key recommendations

- Despite advancements, there are some areas where progress could be strengthened:
  - Develop a holistic, long-term sectoral risk management strategy: Such a strategy should explicitly recognise the need for investments in risk prevention and sectoral adaptation, and would enhance the capacity of the Italian agricultural sector to absorb, adapt and transform in response to natural hazards.
  - Ensure effectiveness of existing reforms: Continued monitoring (and where necessary, adjustment) of recent policy initiatives is needed to ensure they are achieving their aims. Additional investments in data analysis and improved management capacity to act on this data may be warranted.
  - Re-evaluate the current balance in favour of spending on risk coping tools to increase investments in risk prevention and preparedness: Substantial resources continue to be directed toward risk coping tools that are not well-liked to other risk-mitigating activities and may actually weaken resilience to certain risks. Trade-offs and linkages should be explored, as spending on prevention typically results in future cost savings.
  - Take farmer demographics and capacities into account in policy design: Policies and tools must recognise that some groups of farmers may need additional resources or efforts to reach similar levels of preparedness as others.

1. Introduction

Italy is amongst the world's most affected locations in terms of exposure to severe natural hazards, such as earthquakes, floods, landslides and volcanic eruptions. On average, Italy experiences around four major disasters each year, with damages from single events sometimes exceeding USD 1 billion (CRED, 2021[1]). With agricultural activities undertaken throughout the Italian territory, the agricultural sector is also exposed to these risks, having recently experienced significant losses particularly from floods, droughts, and storms. In addition to losses on-farm in terms of assets, agricultural production or productive capacity, these events also result in significant public costs in the form of disaster assistance, as well as indirect losses from supply chain disruptions.

This case study examines how governance arrangements and policy measures help to build the resilience of Italy's farmers and 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 (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 Italian case study focuses on drought. While dry conditions have always characterised parts of the Italian territory, intense drought events are increasingly impacting the agricultural sector. Over the past decade, stakeholders have recognised that droughts are becoming more frequent and more intense, particularly in the southern regions and on the islands of Sardinia and Sicily. Moreover, droughts are also increasingly affecting areas not traditionally prone to drought, such as alpine areas and the upper Po River Valley. With climate change forecast to accelerate these trends, the country's water users – including from the agricultural sector – are reassessing water governance arrangements as crucial for building long-term resilience to drought. At the same time, agriculture sector actors are increasingly recognising that adapting to this drier future will require additional proactive investments in the present to effectively confront the long-term risk landscape, although the approach varies somewhat based on region and sector.

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 hazard (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.

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, 2009[5]; OECD, 2020[3]). 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, 2009[5]; OECD, 2011[6]; OECD, 2020[3]); 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 and WFP, 2019[9]).

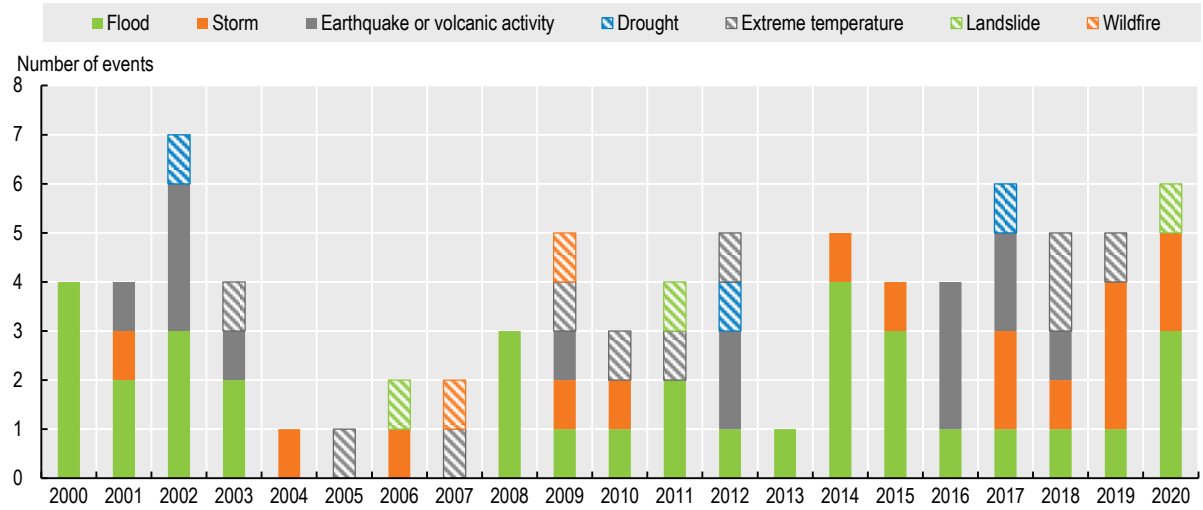
2. Country context

Italy is a major producer and exporter of agricultural goods, leading the European Union in terms of gross value added in agriculture, and ranking as one of the world's primary exporters of a diverse array of products, including apples, bacon and ham, cheese, grapes, olive oil, tomato paste and wine (Eurostat, 2020[10]; FAO, 2020[11]). The sector accounts for 2% of GDP and nearly 4% of the country's employment (OECD, 2020[12]). But these figures on primary agriculture understate the economic importance of the wider agri-food value chain – in 2018, the country's agri-food system (including production agriculture, forestry and fisheries; the

food and beverage industry; retail, food service, and dining) accounted for 15% of GDP (CREA, 2020[13]). As such, natural hazards that directly affect production agriculture can have important cascading effects on both the rest of the sector and the economy more broadly, with severe localised economic impacts on remote rural areas, which are more heavily dependent upon agricultural activity.

In conjunction with the sector's economic importance, diversity is also a characterising feature of Italy's agricultural sector. Agriculture is practiced throughout the Italian territory in a variety of landscapes, including the alpine north, the Po River Basin, the hilly central Appenines, and the Mediterranean south and islands. This variety of landscapes and climatic patterns contributes to the diversity of agricultural production, and it also shapes the types of natural hazards typically faced in the different regions. Indeed, while the country's National Risk Assessment covers seismic events, volcanic eruptions, tsunamis, geological and hydraulic risk, extreme weather events, droughts and water crisis/water scarcity risk and forest fires, the level of exposure to these hazards varies across the territory (CPD, 2018[14]). While the type of hazards experienced in a given year varies, storms and floods have been the most frequently occurring event over the past few decades (Figure 1).

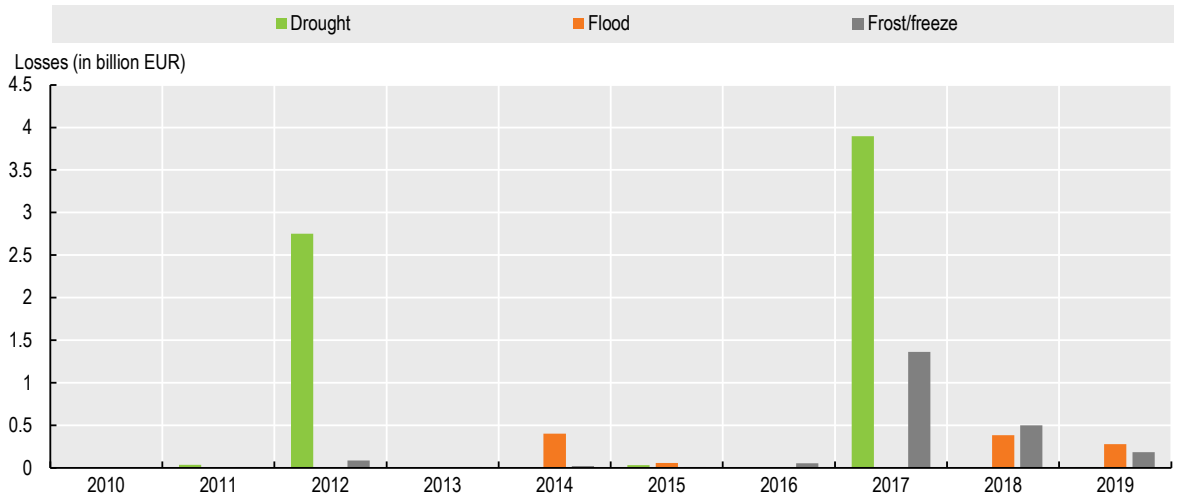
Figure 1. Frequency of disaster events in Italy, 2000-2020



Source: CRED, 2021, "EM-DAT Database".

In spite of the varied exposure to natural hazards, drought – broadly defined as a temporary decrease of water availability in a given water system, caused by prolonged deviations from average levels of precipitation (OECD, 2016, p. 10[15]) – has come to be an increasingly damaging hazard for Italy's agricultural sector. Over the past two decades, droughts have become more frequent in Italy, and are increasingly costly for the agricultural sector (Figure 2) (AGEA, 2020[16]; CPD, 2018[14]). Droughts are also more frequently leading to water scarcity events, where water demand from all uses (including households, hydroelectric power, manufacturing, tourism and agriculture) temporarily outstrips available supplies. Given that irrigation accounts for more than 50% of water utilisation in Italy, and that it is not the priority use in water allocation, this situation can have severe consequences for farmers (Istat, 2019[17]). Moreover, these water crises are increasingly affecting new areas of the country that had not historically experienced drought, including the Po River Basin and pre-alpine lakes (CPD, 2018[14]; Zucaro, Antinoro and Giannerini, 2017[18]).

Figure 2. Losses to agriculture in Italy from three hazards



Note: Values represent the sum of indemnified insurance losses and loss declarations reported to the National Solidarity Fund.
Source: ISMEA (2020), "Perdite economiche per evento" Dataset.

Although typically motivated by meteorological conditions, water crises are also exacerbated by the state of the country's water distribution network. In 2015, surface water leakage along the country's household distribution networks exceeded 40% – considering this dispersion in conjunction with unauthorised withdrawals and other inaccuracies in measurement, sector experts estimate that in Italy, just under half of the water withdrawn at the source does not reach end users (Mariani et al., 2020[19]). This data supports the conclusion of the Italian Civil Protection Department that on a national scale, "…water crises are mostly caused by the difficulty in accessing water rather than by actual resource deficiencies" (CPD, 2018[14]).

The impacts of drought on the Italian agricultural sector vary depending upon the time frame and severity of the event. In the short term, the most substantial direct impacts from drought are typically a decline in crop yields (particularly in rain-fed systems) or reduction in cropped area due to drought-induced water shortage, or negative impacts to livestock production or health (OECD, 2016[15]). Irrigated systems, which account for more than 20% of the country's utilised agricultural area, can also be affected, particularly if the conditions are severe enough to reduce the quantities of water available for irrigation (Istat, 2019[17]). In some cases (particularly for fruits and vegetables), the net effect of drought-induced production shortfalls on overall income may be limited, as the decline in yields may be partially offset by higher prices[2] (CREA-PB, 2020[20]; Musolino, De Carli and Massarutto, 2017[21]). At the same time, competition amongst water users can result in large losses to producers who irrigate if anticipated water supplies are not available when needed. Indirectly, droughts can raise costs for producers, including through higher expenditures on pumping irrigation water, or the cost of purchasing additional external feed if production from pastures is reduced. Moreover, in the long-term, more frequent drought and water scarcity events can compromise the sector's sustainability, as increased demand for irrigation further stresses water supplies, increases operational costs at the farm level, and damages the land's productive capacity through, for example, increased soil salinity or as a result of soil erosion (Rossi, Castiglione and Bonaccorso, 2007[22]). Substantial negative impacts on crop yields have been noted in other countries that have experienced increased drought conditions and a subsequent deterioration in soil moisture, including in Australia and the People's Republic of China (hereafter "China") (OECD, 2017[23]).

