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Navigating pathways to reform water policies in agriculture

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NAVIGATING PATHWAYS TO REFORM WATER POLICIES IN AGRICULTURE

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This report offers a guide on potential reform pathways towards sustainable agriculture water use, based on a thorough review of selected past water and agriculture reforms and extensive consultation with policy experts. A theory of change is developed that emphasises the importance of flexibility in the timing and design of reform processes to achieve practical and effective policy changes. Governments should prepare future reforms, via continued research, education, and governance efforts, to help take advantage of reform opportunities when the timing is right. Five necessary conditions are identified for a successful reform process: (i) support evidence-based problem definition, objective setting and evaluations; (ii) ensure that governance and institutions are aligned with the policy change; (iii) engage stakeholders strategically and build trust; (iv) rebalance economic incentives to mitigate short run economic losses; and (v) define an adjustable smart reform sequencing that provides flexibility in the long run. These conditions are found to be necessary to implement four challenging policy changes: charging water use in agriculture; removing subsidies that negatively impact water resources, regulating groundwater use and addressing nonpoint source pollution. But the relative effort that governments need to devote to fulfilling each of the five conditions will vary depending on the policy change.

Keywords: Agriculture policy, water policy, reform process, water governance, water prices, water subsidies, irrigation, groundwater, nonpoint source pollution

JEL codes: P48, Q18, Q25, Q28, Q52, Q58

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Executive Summary

The agricultural sector faces increasing water risks mainly due to climate change and increased water demand from other economic sectors. In many regions, agriculture production contributes to exacerbating these risks, as a major water user and polluter, while impacting water supply for other users and freshwater ecosystems.

Despite observable progress, further agriculture and water policy efforts are needed in OECD countries to respond to these growing challenges. Governments may be aware of potential policy options but they do not always know how to successfully introduce and implement these options.

This report offers a guide on potential reform pathways towards sustainable agriculture water use. The analysis draws on a thorough review of past water and agriculture reforms in OECD countries, and extensive consultation with policy experts from a wide set of countries through two international workshops organised in 2018.

Three key elements appear key to implement successful water and agriculture reforms: (i) developing a knowledge base in anticipation of a window of opportunity for the reform, (ii) the need to set evidence-based goals while ensuring that any new policy can be adjusted as needed; and (iii) the importance of working with stakeholders and government officers to facilitate policy changes.

The theory of change defined by these three elements emphasises the importance of flexibility in the timing and design of reform processes to achieve practical and effective policy changes. In the context of water in agriculture, flexibility is necessary as water conditions vary and can be uncertain, and crises often act as triggers for change. The theory of change also highlights the role of timing in policy change: an opportune moment can appear when there is a realisation of the problem, an awareness of possible solutions, and favourable economic and political conditions.

These elements and collected evidence help identify two sets of recommendations to successfully implement reforms.

First, while waiting for the opportune time to introduce a reform, governments should:

- Continue to improve their water governance system so as to clarify the roles and responsibilities of the relevant authorities, and to ensure coherence and co-ordination among government bodies;
- Continue to support relevant scientific and policy research that supports sustainable water use in agriculture;
- Continue to educate the public about agriculture and water challenges and risks;
- Continue to build capacity of and to train government agencies so as to improve reform implementation.

Second, when engaging in in the reform, five conditions are needed to ensure the reform process will be effective:

(1) Support evidence-based problem definition, reform objective setting and impact evaluations; diagnose the current situation and the direction of change.

(2) Ensure that governance and institutions are aligned with the policy change; adapt the governance system and the institutions to ensure that they will be able to manage the policy change.

(3) Engage stakeholders strategically and build trust between local policy authorities and farmers, and to foster dialogue at key stages of the reform process.

(4) Rebalance economic incentives to enable policy change. This would include possible compensation mechanisms to cope with short-term economic losses resulting from policy changes, while balancing efficiency and distributional concerns.

(5) Define an adjustable smart reform sequencing. This could combine, for instance, a long-term performance objective, flexible implementation options for the reform at local levels, and credible sanctions.

These five conditions are found to be necessary to implement four challenging water and agriculture policy changes: charging water use in agriculture; removing subsidies that negatively impact water resources; regulating groundwater use; and addressing nonpoint source pollution.

At the same time, the relative effort that governments need to devote to fulfilling each of the five conditions can vary depending on the type of policy change implemented. For example, reforms that focus on water charges and reducing subsidies may require greater efforts at rebalancing economic incentives (condition 4) and adjusting reform sequencing (condition 5) than those aiming to regulate groundwater and pollution, which may necessitate greater efforts to gather robust information (condition 1) and active engagement with relevant stakeholders (condition 3).

These recommendations can be applied to ambitious policy changes that seek to address water risks within the agricultural sector or to reduce the impact of agriculture on freshwater systems. They may also guide other agriculture policy or water policy reforms that feature spatial heterogeneity and information asymmetries. The proposed two sets of recommendations could also serve as the basis to monitor a government's capacity to engage in meaningful reform processes.

1. Navigating through policy reforms in agriculture and water

Why are agriculture and water policy reforms needed?

The agricultural sector is faced with growing risks linked to water (OECD, 2017[1]). In many regions of the world, weather-related disasters – e.g. droughts, floods or tropical storms – that impact agriculture production are expected to increase in frequency and in intensity due to climate change (OECD, 2014[2]; OECD, 2016[3]; OECD, 2018[4]). The rise in sea levels will impact agricultural production in many coastal areas, resulting in increased salinity (Akam and Gruere, 2018[5]). Water demand by other sectors of the economy are projected to affect water supplies for irrigation in productive agricultural regions. (Cooley et al., 2016[6]).

In many regions, agriculture production contributes to exacerbating these risks while impacting freshwater for other users and ecosystems (OECD, 2010[7]; OECD, 2012[8]). For example, intensive groundwater pumping decreases aquifer levels, which in turn provokes costs for current and future irrigated activities, while generating negative environmental impacts (OECD, 2015[9]). Nutrient and pesticide runoffs damage water quality and contribute to eutrophication and acidification of lake and coastal waters, thereby impacting biodiversity, fisheries resources, and the quality of drinking and bathing water (European Commission, 2018[10]; FAO and IWMI, 2018[11]).

Despite observable progress, further agriculture and water policy efforts are needed in OECD countries to respond to these growing challenges. Public action is especially necessary to incentivise all actors involved in agriculture to limit their impact on freshwater and to support the enabling conditions that help strengthen producers' resilience to future water risks (OECD, 2016[12]; OECD, 2017[1]). Policy makers at the national and international levels have called for policy actions along these lines (G20, 2017[13]; Gruère, Ashley and Cadilhon, 2018[14]).

Potential policy options to respond to these challenges are generally known but governments do not necessarily know how they can best choose, introduce and implement the required policy changes. Past OECD studies have analysed agriculture and water policy design, identifying a range of possible options to cope with the water risks confronted by this sector (OECD, 2014[2]; OECD, 2015[9]; OECD, 2016[3]; OECD, 2017[1]), water use (OECD, 2010[7]), or quality challenges (OECD, 2012[8]) These studies have drawn general recommendations, customised to specific situations, using examples of successful policies in different contexts, but have not assessed how to enable the recommended policy changes.

This study aims to fill this gap by characterising ways to develop reform pathways for water policies in agriculture in order to increase the chances of success and lead to observable progress. It identifies a set of necessary conditions to enable effective policy changes on water in agriculture.

Ambitious agriculture and water policy changes are difficult to achieve

There are different types of policy changes depending on the scope of the reform process, the scope of action, and the degree of government involvement (Gruère, Ashley and Cadilhon, 2018[14]). Policy changes may involve, for instance, new water or agriculture legislation, new specific agriculture or water regulations, or simply a more coherent implementation of water-related policies or additional funding.

This study is primarily focused on reforms that introduce significant policy changes that will be effective and flexible at a reasonable public cost. There are potential trade-offs between the ambition of a reform's objective and its effectiveness and flexibility (Gruère, Ashley and Cadilhon, 2018[14]). What are the conditions that can help policy changes achieve a higher level of effectiveness and flexibility, without reducing its ambition? This analysis will not explicitly measure the costs of each ambitious reform, but assume that a more effective process will reduce the overall time and transaction costs necessary to advance and implement needed policy changes. Indeed, a policy that has a higher likelihood of implementation may save time and resources.

Reform of processes for water in agriculture is particularly difficult. They bear similarities with other policy changes, particularly non-water related agriculture policy or non-agriculture related water policy changes. But decision-making on water and agriculture issues faces a combination of the challenges observed separately in other policy areas. Agriculture policies are designed to affect multiple individuals with heterogeneous, often seasonal and market-dependent activities, with various landholding and income sizes. Water policies need to account for dynamic and spatial differences in water resources, water use, and water quality, encompassing multiple relevant geographical scales (aquifers, river basins), as well as user interdependencies – which increase with scarcity – and externalities. Combining problems that stem from both agriculture and water policies requires considering multiple water abstractors, whose water use and water quality impact will vary in space and time according to climatic, seasonal, and market conditions, and the local and regional hydrological context.

This combination of challenges translates into at least three types of information problems that may constrain the design and implementation of policy changes.

- *Imperfect information*: It is difficult to monitor water resources, water use, and water quality impacts for all farms.
- *Information asymmetry*: Farmer characteristics are not known to administrators or regulators (adverse selection), and farmers know more about surface or groundwater use and polluting activities (moral hazard) than administrators or regulators (Xepapadeas, 2011[15]).
- *Co-ordination failure*: Efforts by individual farmers to improve their management of water may not lead to measurable results at the watershed level unless others undertake similar efforts. However, co-ordinating efforts may be difficult due to incentives not to participate in improving management (free riding), significant time lags between efforts and outcomes, hydrological context, and differences in agricultural activities.

Combining evidence with experience to characterise effective reform pathways

This study first builds on a review of eight recent policy changes in OECD countries (Gruère, Ashley and Cadilhon, 2018[14]). The analysis identified factors encouraging the adoption of a reform and those that may have shaped its outcome, in addition to analysing the trade-offs between the original ambition, effectiveness, efficiency, and flexibility of the reform.

This study is also supported by the existing literature. In particular, the OECD has conducted several water policy dialogues which discuss means to specific reforms.[1] In addition, external research has looked at institutional and political economy of water or agriculture policy changes (Conca and Weinthal, 2018[16]; Swinnen, 2018[17]), and a few analyses have looked at the intersections of water and agriculture, focussing mostly on specific policy changes (case studies).

As complement, and to capture recent changes in policymaking, this study also uses the results of extensive consultations with policy experts from many countries. This expertise was gathered over two workshops in 2018 that brought together policy experts and policy makers in this area. The first workshop, co-organised by the OECD and the European Commission, discussed the different stages of pathways that lead to policy changes on water in agriculture, from adoption to implementation (OECD- European Commission, 2018[18]).[2] The second workshop, co-organised by the OECD and the World Bank, focused on the necessary conditions to facilitate specific policy changes – from water conservation to regulating nonpoint source pollution (World Bank - OECD, 2018[19]).[3] The expertise gathered at these workshops provides a robust and consistent basis to understand the key constraints and means to progress on policy making in this area.

Section 2 of this study presents a proposed theory of change, develops guidance, and identifies the necessary conditions to implement effective reform pathways. Section 3 applies these conditions to four policy changes: charging water use; reforming subsidies that negatively impact water resources; regulating groundwater depletion; and controlling nonpoint source pollution.

[1] See for instance the recent studies on Brazil (OECD, 2015[65]; OECD, 2017[41]) and Korea (OECD, 2017[74]; OECD, 2018[139]).

[2] The OECD-EC workshop agenda, presentations and summary are available at https://oe.cd/2bS

[3] The WB-OECD workshop's agenda, presentation and summary are available at: https://oe.cd/2hd

2. Effective pathways to change policies on water in agriculture

Proposed theory of change: Seizing an opportunity with a viable plan

Lessons from past and ongoing reforms in the water and agriculture area (OECD- European Commission, 2018[18]; World Bank - OECD, 2018[19]; Gruère, Ashley and Cadilhon, 2018[14]) have helped to identify a combination of three elpements that define a theory of change to facilitate water and agriculture policy reforms.

First, *governments need to prepare in advance so as to be ready when the time for reform comes and to take advantage of windows of opportunity*.[4] Major water policy reforms of relevance to agriculture have been triggered by crises, particularly droughts and pollution episodes (OECD, 2015[20]; OECD, 2017[21]). Crises reveal problems that may not be otherwise visible to policy makers. For example, droughts create severe impediments problems for agriculture production that lead to calls for high compensation or support. Lessons from past reforms also show that policy changes were adopted following mounting public pressure; for instance, when groundwater depletion becomes a constraint for urban users, or when pollution becomes visible and problematic to other (non-agricultural) water users (Gruère, Ashley and Cadilhon, 2018[14]).[5] Policy changes may also be easier during political transitions, particularly when government majorities change towards more environmentally oriented parties (Ibid.).

While each of these factors — crisis, mounting pressures, political transitions — is often a contributing factor to determining the critical time for effective policy change, it is generally the confluence of these and potentially other factors that create the right time for action.[6] Following the application of the "garbage can model"[7] to public policy making, a policy window opens for decision makers when the realisation of three theoretically independent factors are met: the awareness of the problem, the knowledge of solutions (that may or may not respond to the problem), and favourable political conditions (Kingdon, 1995[22]; Jann and Wegrich, 2007[23]). In practice, past reforms show that these three contextual (exogenous) factors can be interdependent and influenced by other controlled (endogenous) factors. In the case of agriculture and water, for instance, embedded past policy evaluations and the existence of funding or programmes contributing to growing stakeholder awareness can affect the awareness of the problem, knowledge of solutions, and political conditions (Gruère, Ashley and Cadilhon, 2018, p. 50[14]).[8] If governments

[4] The term "window of opportunity" refers to "the time during which there is a chance to do something" (Merriam-Webster, 2019[140]). Once this period is over, or the "window is closed", the specified outcome is no longer possible.

[5] Changes are also often easier during political transitions.

[6] Albeit outside the agriculture and water context, the introduction of the carbon tax in British Columbia, Canada shows that timing of environmental reforms is as critical as the design of the reform (Harrison, 2013[137]). The tax was introduced at a time when political and social demands were aligned, between other periods during which it would not have succeeded.

[7] Originally developed by Cohen, March and Olsen (1972[141]), this model explains organizational decisions by the confluence of four independent and random streams: problems, solutions, participants, and choice opportunities.

[8] Mucciaroni (1992[138]) offers a comprehensive discussion on how the use of the Garbage can model should be adapted in studies of policy making.

cannot fully mandate when the time will be right for a decision to be taken, uncontrolled climate-related, economic, social and political conditions can also play a role. Governments can thus take actions to prepare and to a certain extent influence the conditions under which such moments may occur.

Second, *governments should set evidence-based goals and ensure that the reform process builds-in the means to make adjustments as needed*. Understanding the landscape of water and agriculture is important to define the policy objective and design. As stated above, multiple layers of information problems may affect policymaking. Building a comprehensive understanding of hydrological and agriculture production systems, to the extent possible, is necessary to avoid costly mistakes. Adopting a flexible and open policy pathway is needed to achieve effective change. Past experience has shown the importance of sustaining a dialogue with stakeholders to ensure progress towards an agreed goal, rather than proposing a ready-made plan. Setting fixed policy pathways at the outset risks framing the discussion in a way that could at once close potentially useful options and lead to unrealistic expectations. Moreover, evolving conditions and policies in agriculture or water also require flexibility. Interim paths and adjustments are often necessary to overcome obstacles.

Third, *governments need to facilitate changes in management for farmers and government officials*. The way a reform will modify interactions between stakeholders will play a key role in its success. This can happen at two levels: a reform affects the direct relationship between policy officers and the stakeholders involved in the reform,[9] through instruments like regulations, incentives, behavioural or information approaches; or a reform can change the organisation and relationships between policy officers or institutions that adapt to new functions and adopt new roles. In the context of agriculture and water, policy makers typically aim to influence farmers to change their behaviour and improve the status of water resources from an initial situation with deteriorating water resources due to agriculture or increasing agriculture water risks. They may change the rules, regulations, incentives, or information for farmers. They may also need to adjust governance arrangements of public institutions, changing the functions undertaken by water or agriculture policy officials, as well as their role and relationships to ensure an effective implementation of the policy.

This theory of change provides the general elements to support a practical and effective policy change that is customised to specific physical, institutional and economic situations and that is adaptable when conditions change. This captures some of the characteristics of the agriculture water problem, which implies a geographic heterogeneity and conditions changing overtime, often in an uncertain manner. The importance of timing, which is not completely dependent on policy makers, emphasises the role of broader factors. This flexibility may be costly, in terms of preparation, waiting for the right time, undertaking research and building scientific evidence, and management changes that other plans may not have. But these costs may be necessary to achieve observable progress. In particular, evaluation and assessment transaction costs, which may be initially significant, can be essential to a lasting and effective change (Loch and Gregg, 2018[24]).