Building the agricultural sector's resilience to drought, then, requires effective short-term hazard management improvements, but also investments that will improve the sector's capacity to manage or adapt to these types of events in the long-term. Amongst other challenges, the government must find the most effective balance between investing in preparedness and prevention versus hazard response; more effectively manage water resources amongst competing uses; and incentivise improved farm-level capacity

[2] The degree to which this is the case depends on whether farmgate prices increase versus wholesale or retail prices, as the value of an increase only in wholesale or retail prices will largely be captured elsewhere in the value chain.

to manage drought and adapt to changing conditions. In doing so, stakeholders have an opportunity to reconceptualise how they perceive risk management in agriculture and ensure that policies are better-oriented toward the sector's long-term sustainability rather than solely the capacity to cope with single hazard events.

To ensure that these measures will be effective, they must be carried out taking into account the needs, capacities and objectives of the country's farmers. In that vein, improving the Italian agricultural sector's resilience to drought and other natural hazards is somewhat complicated by differences in farmer demographics and farm business objectives that are also related to the sector's low average productivity growth, limited drive for modernisation and innovation, and diverging capacity to manage risk amongst the country's farms (OECD, 2020[3]). First, the majority of Italian farms are very small, with more than 50% of farm entities generating sales of less than EUR 8 000 in 2016, and over 20% of farms allocating more than half of their production to own consumption (Buglione et al., 2018[24]; CREA, 2020[13]). These farms that are oriented toward own consumption are typically not well-integrated into commercial value chains, such that they may be less inclined toward innovation and growth, less responsive to market incentives, less motivated to purchase *ex ante* risk management tools, and less likely to make risk-reducing investments or adopt risk-reducing management strategies. In addition, Italian farmers are also on average much older than their counterparts in other European countries. In 2016, 41% of Italian farm managers were over the age of 65 – well over the EU average of 33% (Eurostat, 2019[25]). While these managers typically have a wealth of experience, they are less likely to incorporate new technology and innovations into their operations (Genius et al., 2014[26]), and could also be less inclined to make substantial new investments in the long-term viability of their farms.

In this context, the Italian Government and key sector stakeholders have nonetheless made important inroads into improving the capacity of the sector to plan for, cope with, recover from, and more successfully adapt to drought and other adverse events. These improvements cover a wide range of areas, including reforms of water governance frameworks and reorientation of disaster management activities, investments in water distribution networks and irrigation capacity, a recognition of the need for better data to underpin both policy and farm-level decision-making, a commitment to innovating with respect to risk management policy tools, and support for technology and innovation. The following section outlines the current state of disaster risk management as it relates to Italian agriculture both generally, and with a more detailed focus on drought, highlighting examples of good practices while also noting potential for future improvements.

3. Natural disaster risk management in Italy

Resilience to natural hazards is an outcome of measures put in place before, during and after an extreme event. Different measures are typically instituted by certain 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 risk in the agricultural sector in Italy involves activities spread across a variety of ministries and actors at local and national levels according to the temporal and spatial frame in question and the severity of the event, including emergency management frameworks for immediate and catastrophic events, agricultural policies aimed at both short-term risk coping and long-term planning, and longer-term natural resource planning (particularly in the context of climate change). Accordingly, the following sections outline the main actors and relevant governance frameworks, followed by a discussion of policies and activities underway at each stage of the risk management cycle and how they contribute to the sector's resilience, including risk identification, assessment and awareness; prevention and mitigation; preparedness; response and crisis management; and recovery and reconstruction. Many of these frameworks and activities are applicable to a wide range of natural hazards, but the discussion highlights specific relevance for drought.

3.1. Governance frameworks affecting disaster risk management in agriculture

Strong and effective governance arrangements are crucial for building agricultural resilience to natural hazard-induced disasters. Institutions and policy frameworks influence decisions by farmers, government agencies and other stakeholders on whether or not to invest in building resilience, by defining stakeholders'

roles and responsibilities for managing natural disaster risk, and by providing incentives to invest in risk prevention and mitigation, including after a disaster (OECD, 2014[27]; UNISDR, 2015[7]). The different types and severities of risks affecting agriculture in Italy fall primarily under four different governance frameworks involving a variety of stakeholders – emergency management, agricultural risk management, agricultural policies related to investment and development of the sector, and in the case of drought, water governance.

For hazards that threaten human and animal life and public safety (including drought and extreme weather), activities such as risk forecasting, prevention, warning, and crisis response are under the jurisdiction of the Civil Protection Department (CPD), which coordinates with relevant ministries both in times of crisis and in seeking to prevent crisis situations.[3] For example, CPD – together with other institutions – plays a role in forecasting and mitigating the impacts of many types of adverse events, including water crises. However, the CPD emergency response is typically activated only for events that threaten human or animal life and public safety. Accordingly, CPD response activities most relevant to agriculture are largely limited to rescuing people or animals in need of assistance, or providing emergency shelter or other agricultural structures (such as livestock sheds). While drought and water crises are considered under the purview of CPD and their activities do contribute to forecasting and mitigating the impacts of these events, in practice, their response activities during drought events are limited to ameliorating the short-term impacts of water crises (such as providing emergency drinking water supplies) (CPD, 2018[14]). Most adverse events that affect agriculture fall outside of CPD's mandate. That is, although impacts from drought, hail and frost can be economically devastating for farmers, they rarely threaten human life, and as such do not typically invite an emergency response from local, regional or national CPD authorities. Equally, activities related to risk awareness, prevention and mitigation of natural hazards specifically for the benefit of the agricultural sector do not directly fall within the mandate of the CPD.

As a result, the resilience of the agricultural sector is most directly shaped by the various policy frameworks administered by the Italian Ministry of Agricultural, Food and Forestry Policies (MiPAAF) that individually address different aspects of risk management, although with no overarching medium- or long-term resilience strategy for the sector. The policy framework most directly related to risk management is the annual National Risk Management Plan, which defines all of the risk management policy tools available to farmers for that year (MiPAAF, 2020[28]). Tools defined in the plan to help farmers cope with the impacts of natural hazards include those that are partially subsidised using funds from the second pillar of the European Union's Common Agricultural Policy (CAP) (crop, animal and plant insurance; mutual funds; and an income stabilisation tool), and those that are financed through the National Solidarity Fund (FSN). Tools available through the FSN include:

- insurance against the destruction of animals in response to disease
- insurance of agricultural structures
- index-based insurance policies
- revenue-based insurance policies for durum and soft wheat
- *ad hoc ex post* compensation for expenses incurred by agricultural enterprises for the restoration of production activity following damage to production, structures, or infrastructure, only available in cases where the damage is caused by an event not elaborated by the National Risk Management Plan.

Outside of the tools specifically targeting risk management, the sector's resilience to natural hazards is also defined by the broader agricultural policy environment, that can either influence farm-level risk management decisions (through, for example, support for risk-reducing investments, or through direct support that may affect market incentives or resource allocation decisions) or directly impact the overall risk landscape (for example, through investments in irrigation infrastructure that can reduce the impact of drought). In Italy, the CAP provides the policy framework under which both generic and risk-management specific support is

[3] First established in 1982 in the wake of the 1980 Irpinia earthquake, the legal foundations for the department have evolved somewhat over time, with the Italian Civil Protection Department now governed by the Civil Protection Code (Legislative Decree no. 1 of 2 January 2018). Under Italian legislation, CPD's activities are directed to manage risks related to seismic, volcanic, tsunami, geological and hydraulic risks, extreme weather, drought and water crisis/water scarcity risk, and forest fire events. See (CPD, 2018[88]).

delivered to the sector. The CAP is composed of two pillars – pillar one provides funds for direct payments[4] and the common market organisation (CMO), while pillar two provides funding for the Rural Development Programme, through which countries address rural development objectives in six priority areas of choice among a menu of 20 pre-defined policy measures. Italy distributes its rural development expenditures through 21 regional Rural Development Plans (RDPs) and two national-level programmes (the National Rural Development Programme[5] and the National Rural Network,[6] a body whose objectives include improving the quality of regional rural development programming, providing a forum for best practice exchange, and promoting innovation). Aside from support of risk management tools (described above), rural development funds are used to restore agricultural production potential damaged by natural disasters, implement preventive measures, and make investments in physical assets such as irrigation and water management infrastructure with the objective of reducing the impact of adverse events. Indirectly, rural development also supports more general improvements in on-farm resilience capacity through programmes for knowledge transfer, research, advisory services, farm business development, co-operation, and agri-environmental and climate measures. Total public expenditures indicate that Italy has prioritised spending in areas that likely contribute to managing both short- and long-term risks, including Measure 4 on investments in physical assets (22% of Italy's rural development expenditures to date), Measure 10 on agri-environment and climate (16%), and Measure 17 on risk management (10%).[7] Rural development is also the policy framework through which climate change adaptation activities for the agricultural sector are supported (CMCC, 2017[29]).

Although not directly disaster risk governance frameworks, other governance structures directly influence the management of risks to agriculture – specifically, water governance is extremely important to the prevention and mitigation of both hydraulic and drought risk. Water governance in Italy has evolved substantially in the last 20 years, both as a result of the need to comply with mandates under the EU Water Framework Directive (WFD) (Dir. 2000/60/EC)[8] and related national regulations, and as awareness of water scarcity has risen through repeated experience with drought conditions. This shift involved revisions to both the country's water governance structures and legal frameworks towards a river basin district-centric approach, as well as the introduction of a water pricing regime aimed at adequate cost recovery, as the WFD's provisions require an adequate contribution[9] to the recovery of water service costs. Accumulated evidence suggests, however, that this cost recovery is yet to be achieved.[10]

In spite of progress, Italy's water governance, and the associated water allocation regime, remain complex, involving a variety of stakeholders at various levels of government, and potentially hindered by a territorial mismatch between administrative and hydrological boundaries (OECD, 2013[30]; OECD, 2011[31]). Most prominently, while the seven River Basin District Authorities[11] (RBAs) (under the co-ordination of the Ministry for Environment, Land and Sea Protection – MATTM) are the primary planning authorities for the country's surface and groundwater,[12] the Regions are the main authorities issuing water abstraction licenses (WALs) for both surface and groundwater, based on the outlined framework of the RBAs (Santato, Mysiak and Pérez-Blanco, 2016[32]; Mariani et al., 2020[19]). This means that several different planning and management

[4] It should be noted that some pillar 2 programmes also incorporate area-based direct payments, with the key difference that pillar 2 programmes are elective.

[5] The National Risk Management Plan described above establishes the operating procedures for the disbursement of contributions for Measure 17 of the National RDP and for the FSN.

[6] A variety of programmes are contained within the National Rural Network to achieve these goals. For more information, see (RRN, 2020[94]).

[7] OECD calculations based on EAFRD data.

[8] As well as the complementary EU Groundwater Directive (2006/118/EC) and Floods Directive (2007/60/EC).

[9] For a further discussion of the cost recovery provisions of the WFD, see (EEA, 2013[98]).

[10] See, for example, (Giannakis et al., 2016[95]).

[11] With each RBA corresponding to the seven river basin districts described in art. 64 of the law of 28 December 2015, n. 221.

[12] As identified in Legislative Decree 152/2006, and formally established pursuant to art. 51 of the law of 28 December 2015, n. 221.

frameworks can affect agriculture. At the river basin district level, each RBA drafts and implements its own River Basin Management Plan (RBMP) according to WFD and related legislation that lays out the broader objectives for management of water resources and infrastructure, including sub-plans specific to the sectors or issues of greatest importance for the respective river basin district, such as agriculture, climate change,[13] and water scarcity and drought. However, the regions then issue WALs to abstract specified quantities of water (defined in volumetric terms, and not as a percentage of flows) from a specific source for a defined purpose conditional on minimum environmental flows, with licenses valid for up to a maximum of 40 years, as established by national legislation[14] (Santato, Mysiak and Pérez-Blanco, 2016[32]). Trading of licenses is not permitted, and may result in permits being revoked.

Specifically in the realm of agricultural water use by collective irrigation services, WALs are obtained by local water user associations (WUAs) (typically irrigation or land reclamation consortia), who then define a quota or abstraction requirement for individual farmers. More than half of Italy's irrigated agricultural areas are managed collectively in this manner (Zucaro, 2015[33]). In times of drought, RBAs have the authority to promote and agree on temporary limits on surface water abstractions, with those decisions informed by the activities of each RBA's Permanent Observatory on Water Use (OWU) – a collaborative body coordinated by each RBA and composed of relevant actors and stakeholders of the water sector, including representatives from a variety of ministries, national agencies, research institutions, water utilities and associations of water utilities, regional governments, and other water users (such as irrigation consortia) (Box 2).

Box 2. Participatory approaches to governance: Observatories on water use

Previous OECD work has stressed the importance of stakeholder engagement for water governance, noting benefits such as greater acceptance, trust, cost savings, policy coherence and synergy among projects (OECD, 2015[34]). Italy's system of Permanent Observatories on Water Use (OWUs) provide one example of how stakeholder engagement can be leveraged for improved water governance.

To strengthen the co-ordination between water conservation and water saving activities foreseen by the EU WFD, in 2016, the Ministry for Environment, Land and Sea Protection (MATTM) established seven OWUs – one for each river basin district. These OWUs serve as platforms for an integrated approach to water governance. They provide a control room for the management of water resources in times of drought and water scarcity, and develop technical tools to support the planning of the water balances at basin scale (through forecasting and scenario modelling, for example). They were also established to support integrated water management, especially in the case of droughts and water scarcity conditions. Members can slightly vary at river basin district level but usually include participants from MATTM, MiPAAF, the Ministry for Infrastructure and Transport (MIT), CPD, the RBA, national agencies, research institutes [including the Council for Agricultural Research and Economics (CREA) and the Institute for Environmental Protection and Research (ISPRA)], irrigation consortia and water utilities or associations of utilities. The OWUs are co-ordinated by a national technical committee [directed by MATTM, with the participation of representatives from RBAs, CPD, ISPRA, the Italian statistical agency (Istat), CREA, the Italian Water Boards Association (ANBI) and the National Research Council (CNR)] to ensure harmonisation of criteria and methodologies for evaluating criticality levels, and to exchange information to identify water risk situations and intervention priorities at the national level.

The OWUs facilitate the development of common strategies to ensure that all users have adequate water availability during stress situations, based on the principle of solidarity. The solutions adopted are very specific to each drought and water scarcity episode. They are identified at the end of each OWU meeting, and are subsequently reported in the OWU reports and bulletins, as well as on the OWU website. For example, during the summer of 2017, the OWU for the Po Basin Authority agreed on a reduction in abstractions from large derivations located on the western branches of the Po River

[13] Importantly, climate change is a topic considered in all river basin districts, and specific drought management plans have been drafted for all districts except for Sicily (EC, 2019[59]).

[14] Royal Decree 1775/1933.

in the Piedmont and Lombardy Regions, corresponding to 5% of granted withdrawals, to allow greater availability of withdrawals to the Regions further downstream and east, including the Veneto and Emilia-Romagna Regions). Through their activity, which focuses on suggesting the most appropriate measures for mitigating the impacts of drought, the OWUs support participatory approaches to defining actions for prevention and mitigation, working closely with utilities and industry associations responsible for water use. The OWUs also regularly publish a bulletin of water availability on their website, fostering a culture of proactive management of drought events and adaptation to climate change.

OWUs meet on a regular basis (usually bimonthly) even in the absence of a water stress situation. This strategy aims at enhancing prevention and preparedness in the event of future occurrence of water crisis. During drought and water scarcity events, OWUs meet more frequently (even weekly) to better monitor the ongoing situation.

Source: (Mariani et al., 2018[35])

In general, the four governance frameworks are well-defined in their mandate, and overlap in the area of drought management seems limited to activities focused on long-term planning for water infrastructure and utilisation. For drought and water scarcity events, different institutions have a role in forecasting and mitigating event impacts, and there are mechanisms in place to coordinate those activities, with water supply decisions taken using a multi-stakeholder process centred on river basins. Emergency response in water scarcity situations[15] is limited by the nature of the event. Financial assistance to aid recovery is provided through agricultural risk management frameworks. Long-term water resource planning focuses around river basin needs (but projects can be carried out by various actors), and other initiatives to strengthen the resilience of the agricultural sector are carried out under the agricultural policy framework.

3.2. Risk identification, assessment and awareness

Managing risks from natural hazards begins with a shared understanding of natural disaster risks to encourage investments in risk prevention and mitigation by all stakeholders (OECD, 2020[3]). At the most basic level, this requires knowledge of the risk environment currently faced by producers using risk identification and assessment. While general knowledge of risks is typically available, more detailed data on the risk environment – including on damages and losses, or, in the case of drought, data related to water resource availability – helps to facilitate decision-making at later stages of the risk management cycle. Further on from the current risk environment, activities such as modelling, horizon-scanning or data collection efforts focused on climate change indicators help to improve identification and assessment of how the risk environment will likely evolve over the medium- and long-term. In order to effectively contribute to risk management, however, these activities must result in improved risk awareness of relevant stakeholders. Given the public good nature of many of these activities, they are usually carried out by public sector actors. Accordingly, private partnerships or knowledge dissemination activities in conjunction with risk assessment are crucial to maximise their effectiveness in helping to manage risk.

With regards to the current risk landscape, the Italian agricultural sector benefits from a variety of different risk assessment activities from government actors. As noted above, CPD has conducted and made public a National Risk Assessment covering major natural hazards that could affect the country, although the assessment contains little in the way of potential impacts on the agricultural sector (CPD, 2018[14]). In addition, all territorial and local authorities are encouraged to have civil protection plans in place to deal with non-epidemic emergencies, and these plans are compulsory for municipalities. As such, throughout the Italian territory, local authorities are required to have some idea of the risk environment they face, and how they plan to respond to adverse events. The regionalised water and drought management plans undertaken by the RBAs also contribute in this area, as they provide an assessment of the current situation and lay out medium/long-term action plans. A longer-term risk and vulnerability assessment was also carried out with respect to climate change to support the development of the National Adaptation Strategy, including

[15] Largely limited to CPD ensuring sufficient water supplies for human consumption.

information on how future conditions would likely impacts different crop or animals production activities (Castellari et al., 2014[36]; MATTM, 2015[37]).

Risk assessment more focused on the agricultural sector is also carried out through other public institutions. For example, work is currently underway at the Italian Institute of Services for the Agricultural Food Market (ISMEA) as part of its support activities for MiPAAF to analyse and review the definitions of catastrophic events (specifically drought, flood and frost) provided by the risk management plan in agriculture, in order to identify the most suitable damage thresholds for such events based on the meteorological characteristics of Italian rural areas.[16] In the specific case of drought, various drought indices are being tested compared to those currently required by the risk management plan and used the by insurance system. In conjunction, ISMEA is also developing territorial vulnerability analysis with regard to the damages on agricultural production from drought, flood and frost in order to provide support to the decision-making process, overcome inequalities in the distribution of resources between territories and production chains, and improve the capacity for the public sector to respond to these events. In addition to the activities of ISMEA, the public Research Center for Agricultural Policies and Bioeconomy of the Council for Agricultural Research and Economics (CREA-PB) has in place a research programme on climate scenario analysis, including drought analysis and identification of adequate management measures (CREA-PB, 2020[38]). In this work, CREA-PB aims to support policy decision-making by quantifying drought in terms of water deficit for crops through the calculation of a Reconnaissance Drought Index (RDI) (Zucaro, Antinoro and Giannerini, 2017[18]). This research activity was carried out at the province scale, with the aim of providing an overview of drought phenomena at national level.

While these activities do indicate an awareness and expertise on the main risks that affect the country, well-informed risk assessment requires good data on hazard impacts in order to identify the most vulnerable and exposed actors and determine where resources are needed to prevent or mitigate future impacts. In Italy, there is as yet no systematic, consistent and comparable data collection and analysis on the impacts of adverse events in agriculture, nor is there an established effort to consistently track the costs and benefits of risk-reducing interventions in terms of avoided losses. The Italian statistical agency (Istat) is responsible for reporting on Sendai indicator 2c on direct agricultural losses due to hazardous events, but their methodology and reporting on the indicator is not yet finalised. Istat is currently working with the regions and other agencies to determine how existing data can be utilised in this area, and subsequently determine where new investments in data collection and estimation are needed. At the same time, there are some specific and targeted data collection efforts on agricultural losses due to adverse events that have improved risk awareness. For example, ISMEA collects and publishes data on the magnitude of impacts of adverse events on agriculture for insured producers. However, as only 9% of Italian producers are insured, these estimates provide only a partial understanding of actual losses, particularly in the regions with low insurance coverage, or amongst certain groups of producers (Zaccarini Bonelli and Lasorsa, 2020[39]). As an alternative approach, researchers at CREA-PB have instead developed a methodology for estimating farm income losses, particularly due to drought events (CREA-PB, 2020[20]).

While this work is underway on estimating direct agricultural losses, other initiatives are emerging to develop data sources that could demonstrate the costs and benefits of certain *ex ante* interventions, or even the consequences of new management practices. Several data sources and initiatives are worth highlighting in this area. The most prominent of these initiatives are the linked National Information System for Agriculture Water Management (SIGRIAN) and National Database of Investment for Irrigation and Environment (DANIA) databases. SIGRIAN is a water information system (WIS) web GIS platform managed by CREA-PB that serves as the national reference repository for data on irrigation networks, water use, and groundwater abstraction (self-supply included), based on data at the water user level (Zucaro et al., 2017[40]). First operational in 1998, SIGRIAN's utility expanded substantially in 2015 when MiPAAF designated SIGRIAN as the national reference database to collect data on irrigation volumes of both private and public water users in their "National Guidelines for Quantification and Monitoring of Irrigation Volumes by Regions".[17] Data for collectively managed withdrawals are reported by WUAs (either measured or estimated), while data on self-supplied irrigation volumes (either measured or estimated) is collected at user level and reported by regions, with each entity reporting water withdrawals, uses, and return flows. Data can be accessed by relevant

[16] The review activity is aimed at improving the capacity of agricultural insurance and mutual funds to help farmers cope with the financial impacts of adverse events.

[17] These guidelines were published as part of the Ministerial Decree of 31 July 2015. See (MiPAAF, 2015[96]).

agencies and actors involved in the planning and decision-making of water resources. For example, irrigation agencies (such as Irrigation and Reclamation Consortia) can analyse and use the data contained in SIGRIAN to better manage their resources and identify where investments may be needed, while administrative agencies or other bodies competent in the field of irrigation works can use SIGRIAN in planning irrigation infrastructure interventions. SIGRIAN also supports the economic analysis and updating of RBMPs (as required by the WFD) with a socio-economic assessment, analysis of quantitative pressures (via abstractions), and cost recovery assessment.