[9] Farmers, but also potentially other water managers, private companies and civil society organisations that have a stake in local agriculture or water management.

In practice, the succession of events described in this theory of change encompasses activities during two different time horizons:

- In preparation of a reform, governments should build a supportive environment. This includes efforts to continue improving water governance systems, to strengthen information on water and agriculture challenges and opportunities via research and development, to educate the public, and to strengthen the knowledge of current and future farmers, decision makers and managers on the water and agriculture challenges.
- When the window of opportunity is presented, on the basis of the preparatory steps, governments should ensure the policy process combines sufficiently well-informed goals and features with embedded flexibility. This will facilitate the required changes for all concerned stakeholders from the early stages onwards.

The next two sections will outline the specific factors that contribute to progressively building an environment that is supportive of reform. The following section will outline the necessary conditions for an effective reform pathway.

Building an environment supportive of policy changes

Governments can undertake efforts that serve the dual purpose of improving the present management of water resources in agriculture while "preparing the ground" for future reforms when there is a window of opportunity. As explained in this section, governments can strengthen water governance and improve information generation, dissemination and build capacity. These efforts are important and should be continuous, i.e. initiated before and continued after a reform is introduced.

The need for continuous improvement of water governance systems[10]

A strong multi-level governance water system will help support effective reform pathways in agriculture and water. Water governance comprises the formal institutions and the relationships between the private sector, civil society and stakeholders involved in water decision-making both horizontally across sector and vertically from local to international scale (OECD, 2016[25]). A water system where water governing institutions have well-defined roles and co-ordinate with each other at different scales is more likely to enable the implementation of water policy reforms in agriculture. Examples show that ineffective water governance systems can lead to inefficient water policy (Chan et al., 2016[26]).

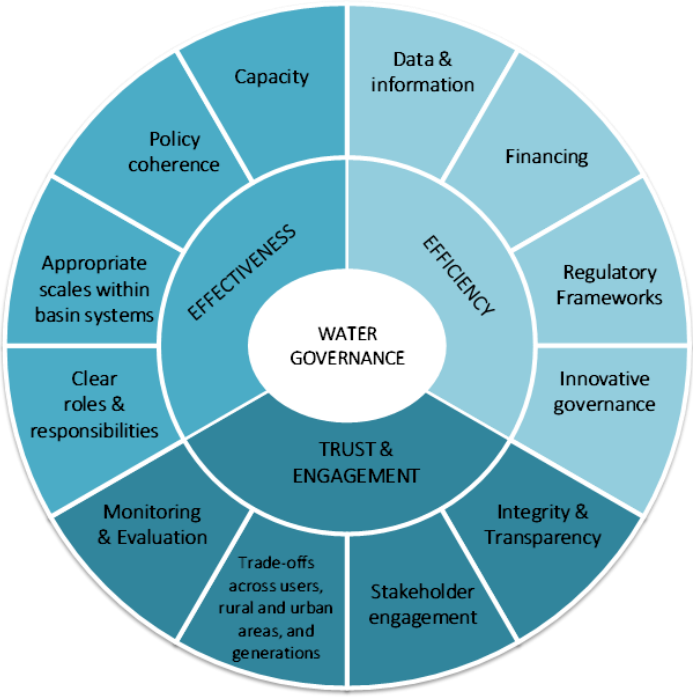
However, water governance is complex because the water sector has specific features that exacerbate the risk of governance failure (OECD, 2018[27]). Hydrological boundaries and administrative perimeters often do not match, creating an "administrative gap". Water management involves multiple stakeholders that need to be consulted and coordinated at different levels to avoid an "accountability gap". Water policy requires effective policy coherence across water-using sectors (domestic water users, industry, energy, agriculture, tourism, and other) to avoid a policy gap. Ecosystem requirements also need to be taken into account in allocation regimes (OECD, 2016[25]). Moreover, water governance is increasingly decentralised and requires strong coordination across levels of government to avoid fragmentation (Ibid). Climate change impacts can create uncertainties and new

[10] This effort will help foster the three other types of efforts. A better water governance system will help in information dissemination and stimulate useful research.

challenges that require governance systems to adapt in order to avoid increasing damages (Baubion, 2013[28]).

Building effective water governance takes time and should be seen as a long-term effort that will support future reforms. Improvements can take different forms. The OECD has identified 12 principles where efforts are needed to ensure an effective governance system in the water sector (OECD, 2015[29]; OECD, 2016[25]) (Figure 1). Particular effort should be dedicated to establishing clear roles and responsibilities among national, state, and basin authorities before introducing a policy change (OECD Principle 1). Such efforts would save time in the future and facilitate the implementation of water regulations, avoiding misunderstandings and uncoordinated actions between the different levels of government.

Figure 1. The 12 OECD principles on water governance



Source: OECD (2015[29]).

Efforts to ensure strong-multilevel governance should go beyond the agriculture-water interface. In particular, an effective governance system is necessary to advance on the other three long-term efforts to enable policy changes (i.e. research, education, capacity). It would also require continuous improvements to ensure clear role and responsibilities among the authorities, to ensure policy coherence and cross-coordination amongst ministries, and that the responsible authorities are competent.

Continuous research efforts are needed to support more sustainable water use in agriculture

Research is essential at two stages. First, it can provide science-based evidence showing the need for policy reform and help focus decision-making. Second, once a policy is implemented, research can help assess its effectiveness, its progress, and facilitate future improvements.

Scientific research can ensure a good understanding of the current state of water and agricultural systems, as well as of historical trends and future projections. It can shed light on water problems in agriculture and identify necessary changes. A good illustration is the Gravity Recovery and Climate Experiment (GRACE) satellite mission that provided, from 2002 to late 2017, global tracking of variations in water storage to complement on-ground measurements (NASA, 2018[30]). The satellite observations improved understanding on water availability and raised awareness on the extent of groundwater depletion in California, Northern India, Australia, and Israel (Famiglietti et al., 2015[31]). Policy makers appear to be the most receptive to new evidence or technologies over the two-year period preceding the review of a policy (McGonigle et al., 2012[32]).

Policy research is also essential to reflect on policy choices and the reform process. The policy literature, using insights from other disciplines (e.g. behaviour economics, sociology, political economy), can draw conclusions from international comparisons, successful reforms or failures, and suggest new instruments and mechanisms to design more acceptable and effective policies. For instance, new developments in behaviour theory contributed to the paradigm shift from "knowledge transfer" – where farmers passively receive information from experts and adopt the proposed technical solutions – to "knowledge exchange" (or human development approaches) which use participatory methods, social interactions, sharing and exchanging ideas via peer-to-peer learning and hands-on workshops as a means of empowering farmers and allowing them to collectively design their solutions to control diffuse pollution (Blackstock et al., 2010[33]). The principles of farmers' participation and ownership of solutions is now incorporated in most policies that manage water at the catchment level, as illustrated by the European Water Framework Directive that requires active stakeholder engagement (Ibid). Literature from social psychology advocates for tailored advice and communication to take into account the diversity of farmers. Building on this, Irish regulators are crafting targeted communication to farmers with personalised and simplified messages to improve compliance with the nitrate emission regulations (OECD- European Commission, 2018[18]).

Continuous education on water and related issues that targets farmers and the general public facilitates reforms

In the long-run, educating farmers and society about water challenges can facilitate the reform process. Hydrology science is complex and incomplete information in the water sector does not help in understanding the rationale behind water policy reforms. An understanding of the different features of the economics of water use may also be missing. Several studies carried in the United Kingdom stressed how farmers are often dubious that their own activities and agriculture in general contribute significantly to water pollution (Barnes, Toma and Hall, 2007[34]; Environment Agency, 2011[35]). Increased education would give people a stronger conceptual basis on which to understand the rationale behind a reform. Information should also be credible and convincing; little belief in the scientific evidence of water pollution[11] contributes to explain farmers' not meeting the regulatory standard of the Nitrate Vulnerable Zones (Barnes, Toma and Hall, 2007[34]). Second, appropriate training of farmers is crucial to ensuring they have the appropriate skills to adopt environmentally-enhancing technologies and best practices to save water and to limit pollution (OECD, 2018[36]). Third, educated citizens are more likely to be engaged in their

[11] Diffuse water pollution is difficult to demonstrate because it is often invisible and it occurs away from farms. Furthermore, nitrogen has a slow impact on water quality, which complicates the attribution of specific agricultural practices to changes in water quality (Shortle and Horan, 2017[115])

community and to support public policy choices that provide an adequate level of public goods like water security and water quality (Khemani, 2017[37]). Policy reforms affecting public goods are ultimately driven by changes in citizens' preferences and beliefs in the ability of their government to provide such goods (Ibid.).

Several actions can be considered to educate society. Multiple channels can provide technical evidence on public goods, e.g. school curricula, civic education, local media, and social networks shape citizen's preferences (Khemani, 2017[37]). Teaching the basics of water management can be included in mainstream education programmes. In Estonia, water management education begins at the pre-school level and expands in primary school (OECD, 2018[38]). In Israel, recurrent water scarcity and intense spells of drought have pushed the government to implement several educational programmes on water. Since 2000, over 140 schools have installed water catchment systems in elementary schools to teach students about water conservation and recycling (Chesla, 2016[39]). To prepare the next generation of water experts, the government launched in 2006 the programme "Youth, water and Knowledge" in co-operation with the Israeli Water Authority and the Israel's Water industry. This programme engages middle and high school kids in advanced learning of water science and technology, and includes site visits of Israeli water technology (Ibid).

Agricultural training systems for farmers can offer sessions on sustainable water management. Such trainings can be part of the agricultural secondary school curriculum or made available to farmers later in their career. Special programmes including peer-to-peer learning opportunities and demonstration farms can complement this initial training and educate farmers about best water management practices. The Catchment Sensitive Farming (CSF) Delivery Initiative by the British government gives free training, including demonstrations, farm walk, farm events, and advice to farmers on solutions to protect groundwater and to reduce diffuse pollution in high priority areas for water quality (Natural England and Environment Agency, 2016[40]).

Continuous capacity building and training of public agencies staff can help improve reform implementation

Capacity building for the staff of public agencies should be considered as a long-term investment. Water challenges are often made up of cross-cutting and complex issues that involve multiple disciplines (e.g. hydrology, agricultural science, governance, economics, and political economy). This sector is particularly exposed to lack of knowledge, human capital, and technology to design and implement effective water policies (OECD, 2018[27]). The technical capacity of public officials is crucial to ensure they can carry out their duties in the most effective way. For instance, due to lack of economic analysis of the river basin, committees and agencies in Brazil to approximate the opportunity cost of water and the cost of pollution was a major obstacle in setting appropriate water charges (OECD, 2017[41]).

More broadly, governments should consider adjusting the recruitment and career management of staff (World Bank - OECD, 2018[19]) to ensure an adequate level of skills, technicity, flexibility, and resilience to organisational change. The capacity of the public sector to innovate, in particular when responding to policy change, requires that its staff is capable and motivated to implement requested changes (OECD, 2017[42]). The hiring process of water professionals should be merit-based, transparent and independent of political cycles to ensure the staff has the appropriate competences from the outset (OECD, 2018[27]). Moreover, training should be provided throughout their career so that skills are updated as water challenges and technology evolve. Staff should also be encouraged to

exchange with colleagues in other government sectors, including those from the ministry in charge of water and the Ministry of Agriculture. Having a policy of (temporary and voluntary) staff rotation within an administration could help increase their adaptability as well as prevent views from crystallising. Finally, staff should be prepared to change duties if new priorities and new evidence emerge. Managers should be trained in change management, to lead and learn from others' experience, in order to ease such transitions.

Managing reform processes: The five necessary conditions

As noted in the proposed theory of change (Section 2), having a robust information base, adjustable pathways, and managing relationships are key to water agriculture reforms. This subsection outlines specific and practical recommendations to do so, which are then described in more details.

The combined evidence from the literature, the review of past reforms, and the inputs of water policy experts indicate the five conditions needed to effectively manage agriculture and water reform processes (Figure 2):

- *Support problem definitions, policy objectives setting and evaluations with robust evidence;*

Water and agriculture policy reforms should be supported by an assessment of the situation. This requires that all hydrological, agronomic and economic concepts are well defined, and that objectives and evaluations are based on robust evidence.

- *Ensure that governance and institutions are aligned with the proposed policy change*

Water and agriculture policy reforms will only work if they are not impeded by existing institutions and water and agriculture governance systems. This requires considering whether the existing governance system should be adapted, and undertaking any necessary changes within institutions to ensure policy changes are properly implemented.

- *Engage stakeholders strategically and build trust*

Implementing water and agriculture policy reform involve changes for many stakeholders, including farmers. Engaging in an informed dialogue with these stakeholders throughout the reform process and building trust, notably between local policy officers and farmers, is needed to facilitate progress.

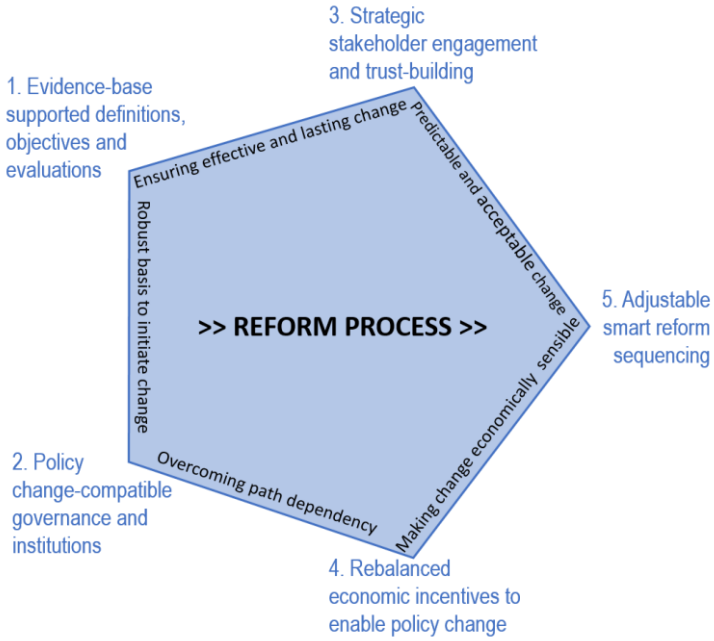
- *Rebalance economic incentives to enable policy change*

Water and agriculture policy reforms may result in significant economic losses for some stakeholders, at least in the short-run. Consider how to limit such losses via some type of compensation, while still balancing efficiency and equity concerns is necessary to advance the reform.

- *Define an adjustable smart reform sequencing*

Ambitious water and agriculture policy reforms take time and need to be adjusted when necessary. A flexible sequencing process needs to defined, both spatially and over time. A model of smart reform sequencing can be used, involving long-term performance-based objectives targeted at the local levels and a credible enforcement system.

Figure 2. The reform process pentagon



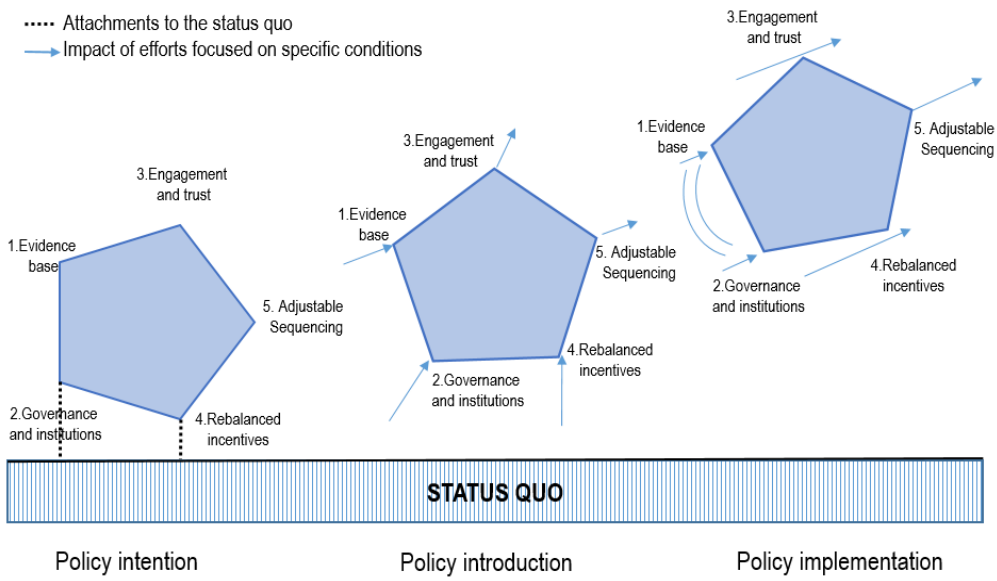
While these five conditions are not necessarily ordered chronologically, they are represented in a particular order in Figure 2 to highlight the purpose they may serve when combined two-by-two. The problem definition (1) and alignment condition (2) are needed to provide robust compelling evidence that supports the need for change. Evidence-based evaluation (1) and stakeholder engagement (3) work towards having effective and lasting change. Alignment of institutions (2) and rebalanced economic incentives (4) help relieve some path-dependency constraints. Trust building and stakeholder engagement (3) and smart reform sequencing (5) help make the policy change predictable and acceptable. Incentive changes (4) and well-designed reform sequencing (5) makes the change economically sensible.