Data from SIGRIAN is linked with the DANIA database,[18] which is a Decision Support tool for planning investments aimed at reducing risks in agriculture, set up in 2018 (Ferrigno, 2020[41]). Indeed, DANIA provides a central repository of projects relevant to collective irrigation (financed and planned), including on investments for irrigation and investments targeting hydrogeological instability affecting agricultural areas. The stored technical and financial data are useful for decision-makers for selecting interventions to be financed, as well as for monitoring and evaluating the effectiveness of interventions and policies. Of relevance to drought management, DANIA provides a common platform to analyse, rank, co-ordinate and evaluate proposed and completed investments in irrigation systems. Both SIGRIAN and DANIA facilitate economic evaluations of proposed interventions to help avoid losses due to natural hazards. Other initiatives have also strengthened the evidence base for water management decision-making, including the public-private partnership ISIL project, which carried out a comprehensive survey of Lombardy's irrigation systems (Box 3).

There are also initiatives underway in Italy to better understand how the risk environment is evolving over the medium- to long-term time horizon. For instance, Italy is working to develop data to help demonstrate the impacts of climate change, which is relevant to tracking the evolving impacts of natural hazards. For example, Istat has participated in two UNECE-level task forces that will produce data to show the impacts of climate change and gauge how actors are adapting or avoiding its impacts. The first of these is on climate change related statistics, and the second is on measuring extreme events and disasters. With respect to the first initiative, the set of core indicators have recently been published[19] (CES, 2020[42]), and the second task force is currently deciding upon a set of core indicators. The development of databases on both agricultural losses and these accompanying initiatives from CREA-PB, Istat and others quantifying the benefits of risk-reducing investments should greatly facilitate the capacity to prove value-for-money in preventative measures, which could in turn motivate greater political support for these types of activities.

Whether due to increasing efforts related to risk awareness and analysis activities, the multi-stakeholder dedication to improving water management, or the increasing frequency of some types of adverse events, there is in general a good level of risk awareness amongst public sector stakeholders regarding the different types of risks to the agricultural sector. In conjunction, there is also a widespread recognition that certain types of adverse events have both become more frequent in recent years, and others are likely to become either more frequent or more intense under probable climate change scenarios (CPD, 2018[14]; Castellari et al., 2014[36]).

However, risk awareness at the farm level is more mixed, with some producers described as generally lacking in awareness, while others are only informed of their exposure and vulnerability to certain risks. Nonetheless, researchers have found that awareness of drought risk among Italian farmers has increased over the past 20 years – notably after producers experienced severe drought episodes (Bozzola, Di Falco and Finger, 2017[43]). Moreover, research has indicated that Italian producers are aware of climate change, but may have different perceptions on what that means for their future business operations. One study found that apple and grape farmers in Northern Italy believe that they will experience greater crop losses in the future (Menapace, Colson and Raffaelli, 2015[44]), while producers in Sardinia acknowledged climate change, but perceived that precipitation was actually increasing and therefore felt no imperative to change their water management regime, despite climate change projections indicating that pressure on water resources will increase (Nguyen et al., 2016[45]). Thus, although Italian producers do acknowledge climate change, their

[18] Access to DANIA is currently available online for all actors in water management, from relevant Ministries to the local actuators of investments.

[19] Among these core indicators, number 28 on "Direct agricultural loss attributed to hydro-meteorological disasters" may prove especially useful in helping to measure and manage the impact of these events in agriculture. For the complete list of indicators, see (CES, 2020[42]).

perceptions about the risk environment may not always accurately reflect scientific consensus, and therefore may act as a barrier to adoption of risk mitigating measures (OECD, 2012[46]).

To improve risk awareness among farmers, some regions have funded climate change information dissemination and awareness campaigns, which include projections on the likely development of future hazards such as drought. At the same time, outreach efforts in these areas can be complicated by the structural realities of the sector (including the lack of integration of subsets of producers into value chains), and initiatives are uneven across the territory, as not all regions prioritise the activity in their RDPs.

Box 3. Lombardy Irrigation Systems Survey (ISIL) project

The Lombardy region of Italy is, and has historically been, one of the most intensively irrigated areas in all of Europe. In fact, many of the region's active canals were constructed in the middle ages, yet continue to provide irrigation, energy generation, environmental services, cultural heritage and recreational benefits (Gandolfi, 2020[47]). However, in a region where water has historically been abundant, detailed data on the irrigation systems was surprisingly poor. Particularly as climate change alters the region's water supply, local actors saw the need for better data on the region's irrigation network in order to make informed decisions to plan for the future.

In order to improve the knowledge base of how water in the region's network is currently used, a comprehensive survey of Lombardy's canals was carried out beginning in 2015 under the ISIL project – a collaboration between ANBI (the association of regional irrigation consortia), the regional government, and researchers at the University of Milan. The survey generated georeferenced data that described how all of the elements in the network were related, following water from when it was first diverted from the river, through the canals and all the way to the fields, where for each irrigation unit, data was collected on the utilised irrigation method and the original source of the unit's water. All told, the survey was able to cover 80% of the irrigated area of the Lombard plain (Gandolfi, Olivotti and Roverato, 2019[48]). After the survey was carried out, the data was organised into a geospatial database, compatible with other existing databases (including SIGRIAN). Current conditions are now monitored under the project, with daily water withdrawals registered to the database during the irrigation season. This water flow and withdrawal data, combined with crop maps and other variables, allows simulations to be carried out using mathematical models.

Since its inception, the database has underpinned new research on water management. This includes demonstrating the importance of feedbacks and consideration of groundwater recharge when analysing widespread changes in water management practices (Cesari de Maria et al., 2016[49]), combining behavioural and climate change models to assess the performance of different policy options to mitigate the effects of drought under climate change (Giuliani et al., 2016[50]), and evaluating the water savings of other innovations in irrigation practices like installing automated, remotely controlled irrigation gates (Masseroni, Castagna and Gandolfi, 2021[51]). The database has supported farmer applications for rural development projects; it is being used by the regional authorities to analyse the likely effects of renewing certain abstraction licenses, accounting for the effects of climate change, and to calculate the regional water balance; and it has aided irrigation consortia in their long-term planning activities.

Crucially, the project has demonstrated that better data and water management capacity can generate substantial benefits and should not be overlooked in favour of investments in irrigation infrastructure as the only tool to modernise water resource management. Moreover, the model under which the project was carried out could be emulated elsewhere. ISIL brought together the private sector, regional authorities, and academics, with each actor contributing particular expertise, creating research synergies that improved the quality and the utility of the output for all.

3.3. 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 mitigating impacts. Government policies

and programmes can also encourage stakeholders to identify disaster risks to their own assets and address gaps in their resilience levels. In Italy, public sector disaster prevention and mitigation activities for the agricultural sector are largely focused on water resource planning and water usage efficiency, but also include initiatives to improve soil, support uptake of financial risk mitigation tools, or carry out research.

In the area of water resource planning, the government takes an active role in ensuring sufficient water supplies through investments in structural measures (including infrastructure development and the installation of more efficient irrigation systems), and has also made advances in certain non-structural measures like water pricing and collaborative resource planning. With respect to structural measures, the Italian Government is investing heavily on water-related infrastructure to improve the resilience of both the agricultural sector and the country as a whole against water scarcity. This investment is mostly concentrated on rehabilitation of existing infrastructure, though other solutions (such as desalinisation and recycling of urban wastewater) are being considered (Mariani et al., 2020[19]).[20] As noted above, the poor quality of Italy's water infrastructure leads to high water leakage, with a recent analysis indicating that Italy would require around EUR 25 billion in water infrastructure asset renewal over the next 10 years (OECD, 2020[52]). Projects and investments undertaken by a variety of actors (including MIT and MATTM) can contribute to improved water and irrigation infrastructure, but projects supported by MiPAAF are directed exclusively toward irrigation infrastructure and as such have the most direct impact on the sector's capacity to manage water supplies. In 2018 and 2019, MiPAAF invested EUR 629 million in irrigation projects (using funding from the National RDP 2014-2020, the National Development and Cohesion Fund, and the national budget for strategic infrastructure), and a further EUR 478 million are programmed for 2020 under the National Strategy for Water Savings (MiPAAF, 2020[53]). Of the interventions funded through rural development, nearly all of the funding has gone to support rehabilitation or improvements for existing irrigation systems rather than the construction of new irrigation systems. These investments seek to raise the proportion of irrigated land under more efficient irrigation systems to 18.8% by 2023 – at the end of 2018, more efficient systems covered just 2.8% of irrigated lands (ENRD, 2019[54]). This push for greater water use efficiency is also seen in the types of projects funded at the regional level. In Sardinia, for example, 13% of infrastructure investment funds have been used to install measurement instruments to monitor water resources, more effectively manage them, and help inform where future investments may be needed (Regione Autonoma della Sardegna, 2020[55]).

Although Italy is devoting substantial resources to structural measures that improve water use efficiency, non-structural measures like an effective water allocation system or long-term water resource planning can play a substantial role in preventing or mitigating water scarcity situations. Most prominently, structural investments should be accompanied by a water allocation system that reflects the sustainable use of water – even under future water availability scenarios – in order to avoid the rebound effect, wherein improving the efficiency of irrigation systems actually incentivises producers to plant more higher-value irrigated crops and use more water rather than conserve it, or to avoid the hydrological paradox, wherein increased efficiency reduces return flows and increases consumption by plants (OECD, 2016[15]; Grafton et al., 2018[56]).

It is unclear whether or not Italy's present system of water allocations is adequate to meet this challenge. As noted earlier, WALs are valid for a period up to a maximum of 40 years, are based on an authorised volume of water to be extracted (not water consumption, and not a share of available resources), and are not tradeable, such that there is limited flexibility to adjust based on changing conditions (OECD, 2015[57]). In some cases, WALs specify an average volume and not a maximum volume, such that users may in fact increase their abstractions during drought events and reduce use in normal years to comply with the average level specified, further reducing availability when it is most needed (Santato, Mysiak and Pérez-Blanco, 2016[32]). And because the WALs are issued by regions, there is no centralised WAL registry for each basin, preventing license prioritisation from taking into account economic value in case of drought. In some basins, volumes authorised under WALs exceed average current availability (Santato, Mysiak and Pérez-Blanco, 2016[32]). In part to address this issue, in 2017 MATTM released guidelines for the *ex ante* environmental assessment of new water abstraction requests,[21] to be carried out by regions in order to take into account environmental quality objectives of groundwater and surface water bodies. This includes evaluating the

[20] While the reuse of urban wastewater is under consideration, there are currently some regulatory obstacles in place preventing more widespread application of wastewater recycling. For further information, see (Mariani et al., 2020[19]).

[21] These guidelines were published as part of Directorial Decree n. 29 of 13 February 2017 of the Directorate General for the Safeguard of the Territory and Waters of MATTM. See (MATTM, 2017[97]).

cumulative effects of the requested new derivations with those already present in the basin. Each RBA has implemented these Guidelines through specific resolutions.

Italy's present system of water pricing also likely does little to incentivise more sustainable water use, as it is presently mostly a cost-recovery model. In line with the EU's requirements under the WFD, agricultural water users in Italy are required to pay full operations and maintenance cost recovery for water withdrawals (Gruere, Shigemitsu and Crawford, 2020[58]).[22] In practice, applying full cost recovery first requires quantification of water withdrawals in order to assess associated charges. While Italy has made progress in this area (with the national guidelines for the quantification or irrigation volumes adopted in 2015[23] and metering obligations for agriculture introduced by regional regulations in 2016), metering is still not universal, and abstractions are in many cases estimated (EC, 2019[59]). As of 2020, eight regions have adopted legislation to apply binomial tariffs (composed of fixed and variable portions) to irrigation abstractions, with an additional three regions instituting incentive pricing (Manganiello, 2020[60]). Even in regions where there are no provisions for the application of the binomial tariff, there are some WUAs that independently apply this type of charge.