The respective importance of these five conditions is further presented schematically in Figure 3. In the first stage, the government shapes the idea of a reform, feeding on knowledge continually generated and disseminated (Section 2). [12] The main constraint to moving forward is trying to maintain the *status quo*, namely the perseverance of institutional attachments and economic rents. In the second stage, when a policy idea is introduced, aligning governance and institutions and working on rebalancing economic incentives, together with a robust evidence base on the status of situation and requirements to change, will overcome the *status quo* and work towards achieving the reform in question. It will also benefit from the pull effect from initial stakeholder engagement, discussing why and how to achieve such change. Planning the sequencing and developing a robust evidence base will help define the direction the reform will take. In the third stage, implementation of the policy change, the new institutional setting and robust evidence and data analysis will help the move the reform forward according to the proposed sequencing. Stakeholder

[12] Such steps may happen in particular when a new and unseen situation appears, such as the first occurrence of serious drought events in regions of Northern Europe in the summer of 2018.

engagement will continue and adjustments of economic incentives will ensure the reform does not veer too far off the desired pathway.

Figure 3. Steering the reform process



Defining the problem, policy objectives, and evaluations

Diagnosing the situation

An initial assessment of a hydrological situation should identify the problem and what is at stake. This is particularly true when considering water. A diagnostic of the problem which involves water must rely on a proper definition of the concepts involved in water policy. In particular, in the case of water conservation, care should be taken to avoid confusion about concepts such as the water balance, water efficiency, water withdrawal, applied or consumed, water efficiency, water saving, and water productivity and their respective measurements (Giordano et al., 2017[43]). Inaccurate use of concepts can lead to misleading assessments of the initial situation and unwanted outcomes (World Bank - OECD, 2018[19]). Water saving or efficiency improvement should in particular not be the sole focus or target as it often leads to negative consequences on the overall resource. For instance, an incomplete assessment in Pakistan of the effect of conservation practices on the water balance components (e.g. return flows to the aquifer) aggravated groundwater depletion in the Punjab province (Ahmad et al., 2007[44]). The resulting programme, which intended to reduce water use via laser land levelling and the use of zero tillage, resulted in reduced water application at the field level. However, these water savings lowered the return flows to the aquifer (i.e. deep percolation and runoff) and deprived downstream users from a source they used to pump. The programme also increased water use and further depleted groundwater resources as farmers expanded their irrigated area.

Existing policies and institutional settings that underpin a reform should be analysed and those that may counter the reform objective be identified. Water systems are the outcome of previous water policies and historical institutional arrangement that may constrain future policy change. For instance, changing water allocation can be very difficult once it become rooted in the river and basin history (Hooper and Lankford, 2016[45]). Similarly core

agriculture policies that rarely change may prevent new reforms to improve water management.

Depending on the starting point, evidence may need to be built first by investing in monitoring and assessment before conceiving a reform. Past experience shows that the effect of water policy reform will be different according to the starting point. The evolution of water allocation regimes in the Murray-Darling Basin in Australia or Israel's agriculture water pricing have evolved gradually, with significant changes for water users, but unlike those required in the case of the completely new regulation of groundwater under the Sustainable Groundwater Management Act in the state of California (Gruère, Ashley and Cadilhon, 2018[14]). In the former cases, water use monitoring and assessments were in place with the latest reform iteration, while the latter case required building evidence on the local status of groundwater bodies, institution building, and brand new policy plans.

Indicate where the reform is heading

Several elements needs to be considered when designing the objectives of a water policy. First, the objectives should be based on robust scientific and economic assessment to go beyond ideological or misconceived statements. Secondly, the scale of the reform is of particular importance: in most cases, the reform should be undertaken at basin level rather than at the administrative level to take into account the hydrological characteristics of the system. Thirdly, the scope of the objectives should be broad enough to encompass the influence on other water-related policies and sufficiently flexible to adjust to the future change (OECD- European Commission, 2018[18]).

Performance indicators or evaluation criteria should be designed to monitor and evaluate progresses towards the objectives. The metrics is particularly sensitive and should reflect the policy objectives as much as possible. For instance, design standards for water charges or water quota in agriculture are usually based on the quantity diverted as opposed to the water consumed by the crop, which is more difficult to measure. However, measuring consumption is better suited for environmental performance because some portion of the water diverted generates return flows to the environment (Peterson and Hendricks, 2016[46]).

Ensure governance and institutions are aligned

Institutional arrangements may constrain or block the reform process (path-dependency-effect[13]). Governments should first aim to *remove dysfunctional governance systems* that can compromise the effectiveness of the reform. Silo approaches across ministries can hinder effective policy coherence across sectors and divergent objectives between authorities can have counterproductive effects. For instance, the People's Republic of China's (hereafter China) "top-down" water governance system has not resulted in effective enforcement of mitigation measures for diffuse pollution at the farm level because of misaligned priorities and incentives between different government levels. While central and provincial authorities design guidelines for water conservation, local authorities in charge of enforcement keep prioritising production and growth (OECD, 2018[47]; Smith et al., 2017[48]).

[13] Path dependency happens when future choice sets are constrained by past and ongoing trajectories of change (Kay, 2005[135]). For instance, the development of institutions to implement a water or agriculture law over decades may make it more difficult to accomplish a meaningful change of law.

Secondly, *simplifying the existing regulatory framework* should be a priority. Successive layers of regulations increase the risk of overlapping or conflicting policies that can only generate confusion. Rather than systematically adding new rules, policy makers should suppress incoherent policies, and replace or merge existing regulations (OECD- European Commission, 2018[18]).

Third, governments should *engage with the public agents* in charge of implementing the reform. Research on the political economy of public policy suggests that government agency structures and staffing can be an obstacle to advancing change in the provision of public goods. Selection processes, career concerns, and elite capture may provide weak incentives for public agents and local regulators to perform well in the delivering of public services (Khemani, 2017[37]). In particular, political patronage in government jobs can constrain the delivery of public goods if policy makers are not inclined to undertake political reforms (Ibid).

Consulting and engaging staff in public institutions during the whole process of change is essential to ensuring agents will be willing to change their behaviour and adopt new rules (OECD, 2017[42]). Managers and staff should jointly diagnose the problem, address fears and concerns, and collaborate in organisational changes (Coram and Burnes, 2001[49]).[14] Exchanging staff is a valuable option when the qualification and capacity of the agents do not fit the position. If needed, the incentive system may be restructured to reflect the job description (compensation for change of work activities, time, etc.) to provide additional staff motivation.

In some cases, the authority to implement a reform may need to be given to independent or quasi-independent agencies in order to isolate public agents from changing political conditions that may affect the level of ambition of the reform.[15] This is the case when political volatility is a major impediment to change. For instance, reform of the drainage system in Pakistan was delayed due to political turmoil and repeated changes in the leadership of provincial governments between 1993 and 2001. Civil servants became reluctant to implement the voted reform because their new superiors were opponents of the reform. As a consequence, they had to spend time educating their managers on the need for and the purpose of the water reform at the expense of initiating the reform (Dinar, Balakrishnan and Wambia, 2004[50]). In its 2005 Water Law, Israel set up an water agency that was independent from ministries in order to help resolve a political standstill around the regulation of water resources under increased scarcity (Gruère, Ashley and Cadilhon, 2018[14]). At the same time, an agency regrouping the same staff with no change in habits and norms will not always impact policy change and may be difficult to change in the long time (OECD, 2018[51]).

[14] Public administrations in OECD countries tend to consult their staff when developing new regulations, but mostly towards the end of the process (OECD, 2015[136]).

[15] Deferring the authority to implement water policy to an independent body is needed in cases in which water policies place an obligation on government which needs to be credibly enforced. For instance, the government may be required not to over-allocate water resources or to undertake cost-benefit analyses.

Strategic stakeholder engagement and trust-building

Stakeholder consultation is essential when engaging in a water reform because it is a decentralised and fragmented sector that involves several layers of interdependent actors with asymmetry of information.

There are four types of benefits to be derived from stakeholder engagement (OECD, 2015[52]): acceptability (facilitating effective implementation of the reform); capacity development (awareness raising and information sharing); economic efficiency (cost saving and greater policy coherence and synergies across projects); and equity and cohesion (building trust and confidence). Overall, stakeholder contribution to the design of the "rules of the game" (incentives, sanctions, procedures etc.) generates "procedural utility" because the actors develop a sense of ownership, and thus trust the process and its outcomes (Benz, Frey and Stutzer, 2002[53]).

Several parameters need to be clarified when engaging stakeholders: when, where, and how the consultation process should be undertaken and the profile of the stakeholders. Careful consideration should be given to defining *when* stakeholders are consulted in the policy cycle. Two stages are particularly important. First, such engagement is essential in the early stage (conception planning, design, feasibility studies) so as to raise awareness, ensure buy-in, and bring a multi-level perspective to the debate to fully understand the complexity of the issue (OECD, 2015[52]; OECD, 2017[41]). Communicating the goal of the reform and the cost of inaction should improve its acceptability and general understanding (Tompson, 2009[54]). Secondly, the stakeholder's view is valuable during the implementation and monitoring phase because it provides a "reality check'' and the feedback received allow the reform to be adjusted as necessary (OECD, 2015[52])**.**

It is important to define the *level and intensity* of stakeholder engagement: consulting them to share information does not require the same amount of time as does co-operation in defining norms. Establishing a timeframe will help determine the correct balance between the time needed to involve stakeholders at a satisfactory level and the necessity to take a quick decision. Consultation of stakeholders should not delay the start of reforms nor be a substitute for government leadership (Tompson, 2009[54]). Nevertheless, stakeholders should be informed on how their contribution was taken into account in the final outcome (OECD, 2015[52]). The final decision-making process (i.e. who manages the outcomes; who has veto power) should be defined in advance to ensure that all decisions will be taken on time (Ibid).

Attention should be given to the *number and the profile* of the stakeholders taking part in the reform process. The more stakeholders are consulted, the harder it will be to take into account all contributions (inclusiveness – empowerment trade-off). Vested interests and low representativeness of stakeholders are particularly challenging in the water sector since agrarian interest groups are often powerful and well organised and can influence the outcome of the decision-making process (Renger, 2000[55]). Transparency throughout the whole consultation process is necessary to avoid consultation capture (OECD, 2015[52]).

Trust is essential to reach an agreement with stakeholders and to facilitate the enforcement of regulation via farmer cooperation (OECD, 2013[56]; World Bank - OECD, 2018[19]). However, engaging stakeholders during the decision-making process may not be sufficient to build confidence. Trust is more a matter of human relationship, shared vision and values (Mase et al., 2015[57]). Therefore, a continuous dialogue between farmers and regulators is important to move forward towards a commonly agreed goal and to foster voluntary changes (World Bank - OECD, 2018[19]). A Scottish programme implemented between

2010 and 2015 to tackle rural sources of diffuse pollution promoted regulators' one-to-one engagement with farmers (OECD- European Commission, 2018[18]). Farm visits and on-farm workshops organised by regulators significantly increased compliance of farmers with the Diffuse Pollution General Binding Rules, while sanctions were used as a "last resort" after several visits (Aitken and Field, 2015[58]).

Rebalance farmers' economic incentives to enable policy change

The welfare gains of a policy change in the water sector may create winners and losers, at least in the short term. Upon an assessment of the possible negative impacts on farmers' income or assets, governments may consider some type of compensation, in order to maintain its level of ambition. The cost associated with any such compensation should in principle not exceed the overall welfare gains of the policy change (Martini, 2007[59]).

When considering compensation mechanisms, it is important to consider the nature of the initial situation: the removal of a subsidy may lead to the same economic equilibrium as the introduction of a tax, but farmers' perception of the reform is likely to be different. In the first case, farmer's may perceive the reform as the withdrawal of an embedded privilege —the subsidies granted by the government—while in the second case, the new tax may not be considered as a diversion from an entitled benefit.

There are generally two types of compensation considered in agriculture and water: monetary transfers, including transition and voluntary payments (or free allocation or tradeable rights), and long term (in kind) guarantees, such as investment for improved water security. For instance, the agreement signed in 2006 with Israeli farmers to increase water prices was achieved in exchange of the government promise to ensure more secure water supplies through investment in wastewater treatment and desalinated water (Gruère, Ashley and Cadilhon, 2018[14]). The nature and the level of the compensation will depend on the ambition of the reform and the characteristics of the targeted groups including their size, localisation—upstream or downstream—and political influence.

Any compensation should respect several criteria to be effective. In addition to being cost-effective, it must be tailored to the policy, targeted, and especially temporary so as to avoid an "entitlement mentality" (OECD, 2007[60]). Compensation payments can create a dependency and lead to inflexibility when they become embedded in the expectations of future reforms. Although they are costly, voluntary payment programmes remain flexible since their objectives can be adjusted at the end of each funding period (Gruère, Ashley and Cadilhon, 2018[14]).

Governments should also consider adjusting policy design to account for trade-offs between efficiency and equity. Efficiency can be interpreted as the maximised amount of wealth (or utility) a given resource can generate.[16] Equity considers the redistribution of wealth to society (Tsur and Dinar, 1995[61]). The trade-offs between the two has been widely discussed in the economic literature: efficiency does not bring equity when the overall gains benefit the better-off, and pursuing equity can be at the expense of efficiency because of the direct and indirect costs of redistribution (i.e. administrative costs, changes in work habits, attitude, savings, and investment behaviour) (Okun, 1975[62]). However, the two objectives can in some cases complement each other. For instance, welfare gains

[16] An efficient allocation of resource is Pareto optimal, i.e., it is impossible to make one individual better off without making at least one individual worse off.

obtained after the introduction of water charges targeting the largest water users may meet both equity and efficiency goals relative to an untargeted water charge.

Finding the balance between efficiency and equity may depend on the prevailing political and cultural context. A proxy for national preferences for equity or efficiency can be seen in the Constitution and water law (Roa-García, 2014[63]). Overall, the literature highlights the emphasis placed by lawmakers on efficiency of the allocation of water in some cases because of limited participation by small users in the decision-making processes (Ibid). However, the right balance between the two principles depends on the objective of the water reform. Water charges will be designed differently if they try to address cost recovery and allocation efficiency or equity in access to the resource.[17]

Adjustable smart reform sequencing

Pilots experiments and spatial sequencing

Pilot and field experiments should be encouraged to identify necessary adjustments prior to implementing the reform on a broader scale (OECD, 2015[29]). Experiments are useful to test a reform in a variety of circumstances and to learn from mistakes or successes. For instance, pilot experiments conducted in the Mexican states of Jalisco, Guanajuato, Colima and Hidalgo have been successful to address aquifer over-exploitation and have brought innovative approaches on water tariff setting with the introduction of a price on ecosystem services that have then been applied (OECD, 2013[64]).

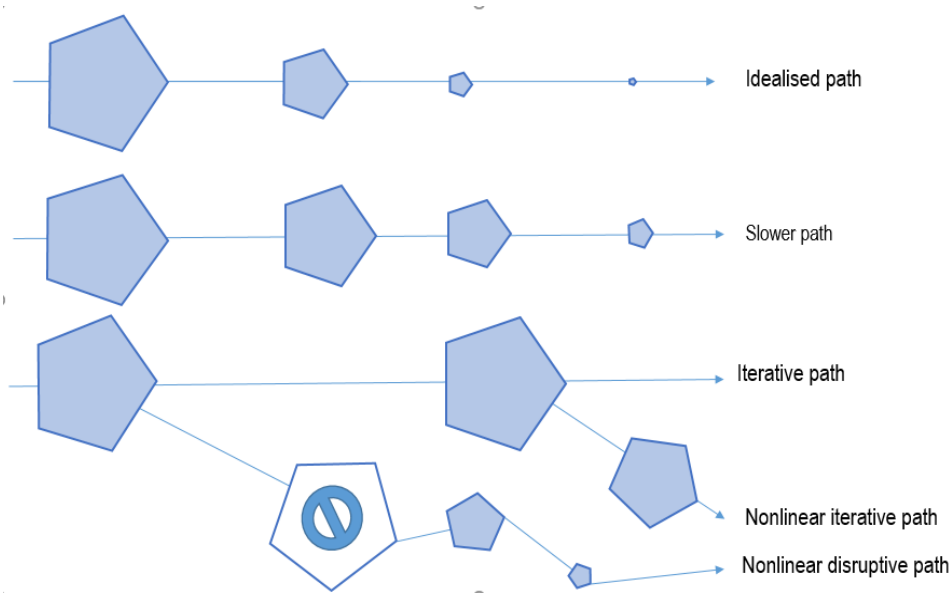
The scope of the initial steps of the reform must be carefully defined: where shall it be initiated and who should be targeted? The reform can be sequenced spatially to give priority to "'hotspot" regions (where the water situation is most critical in terms of quantity or quality), or to target specific users who contribute the most to water problems (OECD, 2015[65]; OECD, 2017[1])**.**

Flexible timing and adjustable pathway

There are gains in designing a reform with a mechanism to regularly assess progress and its flexibility to make incremental changes when needed (OECD, 2007[60]) (Figure 4). The implementation and the result of the policy change should be monitored and evaluated periodically by an independent agency.