Setting aside the country's water allocation and pricing system, Italy has adopted some innovative approaches to water resource planning for preventing or mitigating the impact of adverse events. While water management is the primary responsibility of RBAs, their actions in times of crisis are informed by the decision support structure of the OWUs[24] (see Box 2). OWUs bring together relevant actors in water governance to monitor developing conditions of water availability and use (particularly as a drought or water crisis unfolds), and recommend appropriate courses of action to minimise negative impacts. These OWUs are an example of participatory governance, offering a venue for all actors to reach a common understanding of competing demands on water resources, and find collaborative approaches to proactively addressing common problems. While these bodies can advise as to recommended prevention and mitigation actions, they do not have access to funding sometimes required to act upon identified needs, which remains the responsibility of other private or public actors.

While most public resources for prevention and mitigation are devoted to ensuring adequate water supplies, other initiatives also contribute to these goals. First, there is an increased awareness of the role of soil health and conservation in hazard impact mitigation, as soil with higher organic content better retains moisture and is less susceptible to erosion. Several regional RDPs included funding for focus area 4C on preventing soil erosion and improving soil management (including the promotion of practices that improve soil stability, such as minimum tillage), and by 2018, 12% of the country's agricultural land was under management contracts to improve soil management (ENRD, 2019[61]). There is also a push to improve data on soils to inform management efforts. For example, Lazio has recently compiled a region-wide soil database that will contribute to monitoring changes in soil quality and informing farm-level management decisions, as well as provide a foundation for improved flood modelling (Napoli, Paolanti and Di Ferdinando S., 2019[62]). In addition to soil health activities, other rural development initiatives could also contribute to the prevention or mitigation of the impacts of drought or other adverse events, but in most cases these efforts are fragmented, one-off exercises. Small amounts of funding under focus areas 3B on farm risk prevention and management and focus area 5A on water efficiency were devoted to measures on knowledge generation, advisory services, damage restoration or preventative actions, and co-operation.

At a cross-cutting level, research and innovation structures can make an important contribution to prevention and mitigation activities – particularly when considering long-term risks and future conditions under climate change – because they provide the evidence base needed to underpin decision-making processes and programming designed to facilitate adaptation to evolving conditions. Innovation is generated by a variety of actors for the Italian agricultural sector, including both public and private entities. In the public sector, this

[22] Reflecting the various reforms undertaken over the past decade, Italy is one of the OECD countries whose agriculture and water policies are now most well-aligned with OECD Council Recommendations on Water – substantial progress has been made in all areas, including goals on managing water quantity, managing water risks and disasters, ensuring good water governance, and ensuring sustainable pricing for water and water services. See Gruère, Shigemitsu and Crawford (2020[58]).

[23] See (MiPAAF, 2015[96]).

[24] In fact, OWUs were identified as a specific measure within the WFD Programme of Measures (PoM), which was adopted in March 2016 and approved in October 2016.

role is primarily filled by the various research centres of CREA. CREA has conducted climate scenario analysis to advise policy makers on the likely impacts of certain interventions under future conditions, and also is charged with communicating findings to the sector at large by organising meetings, workshops and focus groups with stakeholders. Research projects also increasingly involve sector stakeholders in the project design in order to ensure the relevance of the research and improve project design. In addition, activities undertaken through the National Rural Network (NRN) have sought to better co-ordinate research and innovation actions and ensure that related information is more widely available. Specifically in the area of resilience to natural hazards, the network has sought to build a sustainable national integrated research system and develop a reference framework on agri-environmental and climate measures, supporting practices such as conservation agriculture and sustainable management of soils. NRN programmes such as Innovarurale and Italy's LEADER[25] network (a collection of local action groups) both seek to build and share knowledge on new innovations or good practices. In seeking to cast a wide net for their outreach and knowledge transfer efforts, NRN has employed a variety of delivery modes and tools, including e-learning courses, conferences, workshops and farmer field days. Research outside of the agricultural sector also contributes to improved water crisis management. For example, CPD is currently supporting applied research in the field of forecasting water crises, in order to give enough time to other institutions to implement adequate mitigation measures. Presently, the National Research Council is working with CPD to develop a decision support tool for this purpose.

Outside of the public sector, universities carry out a wide range of research relevant for preventing or mitigating the impacts of short- or long-term risks, and agricultural sector organisations also encourage and support innovation. For example, Confagricoltura (the General Confederation of Italian Agriculture) sponsors annual awards for innovation in agriculture, recognising farms that develop or implement innovative solutions in a variety of categories (Confagricoltura, 2019[63]). The survey of Lombardy's irrigation system has also generated various research outputs (see Box 3), including findings on how the co-adaptation of water supply and demand measures could help the region's farmers avoid estimated potential losses of more than EUR 10 million per year under projected climate changes (Guiliani et al., 2016[64]).

While research is carried out by a variety of actors who utilise an array of dissemination strategies, some stakeholders reported breakdowns in the "last mile" between research output and farmers, such that new innovations in risk mitigating investments or management practices may not be reaching some groups of farmers. At the same time, there's an awareness that producer organisations, co-operatives or consortia can act as this missing link, but doing so would require collaboration and buy-in at the research design phases, and both top-down and bottom-up motivated research initiatives. Some private initiatives are already underway in this area, such as Coldiretti's (the National Farmers Confederation) "Innovation Advisors" training programme, which has to date certified 60 professionals to serve as innovation designers and facilitators to establish innovation partnerships and connect various interested actors, with the intent that farmers can be co-producers of innovation (Coldiretti, n.d.[65]).

While the aforementioned activities are intended to either prevent or mitigate the physical impacts of adverse events, the government has also devoted substantial resources to risk management tools designed to mitigate the financial impact of these events on the sector. Although MiPAAF offers a variety of tools each year under their "National Risk Management Plan," the most widely-utilised tool in Italy are subsidised insurance policies, which are delivered by private companies, but whose premiums are subsidised at up to 70% of cost (ISMEA, 2020[66]). The Plan defines different packets of yield insurance policies that each cover two or more adversities, such that farmers choose the type of coverage as well as the specific hazards they will insure against. Italy has been moving towards a system of subsidised insurance products over the past several decades, partially as a means to better ensure the timely delivery of *ex post* assistance to stakeholders in lieu of ad hoc assistance packages, which have not been found to provide timely assistance, and are difficult to target to ensure that the most affected parties receive the assistance. However, even given the generous financial incentives, most farmers are still not purchasing insurance, with coverage very heavily concentrated geographically and by commodity. Insurance coverage is heavily concentrated in the country's northern regions, which accounts for more than 75% of insured farms and over 80% of insured value (ISMEA, 2020[66]). High-value crops also dominate coverage, with wine grapes, apples and rice accounting for more than 50% of the country's insured value (ISMEA, 2020[66]). This geographic and product

[25] The acronym comes from the French "*Liaison entre actions de développement de l'économie rurale*", meaning "Links between actions for the development of the rural economy."

concentration can expose insurers to systematic losses, which has made private insurers somewhat reluctant to enter certain markets. Both public and private sector actors are working to encourage further uptake of financial tools for risk management in agriculture, in an environment where the magnitudes and impacts of natural hazards are on the rise in Italy. On the public side, the government has launched a reinsurance fund with the intent of incentivising insurance companies to experiment with new policies and innovate. They are also trying to further incentivise the purchase of insurance policies, both by raising the government support of premiums (raised from 65% to 70% from 2018) and lowering the damage threshold on policies (from 30% down to 20%) as allowed under the EU's 2017 Omnibus Regulation (ISMEA, 2019[67]), and by in some cases requiring the purchase of insurance to qualify for other funding available from regional RDPs. On the private sector side, insurance companies are seeking means of leveraging technology and innovative policy designs to reduce delivery costs. They are also considering the possibility of forming consortia to share risks more broadly amongst pools of producers.

In part due to the heterogeneity of the sector, both public and private actors are advocating for the development of new tools that are better suited to the realities of different production systems. For example, only recently have index insurance products become available, which may be more effective at ensuring coverage for low-value commodities like cereals, for which Italian producers historically have not sought out insurance coverage. Index products could also be effective at covering producers who have difficulty providing production history, but the products need to be simple enough so that farmers feel confident in adopting them. Other stakeholders are considering the possibility of mandating that producers carry at least minimum catastrophic insurance coverage, as occurs in other EU countries. In fact, Italy has recently proposed a new risk management tool – a mutual fund for catastrophic risk in which producer participation would be mandatory – that would provide some degree of coverage to all of the country's farmers (Box 4).

Box 4. Italy's proposed mandatory mutual fund against catastrophic adversities

The MeteoCAT fund is a risk management tool proposed by MiPAAF in the context of the next CAP that is being considered as a potential programme to strengthen the resilience of Italian farmers. The tool would be set up as a mandatory mutual fund. Producer contributions to the fund would be subsidised by up to 70% through risk management instruments under pillar II, while farmers would be responsible for contributing the remaining 30% by redirecting a small percentage (up to 5%) of their direct payment entitlements under pillar I. The mutual fund would cover the three events responsible for most agricultural damages and losses in Italy – drought, flood and frost – aiming to overcome the challenges of traditional insurance and reinsurance models to compensate for these increasingly frequent, high-intensity events. Pay-outs would be triggered using a two-stage process – first, the event must trigger an index threshold in a defined geographical area, and then farms within that area would be eligible to submit a claim if their damage exceeds 20% of the farmer's historical average production. Concurrently with the introduction of the MeteoCAT fund, the FSN compensation tool would be abolished, such that Italy would no longer have a mechanism for ad hoc assistance and all risk management tools would be defined *ex ante*.

There are many potential benefits to the design of the proposed tool. First, it will bring more predictability to both farmers and policy makers, as thresholds are transparent and defined prior to the event. Second, by making participation mandatory, the fund will avoid the adverse selection problems common to insurance programmes. Moreover, the programme's mandatory nature will also resolve the territorial mismatch observed in subscriptions to subsidised insurance policies and create a large pool more likely to be able to meet the demands of catastrophic events.

At the same time, the design and implementation of the tool will be crucial to its success as a risk management instrument. First, although the two-stage process will help to better target payments to farmers in need of assistance, this individual claims verification will make the programme more costly to administer than purely index-based programmes. Second, the programme may need to build in flexibility to periodically adjust trigger thresholds as conditions evolve with climate change.

Additional policy adjustments could be foreseen if the MeteoCAT fund is implemented to better align incentives and improve the resilience of the sector. First, with government support directed at this tool, phase-out of subsidies for crop insurance should be considered to avoid crowding out of private

insurance tools where premiums reflect the true risk premium. Second, government should strongly consider a commensurate increase in support for activities that reduce the likelihood of impact from all adverse events, including preventive infrastructure, business advice and innovation.

Source: (Zaccarini Bonelli and Lasorsa, 2020[39]).

Innovations and initiatives that mitigate or prevent negative impacts of adverse events are also coming from the private sector and farmers themselves. New digital tools and decision support systems in particular have been developed to help farmers mitigate the impacts from adverse events. Specifically in the area of water management, several digital decision support systems have been developed to inform farm-level management practices that improve water use efficiency and reduce consumption, with one in particular – IRRIFRAME – now widely available throughout the Italian territory (Box 5). While IRRIFRAME uses a water balance approach, tools like IRRISAT developed for the Campania region are instead based on satellite imagery, with the added benefit of helping WUAs to monitor illegal abstractions (Irrisat, n.d.[68]). In addition, the uptake of new technologies like optical sensors on drones and precision agriculture has contributed to significant reductions in water use in certain sectors.[26] However, as with the investments in infrastructure, care should be taken to ensure that these efforts do not hinder other longer-term water saving adaptations.

Box 5. IRRIFRAME

The IRRIFRAME[1] service – a project of the Italian Water Boards Association (ANBI) that uses the knowledge base developed by the Consortium of the Emiliano-Romagnolo Canal (CER), with the support of MiPAAF and CREA – is a real-time irrigation decision support software that aims at maximising water productivity for agricultural producers. The service provides tailored advice to producers for irrigation at field scale, setting irrigation schedules based on a daily water balance model and considering economic costs and returns for 50 crops. The advice is developed based on a range of information layers, including soil maps, meteorological data, groundwater data, data from satellite images and drones, soil sensors, and information from the farmer about their crops and irrigation equipment. The advice is delivered to farmers for free, via web, mobile app, or text message (operational costs are covered by local water boards). Future developments of the service will seek to further improve irrigation efficiency by differentiating irrigation volumes needed at subplot level.

The system also provides a real-time planning resource for water managers. Farmers confirm their irrigation volumes in the software, and that data is then aggregated and integrated into the water management systems of WUAs. This allows managers to maximise efficiency of irrigation networks along the whole system – from source to farmer to field.

In 2019, IRRIFRAME was used on 15 000 farms in the management of 399 609 hectares (Battilani, 2020[69]). Estimates have indicated that utilisation of IRRIFRAME has resulted in water withdrawal savings of 350 million m^3 per year in 2017 – although this does not necessary imply similar change in water consumption – without depressing yields (Montanari, n.d.[70]). While the bulk of IRRIFRAME's users are located in Emilia Romagna, the service is now available in 16 Italian regions.

Note: 1. The service was originally developed as IRRINET by CER, with support from EIP funds allocated by the Emilia Romagna region.
Sources: (Battilani, 2020[69]); (Climate ADAPT, 2019[71]); (Montanari, n.d.[70]).

Outside of these new tools and technologies, farmers and their advocacy organisations are increasingly aware of how certain practices like improved water efficiency or soil conservation can improve resilience to natural hazards, including drought. At the same time, part of the impetus for private actors to implement preventative or mitigating practices (including the adoption of adaptive practices to changing climate conditions) comes from clear incentives and signals from the policy environment on response processes, farmer responsibilities, and the limits of policy response (OECD, 2009[5]; Ignaciuk, 2015[72]). In this area, the policy signals are less clear. First of all, the thresholds for defining when government assistance will be provided in a natural disaster event are somewhat ambiguous. In the case of CPD, response is triggered when a region is unable to cope with the impact of the event, and then solicits assistance from national

[26] Stakeholder interview, 4 February 2020.

authorities. In the case of ad hoc assistance delivered through the FSN, events must cause damage in excess of 30% of gross saleable production, with the ministry determining how much assistance will be provided based on funding availability and priorities. Other agricultural policies may also affect farmer incentives to adopt risk-reducing strategies. For example, annual direct payment support available under CAP's pillar one are typically large enough to cover variable costs of most Italian farms, which may affect producer motivations to understand the risk environment and prepare for shocks, as well as reduce the incentive to seek out and subscribe to other risk management tools (Pontrandolfi et al., 2016[73]).

3.4. Risk preparedness

Disaster preparedness and planning are crucial for effective crisis management – by public and private stakeholders with a role in disaster response, and on farms. A wide range of activities can contribute to improved preparedness, including investing in risk monitoring systems, risk education, and planning (supported by simulation exercises such as drills and table-top exercises). Critically, preparedness requires actions on the part of both public and private stakeholders, but also relies on their capacity to work together.

Risk monitoring systems generally are housed within CPD, which carries out, in coordination with the distributed network of regional centres, continuous forecast and surveillance activities for a variety of hazards (including meteorological forecasts, combined with data from rain gauges, river gauges, snow gauges and soil moisture sensors). CPD formulates daily risk forecasts that are summarised in National Vigilance Bulletins that are publicly available, and synthesises the alerts issued by the regional centres in a national bulletin for geological and meteo-hydrological hazards that is also disseminated to the country's 8 000 municipalities (CPD, 2020[74]). Weather and climate monitoring of indicators more relevant to the agricultural sector is provided by regional authorities through weekly and monthly "Agrometeo" bulletins and forecasts.[27] At the national level, a collaboration between CREA's Agriculture and Environment division and the National Rural Network produce a weekly phenological bulletin that reports on both weather and crop development stage for wine grapes, olives, chestnuts and black locust trees (CREA-AA/RRN, 2020[75]). Increasingly, private sector decision support service products are also providing locally-tailored meteorological information to producers.[28]

Monitoring and surveillance of drought conditions is better characterised as a gradual process of monitoring a variety of indicators in a collaborative setting among several actors in the context of periodic OWU meetings. In these meetings, the various public and private actors analyse the set of available drought data and indicators available at national and regional/local levels to estimate the stress on water resources. Based on a set of 21 common indicators,[29] observatory actors assess the severity of the situation and co-ordinate corresponding actions to manage the event. While exact monitoring operations and activities may differ slightly between the observatories, they typically include the publication of alerts, status update bulletins, and outlook for future conditions. Italy also benefits from EU-level drought monitoring efforts undertaken by the EU Joint Research Centre's European Drought Observatory (JRC, 2020[76]). Alongside the OWU activities, CPD shares data monitoring rainfall, snow water equivalent and water availability data (reservoir storage, streamflows, groundwater levels, etc.), and carries out medium-term forecasting; ISPRA calculates a monthly standard precipitation index map (ISPRA, 2020[77]); and CREA calculates their Reconnaissance Drought Index.

With respect to risk education, nine regions devote financial resources to knowledge transfer, information actions, and advisory services specific to farm risk prevention and management under rural development focus area 3B (ISMEA, 2020[66]). In the Veneto region, for example, the Regional RDP funds a programme that offers consultancy services to young farmers to help them identify risks to their farm business, and then identify available tools or strategies to manage those risks (Regione Del Veneto, n.d.[78]). There are further examples of innovative knowledge transfer initiatives related specifically to water management, including the

[27] See, for example, https://www.arpae.it/dettaglio_generale.asp?id=2807&idlivello=1590; https://www.arpalombardia.it/Pages/Meteorologia/Previsioni-e-Bollettini.aspx?meteo=ag#/topPagina; http://www.sias.regione.sicilia.it/home.htm; http://meteo.regione.marche.it/notiziario.aspx.

[28] See, for example, https://www.horta-srl.it/servizi/rete-agrometereologica/.

[29] In 2018, researchers at ISPRA and IRSA-CNR, in conjunction with other government stakeholders, developed guidelines for the OWUs on recommended indicators to assess drought and water scarcity. Further details on these indicators can be found in (Mariani et al., 2018[35]).

Acqua Campus irrigation technology experimentation and demonstration site in Emilia Romagna. To the extent that these risks are related to climate change, these activities – knowledge transfer, consultancies and technical assistance to farmers – are all recognised as action items in the National Climate Change Adaptation Plan (CMCC, 2017[79]). However, because these efforts occur within the context of regional RDPs, activities are at present fragmented and reach only a small proportion of farmers in very specific areas. Moreover, because the support is allocated and delivered by the regions, programmes may not be well-connected to river basins and basin management plans.

Preparedness is also supported by pre-arranged risk management and response plans for both the short- and long-term, with the caveat that all actors are well-informed of their roles within these plans. In Italy's public sector, short-term contingency plans for adverse events are mandatory for municipalities, and drought and flood management plans are also in place for RBAs thanks to the requirements of the WFD. Familiarity with response processes and roles defined in these plans can be learned and practiced through the carrying out of practice drills and exercises. Stakeholders from the Italian agricultural sector do participate in drills to simulate impacts of adverse events and help to identify weak points and criticalities to be addressed before an emergency situation develops. For example, a recent exercise in the Veneto region helped make stakeholders aware of the existence of certain data that would be useful to other emergency response actors in the event of a crisis.[30] Long-term planning and its importance to improved management of natural hazards for the agricultural sector, however, has not been prioritised in Italy's recent past. Water resource planning in general has been problematic, characterised by high fragmentation, insufficient accounting for conflicts amongst users, and insufficient investment (Mariani et al., 2020[19]; CPD, 2018[14]). At the same time, activities related to the implementation of the WFD and the National Climate Change Adaptation Strategy seem to have motivated a renewed focus on the importance of long-term planning to confront likely future conditions. For instance, in January 2020, MiPAAF presented a new "National Strategy for Water Savings" that lays out a plan for the country's irrigation networks, taking into account projections for a more arid future under current climate change scenarios.

While public sector actors are making strides in improving preparedness through monitoring and planning, the level of on-farm preparedness for single adverse events is uneven, with the situation characterised by a lack of co-ordination between government, the private sector, and interest groups to address industry preparedness in a systematic way. Multiple stakeholders reported that the lack of involvement of farmers in risk prevention and planning activities was a key challenge to improved resilience of the sector. At the same time, there is growing awareness of this gap in capacity and efforts to address it. For example, in early 2020, CPD had planned a national meeting on farming management in disasters, and they also reported plans to draft general guidelines for regional administrators to better integrate farming management into civil protection plans.[31]

Nevertheless, the level of preparedness to changing long-term conditions and increased incidence of drought seems to be improving as farmers gain greater awareness of climate change and its potential impacts. Widespread adoption of adaptive practices has been noted, including earlier planting dates, and shifts in crop varieties planted according to changing conditions.[32] Recognising that building a resilient sector takes time and widespread shifts in perceptions and national priorities, some stakeholders consider that Italian farmers are poised to lead in this area, as they are already accustomed to managing risks posed by a variety of natural hazards. In fact, Italian farmers themselves believe that they are highly adaptive and well-equipped to transform in response to a changing risk environment (Spiegel et al., 2017[80]).

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 Italy, public sector actors play an active role from risk notification through to the response and co-ordination.

[30] Stakeholder interview, 3 February 2020.

[31] Stakeholder interview, 5 February 2020.

[32] Stakeholder interview, 7 February 2020.

In general, notification of imminent hazards is typically broadcast through early warning systems (EWS). Italy does have systems of early warning in place for some hazards,[33] under the direction of CPD. Risk alerts are generated by the national CPD, but are disseminated to the public through regional authorities via TV and radio, with direct cell phone notification systems to be rolled out soon. Farm sector organisations, however, report that these alerts sometimes do not reach rural areas in an effective and timely manner, due to fragmented technology availability and poor connectivity infrastructure.[34]

Civil protection in Italy is based on the principle of subsidiarity, meaning that once any natural hazard has struck, response is first marshalled through civil protection authorities at the local level, and then escalated to regional or national level CPD if local/regional actors are unable to cope. CPD functions as a co-ordination and direction body, bringing together representatives of all ministries (and sometimes private sector actors) whose jurisdictions may potentially be affected by the event and convening them as part of the Civil Protection Operational Committee. This committee meets on a nearly daily basis in cases of national emergency in order to ensure that all relevant stakeholders have the latest information on evolving threats and risks. Although response is co-ordinated by CPD, different agencies respond according to their mandates, such that veterinary authorities may be in charge of animal health or rescue, while MiPAAF or the Ministry of Health may be more involved in ensuring appropriate response for agricultural production activities and safety of food supplies.

Crucially, the approach to disaster response in rural areas has evolved to recognise the importance of business continuity in emergency operations. Accordingly, recent emergency response efforts have included business continuity among the priority activities, forging linkages between actors and creating a template for how these responses can succeed in the future (Box 6). Response is also aided by innovative tools or practices. For example, for emergencies impacting animal health,[35] two-way communication tools in new sector-specific platforms have been developed by national veterinary authorities that greatly streamline and help to target response efforts (Box 7).