[17] See section 3.2.

Figure 4. Pathways to better policies often include iterations and changes of directions



Note: lines indicate a particular reform process. The size of the pentagon expresses the intensity of efforts required to move forward. The "no way" sign shows a case where a reform has to be eliminated.
Source: Author's own work.

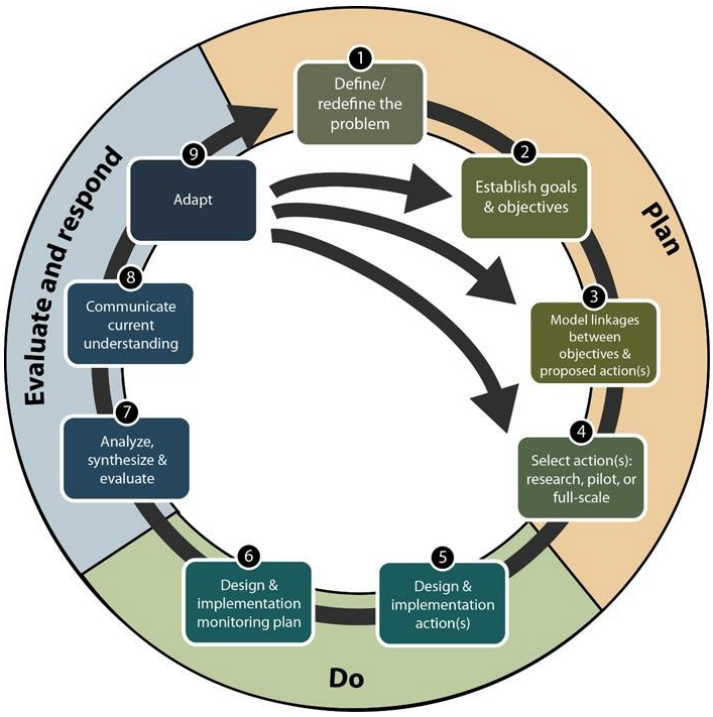
Water policy reforms rarely follow a linear pathway. They will generally not fit the classic representation that begins with the marketing of solutions, i.e. where the initial problem is framed to fit a solution (OECD- European Commission, 2018[18]). Instead, the reform process can be considered as a "dialogue of alternatives". Such iterative processes afford multiple opportunities for revisions and reframing the pathways selected as policies are modified (Ibid).[18]

Thus governments should be ready to continuously adjust to unexpected outcomes and consider alternative options along the pathway, while moving towards an overall goal that is clear throughout the process. As an illustration, California's Delta Plan to manage the challenges of water quality and quantity in the Sacramento-San Joaquin Delta explicitly embeds regular evaluations of the plan's implementation and allows for redefining the plans as needed based on collected evidence (Figure 5).

Embedded flexibility may also require the inclusion of an exit strategy providing options to eliminate part of or even the entire reform, under the condition that it is found to be ineffective or inappropriate by an assessment without requiring a new legislation or act. This would ensure that future change is feasible without creating further path dependency constraints. Such an exit option is particularly important when considering the growing uncertainties associated with water resources under climate change (OECD, 2014[2]).

[18] The separation between decision making and implementation can therefore be misleading, as refined decisions results from insights gained after implementation and vice versa.

Figure 5. Adaptive management cycle



Source: Delta Stewardship Council (2013[66]).

A smart reform package: Combining long-term targets, flexible implementation at the local level, and credible enforcement threat

Recent reforms help to identify elements that could be used to design a "smart reform package'' tailored to the agriculture-water interface. A review of these reforms through a dialogue with experts highlights the effectiveness of combining flexibility and strict enforcement: performance objectives should be set at the relevant geographic level (e.g. water basin, groundwater body) within a sufficient long timeframe, and actors should be free to choose their preferred way to meet the set goals (e.g. technology, behavioural change, adoption of new practices). It is also important that a credible commitment to enforce implementation be supported by regulatory sanctions or penalties at the end of the specified period if the objective is not attained. Such an approach is similar to the one used by California in its 2014 groundwater management reform which states that the government will take over management if local bodies do not take action (Gruère, Ashley and Cadilhon, 2018[14]). Penalties may not always be needed to encourage implementation, a credible threat of regulatory action may suffice. For instance, a survey carried out in the western part of the Lake Erie watershed in the United States demonstrated how the threat of additional regulations or rules related to nutrients was a powerful motivator for farmers to voluntarily adjust practices (Prokup et al., 2017[67])**.**

3. Applying the five conditions to agriculture and water policy changes

This section analyses whether the five conditions identified in Section 2 apply to the case of four challenging water and agriculture policy changes: charging water use in agriculture, removing subsidies that negatively impact water resources, regulating groundwater use, and addressing nonpoint source pollution. It illustrates how the application of each condition needs to be customised to a specific type of policy change, based on lessons from past reforms and information gathered from the literature and during the 2018 OECD workshops.

The policy changes considered were selected based on the interest they present for the present analysis and on the observed challenges their implementation face in some OECD and non-OECD countries. In the first two cases of water charges and subsidy removal, the policy changes correspond to the policy instruments, thereby framing a solution before even starting the reform. This is not consistent with the idea of opening a dialogue and could prevent other potentially more effective options). Past examples have shown, however, that governments may define these policy changes as objectives and not just as the means to achieve progress (e.g. the reform will focus on subsidy or water charges), potentially within a broader set of measures. Such implicit or explicit framing is rarely observed in the case of groundwater and pollution regulations.

The first section summarises the overall findings on the applicability of the identified conditions. The subsequent sections detail how the five-condition framework apply to the four reviewed agriculture and water policy changes.

Review of the findings: Shared relevance of the five conditions, with specific emphasis in each case

The analysis shows that the five conditions are necessary for the success of all reviewed policy changes (Table 1). Assuming the proposed policy changes are significant, not just minor revisions of an existing base, they will each require a robust information base and adjustments in governance and institutions in order to be cost-effective. A strong engagement with farmers and other water users, and a reflection on compensation mechanisms is needed to ensure the reform's acceptance and implementation. Reform sequencing will reduce the cost and increase the likelihood of success if it proposes a flexible path to results and defines credible enforcement mechanisms.

While the framework of the five conditions applies, the effort required to fulfil the five conditions varies as the main bottleneck factors are not identical for each of the reviewed policy changes (Figure 6). Some conditions appear to be relatively more important than others depending on the type of reform. Similarities can be found between reforms focused on water charges and removing subsidies that negatively impact water resources. These two policy changes force a reconsideration of the value of water for farmers and therefore both require greater efforts towards rebalancing incentives (condition 4) and finding an adequate sequencing to achieve the objectives (condition 5). Similarities can be found as well between reforms focused on regulations of groundwater and water quality. These two policy changes are characterised by strong asymmetries of information, knowledge gaps, and the importance of local action. Both require much effort to gathering evidence that will guide decision making (condition 1) and engage stakeholders so as to build trust (condition 3).

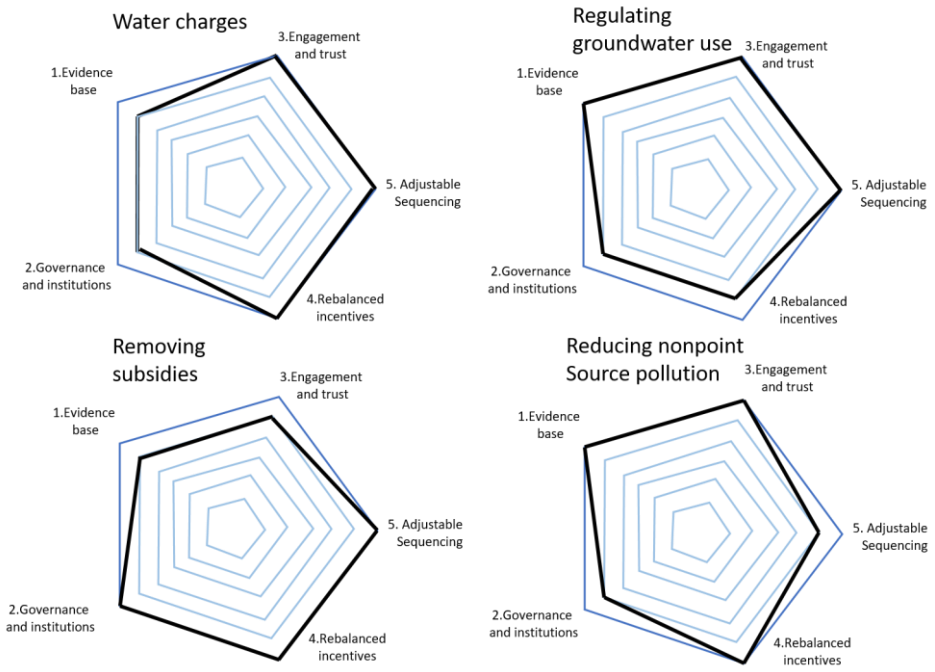
This implies that governments' relative efforts across the five conditions will need to differ at least partially depending on the type of policy change. For instance, governments may need to take more time to prepare groundwater or water quality reforms to gather information and initiate a robust and lasting stakeholder dialogue than in the case of water charges or subsidy removal. Equity considerations on the other hand may be more important to consider for the latter than the former.

Table 1. Applying the reform conditions to four policy changes

	Charging water use in agriculture	Removing subsidies that negatively impact water resources	Regulating intensive groundwater use	Addressing nonpoint source pollution
1. Evidence-base supported definitions, objectives and evaluations	Defining price objective, running price scenarios, and evaluating results	Running a diagnostic, experimenting scenarios	Analysing the status of groundwater resource and use, considering metering options	Analysing the pollution sources and dynamics to help policy design and evaluations
2. Policy change-compatible governance and institutions	Defining institutions in charge of revenue collection and monitoring	Revisiting the legal framework, addressing governance failures	Ensuring regulatory authority is at the right scale, remove incoherencies across governance scales	Ensuring co-ordination at local level, shift public agents' paradigm from compliance to collaboration
3. Strategic stakeholder engagement and trust-building	Instituting a dialogue on water charges from the initial stage to implementation	Dialogue on options, building trust to overcome resistance	Work with farmers and other users at the local level, building trust for lasting results	Work with farmers and other stakeholders to identify cost-effective solutions
4. Rebalanced economic incentives to enable policy change	Considering transitory compensation for low income users, accounting for the efficiency-equity trade-offs	Considering transitory compensation under the decoupling option	Considering common objective as a benefit for all, offer options for self-regulations	Considering compensation for efforts beyond regulatory limits requirements, or with pollution permits
5. Smart reform sequencing	Defining sequencing for charges, changing the course as needed	Running pilots and experiments Adapting pace of compensations	Defining a long term horizon objective with clear monitoring and enforcement mechanisms	Defining an adjustable spatial prioritisation plan, that leaves time for implementation

Figure 6. Required efforts for specific agriculture and water policy changes vary slightly

Bold lines indicate the level of effort required for each condition,
the further from the centre, the higher the effort should be



Charging water use in agriculture

Water prices and charges are essential components of a comprehensive water management system (OECD, 2016[25]). Although both apply the same economic instruments, water charges and water pricing are *stricto sensu* two distinct concepts. Water charges (or water tariffs) are applied to recover the costs of water supply, while water pricing seeks to reflect the opportunity cost of water to manage demand and contribute to water allocation (OECD, 2010[7]; OECD, 2015[20]). This section will examine both water pricing and water charges, as they may face similar reform process characteristics, albeit with different objectives and design. The term water charges is used to cover both in this section.

Design characteristics for water charges are important to consider and need to be adapted to the objective and situation. Irrigation charges aimed at cost recovery are usually volumetric with a fixed-rate per unit of water received. A flat annual charge can also be set, using the type of crop or the area irrigated as proxies for the volume of water diverted. Water charges raised to manage demand needs to take into consideration the responsiveness of farmers, which remains difficult to predict. At low price ranges, water demand is inelastic but above a certain threshold, it becomes more responsive to price increases (OECD, 2010[7]). Low elasticity does not prevent water charges from being a relevant tool to induce water saving, especially when farmers initially use large amounts of water

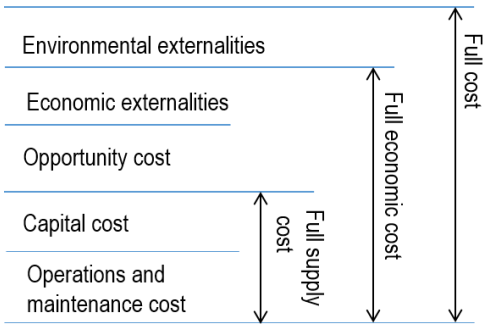
(Scheierling, Young and Cardon, 2004[68]). Pricing water may also be done through the development of water markets.[19]

Case studies from Australia, Israel, Chile, and Spain suggest that major policy changes related to water charges were triggered by crises and exogenous events (e.g. drought, regional or country scarcity, loss of water for the environment) or by a change in political regime (Dinar and Zilberman, 2016[69]; Gruère, Ashley and Cadilhon, 2018[14]; Albiac, 2017[70]).

Evidence-based problem definitions, policy objectives and evaluations: defining concepts, options and metrics

There are three ways to aggregate water costs (Figure 7). The *full supply costs* are the costs covering the supply of water to consumers. They comprise the operation and maintenance (O&M) costs to address the daily running of the water supply, covering electricity for pumping, repair and labour costs, and the capital costs for renewal investment of existing infrastructure as well as new capital investment costs. The *full economic costs* are the sum of the full supply costs, plus the opportunity costs that reflect the economic impact of one consumer depriving another of the use of the water and the economic cost of externalities for other water consumers (typically downstream). The *full costs* are the sum of full economic costs, plus a valuation of the environmental externalities associated with the water use given the public health and ecosystems impacts this use may have.

Figure 7. Costing water



Source: OECD (2010[7]) based on Rogers, De Silba and Bhatia (2002[71]).

According to the "user pays principle", the full cost of water should be entirely reflected in the water charges paid by users. However, few OECD countries achieve full cost recovery through water charges, or even the full supply cost recovery. Water charges rarely reflect scarcity, social values, or environmental costs and benefits, which are often supposedly addressed by other policy measures (e.g. agro-environmental payments, pollution taxes, water trading mechanisms) (OECD, 2010[7]). This situation is partly explained by the difficulty of assessing opportunity costs and valuing the environmental externalities associated with agricultural use of water resources, and by the difficulty to communicate

[19] A few countries, such as Australia and Spain, have introduced water trading system. Water markets enable a regulator to set a cap on abstraction (based on an assessment of available water resources) and distribute water rights between users. Water trading systems are not widespread as they require strong institutions and infrastructures that are capable of measuring and controlling delivery to holders of individual entitlements costs (OECD, 2010[7]).

these concepts to stakeholders. Moreover, there is often a large gap between the water charges paid by agriculture compared to urban water users. Lower water tariffs in agriculture are often rooted in public irrigation schemes that historically prevailed to supply water to agriculture at costs covering only operation and maintenance of water delivery. At the same time, irrigation water, unlike urban water, is usually not treated nor required to be available on demand which might explain having the lower charges (Ibid.).[20]

Water charges can have multiple objectives that need to be properly defined prior to the reform. The most common objectives of water charges are cost recovery (for financial sustainability of water delivery systems), demand management (for water conservation and allocative efficiency), and equity (affordable prices or income distribution) (Cornish et al., 2004[72]). These objectives can conflict and do not necessarily imply the same pricing method. Non-volumetric methods –such as area-based systems- are best-suited for a system that aims to recover costs but will not provide incentives to conserve water and farmers may feel entitled to use all the water "they have paid for".[21] On the contrary, volumetric methods are not fully adapted to the recovery of costs since the revenue flows are uncertain – they depend on the volume of water consumed – and therefore, they do not necessarily provide operating agency with the financial security for the operation system (Ibid.).[22] Volumetric methods are generally designed to manage demand and may not be effective for equity purposes as they can adversely affect the poorest if the charge is regressive.[23]

The unit used to measure water charges – e.g. unit of water consumed or withdrawn – must be chosen to reflect the objectives of water pricing. Studies on the impact of pricing may help guide policy design. Standards for water charges or water quota in agriculture are usually based on the (measurable) quantity of water withdrawn as opposed to the water consumed by the crop[24] in order to achieve cost recovery. Such standards give irrigators an incentive to increase the conversion of water withdrawn to the use by the plant, thereby raising consumptive use, which may result in less return flows to the watercourse and less water available to downstream users (Peterson and Hendricks, 2016[46]). Furthermore, the demand for water consumption tends to be less responsive to water pricing than the demand for water delivery, especially if farmers can adjust their irrigation practices (irrigation acreage, crop mix, number of irrigations, irrigation technology improving the efficiency of water application). This implies that water pricing may reduce water withdrawals but it may have a limited impact on water consumption (Scheierling, Young and Cardon, 2004[68]). When the goal is to ensure resource sustainability and to save water for other

[20] Assuming it does not create negative environmental externalities.

[21] This can be due to the conception that farmers pay for water when they pay for the delivery service of water.

[22] Volumetric methods are often one part of two-part tariff approaches which try to recover most of the costs via fixed charges but then send additional signals via variable charges. It should be noted that "volumetric" type charges are based on characteristics of the system, rather than the volume of water delivered, which allows for better matching with cost structures.

[23] Some regions use a mixed system with volumetric and non-volumetric water pricing methods that are based, for example, on crops' water needs that are related to water volumes.

[24] Water consumption refers to the amount of water depleted from evapotranspiration and embodied in the plant product, a concept that it much more difficult to track and to measure than water withdrawals.

uses, volumetric charges should ideally be based on the consumption and account for the return flows even if these are difficult to measure and to monitor (Ibid.).[25] At the same time, non-volumetric charges could be beneficial in areas where water leakage contributes to the resource sustainability. For instance, inefficient canal systems may contribute to ecosystem preservation or groundwater recharge in water-scarce areas, so pushing for less volume through volumetric charges may impact water-related ecosystems and the reliability of aquifer.

Align governance and institutions: Addressing governance failures, assigning revenue collection and monitoring

Water charges reforms are often hampered by institutional and political factors. Cornish et al. (2004[72]) highlight some of the main obstacles: a lack of political will to impose higher costs on farmers; a vicious circle of low charges resulting in bad performance of the water delivery system and therefore fuelling farmers' reluctance to pay more for water; and the lack of resources (time, money and training) to plan and implement effective charging mechanisms. In Brazil, weak governance of the water sector was found to be the main obstacle to the reform of water charges, with water users dominating river basin committees and opposing reforms (Box 1). In Korea, since the late 1990s, most irrigators are not charged for water use, except minimal tariffs for those irrigators who depend on water managed by local governments (OECD, 2018[73]). This situation results from an agreement whereby farmers redeemed the management and ownership of reservoirs and related facilities to the Korean Rural Corporation (KRC) in exchange for the elimination of previously raised water charges (Ibid). This agreement has resulted in the fierce opposition of irrigators to raise new water charges despite significant water stress in parts of the Korean peninsula, and engaged efforts to raise water charges for urban and industrial users (OECD, 2017[74]).

Implementing water charges requires appropriate institutions – such as a central water agency or water users' organisation – with clear responsibilities to set charges, monitor use, apply penalties for non-compliance, and ensure the quality and efficiency of the water delivery system. The agency should be neutral and independent from any vested interest so as to avoid inertia and policy capture from water users (OECD, 2015[65]). Furthermore, transparency of its the activities is necessary to avoid the corruption of agents and irrigation officials, which is a main driver of low water fee collection rates (Easter and Liu, 2005[75]).

Ensuring that water charges are properly implemented also requires trustful monitoring devices. Volumetric pricing requires introducing and maintaining a metering system. Such systems are applied in several OECD countries, but are not exempt from being tampered with or from water theft. In places where water charges have not been introduced, resistance by farmers can complicate the introduction of metering devices. In such cases, proxies for water consumption, such as acres or crops may be preferred at least temporarily.

[25] An alternative could be to couple credits for return flows or mechanism to pay farmers for non-consumptive use.

Box 1. Water governance improvement as prior to reform water charges in Brazil

Brazil holds 12% of the world's freshwater resources, which makes the country relatively well endowed although important regional disparities exist between the semi-arid north-eastern states and the water abundant amazon region. Irrigation represented 67% of the total water consumed in 2015 and demand for water in agriculture is expected to sharply increase in the future. One of the avenues explored to cope with this problem, while raising charges, has been the revision of existing water charges, which have been only partially applied in some states and interstate river basin, with limited charges on agriculture, much below charges, not able to recover sufficient revenues.

The 2014 water scarcity crisis in Brazil opened a window of opportunity to reform water charges. Starting in 2015, a policy dialogue carried out with over 150 stakeholders was initiated to assess the situation of water charges in Brazil and to learn from international best practices to move forward. However, the reform of water charges faced serious resistance. The image of "'water abundance"' in Brazil hindered the willingness of politicians to introduce water charge at state level and fostered user's perception that water charges in agriculture are additional taxes rather than a collective effort to secure future access to the resource.

The analysis showed that difficulties in introducing new water charges were largely due to underlying water governance issues. In the aftermath of the democratic transition, water management was decentralised to the 27 states and the federal districts supported by 200 river basin committees. However, river basin committees were dominated by water users who decide on setting water prices and on formulating the mechanisms, therefore blocking the reform process. Moreover, the system was unable to ensure effective implementation of decisions due to governance gaps and lack of coordination. Firstly, the "double dominion" system derived from the constitution created situations where water charges are applied and governed at both state and federal level. Overlaps and "double grids" also occurs because of the mismatch between administrative level (municipal, state and federal) and hydrological boundaries. Second, the silo-approaches among water-related ministries hindered policy coherence at the national level to link water issues with land-use, environment or sanitation. Third, the lack of capacity in terms of skilled staff, funding and political commitment in deliberative bodies and public administration weakened the implementation of water reform.

Reform of water charges will therefore need to be backed up by improved water governance and management of change in public administration. Such changes include a greater coordination of water-related ministries; a culture of continuity in state public policy with more long-term vision and a more professionally based recruitment of water professionals with enhanced financial and technical capacity of state-level institutions. Furthermore, a stronger consultative role of the river basin committees and greater devolution of deliberative and executive powers to water agencies could overcome blockages from water users to introduce new water charges or increase the existing one.

Sources: Gomes Zoby (2018[76]); OECD (2015[77]; 2017[78]).

Strategic stakeholder engagement and trust-building: Discussing design and monitoring impact

Particular attention should be paid to vested interest that can put pressure to divert a reform or lead to suboptimal water prices that result in overuse of water, thereby damaging the environment (Dinar, 2000[79]). The role assigned to stakeholders in the consultation and decision making-process in the river basin committees need to be clear so as to avoid such blockages (OECD, 2017[41]). Third parties, such as civil society organisations and some agro food companies, are increasingly calling for water charges in agriculture and could be involved in the engagement, together with other actors in the river basin.

Prior to the reform, it is crucial to engage a dialogue with the irrigators while launching awareness campaigns to explain the components of the proposed water pricing and charging system, as well as to demonstrate its benefits for them and society in general (Dinar, 2000[79]). It may also be useful to understand the preferences of irrigating farmers over potential tariff structures, for example via the use of surveys with best-worst options to select the preferred options (Cooper, Crase and Rose, 2017[80]).

Stakeholders should be regularly consulted during the implementation phase of the water charges system to identify and make the necessary improvements. In Israel, the three-tiered block pricing system introduced in the 1990s has been revised several times to take into account feedback from stakeholders. In particular, an agreement was signed in 2006 with farmers to increase charges in exchange for more secure water supplies. In 2014, a unique tariff rate replaced the three-tier block rates following growing calls and discussions with economists who proved the inefficiency of the three-tiered block pricing system (Gruère, Ashley and Cadilhon, 2018[14]).

Rebalance economic incentives: Addressing the efficiency-equity trade-offs

Farmers who used to pay limited or no water charges may be reluctant to accept the reform even when they can afford water prices. The rationale for the reform should be recalled to farmers, based on impact evaluations, stressing the long-term benefits it will carry (e.g. water security, better water quality services, equity among water users) (Postel, 1999[81]). Providing farmers with information on how funds generated will be re-invested (e.g. infrastructure investment, development of alternative water resources, water recycling) and about case studies where successful win-win outcomes have been obtained could improve their acceptance of the need for the reform (OECD, 2017[41]).

Compensations are justified when they respond to concerns over water affordability (OECD, 2016[25]). Social and adjustment policies may be necessary to compensate the poorest farmers (OECD, 2016[12]). One possibility is to redistribute part of the revenue to users through subsidies for reducing water abstraction or pollution ("feebate") (OECD, 2017[41]). However, such compensation should be temporary and related to clear policy targets, otherwise the subsidies may become difficult to remove in the future (Ibid).

When raising water charges, governments may need to ensure at once that the new charges do not impact the smallest farmers disproportionally, nor hinder the overall efficiency of the system. The trade-off between efficiency and equity is, however, particularly salient in the case of water pricing.

- An efficient water charges system would define prices on the full cost of water, which internalises the marginal cost of water plus its scarcity value. However, when the scarcity value is high, the price per water unit (based on the marginal cost) rises substantially, which may drive subsistence-level farmers out of production (Johansson et al., 2002[82]). Volumetric charges may affect negatively the poorest farmers and therefore variations of volumetric pricing (e.g. block tariff or two part charges combining fixed charge with volumetric charges) can be used to redress the distributional impact. Easter and Liu (2005[75]) suggest designing block tariffs to cross-subsidise poor farmers: the price of the first block would be set below operations and maintenance costs to support a farm family, while any water used that exceeds the first block would be paid at a rate covering O&M costs and reflecting the marginal cost of operations.
- Conversely, equity can go against efficiency. Although water charging mechanisms serve as a poor vehicle to reduce income inequalities among farmers (Tsur and Dinar, 1995[61]), governments sometimes increase water made available to poor farmers through subsidised water provisions or differing pricing mechanisms that account for disparate income levels (Dinar, Rosegrant and Meinzen-Dick, 1997[83]). Such mechanisms may reduce the overall efficiency of the system and create disincentives for sustainable water use since the water pricing does not reflect the full cost of water. In 2017, Israel amended its water law to eliminate water price

variations across regions, removing a water extraction levy and introducing a uniform tariff for users of the national water company for equity purposes (Gruère, Ashley and Cadilhon, 2018[14]). But the new system does not reflect the diversity in regional changes in water conditions, with a potential loss in efficiency (OECD, 2018[84]).

Considering both objectives will therefore require dialogue to find an acceptable and effective path to pricing.

Adjustable smart reform sequencing: Prioritization and gradual evolution

Targeting specific users or regions can be a relevant option to bring rapid and visible results during the first stage of the reform. In Spain, after several drought episodes coupled with water pollution, reforms were first introduced in water-scarce regions: volumetric pricing replaced the former acre-based system and water supply was improved by investing in desalination and water recycling (Dinar and Zilberman, 2016[69]). In Brazil, the 2017 plan intends to introduce water charges that target large farms that abstract the vast majority of water and generate a large share of water pollution in order to minimise the transaction costs of the reform, at least at an early stage (Luiz and Zoby, 2018[85]).

In terms of timing, a gradual pathway over which tariffs increase progressively so as to cover operation and maintenance costs can precede capital costs, and eventually the externality and opportunity costs of water in agriculture (OECD, 2010[7]). However, when the initial situation is characterised by very low tariffs compared to full cost recovery, a more drastic increase in price should be adopted (Ibid). In Israel, the three-tiered block pricing system introduced in 1991 for irrigation water initially corresponded to the average cost of water.[26] The system remained flexible and over the past 20 years prices have progressively increased to recover the costs of desalination and to incentivise farmers to reduce freshwater use (Gruère, Ashley and Cadilhon, 2018[14]). Case studies from Australia, Chile, and Spain confirm that major water pricing reforms or the introduction of water markets take times and go through progressive changes (e.g. gradual introduction of volumetric system, desalinisation plants, water recycling, water conservation technologies) (Dinar and Zilberman, 2016[69]).

Removing subsidies that negatively impact water resources

Two types of farm subsidies can negatively impact water resources and be considered "water-harmful" in specific contexts (Sur, Umali-Deininger and Dinar, 2002[86]). First, several types of water-related input subsidies (of the cost of irrigation,[27] fertilisers, pesticides or groundwater pumping) can have, by lowering input costs, a direct and harmful effect on water resources in specific contexts (Ibid).[28] Second, certain types of support for

[26] Farmers did not pay the full cost of water supply so as to avoid poor farmers being driven out of the business.

[27] The exemption of water charges for irrigation can be considered in this category. For instance, Valsecchi et al. (2009[134]) estimated that subsidies associated with irrigation water charges remaining under full cost recovery rates in Spain amount to EUR 165 million/year.

[28] The situation of water resources and the impact of water-related input subsidies will be different according to local situations. Irrigation subsidies can support public good provision, such as schemes to support paddy farming that provide flood protection or groundwater recharge (OECD, 2015[110]).

agricultural activities can affect water resources indirectly if they encourage the use of water, fertiliser, pesticides, or livestock intensification. For instance, artificially raising the price of a particular crop that requires a significant amount of water (via tariffs or other means) in a region subject to droughts will encourage farmers to continue growing such a crop. These two types of subsidies can be particularly harmful for water resource as they encourage overuse and overconsumption of water, or lead to the pollution of surface and groundwater (Ibid.).

Three main policy reform options exist to remove these subsidies: the elimination of the subsidy; the gradual reduction of the amount of subsidies; or decoupling the subsidies from production (Dinar, 2018[87]). In practice, policies to phase-out subsidies that negatively impact water resources are rarely considered and implemented. Reducing subsidies is difficult due to strong opposition from entrenched pressure groups – landowners, farmer lobbies, electricity and supply companies, and fertiliser producers. Subsidy reforms are often politically costly; politicians are rarely willing to campaign to seek a popular mandate for a policy change for the common good, especially when water-consuming farmers have important electoral power (Alkon and Urpelainen, 2018[88]). Moreover, the public has little interest in supporting reforms because the cost of agricultural and water subsidies are widespread among tax payers and not always transparently communicated, while the benefits of the subsidy are visible and concentrated in the hand of small groups who can more easily organise and lobby for the status quo (OECD, 2007[60])**.**

Evidence-based problem definitions, policy objectives and evaluations: Diagnosing the situation and running ex-ante experiments

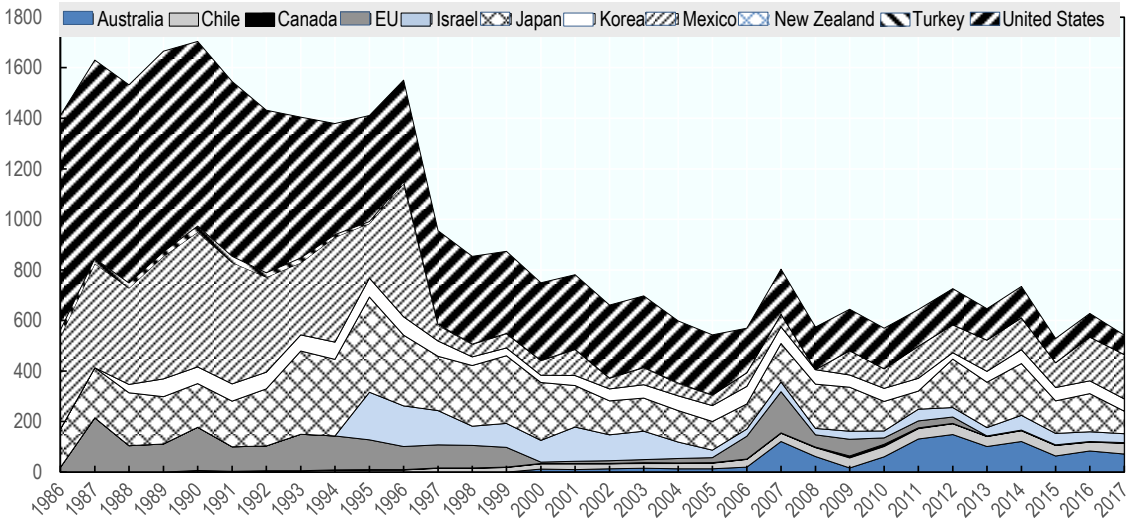
Evidence is needed on the level of the subsidies and their effect on water use and pollution before engaging forcefully in the reform. Limited data are available to assess and compare the situation of OECD countries in terms of water subsidies (OECD, 2005[89]). Available producer support estimate data suggests that transfers for irrigation declined in OECD countries from 1986 to 2017 to USD 500 million in 2017 (Figure 7). These figures, however, may not be complete nor is it possible to identify all transfers that may have had a negative impact on water resources.

Farm subsidies that negatively impact water resources are often designed for another purpose (OECD, 2007[60]). Subsidies on agricultural inputs help raise agricultural production and profitability, but they can also promote an inefficient use of the water and budgetary resources, encouraging aquifer depletion or water pollution (Ibid). For example, subsidies for irrigation can encourage intensive-crop farming using high levels of fertilisers and pesticides, with the result that runoff from irrigated crops may contain high levels of nitrates and dissolved salts (Ibid.).