Box 6. Prioritising business continuity: The Central Italian earthquakes of 2016/17

Italy is a mountainous country exposed several natural hazards. Accordingly, Italian authorities are often called to respond to disasters impacting rural areas where agriculture is the predominant economic activity. In 2016 and 2017, a series of earthquakes affected four regions in central Italy, with impacts on the agricultural sector. In response, an interregional technical co-ordination centre (CTI) was established to ensure food safety, business continuity and animal welfare, with the participation of the national CPD, the Ministry of Health, MiPAAF, regional veterinary services, regional agricultural services, and veterinary institutes. Through the CTI, actors were able to both co-ordinate activities to support local services, as well as assess impacts using a pre-established checklist that served as a decision-making template to prioritise and decide which emergency measures should be taken.

This co-ordinating structure and approach allowed stakeholders to identify the specific necessities of farming communities and address them within the framework of the existing emergency response system. For example, temporary modular housing units were provided for livestock producers who needed to stay near their animals in order to deliver proper care, while other affected persons were required to relocate to temporary shelters in more centralised locations. Temporary animal shelters were also provided on the basis of the damage assessment, and continuity of milk collection and delivery was ensured by providing drinkable water for the cleaning of milk tanks.

[33] The current EWS from CPD is primarily focused on hydraulic and hydrogeological risks, such as heavy rainfall events, floods and landslides, but they are working to expand their early warning capabilities to other types of hazardous events covered under the new directive, including snow, thunderstorms, and tsunamis.

[34] Stakeholder interview, 4 February 2020.

[35] The mandate of the CPD, as laid down in the 2018 Civil Protection Code, includes a call to protect both human and animal life.

The long-term impact of these interventions is still to be assessed. However, preliminary data collected in the aftermath of the events indicate that no substantial differences were reported in milk deliveries or farm closures compared to the previous year.

Source: (Leonardi, 2020[81]).

The nature of drought events, however, necessitates that drought warning and response activities take a different form to measures taken for other hazards. The slow-onset nature of the event implies that "alert" systems are covered by periodic updates in established monitoring systems through the OWUs, discussed above. When an assessment of the available data indicates a water stress situation, the OWUs publish alerts, and help to co-ordinate corresponding actions to manage the event. For example, the Observatory for the Po Basin Authority produces monthly bulletins of current and expected conditions, and also generates weekly "Crisis Bulletins" when crisis conditions manifest (ADP Po, 2020[82]). The alerts are general in nature, however, and do not include targeted messaging for agriculture sector stakeholders. Some OWUs utilise and publish traffic light indicators to communicate the level of severity of current conditions. While exact outputs may differ, each OWU has a regulation defining the levels of severity of water scarcity and the actions to be implemented for each level of severity. During meetings of an OWU, after assessing the indicators referenced above and in line with the recommendations provided by the national technical committee regarding the determination of the severity levels of the phenomena of water scarcity, the RBA in question can officially declare the level of water scarcity severity and consequent possible and necessary actions, such as the temporary derogation to minimum flow in case of a high level of scarcity, the reduction of abstractions or other measures. If the water scarcity situation is extreme, regional governments can use the indicators and information discussed in the OWUs to request "exceptional event" assistance from CPD.

The OWU participants use the information generated to inform their own management processes and actions. While ultimate authority for withdrawals from the main waterways lies with the RBAs, other actors (such as WUAs) retain decision-making power for their allocated resources. Most relevant for farmers, irrigation agencies could restrict water withdrawals if their own allocations were to be reduced. Water prices likely play very little role in adjusting farmer behaviour during droughts – although volumetric pricing is in place in most regions, prices are typically set annually and thus have limited effectiveness in signalling water availability. However, because OWUs meet periodically, farmers would typically have some lead time to adjust their management strategies to developing circumstances and potentially curtailed allocations.

When circumstances escalate into a full-scale water crisis – that is, water demand outstrips available supply – CPD is called to respond and provide emergency water supplies. However, this assistance is limited to providing dual use (potable) water largely for civilian use, and would generally not extend to providing water for agricultural purposes (indeed it would be neither feasible nor recommended to do so) (Duro, 2020[83]).[36]

Box 7. Using the SIVENE tool to improve response to veterinary emergencies

The Veterinary Information System for Non-Epidemic Emergencies (SIVENE) is a tool developed by the Italian National Reference Centre for Urban Hygiene and Non-Epidemic Emergencies (IUVENE) to facilitate emergency response. The SIVENE application collects, manages and visualises data related to animal health to support emergency management, incorporating various layers of geospatial data, including the georeferenced Italian National Database for Animal Identification and Registration (NDB), information regarding the situation of buildings and supporting infrastructure, vulnerability maps, and information on emergency events.

SIVENE is a decision support tool to help emergency responders identify where and what type of assistance is needed. It provides a unified portal that allows information to be systematically collected and transmitted on conditions at the farm level to competent authorities. Among its most notable

[36] As CPD's mandate covers the health and well-being of animals, their response could include the provision of drinking water for farm animals. However, in previous water crises situations, they have not been called upon to do so, as farmers have thus far been able to make their own arrangements for providing water to livestock.

features, SIVENE can be used to generate check-lists in real time that are tailored to specific emergency scenarios, and can serve as a help-desk to support the collection of appropriate information. SIVENE provides a visual mapping of all assistance requests and a snapshot of damages to animals and infrastructure that help to define assistance and reconstruction priorities.

The SIVENE system is increasingly seen as an important tool that can be used to retrieve otherwise untapped knowledge from a range of stakeholders, such as agricultural consortiums. There is also recognition that the SIVENE system can be used for awareness raising purposes, to inform models and damage scenarios, and for risk mapping beyond veterinary institutions. In the future, it is expected that SIVENE will be fully integrated into the National Information Platform managed by CPD.

Sources: (Possenti et al., 2020[84]; Dalla Villa et al., 2018[85]).

3.6. Recovery and reconstruction

Following a natural disaster, recovery and reconstruction efforts offer an opportunity for public and private stakeholders to "build back better"[37] by addressing underlying gaps in resilience, and building the capacities needed to manage natural hazards in the future. This requires all stakeholders – including producers – to learn from natural disasters in order to adjust DRM frameworks and measures with a view towards long-term resilience.

Recovery and reconstruction activities for natural hazards in Italy will vary depending upon the event in question, and range from large projects like repairing damaged infrastructure, down to programmes that support the financial recovery of farmers. Different public or private actors – including CPD, MiPAAF, health authorities, and WUAs – may play a role in repairing damaged infrastructure or helping to restore productive capacity. For example, in 2019, the FSN's ad hoc compensation programme provided EUR 29 million in assistance to rebuild infrastructure (roughly 4% of total assistance in the programme).

However, contrary to recovery efforts for other events, full-scale recovery from drought relies on either renewed access to water supplies, or else adaptation to circumstances such that access to water is no longer a threat, potentially requiring that farmers take measures designed to better position their operations for recovery. As such, recovery from drought events largely happens on farms, with government involvement mostly limited to providing tools that ensure that farmers can recover financially from the impacts of drought.

Financial coping tools employed by farmers can include drawing down own reserves, pay-outs from insurance products, or public funds. In the agricultural sector, insurance indemnities are typically an effective coping tool, as damages are assessed in the immediate aftermath of an event, and pay-outs can be processed quickly. Because insurance in Italy is offered through private companies, this is typically the case for those producers that carry coverage against the event in question. But, as detailed above, most producers are uninsured, and even among those who are, drought is not amongst the top three most commonly insured hazards (AGEA, 2020[16]). With respect to other government-supported coping tools, some (such as the IST or the mutual funds), have been in use only a short time, so it is not possible to assess their effectiveness in this area. For others (primarily the ad hoc compensation offered through the FSN), their utility is likely curbed by unpredictability in both the timing and the amount of assistance. For example, assistance paid out from the FSN typically only covers a fraction of declared damages, and is usually delivered at a significant delay to the actual event. Similarly, financial assistance is sometimes delivered in the form of ad hoc tax bill discount programmes for farmers who have experienced catastrophic events, but this type of relief would also likely be delivered too late to serve as an effective coping tool (OECD, 2020[3]).

Because of the lack of coverage and the substantial delays involved in receiving *ad hoc* assistance, often the best means of financial response to an adverse event is ensuring that business operations can return to normal as soon as possible, in line with the business continuity efforts of CPD operations outlined above

[37] Building back better is defined as using the recovery, rehabilitation and reconstruction phases after a disaster to increase the resilience of nations and communities through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems, and into the revitalisation of livelihoods, economies and the environment (UNISDR, 2015[99]).

(Box 6). This approach may be less useful for drought circumstances in agriculture, however, given that returning to business as usual is predicated upon access to "normal" water resources, particularly during the growing season when irrigation volumes are in highest demand.

To some extent, farmer effectiveness in drought recovery depends to a large extent on how the preceding risk management activities are carried out. This dilemma underscores the imperative behind longer-term improvements in water resource availability through infrastructure rehabilitation and more efficient farm-level utilisation of available water resources – that is, the most effective means of minimising the impact of drought and water crisis is ensuring that one does not occur in the first place, or ensuring that farm activities can continue even in the face of drought, taking management decisions where necessary with a view toward recovery. To some extent, the planning of current infrastructure investments and initiatives to improve water management capacity takes this approach, "building back better" in the face of recent droughts to reduce the impact of future drought events.

Post-event evaluation and assessment of drought events may take place within certain RBAs in the context of the OWUs and within individual WUAs, but it is not clear that such an assessment or evaluation is mandated, nor is it clear how such assessments have led to improved future processes (partly due to the only recent advent of the OWUs). Major disaster events involving CPD response always receive a post-event evaluation, but as noted above, drought events do not always escalate to the water crisis level necessary to initiate CPD action.

Part of the response and recovery process also involves critical analysis of the adequacy of institutions and processes in place to prepare for and respond to adverse events. To some extent, Italy's regular exposure to natural hazards has led to a system that adapts and evolves, and a perpetual desire to improve prevention and response capacities and tools. There is substantial awareness that climate change will continue to change the country's risk profile, so investments are needed now to successfully adapt in order to mitigate those effects in future. Italy has demonstrated that its policy frameworks are not path dependent, through its willingness to introduce new systems and structures, and recognise that ineffective policies need to be either scrapped or retooled.

4. Analysis and assessment

4.1. Agricultural risk management in Italy follows an all-hazards approach, but could benefit from a holistic long-term vision integrating the various governance frameworks

Risk governance in Italy is characterised by an all-hazards approach (whether through the response to severe emergencies headed by CPD, the multi-risk management tools offered through MiPAAF, or the rural development expenditures in longer-term environmental resilience to natural hazards), and the country's disaster risk management systems for agriculture offer several examples of how the system is incorporating more inclusive processes (such as the OWUs) and taking a holistic approach (investing in natural resource management to reduce disaster risk). At the same time, risk governance for agriculture lacks a holistic long-term risk management framework that links together the different components of risk management in a cohesive way. For example, there appear to be few concrete initiatives recognising that investing in risk prevention could be the most cost-effective approach to reduce *ex post* expenditures on response and recovery. Drought management is one of few the cases wherein preventative investments are prioritised, as evidenced by the country's primary rural development expenditures.