Exceptions also arise in contexts where some of these inputs are missing or at very low levels, like in context where irrigation needs to be developed or infertile land (mostly in less developed non-OECD countries). In these latter cases, however, such subsidies can become harmful with increased input use.

Figure 8. Irrigation support has been declining in OECD countries (1986-2017)

2000 USD millions



Note: Water pricing subsidies are not accounted for if not declared in the PSE database.
Source: Derived from OECD (2018[90]), irrigation-related PSE transfers in the category of input payments (PI).

Some subsidies can have unintended consequences on water quality and quantity, and therefore the attribution of the harmful water effects to the subsidy may be politically sensitive. Support for irrigation efficiency technologies, for instance, may in fact increase water consumption to the detriment of other users and water ecosystems due to a misrepresentation of the local hydrology or to farmers' response (Grafton et al., 2018[91]). In the Central Plains of the United States, the shift to low-pressure and high-efficiency sprinklers, funded in part by the Environmental Quality Incentives Program (EQIP) did not entirely meet the intended goal of reducing water use because it resulted in some farmers expanding irrigated acreage and/or increasing irrigation intensity, which offset the water savings (Pfeiffer and Lin, 2014[92]).

Diagnosing the current situation also implies an understanding of who benefits and who loses from the status quo. Subsidies that negatively impact water resources often sustain inequalities; for instance, when the size of the subsidy is proportional to the amount of land owned, subsidies are more likely to benefit large and wealthy farmers (Sur, Umali-Deininger and Dinar, 2002[86])**.** An illustration is the Mexican electricity subsidy on groundwater pumping (Tarifa 09): 10% of farmers benefit from 90% of the subsidy volume (Alkon and Urpelainen, 2018[88]). Moreover, these subsidies can have an indirect effect on equity: irrigation subsidies may exacerbate existing operations and maintenance deficits by encouraging more water use, which in turn deteriorates the quality of the service and of the physical supply of water for agriculture. Poor farmers are likely to be the most affected since they are often downstream users at the tail end of the irrigation system and they cannot afford to invest in alternative sources of water or cope with the degradation of water quality (e.g. salinisation) (Sur, Umali-Deininger and Dinar, 2002[86]).

In cases where the subsidy reform is particularly politically sensitive and the situation is blocked, the design of the policy reform can benefit from experimentation and testing at a local level before it is scaled up. Research and experiments can help assess realistic solutions to phasing out subsides that negatively impact water resources and identify the optimal option (elimination, gradual removal or decoupling the subsidy) and the adequate

scale and the scope of the reform. In Mexico, the reform of subsidies to electricity for irrigation pumping (Tarifa 9) has long been debated, but the removal of the subsidies remains an overwhelming task due to entrenched interests and the vast amount of money at stake (MXN 6.8 billion in 2010) (OECD, 2013[64]). To simplify the problem and pave the way forward, pilot programmes have started since 2011 in 13 aquifers and aim at replacing subsidies to electricity for irrigation pumping with the equivalent amount in cash transfers (Box 2).

Box 2. Pilot experiments in Mexico to phase out the electricity subsidy for groundwater pumping

About 29.5 km^3 of water in Mexico is extracted annually from aquifers, of which 70% is used for irrigated agriculture. In the early 1990s, the Mexican government introduced a subsidy called "Tarifa 9" for electricity used to pump groundwater for irrigation in order to help farmers compete within NAFTA. The fiscal cost of Tarifa 9 was estimated by the World Bank to have reached MXN 8 billion in 2009, more than for all other federal irrigation expenditures.

This subsidy raises environmental concerns as well as equity issues. Tarifa 9 is volumetric: the more electricity used to pump groundwater, the higher the subsidy. Consequently, subsidised pumping encouraged the unsustainable use of water in irrigation and has contributed to the depletion of aquifers; 101 of 188 were overexploited in 2005. Moreover, the subsidy is very regressive since 90% of the subsidy volume benefits the 10% richest.

Removal of the subsidy faces serious opposition from bureaucrats (for job security concerns), large farms, and agroindustry stakeholders who largely benefit from the status quo.

To circumvent this blockage, research has been carried out to study farmer responses to different reform options and the political economy challenges these options may imply. Ávila et al. (2005[93]) simulated different reform options and found that decoupling the subsidy from groundwater pumping could reduce aquifer depletion by 15% and provide successful incentives to use water-saving technologies. Foster et al. (2018[94]) conducted a field experiment in three Mexican cities (Léon, Guanajuato, and Mexico City) to compare the effectiveness of three options (elimination, reduction, and decoupling) with a laboratory experiment undertaken with US undergraduate students and subsequently Mexican farmers. They consistently found that decoupling produces the same results as the elimination of subsidies in terms of water saving, while reducing the risk of political obstruction.

These solutions have not been adopted by the government authorities, but they have contributed to opening a dialogue. Further pilot studies may help advance towards an acceptable solution.

Sources: Ávila et al. (2005[93]) ; Foster et al. (2018[94]); OECD (2013[64]).

Align governance and institutions: Adapting legal arrangements to ensure transparency

Removing subsidies that negatively impact water resources faces path-dependency constraints as they are embedded in legal arrangements. Phasing-out these subsidies thus requires the removal or amendment of existing legislation, a step that is not necessarily needed for other reviewed water reforms, such as the introduction of water charges. In Mexico, for instance, decoupling the energy subsidy for water pumping would necessitate amending two articles of the Law of Energy for the Agricultural Sector. Political bargaining would be needed to reach a consensus (Muñoz Piña et al., 2005[95]). In India, where groundwater subsidies have been estimated to exceed expenses for education (Birner, Gupta and Sharma, 2011[96]), any reform requires legal changes in the concerned States, which are constitutionally responsible for water and agriculture. The Federal government has long sought progress on this front, but states are not obliged to apply their bills from the national parliament.

Removing historical irrigation subsidies often requires addressing governance failures. This includes tackling policy capture and corruption from the field level to the highest levels of irrigation bureaucracy (Transparency International, 2008[97]), patronage for irrigation jobs, crime syndicates, and divergent priorities and interests between the state and the federal levels. Irrigation subsidies are often renewed automatically with no assessment of the performance of the irrigation system. This lack of accountability in the provision of large public subsidies can foster the corruption of bureaucrats and irrigation officials (Ibid).

Transparency on the nature, amount, recipients, and impact of subsidies is necessary to establish the truth and generate pressure for subsidy reform from the legislative body and society in general (OECD, 2007[60]). An independent body should be in charge of evaluating the impact of the subsidy programmes and the reforms to avoid political pressure on the assessment.

Strategic stakeholder engagement and trust-building: Discussing options, building trust

Entrenched pressure groups and powerful opposition from stakeholders – such as farmers benefiting from subsidies and industries – are often obstacles to reforming subsidies. Vested interests often develop around subsidies, exerting pressure on farmers willing to phase-out subsidies during stakeholder consultation. Subsidies that negatively impact water resources often fuel patriarchal relations in which big farmers exert power over their smaller counterparts in order to maintain the status quo (Alkon and Urpelainen, 2018[88]).

Although a strong political will is crucial to advance a subsidy reform, stakeholders should nevertheless be consulted to decide on policy options (e.g. gradual removal, decoupling of the subsidy) and on the possible means to implement the reform (see groundwater subsection). Working with a coalition of farmers willing to start a dialogue can help move the debate forward and overcome future blockages.

Trust in public authorities may avoid adverse political fallout resulting from the removal of subsidies that negatively impact water resources. A survey of 2 100 farmers benefiting from long-term energy subsidies for groundwater pumping in the Indian states of Bihar, Gujarat and Rajasthan showed that trust in government (both state and central) was associated with the farmers' support to engage in reform of the subsidies they received. A credible commitment by the government through a demonstration of its good intention to provide compensation to farmers (cash transfer or long-term water security) is crucial to overcoming resistance (Alkon and Urpelainen, 2018[88]). Transparency and communication with farmers is also important to overcoming false perceptions by explaining the reform's long-term benefits.

Rebalance economic incentives: Considering decoupled payments as a transitory measure

Short-term negative consequences on farmer incomes and production that result from the subsidy reform (OECD, 2005[89]) can be rebalanced by offering long-term benefits (e.g. water security, good water quality, better services etc.). For instance, removing irrigation subsidies will at first increase irrigation costs for farmers, and thereby reduce the cultivation of certain water-intensive crops (Ibid), but it should also improve the quality of irrigation services and secure future access for water. Equity between water users across different sectors (urban and agriculture) and different administrative areas (i.e. provinces, states) can be another rationale to motivate stakeholders to embrace the change.

Compensations may be introduced if stakeholders are opposed to the reform. Blockage is likely to arise when long-term provision of subsidies creates a dependence effect so that farmers tend to consider subsidies as a right taken for granted (OECD, 2007[60]). Consequently, the removal of the subsidy is likely to be perceived as the withdrawal of an entitled benefit, thereby generating resistance and making additional compensation and extra effort necessary to ensure farmers' buy in. In such a case, transitory and time-bound compensations may be necessary to assist the structural change and overcome resistance. Direct or indirect compensations need to be carefully designed when they are used to ease the reform process. Lump-sum decoupled payments enable farmers to keep the same welfare (farmers are given cash transfer of an equivalent amount of the subsidy) while the new price gives inventive to undertake changes in water consumption (change in crop patterns, reduction of irrigated area, adoption of water saving-technologies) (Ávila et al., 2005[93]).

Several parameters should be considered when choosing the decoupling option. Specific challenges will arise depending on the scale of the measure (all aquifers or only overexploited aquifers), the farmers targeted (concession holders only or all farmers), the base used to calculate the cash transfer (historical consumption, plot size or number of farmers), the gender of the recipient (in some cultures, men and woman may spend lump-sum payment differently), and the timing of the transfer (before or after the beginning of the season). For instance, refunding based on historical consumption will maintain the status quo in terms of nominal payments but may create tensions regarding the period used for averaging quantities of input used. On the other hand, refunding on average subsidy (total amount of subsidy divided by the number of farmer) will benefit small concession holders and disadvantage the larger ones, and therefore may create resistance (Asad and Dinar, 2006[98]). Indirect compensations disconnected from the subsidy can also be effective. In the Indian states of Gujarat and Rajasthan, the reduction of the energy subsidy is likely to be packaged with other fundamental policy changes (improvement in the quality of energy supply and introduction of social policies) to enhance the acceptability of the reform (Alkon and Urpelainen, 2018[88]).

Adjustable smart reform sequencing: Pilot and demonstration, adjusting pace

Pilot initiatives and demonstration projects can be set to find innovative solutions and be scaled up as they progress. Several pilot projects have been implemented in India. In Gujarat, the village of Dhundi launched the "Solar Power as Remunerative Crop (SPaRC)" pilot programme whereby farmers surrender the subsidised grid-electricity in exchange for a subsidised solar pump of the same capacity. To encourage water conservation, farmers can sell the surplus of solar energy (as an alternative to using the power to pump) to a local distribution company under a 25-year power purchase guarantee (Shah et al., 2017[99]). Results to date indicate that the farmers involved in this scheme have sold most of their energy, thereby reducing pumping and increasing their revenues (Shah, 2018[100]). The state of Gujarat also introduced the "Jyotigram scheme" to address the problem of agricultural energy subsidies that foster groundwater depletion and put pressure on the electricity grids of non-agriculture users. The scheme separates the agricultural from the domestic grid; farmers now benefit from a limited supply of electricity subsidies (eight hours a day), which slows down groundwater pumping, while the other users pay higher electricity prices but enjoy continuous power supply (Alkon and Urpelainen, 2018[88]). In the Indian state of Punjab, two experiments are being tried by the World Bank to circumvent unmetered supply of subsidised electricity to farmers. The first introduces an upfront payment for electricity and a metering system charging real prices (farmers keep the savings) and the

second experiment free power quota with meters, use above the quota being charged (Shah, 2018[100]).

Different reform sequencing strategies are possible, depending on the level of compensation —reflecting the number of losers and the intensity of the opposition to the reform— and the duration of the implementation period, which is based on the political urgency and time available for the reform (Table 2). A gradual removal of the subsidy calls for a long implementation period as well as a consistent political effort. The removal of the subsidy can be accompanied with cash-payments ("cash out" option) or without compensation so as to reduce political intervention over time ("squeeze out" option). In contrast, a rapid reform terminates a policy without a phase-out period, either associated with a compensation payment ("buy-out" option) or not ("cut-out" option) (OECD, 2007[60]). However, a dramatic reform may increase the likelihood of policy reversal.

Table 2. Subsidy reform strategies

Compensation	Duration of implementation period	
	Long	Short
Yes	Cash-out	Buy-out
No	Squeeze-out	Cut-out

Source: OECD (2007[60]).

A slow phasing out of a reform with a time-limited end-point, with adjustment over time of the parameters (for instance, the decoupling options can be revisited), can help secure the outcome of the reform and ensure its irreversibility (OECD, 2007[60]). The assistance-measures should also be time-bounded and monitored. One-off measures or multi-year schemes with provisions known in advance are more plausible than year-by-year decisions (Ibid).

Regulating intensive groundwater use for irrigation

Groundwater resources represent a significant and growing share of water supply for irrigation. In 2010, groundwater accounted for about 20% of irrigation withdrawals in OECD countries, which represented an annual volume of 123.5 km^3 applied to 23 million hectares (OECD, 2015[9]). Groundwater irrigation is particularly important in semi-arid areas of OECD countries in North America and in the Mediterranean region (OECD, 2015[9]; Cooley et al., 2016[6]). Other hotspots of agriculture groundwater use are found in regions of China, India, Pakistan and Middle Eastern countries (OECD, 2017[1]).

Intensive groundwater pumping for irrigation in these regions drives aquifer depletion and can generate negative, and sometimes irreversible, environmental externalities (OECD, 2015[9]). This includes stream depletion (revealing surface water-groundwater interactions), salinization of coastal aquifers, land subsidence, or pollution (Ibid).

Given that groundwater remains a largely invisible resource, observable phenomena like a river drying up or the water table declining rapidly in a situation of drought have acted as drivers of policy changes in the past (World Bank - OECD, 2018[19]).

Evidence-based problem definitions, policy objectives and evaluations: Diagnosing and monitoring the local situation

Groundwater is a local and highly differentiated resource. It is therefore crucial to understand its local specificities to design policy instruments tailored to the hydrogeological situation. Proper characterisation of groundwater irrigation systems requires information on current and future agro-climatic conditions, access to surface irrigation systems, the degree of availability of accessible and usable groundwater resources, and the trends in use and profitability of groundwater irrigation relative to other uses (OECD, 2015[9]). Assessing the state of aquifers, however, is complicated by the limited knowledge of groundwater hydrogeology and the relative lack of data (Smith et al., 2017[48]; OECD, 2015[9])**.** Difficulties to assess the groundwater situation is explained by the "hidden" nature of water tables which limits its public exposure and interest, the often widespread surface covered by aquifers, and the multiple points of abstraction (including illegal drilling).

Setting the policy objective requires knowing what level is needed to reach a sustainable outcome, which can be difficult with imperfect knowledge of the system, and often requires local adaptation. A solution is to define how negative outcomes can be avoided as the objective. In California, the 2014 Sustainable Groundwater Management Act defines sustainability by the avoidance of six undesirable results, such as significant and unreasonable depletion, sea water intrusion, land subsidence, quality deterioration, or stream depletion (USGS California Water Science Center, 2018[101]).

Groundwater management is a long-term exercise which requires advance planning. This requires not only knowing about the aquifer system and its evolution, but also assessing the cost-effectiveness of different instruments in advancing towards the objective, accounting for the time lags between a change of pumping and the actual results in an aquifer. Water economic models can help conduct such an assessment and support groundwater management units in developing plans.

Groundwater-use monitoring can be done effectively with meters but installing metering devices can be politically challenging and lead to the use of replacement proxy measures. Installing meters on wells in pilot plots of large aquifers can provide valuable information to quantify extractions and to help understand changes in piezometric levels (water table levels) before and after the introduction of a reform. However, farmers may perceive this as a regulatory tool to control groundwater pumping. Studies conducted in the US State of Nebraska have shown that metering devices are more easily accepted when they are offered as an educational tool to raise farmer awareness on conservation issues (World Bank - OECD, 2018[19])**.** When farmers frontally oppose meters, as seen in Peru, indirect measures can be envisaged to provide an estimation of the aquifer level, e.g. using a remote sensing system, broader estimations based on cropping area, or correlation between energy used for water pumping and water consumption (Ibid).

Align governance and institutions: Addressing multi-level governance gaps

Groundwater governance remains fragmented and incomplete in most OECD countries. Historically, the priority has been given to surface water legislation rather than groundwater management for three main reasons (Akhmouch and Clavreul, 2017[102]). First, groundwater is more difficult to regulate because of its specific characteristics: the resource is "invisible", and in some regions open-access and exploited by a plethora of individual users whose responses are difficult to monitor and co-ordinate (FAO, 2016[103]). Secondly, authorities often have low regulatory pressures because aquifers typically take a long time

to be impacted from intensive exploitation and pollution due to very slow groundwater flows and transport processes (Mechlem, 2012[104]). Third, river basin boundaries often mismatch aquifer boundaries, which can result in counteracting reform efforts. Some type of reconciliation between the three is needed to avoid unwanted results and inconsistencies in water resource allocation (OECD, 2017[105]).

Groundwater resources management requires actions at the national and local administrative levels (Foster and Kemper, 2006[106]). Top-down management and regulation is rarely the option chosen for the management of aquifers. Decisions are usually decentralised and taken by water well owners who are better informed of the local situation (FAO, 2016[103]). Government capacity to administer and enforce groundwater regulation requires national leadership through the establishment of a national groundwater unit (or dedicated team in a larger environmental or water-resource agency) (Ibid). Such units should be provided with specialist staff who have adequate training in groundwater resource management. Local agencies or management units are needed to operationalise the policies, adapting their approaches to work successfully with a collective of farmers (OECD, 2015[9]). A major task of public efforts to improve the use of conjunctive surface-groundwater management in Australia as part of the National Water Initiative involved assigning roles and responsibilities (Ross, 2017[107]).

Specific attention should be given to removing incoherent policies and silo approaches to avoid dysfunctional groundwater governance systems. First, subsidies for water-well construction, water intensive crops, and energy that encourage farmers to pump groundwater should be gradually removed so as to be coherent with the policy objectives that protect groundwater resources (Foster and Kemper, 2006[106]). Secondly, cross-coordination across policy sectors is particularly relevant for the management of groundwater because the rates and quality of groundwater recharge is directly affected by other policy fields (e.g. mining and industrial pollution, energy production, agricultural practices including land use, crop choice, irrigation type and energy contracts) (Akhmouch and Clavreul, 2017[102]). Thirdly, links and synergies between groundwater and surface water are better addressed through joint management in a basin organisation and when the national and local government agencies in charge of these two resources are part of the same ministry or organisation (FAO, 2016[103]).

Strategic stakeholder engagement and trust-building: Enabling collective action, building long-term trust

Because groundwater is a highly decentralised resource, policies that regulate groundwater need to involve stakeholders in consultations, planning, and day-to-day aquifer management, such as monitoring water extractions, deciding on water well construction or use, etc.[29] For instance, Foster and Kemp (2006[106]) recommend to consult stakeholders to define the priority services provided from an aquifer system, define the allocation of groundwater between user sectors, to choose the acceptable levels of aquifer and groundwater supply protection, and to find a balance between agricultural production goals, groundwater availability, and quality protection.

In practice, stakeholders remain poorly engaged in groundwater governance. Co-operation of stakeholders is hampered by the vast number of actors involved with divergent objectives. Furthermore, weak stakeholder engagement can also be explained by an

[29] As noted by John Berge, Manager at North Platte Nebraska Resource District, at the 2018 World Water Forum, regulators need to transition “from water sheriffs to water partners”.

"awareness gap" regarding the challenges faced by aquifers, as groundwater remains invisible compared to surface water and is often perceived as a private good regardless of existing legislation (Akhmouch and Clavreul, 2017[102]).

Ensuring the role of collective action in groundwater management is required to complement top-down regulations and induce changes in behaviour of users at the local level (OECD, 2015[9]; FAO, 2016[103]). France introduced collective management bodies (*organismes uniques de gestion collective*) composed of a wide-range of stakeholders (agriculture chambers, irrigators, owners of irrigated lads, territorial associations) in charge of collecting water withdrawal requests and set annual plans for the allocation of acceptable volumes for groundwater for pumping among irrigators (OECD, 2017[108]). Leaving room for stakeholders to operate can provide better results than traditional command and control regulations. In Kansas and Colorado, local initiatives succeeded in reducing groundwater extraction that top-down management had failed to address (Box 3).

To build trust in groundwater management, local regulatory authorities should improve the transparency and accountability of governance. Community-based groundwater management is often weakened by vested interests and corruption that hinders compliance with the law, as observed in the case of illegal drilling or ground disposal of pollutants in groundwater protection zones. Furthermore, there is a need for transparency on the provision of information on groundwater resources, water well users and uses, quality status, and watershed abstraction licences.

Box 3. Examples of self-regulated groundwater use in Kansas and Colorado

Voluntary reduction of irrigation pumping from the Ogallala aquifer (Kansas)

Irrigation in Kansas represents over 80% of water use, with 90% of the groundwater coming from the Ogallala-High Plains Aquifer. This aquifer is non-renewable and sustained groundwater extraction for agriculture has resulted in serious depletion problems.

Kansas has a solid regulatory framework on groundwater. The Kansas Water Appropriation Act (KWAA) enacted in 1945 entitles the Chief Engineer of the water resources division to regulate surface and groundwater rights according to the doctrine of *a priori* appropriation. Water rights authorise irrigators to pump a limited annual quantity of water and users must report annual water use data (including annual quantity pumped, pump rate, type, and place of use, point of diversion) to the Chief Engineer. Noncompliance with these requirements result in civil penalties.

In 1972, the Kansas Groundwater Management District Act (KGMDA) established five groundwater management districts (GMDs) for the Ogallala aquifer to foster local control over the resource. The GDMs have no independent administrative or legal authority but they can tax, purchase, sell real property, and regulate water use within these districts. By the late 1970s, aquifer depletion became a public issue and the KGMDA was amended to enable the Chief Engineer to create Intensive Groundwater Use control Areas (IGUCAS) to impose reductions in pumping. However, vested interests of large irrigators prevented the establishment of IGUCAS over the Ogallala Aquifer because they distrusted the authority of the Chief Engineer, whom they perceived as a regulator who would impose excessive reductions in authorised pumping.

In 2010 and 2011, a group of irrigators decided to generate their own plans to cope with groundwater depletion. They pushed for the establishment of Local Enhanced Management Areas (LEMA) which gave more local control to irrigators over corrective control provisions than did the IGUCAS. In 2013, the first LEMA was created in Sheridan and Sherman counties in Northwest Kansas, and imposed a 20% reduction in irrigation pumping over approximately 100 square miles of land. The plan set a maximum amount of water that could be pumped over a five-year period, while giving flexibility to irrigators to decide which portion of that water to allocate each year. The target was successfully achieved with no harmful economic effects on the agriculture sector.

Self-impose groundwater-pumping fees in San Luis Valley (Colorado)

After facing continued groundwater depletion and a threat of state intervention to shut down wells, farmers in the San Luis Valley (Colorado) decided to collectively reduce their withdrawals via self-regulation. Sub-districts were created and irrigators within the Rio Grande Water Conservation District implemented a variable pumping fee that internalised the scarcity value of groundwater (in 2012, the tax was USD 75 per acre foot). Unlike command and control regulations, this financial incentive allowed irrigators to vary their own response and adjust to the tax through technology, crop, and irrigation choices. This natural experiment resulted in a 33% reduction in groundwater use, mainly through lower irrigation intensity. The outcome was attributed less to a shift away from water-intensive crop, but more to a reduction in the acreage irrigated.

Overall, putting a price on groundwater raised awareness on its scarcity and value, and increased the willingness of farmers to change irrigation practices.

Source: Griggs (2014[109]); Smith et al. (2017[48])

Rebalance economic incentives: Compensation for additionality, differentiating options locally

The main long-term benefit of groundwater management is increased water security for all users, including farmers. Regulating groundwater use can be presented as a means to solve a co-ordination failure that stuck famers in a bad policy equilibrium and would have otherwise led to groundwater depletion and future losses in farmers' income. Another benefit may be that farmers will not have to pay to dig wells deeper since a greater stability of groundwater levels would be guaranteed. A reform may also enhance the legal environment surrounding groundwater rights or well permits, and increase the likelihood that groundwater will not be further depleted by illegal drillers.

Compensation may be applied if farmers contribute to further efforts to increase groundwater recharge. There are multiple examples of cities or water-using industries that either exchange surface water allocation for groundwater recharge or provide financial transfers to farmers who contribute to recharging aquifers without harming groundwater quality (OECD, 2015[110]). In Kumamoto City in Japan, an effective "payment for ecosystem services" scheme was introduced by a local technology company with third party participation from the municipality to pay farmers to use flooded irrigation techniques with the objective of offsetting the company's groundwater consumption by farm-induced groundwater recharge (OECD, 2017[111]).

The efficiency-equity trade-offs that are prevalent in groundwater management may be partially addressed by adapting regulations locally. Equitable regulation – e.g. uniform quotas or equal allocation of groundwater pumping rights – is efficient only if there is little spatial variation in the benefit function of users and their impact on groundwater (OECD, 2015[9]). But the more heterogeneity in the users, hydrology and level of water stress, the more the regulation needs to be targeted based on the profile of the irrigator, and hydrology and irrigation technology. Instituting equitable approaches at the local level can help to advance on both fronts.

For instance, the aquifer located in the French region of La Beauce— the largest aquifer in Europe and France's largest cereal region– transitioned from a uniform ban on water withdrawal to an individual condition-dependant quota system. In 1993, considering the recurrent depletion of the water table exacerbated a three-year period of droughts, local authorities introduced a temporary ban on pumping. But this decision faced resistance by irrigators. After rounds of discussions within the multi-party inter-basin commission, an original individual quota system based on farm location and acreage was designed in 1999,

assigning quota reduction according to thresholds in the average water table (Petit, 2009[112]). However, the system did not reflect the difference in parts of the aquifers; in 2010, four aquifer zones were created with differentiated coefficients to be multiplied by the applied reduction. Farmers are informed in advance of their annual volume of water and can plan accordingly their cropping pattern and save portions of water from the quota to use it in the following years (Graveline, 2018[113]).

Adjustable smart reform sequencing: Spatial and temporal sequencing, applying a smart reform package

Groundwater policy should be introduced gradually, both spatially and temporally. Pilots areas can be set in sub-aquifers with priority given to areas that face water stress (Foster and Kemper, 2006[106]; OECD, 2015[9]; OECD, 2017[1]). The reform sequencing should start with the elaboration of long-term goals adapted to the aquifer situation, with a clear timeframe for each defined groundwater unit. Stakeholders should then be free to operate and meet the targets before the end of the period, at which time sanctions could be implemented. Regular monitoring of groundwater levels will help assess progress and implement revisions when necessary. The 2014 California Sustainable Groundwater Management Act is an example of a performance-based process setting long-term sustainable objectives implemented by local agencies with credible sanction in case of non-compliance. Groundwater Sustainable Agencies were created to adopt Groundwater Sustainability Plans in medium and high priority areas by 2022 and implement them by 2042. If local agencies fail to implement the objectives on time, the state will take over their responsibilities (Gruère, Ashley and Cadilhon, 2018[14]).

Groundwater policies should be accompanied by credible monitoring and enforcement of sanctions in case of violations (OECD, 2015[9]; OECD, 2017[105]). Monitoring the aquifer situation include studies and assessments of water quality and metering groundwater extraction. Individuals meters on wells capture individual efforts to reduce groundwater extraction and provide an alternative to the average measurement of water uptake that penalises virtuous farmers and benefits those who over extract the resource. However, measuring individual groundwater pumping may face fierce resistance from farmers and does not guarantee effective enforcement (OECD, 2017[105]). Voluntary reporting of meter data may provide little incentives for accurate reading unless there is a threat of fines and penalties for violators (OECD, 2015[9]). Conversely, agents can undertake water meter readings, but this could fuel a climate of distrust. La Beauce found a balance between these two approaches: farmers voluntarily declare online their uptake of groundwater, while the government undertakes random controls. Thanks to a climate of trust, farmers accurately declare their water uptake even when they exceed their quotas (Graveline, 2018[113]).

Addressing nonpoint source pollution from agriculture

Despite substantial progresses, water quality remains a significant challenge in OECD countries because of diffuse pollution caused primarily by agriculture run-offs or seepage of nutrients (OECD, 2017[21]). Diffuse pollution may appear negligible at the farm level but can have serious aggregated impact on water quality at the sub-catchment or river basin level, affecting the aquatic ecosystems, and other water users (OECD, 2013[56]). In Europe, for instance, the 2018 assessments on the implementation of the Water Framework Directive underlined that excessive emissions of nutrients and chemicals from fertilisers and livestock manure remains one of the main pressures on surface water body and an

obstacle to achieving "good ecological status'' in European waters (European Environment Agency, 2018[114]).

Ineffective policy architecture is partially responsible for this situation **Invalid source specified.**. Diffuse agricultural water pollution involves a wide range of actors with various farming systems and practices, creating high transaction costs to co-ordinate the responses of individual farmers. Governments remain reluctant to strictly regulate diffuse pollution and to apply the polluter-pays principle and to co-ordinate their efforts across watersheds, sub-national jurisdictions, and countries in order to address the multiple sources and impacts of diffuse pollution (OECD, 2012[8]). Instead, OECD countries generally rely on voluntary mechanisms to manage non-point source pollution even though their impact on water quality are limited (Albiac, 2017[70]). These instruments often fail to address diffuse pollution because they do not target the major polluters and rely excessively on subsidy-based programmes that face increased public budget constraints **Invalid source specified.**.

Calls for policy changes in this area can result from mediatised scientific water quality assessments, affected citizens facing unsafe drinking water, visible river and coastal water algae bloom phenomena, water utilities paying too much for water treatment, or even from government agencies realising via evaluations that their efforts do not pay off.

Evidence-based problem definitions, policy objectives and evaluations: Diagnosing local situation and assessing relevant options

Unlike other reviewed water challenges, agriculture's main water quality problems — nutrient runoffs— are relatively well-understood.[30] The problem is to evaluate the exposure and hazard pathways, and their impact within specific basins and to design locally customised effective responses.

Advanced data and modelling are increasingly used to help assess diffuse pollution problems. Incomplete and asymmetric information on water diffuse pollution creates uncertainty on the definition of the problem and complicates the measurement of any policy's outcome. Neither regulators nor farmers know exactly where, when, and how nutrient or other pollutants flows into a water basin. Limited information on non-point source pollution is compounded by the multiplicity of pollutants coming from various farming systems and practices, the non-observability of the pollutants, their high spatial and temporal variability, and the complex pathways they may follow (e.g. surface water flow, ground water flow, atmosphere) (Shortle and Horan, 2017[115]). Thankfully, models combining hydrological systems and agronomic parameters can help to obtain increasingly accurate if imperfect assessments. Remote sensing and the use of sensors can also validate such assessments.

Policies to tackle diffuse pollution may miss their target if they are not well-tailored to a specific context, and if the outcome is not regularly measured and analysed. The case of western Lake Erie illustrates the complexity of solving diffuse pollution problems. In the 1990s, that part of the lake was subject to serious eutrophication due to phosphorus runoffs. To tackle this situation, farmers were required to reduce their application of fertilisers or manure and encouraged to adopt conservation practices, particularly no-till. These efforts,

[30] Pesticide runoffs are also problematic in certain regions. Recent discussions have focused on contaminants of emerging concerns, some of which originate from agriculture activities (e.g. antibiotics and drugs for animals) (OECD, 2017[21]).

in combination with point source pollution control, including wastewater treatment plant upgrades, resulted in an observed decline of dissolved P concentration.[31] However, this progress was reversed starting in 1995 with a rapid increase of P causing new episodes of algae bloom in the lake. Studies have shown that the increase in dissolved P coincided with the voluntary adoption of no-till practices encouraged by industry and conservation agencies in the mid-1990s (Kleinman et al., 2015[116]). This is due to the fact that conservation practices designed to reduce erosion and particulate P transport may, under specific conditions, increase dissolved P loads (Jarvie et al., 2017[117]).

Policy makers must also be aware of delays in catchment response to nitrogen and phosphorus mitigation measures when designing measurement and evaluation programmes. The persistence of historical pollution and time lags between the introduction of pollution control activities and their impact on water quality complicates the evaluation of pollution mitigation programmes (Shortle and Horan, 2017[115]). Data to track spatial and temporal changes in water quality may not immediately reflect the effectiveness of nutrient mitigation measures and change in land use. The positive effects on water quality can occur from 1 to 10 years after the implementation of changes in farm practices, with the time lag increasing the larger the catchment size (Melland, Fenton and Jordan, 2018[118]). It takes even longer – between 4 and 20 years – to statistically measure significant groundwater quality changes (Ibid). Hydrological time lag is explained by the travel time for nitrogen in groundwater and by the adjustment period of thousands of individual farmers who must accept cultural and structural changes in agricultural practices to meet new regulations (Kronvang et al., 2008[119]).