Risk governance in Italian agriculture would also benefit from more explicit thresholds that define when natural hazards are too big for farmers and private actors to cope with, such that government actors will respond. At present, the criteria for when a government response will be triggered are poorly defined, providing no clear incentive for regions, provinces, or farmers to invest in risk reduction because of the likelihood that ad hoc public disaster assistance may be provided. Further on from financial responsibility for response and risk coping, the level of personal responsibility to prevent, prepare for, and respond to risk is also unclear, as there is at present only limited interaction between agricultural stakeholders and emergency management authorities in the absence of a crisis. More frequent interactions between local, regional, and national emergency management bodies and farmers and other actors in the agricultural sector in the absence of crisis situations would help to create a culture of awareness and preparedness, as well as to

foster the relevant linkages needed to ensure effective response. Moreover, these interactions would help to ensure that long-term planning exercises for both emergency management and the agricultural sector are aligned and complementary, better informing public resource allocation decisions for prevention and mitigation activities. Farmer knowledge of their own risk management responsibilities and the limits of policy response is especially crucial for incentivising farm-level adaptation to hazards that will be exacerbated by climate change, like droughts in Italy (Ignaciuk, 2015[72]). Without these signals, most farmers are unlikely to take sufficient action to improve their resilience to drought events.

4.2. Italian actors are heavily investing in generating better data to inform planning and investment decisions related to agricultural risk management

Italy has well-developed general public expertise in risk identification, assessment and communication, particularly when it comes to natural hazards that could result in the loss of life. Additional efforts are underway to improve the understanding of the risk landscape faced by the agricultural sector, to help both public and private actors take informed decisions to reduce risk exposure and increase preparedness. Critically, a co-ordinated and systematic methodology to estimate the impact of adverse events specifically on agricultural production is being developed, in line with Italy's Sendai and SDG reporting obligations. Once this data on losses are more widely available, stakeholders will have better information on which to base resource allocation decisions. This and other recent data collection efforts (including through SIGRIAN, DANIA, SIVENE and ISIL) can also be used to show the cost savings of proactive investments for risk management, including both the strengthening of on-farm resilience capacities and the development of preventative infrastructure. At the same time, once this data is generated, stakeholders need to commit to using it to inform planning and investment decisions. This may require additional investments in research and analytical capacity, but such activities are vital to capturing the full benefit of data collection initiatives.

There are further opportunities to improve the risk awareness within the agricultural sector, however, with a view toward supporting the capacity of farmers to prepare and plan for natural hazards. First, while there are a variety of weather alert products available, there is space for developing alert and information systems that are more tailored to the needs of farmers, including by providing information on the implications of forecast events for critical farm management decisions, in turn allowing producers to take appropriate mitigating actions. These efforts need not come from public actors. Indeed, private actors are active in developing innovations in digital technologies in this space. An analysis of existing digital tools could help identify where additional development of further technologies may be needed.

At the same time, relying solely on digital technologies to improve farmer capacity to prepare for and respond to risk will likely be insufficient as a means of risk awareness and communication given the sector's demographics. Although most alert systems for quick-onset events depend upon some form of technology, risk awareness for slow-onset events and knowledge of longer-term climate trends could be improved through low-tech approaches. For example, more targeted outreach programmes on risk awareness and advising could be developed to provide up-to-date information on developing risks to older farmers and to farmers that are not well-integrated into value chains. Such initiatives should involve local actors, civil society organisations, or farmer groups to ensure good coverage.

4.3. Improving availability of water resources to mitigate the impact of drought events is a priority in Italy, while agricultural risk management policy tools are moving away from ex post measures

There is general acknowledgment amongst government stakeholders of the advantages of taking an *ex ante* approach to disaster risk management. Specifically, reforms in water governance and recent drought events have highlighted the urgent need in Italy to invest in more efficient water infrastructure, and large investments are underway. In order to ensure that these investments do not end up contributing to a further deterioration of water supplies, however, they must be accompanied by a functional water allocation system that prevents unsustainable use of water resources. While Italy does currently utilise a formal water allocation system using licenses, the system is inflexible, not allowing for trading, adjustment, or prioritisation as a means of responding to or mitigating drought impacts. Stakeholders should also keep in mind that there are other strategies that could be more cost-effective in saving water, including by investing in knowledge of water systems and improved management capacity, or by adjusting agricultural practices. For example, Italian researchers have estimated that substantial water savings can be achieved through planting less water-

intensive crops (Daccache et al., 2016[86]) – an adaptation strategy also identified in the National Climate Change Adaptation Plan (CMCC, 2017[79]).

In addition to investing in preventative infrastructure, Italy has made a transition to a largely *ex ante* approach through a reorientation of available risk management tools. Rather than relying on *ex post* assistance, Italy has developed tools that are defined and specified *ex ante*, including insurance, an income stabilisation tool, and mutual funds. Government support of risk management tools reflects this reorientation, with nearly 80% of estimated risk management spending devoted to *ex ante* instruments versus *ex post* initiatives (ISMEA, 2018[87]). Despite these efforts, only a small share of producers are subscribing to these tools at present, potentially indicating either that the existing tools may need to be adjusted or redesigned, that producers already have sufficient coping strategies in place for their needs, or that producers still believe that ad hoc support is accessible. Further on, while insurance can be a valuable coping tool, programme design matters, and stakeholders should take care that insurance not crowd out other risk management strategies like crop diversification, nor undermine adaptations necessary to the sector's long-term resilience. To this point, there is considerable evidence[38] from other countries that subsidised crop insurance (where premiums do not accurately reflect the underlying risk) changes the decision-making landscape, incentivising riskier behaviour that in many cases hinders long-term resilience.

Aside from risk coping tools, Italy is also investing in public goods and programmes that will contribute to sector productivity and sustainability even in the absence of adverse events, or that help producers to prepare, plan for, absorb, respond, recover from, and more successfully adapt or transform in response to natural hazards. These initiatives are typically funded through regional rural development expenditures. While there are a variety of successful programmes and initiatives in this area, the regional nature of these programmes means that efforts are somewhat fragmented and inconsistent across the territory, with different regional capacities to conceive and carry out interventions (although activities carried out through the NRN seek to close this gap).

Stakeholders should take care to ensure that the entire agricultural policy landscape (including all other sources of farm assistance and transparent trigger thresholds for receiving assistance from public sources to compensate for damages) neither presents an impediment to structural changes that would strengthen sector resilience, nor permits the continuity of production systems that endanger long-term resilience by exacerbating existing environmental constraints. Doing so requires that appropriate market signals on the costs of risks be borne by producers and not taxpayers. This may require dialogue and difficult decision-making processes that set the long-term priorities for the sector and rural areas more broadly and carefully analyse the trade-offs of different options.

4.4. Business continuity is a priority for natural hazard response, but focus on "building back better" could be greater

Emergency response functions in Italy are well-tested given the country's historical risk profile, but are also sufficiently flexible to adapt and incorporate new practices when needed. Recent innovations in response approaches, co-ordination mechanisms, and two-way communication all facilitate more effective emergency response that help the sector to recover more quickly from natural hazards. In particular, the prioritisation of business continuity ensures that producers and their animals are not merely safe, but also recover more quickly from adverse events by preventing cascading economic impacts. This approach requires close co-ordination from different stakeholders to be effective, and Italy is building these linkages into its response functions thanks to positive outcomes during recent extreme events.

At the same time, there is only a limited role for government in crisis response and recovery when it comes to drought, as the nature of the crisis necessitates that most activity be directed toward preventing the crisis

[38] Among the impacts that researchers have identified of subsidised insurance on farm-level management decisions related to drought are that these products can disincentivise the adoption of farm-level risk management practices (Schoengold, Ding and Headlee, 2015[91]) and increase irrigation water withdrawals (Deryugina and Konar, 2017[92]) In the long-term, subsidised has been found to discourage farm-level adaptation to changing climate or even bring about maladaptation by blunting incentives to cultivate more resilient crops or by motivating farming in riskier locations (Annan and Schlenker, 2015[89]; Chen and Dall'Erba, 2018[93]; Ignaciuk, 2015[72]). More recently, the prevalence of subsidised insurance has been found to discourage innovation and research into more drought-tolerant crops (Miao, 2020[90]), such that reliance on insurance to manage drought risk may actually harm the sector's ability to confront future droughts.

in the first place. In attempting to provide greater opportunity for the implementation of collaborative preventative or mitigating measures, the establishment of the OWUs was a positive development. These bodies are a practical means of approaching a problem that affects multiple stakeholders, as they provide an environment to exchange data and information and prevent misunderstandings of decisions taken in emergency situations. Presently, however, these bodies are largely focused on mitigating and preventing only developing crise. While OWUs are already providing a fora for defining tools and indicators that can support integrated water management, there is scope for utilising these structures more proactively to achieve greater buy-in on what investments or interventions may be most cost-effective at improving the long-term management of water resources.

5. Conclusions

Italy's systems and processes to manage natural hazards affecting agriculture, including drought, include many examples of innovations and good practices that contribute to the sector's resilience by helping producers to take responsibility for the risks they face, and allowing the government to focus its response efforts on catastrophic events. First, recent reforms (in water governance, for example) and policy changes (including a shift in support to more *ex ante* risk management policy tools) have sought to ensure that actors are more aware of the risk environment, are better prepared for adverse events, and can respond quickly and effectively when they occur. In particular, Italy's OWUs offer a concrete example of how participatory processes can be employed to mitigate the impacts of adverse events.

Second, Italy is also making substantial efforts to improve data collection and develop digital tools to improve agricultural risk management, including efforts to better assess damages from natural hazards; develop data sources on water resource uses (such as SIGRIAN) and on required investments in irrigation and against hydrogeological instability affecting agricultural areas (such as DANIA); encourage the uptake of decision support systems for irrigation (IRRIFRAME); and develop tools that facilitate hazard impact assessment and response (SIVENE). These initiatives must be combined with data analysis and management capacity-building efforts, in order for them to support more informed decision-making processes that help both public and private actors more effectively prevent, mitigate and respond to risk.

Third, policy makers also generally recognise the benefits of prevention and an *ex ante* approach to risk management. Particularly in the area of drought, substantial efforts have been devoted to more proactive approaches, with a large proportion of rural development activities directed toward measures designed to improve agri-environmental and climate outcomes that will help producers be more resilient to all types of natural hazards. Finally, when hazards do occur, response processes are in place. Importantly, these processes increasingly prioritise helping producers restart operations as soon as possible following an adverse event. By shortening the amount of time that farm operations are interrupted, income losses are minimised, such that producers and their communities recover more quickly from the effects of adverse events.

Although Italy's actions in these three areas are in line with good practices, many of the actions and innovations highlighted are sufficiently recent to have not yet borne fruit. Accordingly, in order to realise the benefits of these actions, execution and follow-up will be needed. In addition, a continued commitment to analysis and adjustment where needed will also contribute to improved outcomes for the sector.

Despite several good practices, Italy still lacks a holistic agricultural DRM system – although there are activities underway targeting all phases of the risk management cycle, there is still a need for an overarching vision to ensure the co-ordination of prevention, response and recovery activities for agriculture. The production of a long-term sectoral risk management strategy, to be updated and assessed periodically, would address the current disconnect. More explicit linking of climate change adaptation plans with short-term risk management measures would provide a natural point of entry for formulating a more holistic long-term plan.

Second, stakeholders should re-evaluate the balance between spending on risk coping tools and other investments in risk prevention, ensuring that spending on response and coping tools is targeted and complementary to measures that seek to proactively mitigate the impact of adverse events. Presently, substantial resources and policies continue to be directed toward response and coping that are not well-linked to other risk-mitigating activities and may actually weaken resilience to certain risks. Because

additional spending on preventative measures in the present will result in future cost savings, these trade-offs and linkages should be further explored, and programme design should consider the value of risk-reducing farm-level investments.

Finally, any long-term planning or resource reallocations must be done in the context of the country's agricultural sector's diverse demographics and capacities, recognising that farmers in one area may need additional resources or efforts in order to arrive at similar levels of preparedness. The regionally-diversified RDPs recognise this diversity, but at present do little to account for much lower baseline capacities of local actors and authorities to take the necessary steps to access available aid. Additional in-person, intraregional knowledge-transfer initiatives may be one solution worth considering.

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