Given these different scientific challenges, policy research remains critical in helping guide policy makers towards locally-tailored and effective solutions. Recent research approaches are aimed at combining hydrologic, soils, and agronomic models with farmer behavioural responses to help provide simulations of targeted or hotspot approaches (Garnache et al., 2016[120]; Liu et al., 2018[121]). Preparing a reform in this area will benefit from recent knowledge to build on innovative ideas, while avoiding repeating past mistakes.

Align governance and institutions: Co-ordinating actions at different levels, partnering with others, engaging public agents

Limits to existing water governance systems may reduce the effectiveness of new policy efforts to tackle diffuse pollution problems. First, the management of diffuse pollution must be made at the local level, which requires sharing and coordinating with different levels of government to respect the overarching objectives. Because diffuse pollution is largely linked to hydrological processes, the catchment or basin scale is often the best scale for management (OECD, 2017[21]).[32] The objectives should also be defined with a sufficiently long-term horizon to obtain observable results. Catchment approaches, which are increasingly being considered as effective solutions for water quality, rely on water management at the basin level, sometimes interfering with agriculture administrative levels (Gruère, Ashley and Cadilhon, 2018[14]; OECD, 2015[110]). Hotspot regulatory approaches that go beyond catchment to determine which farms are contributing the most to a pollution

[31] More details are available in Section 2.4 of Environment and Climate Change Canada and Ontario Ministry of Environment and Climate Change (2018[126]).

[32] Efforts should be made to ensure that stakeholders understand how their water usage impacts other parts of the catchment basin. Basin-wide initiatives may not always be the most appropriate scale to address water demand in agriculture on a micro scale.

problem also require a combination of broader modelling with farm level advisory services requiring co-ordination between different administrative and regulatory agencies.

Second, water pollution is generally too complex to be managed by a single agency and therefore co-operative partnerships between agencies, land managers, and other interest groups such as cities, water utilities, and water user association are necessary (OECD, 2013[56]). This is especially true when considering policies that involve partnerships between water users, e.g. between cities and farmers (New York, Munich, Rennes) (OECD, 2015[110]).

Government agencies may also benefit from looking at the potential need to revisit their staff organisation and skills to change the work paradigm to achieve greater progress. In Scotland, for instance, in view of the low compliance with existing regulations on nutrient emissions, the Environmental Protection Agency shifted the focus of its staff from monitoring non-compliance and enforcement to collaborating with farmers towards a pollution reduction goal (Scottish Environment Protection Agency, 2012[122]; OECD-European Commission, 2018[18]).

Strategic stakeholder engagement and trust-building: Choosing options, outreach and communication activities

Stakeholder engagement is needed to determine the level of acceptable water pollution to society and to set regulations at the local level (OECD, 2013[56]; OECD, 2017[21]). The Canterbury Water Management Strategy (CWMS), developed between 2007-2009 in New Zealand, is a good illustration of a collaborative governance framework where "local people plan locally" (OECD, 2017[123]). Under the CWMS, the Canterbury region was divided into ten zones managed by a Zone Committee, with representatives of the local community, the district and regional councils, and the Māori (indigenous) tribal authority. Each committee is in charge of developing Zone Implementation Programmes to meet overarching targets. Stakeholders are involved in the deliberations and decision making (in the form of field trips, workshops, and one-on-one meetings). The work of the committees is supported by a technical staff (including scientists) to help stakeholders understand the issues. Reaching a consensus may take time under a collaborative governance framework, but then it facilitates the ownership and acceptability of solutions and therefore their implementation by local actors (Ibid.).

Exchanging knowledge directly with farmers is essential to facilitating the adoption of best nutrient management practices. Farmers need to be equipped with an adequate level of technical skills to identify and implement these practices. A survey conducted in the western Lake Erie Basin showed that farmers' belief in the effectiveness of a recommended practice was the strongest factor of adoption of best nutrient management practices (Prokup et al., 2017[67]). Therefore, it is essential to provide farmers with certainty and confidence on the outcome of new technologies and practices to overcome their initial reluctance. To that end, applicator training and expert farm advisors providing personalised and hands-on information can equip farmers with the will and ability to effectively implement change (Inman et al., 2018[124]; Prokup et al., 2017[67]). In the United States, an increasing number of state agencies are developing data visualisation tools and on-field technology demonstrations (Gewin, 2018[125]). In Ireland, regulators experiment with innovative approaches to encourage farmers to improve water quality through personalised communication and farm advisory programmes (Box 4).

Trust in the source of information and in the person providing the outreach is equally important to convince farmers to change their practices (Prokup et al., 2017[67]; Blackstock

et al., 2010[33]). Crop consultants and extension personnel are generally perceived by farmers as trusted sources. A study conducted in the US Midwest suggests that farmers are more likely to trust information on water conservation when it comes from people sharing similar goals and values, or from a familiar organisation such as government agencies (Mase et al., 2015[57]).

The adoption of best management practices also relies on social norms and peer pressure. Farmers often trust their counterparts who have successfully adopted new technologies and practices. Building on this insight, the Belgium Watering Organisation working in the Dommel Valle to foster the adoption of buffer strips developed informal contacts with farmers and referred to a trustworthy and admired farmer involved in the programme to convince his peers to follow his example (OECD, 2013[56]). Encouraging farmers to share their personal experiences and to learn from each other is also important to complement farm advisory programmes. The Canada-Ontario Lake Erie action plan supports peer-to-peer learning initiatives to reduce phosphorous loading into the lake. Among these initiatives, a coalition of farm organisations in Ontario ("The Timing Matters" peer response) is an example on informing producers about the risks associated with spreading nutrients on snow-covered ground and helping them to identify practical alternatives (Environment and Climate Change Canada and Ontario Ministry of Environment and Climate Change, 2018[126]). In the US Midwest, a growing number of no-till and cover crop practitioners are using online demonstration farms and social media to share images and videos to connect with other farmers and exchange best practices (Gewin, 2018[125]).

Box 4. Innovative approaches in Ireland encouraging farmers to improve water quality

The overall quality of water in Ireland has improved since 2006. Nevertheless, the 2017 European Water Agency report on water quality showed that only 57% of rivers and 46% of lakes had either good or high status under the requirements of the Water Framework Directive. The level of seriously polluted water declined over the period 2010-2015, and yet there was a decrease in the number of the highest quality sites. Nutrient losses from agriculture and domestic watershed discharges were identified as the main reasons for the lack of improvement in Ireland's water quality standards. Water quality in Ireland is also facing increasing pressure from the ever-expanding dairy industry.

Irish farmers are subject to regulations to ensure water quality and preserve the ecosystems. Under the Nitrates directives, farmers must not exceed 170 kg of nitrogen from organic manure applied per hectare per year. Despite the threat of costly EU fines and penalties, non-compliance remains an issue which encouraged Irish regulators to test new approaches to increase the effectiveness of the reminder letters sent to farmers. Using insights from behavioural sciences, regulators crafted and targeted communication with personalised message sent to farmers in order to reduce complexity and the likelihood of procrastination to meet nitrate emission regulation.

In addition to a simplified communication strategy that improved compliance with regulations, Ireland developed farm advisory programmes and predictive models to assist farmers to anticipate water pollution. In 2017, the government launched a "Sustainability Support and Advisory Programme'', a four-year trial initiative to improve water quality. The programme relies on a cross-sector approach based on a public-private partnership implicating two ministerial departments (based in the Ministry for Agriculture, Food and the Marine and the Ministry for Housing, Planning and Local Government), the local authorities, Teagasc (the agriculture and food development authority), the Dairy Co-ops and Bord Bia (the Irish Food Board). The programme involves the establishment of 30 trained agricultural sustainability advisors who will work closely with farmers to protect water quality. These advisors support change in practices and facilitate knowledge transfer to achieve better farming practices in 190 priority catchments identified by the EPAs in consultation with departments and government agencies. The dairy co-ops will support farmers to manage on-farm risks, promoting best farmyard and nutrient management processes across their suppliers.

Sources: OECD-European Commission (2018[18]); Irish Environmental Protection Agency (2017[127]); Teagasc (2017[128]).

Rebalance economic incentives: Providing information, allocating discharge allowances

Financial compensation for farmers should in theory only apply if farmers provide a measurable effort above the regulatory requirements (OECD, 2010[129]). In such cases, targeted and performance-based payments could be implemented, with interim evaluations as needed (Ibid). Examples involving cities in Europe and the United States, or within catchments in the United Kingdom, show that supporting farmers can help with making progress (OECD, 2015[110]; Gruère, Ashley and Cadilhon, 2018[14]).

At the same time, in-kind advisory support and innovative information tools may help in the transition to more stringent regulatory policies on water quality. The European Commission 2018 proposal for the Common Agriculture Policy includes a requirement for beneficiary farmers to use a dedicated electronic tool called the "Farm Sustainability Tool (FaST)" as a means to optimise the use of nutrients. The tool was developed by the Commission and allows farmers to obtain precise information at the field level on best practices to apply fertilisers (World Bank - OECD, 2018[19]).

The efficiency-equity trade-off needs particular attention in the case of policy instruments that target farms based on their location. This is the case, for instance, of instruments that allocate agricultural nutrient discharge allowances (water quality trading) based on the land use absorption capability (e.g. natural capital approach) rather than on current or past land use.[33] Economic modelling suggests that there is no universal "best" allocation approach, the best choice depends on existing land use, land characteristics, and the stringency of the regulation (Greenhalgh, Daigneault and Samarasinghe, 2015[130]).

The approach based on current land-use is the most commonly adopted in OECD countries as it protects current land use configuration. The grandparent approach (in which nutrient loss limits are allocated based on past nitrogen leaching rates during a baseline) is not efficient because historic polluters are rewarded even though they may be able to reduce pollution at a lower cost. Moreover, this approach creates high opportunity costs for property owners who have not yet developed their land or who may wish to intensify production (OECD, 2017[21]).

The natural capital approach consists in allocating a nutrient discharge allowance according to the natural biophysical resources in the catchment area (land use capability), thereby encouraging intensification of the most productive land. This innovative approach, implemented in the Manawatu-Wanganui region of New Zealand, relies on the idea that different soils and topographies differ in their productive potential and their ability to filter and retain water and nutrients (Ibid). This approach has the advantage of not restricting future land use options and to treat owners with the same soil resources in the same manner (OECD, 2017[123]). However, decoupling pollution allocation from land use may seem unfair because farmers with similar crops and agricultural practices may have to reduce their nutrient leaching differently according to their location and soil quality, independently of their land practice. Moreover, new farmers may have to pay for the bad soil use management practices of previous landowners (Ibid).

[33] Denmark is studying the possibility of customising regulatory requirements for farms depending on their location (Box 5), with the aim to have a flexible compensation system that accounts for such additional requirements.

To correct the inequity of certain allocations of pollution allowance, compensation should be set for farmers who have the lowest pollution abatement potential, the fewest mitigation options, and less ability to pay for a reduced level of pollution (OECD, 2017[21]).

Adjustable smart reform sequencing: Spatial targeting, applying smart reform package

Spatial sequencing is important to consider when designing policy response to diffuse pollution. The cost-effectiveness of a water quality policy instrument varies greatly across and within watersheds, which calls for spatially-targeted measures to achieve the greatest impact on water protection **Invalid source specified.**. Prioritising the risk of diffuse pollution and then targeting the most vulnerable areas (or hotspots) should be employed, rather than implementing policy instruments in a scattered fashion (OECD, 2017[1]). In Denmark, several studies have shown how spatially differentiated measures can achieve both maximum pollution reduction and minimum loss of production via decreases in agricultural land (Box 5). In Pennsylvania, the Chesapeake Conservancy uses a high-resolution digital mapping tool to prioritise areas where riparian forest buffers are the most cost-effective in improving the quality of the waterways. This tool generates a customised report with information on the watershed and wild life species living in the farm area and, according to the selected management priorities (e.g. improving hunting and fishing or supporting agricultural land uses), farmers can learn about tailored restoration practices (Chesapeake Conservancy, 2017[131]).

Box 5. Spatial targeted regulation of mitigation measures in Denmark

Denmark was one of the first countries in Europe to become aware of nitrogen pollution. Since 1985, the country has implemented seven national Action Plans to address pollution from point sources and diffuse losses in agriculture. Historically, the regulation on nitrate diffuse pollution was based on two main instruments: a mandatory fertiliser and crop rotation plans and a norm for the ratio of manure to plant. The design of the regulations involved researchers and farmers, and has been followed up by extension and education. The nitrate regulations have proven successful in improving the nitrate efficiency in farming systems and reducing nitrate leaching.

However, despite significant reduction of nitrate leaching since 1990, current nitrogen (N)-loading to coastal water does not yet respect the level set by the Water Framework Directive. The N-regulation remains largely input-based and is applied uniformly without considering the required N-load reduction targets for a given catchment. In 2016, the Food and Agriculture Package introduced for the first time targeted measures to reduce N loadings to surface waters and groundwater but such policy has not been yet been implemented.

Several studies have pointed to the need to develop a new targeted and differentiated regulation to improve management of nitrogen in agriculture in Denmark. Spatially differentiated measures, if correctly designed, can achieve both maximum pollution reduction and minimum loss of production through a reduction in agricultural land. Several modelling studies have focused on targeting regulations to apply N-mitigation measures in areas with low natural process reduction of nitrate (N-reduction). A key instrument to assessing critical source areas is N-reduction maps that show the amount of N removed by natural processes – the ratio between the N-load out of the catchment and the N-leaching from the root zone for each spatial unit of the catchment. The greater the spatial variation across the catchment and the farm, the greater the potential to target measures for N load reduction. Hansen et al. (2017) found that spatially-targeted regulations have greater benefits over a spatially uniform regulation in the Nordsminde catchment in Denmark. Indeed, the reallocation of the existing agricultural practices to critical source areas can decrease the N-load of the catchment area by up to 8% without any decrease in fertilization inputs.

Source: Hansen et al. (2017[132]); Hashemi et al. (2018[133]); Kronvang et al. (2008[119]).

A water pollution management framework needs to be adjustable over time. Hydrological time lags make it difficult to track spatial and temporal changes, and to attribute water quality outcomes to specific measures. Moreover, the nature of the problem may vary over time especially when the initial assessment of the situation was complicated by divergent opinions and lack of data. The reform process should be sufficiently flexible to adjust to unexpected outcomes. For instance, the 2018 Canada-Ontario Lake Erie action plan to reduce phosphorus loadings into Lake Erie integrates a review mechanism every five years that will allow for the possibility to adjust the plan over time (Box 6).

Box 6. The Canada-Ontario Lake Erie action plan to reduce phosphorus pollution

The Canada-Ontario Lake Erie action plan aims to reduce phosphorus loadings into Lake Erie. The plan is a response to the eutrophication of the lake that has led to the proliferation of harmful and nuisance algal blooms as well as zones of low oxygen (hypoxia), threatening the ecosystem and human health.

The plan is based on five principles:

1) *Science-based foundation:* The action plan was built on 40 years of field data, published reports, and current ecosystem-level understanding. During the monitoring phase, research and modelling programmes will provide data to control the effectiveness of the action plan but also to consolidate knowledge on the sources and impact of phosphorus pollution to the lake.

2) *Continuous improvement:* The plan is based on an adaptive management framework to assess progress toward targets and change direction if needed. Every five years, a review mechanism will give the possibility to adjust the plan over time either by reassessing the nature of the initial problem, setting new goals and objectives, or designing new actions based on additional research, pilot or full-scale experiments. This iterative process should provide a mechanism for continuous improvement. The implementation and the results of the action plan will be monitored and evaluated by regulatory agencies and partners, and used to inform the research agenda. Performance measures will be supported by a rigorous metric to track the impacts of actions over time, including changes to phosphorus loadings.

3) *Shared responsibility – collaborative approach:* The Action Plan relies on the effective engagement of stakeholders. During the development phase, Canada and Ontario established a multi-sectoral Lake Erie Nutrients Working Group, which engaged Indigenous communities, municipalities, conservation authorities, environmental organisations, members of the agricultural community, and the public. Early actions and a draft plan were posted online to gather additional feedback from stakeholders while input was also gathered through in-person engagement sessions and written submissions. During the reporting process, partnering agencies will be involved and each participating agency is committed to making its data available to a broader audience through the Canada–Ontario Agreement on Great Lakes Water Quality and Ecosystem Health.

4) *The plan will be supported by a communication strategy* to educate farmers and citizens in general about phosphorous pollution to encourage behavioural change and the engagement of communities. Educational programmes will connect teachers, students, and school boards with opportunities to use Lake Erie and its watersheds as a context for teaching and learning. In the agricultural sector, the plan supports the communication of best practices through educational materials, events, technology demonstrations, and peer-to-peer learning opportunities.

5) *Economic sustainability:* This plan aims to protect the economic value of Lake Erie watershed's natural resources, water quality, and ecosystem integrity for future generations.

Source: Environment and Climate Change Canada and Ministry of Environment and Climate Change of Ontario (2018[126]).

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