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MEASURING PROGRESS IN AGRICULTURAL WATER MANAGEMENT:
CHALLENGES AND PRACTICAL OPTIONS

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Measuring Progress in Agricultural Water Management: Challenges and Practical Options

Guillaume Gruère and Makiko Shigemitsu

Measuring policy progress on agriculture and water policies is essential to help decision makers identify necessary policy changes and understand how further progress may be achieved to improve agricultural water management. A thorough review of existing evaluations of agriculture and water policies suggests three types of progress to be measured: policy design, policy implementation capacity and policy results. The quality and robustness of these measures of policy progress depends upon three main factors. First, assessment of policy design requires matching policy alignment with cross cutting objectives or with a reference text. Second, assessment of progress in implementation capacity requires gauging evolution towards predefined capacity needs or identified governance gaps. Third, evaluation of policy results requires clearly defined objectives, timelines and scales for assessments. Seven practical options are identified for applying these principles to agriculture and water policies, illustrated by applying them to assessing progress in the sustainable management of water for irrigation under climate change and in controlling diffuse nutrient pollution.

Keywords: Agriculture policy, water policy, policy evaluation, reform process, water pollution, water scarcity, water risks

JEL Codes: Q18, Q25, Q28, Q58

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Key messages

- Agriculture and water policy progress can be measured in terms of policy design, implementation capacity, and policy results. The quality and robustness of these measures depends upon the extent to which specific principles are applied in each type of assessment.
    - Assessing *policy design* requires matching a policy change with cross cutting objectives or measuring policy alignment with a reference text.
    - Assessing progress in *implementation capacity* requires gauging the evolution towards predefined capacity needs or identified governance gaps.
    - Evaluation of *policy results* necessitates a good definition of objective, timeline and scale of assessment. This should account for the evolution of existing policies, the relative effects of policy changes versus factors and policy changes, and should analyse the cost effectiveness of alternative policy changes.
- Seven practical options are available for applying these principles to agriculture and water policies: policy screening, policy modelling, developing indicators, comprehensive policy reviews, surveys of stakeholders and ex-post quantitative evaluation.
- Case studies on the sustainable management of irrigation under climate change and on diffuse nutrient pollution management highlight the difficulties associated with uncertainties, imperfect data and measurement, and measuring policy progress across multiple objectives.

Executive Summary

Agriculture and water policy challenges are increasingly interconnected. Agriculture depends on water and faces growing water risks in many regions, largely due to water-related disasters and competition with other sectors for water use. Surface and ground-water resources are also under pressure in many watersheds from intensive irrigation practices, erosion and pollution associated with farming activities. While their degree and scale is unevenly distributed, and relatively concentrated in some agricultural regions, these challenges affect most OECD countries and are continuing to evolve.

Orienting agriculture and water policies – defined here as all policies that affect the interaction of agricultural production with water – to cope with these challenges requires an understanding of past progress and areas for further improvement. This paper discusses ways to measure policy progress on agriculture and water policies to help decision makers identify necessary policy changes and understand how further progress may be achieved.

The analysis demonstrates that the quality and robustness of measures of policy progress, whether in terms of policy design, policy implementation capacity, or policy results, depends upon the extent to which specific principles are applied in each type of assessment.

Assessing progress in *policy design*, which involves reviewing the specific features of policy changes, should be based on clear criteria specifying the reference text for comparison or cross-cutting objective against which policy alignment is assessed, preferably using an evaluation grid. In practice, this may be done by screening policies for compatibility with cross-cutting objectives or a reference text, conducting simulations on a farm or water system, or developing indicators to track the distance of a policy change to a reference policy design.

Assessing progress in *policy implementation capacity*, which involves monitoring efforts to fill technical, financial and human capacity gaps, or to address water governance weaknesses that may constrain policy implementation, requires measuring changes in capacity with predefined capacity needs or identifying governance gaps and assessing their impact on implementation. In practice, this can be done via comprehensive reviews of policies and the capacities for their implementation, or screening the coherence of policy changes with water governance systems.

Assessing progress in *policy results*, which involves evaluating how a policy change leads to changes in agricultural water management practices or environmental outcomes (such as groundwater or pollution levels), requires the application of four principles:

- Defining progress, as well as the timeline and geographical scale for evaluation.
- Accounting for the evolution of existing policies and other factors in the absence of policy changes (the counterfactual).
- Attributing the role of the specific policy change in comparison with other policy changes.
- Analysing and identifying modalities that may lower the cost and improve the effectiveness of the policy change.

In practice, there are four possible approaches through which these principles can be applied: monitoring policy outcomes via indicators; conducting comprehensive policy reviews combining semi-quantitative and qualitative information; quantitative analysis of the impacts of a policy on the target population and the environment; and quantitative analysis of the impact of the policy on specific outcomes.

Applying these principles to the challenge of managing irrigation sustainably under climate change shows that problem definition is not trivial. Considering how to orient policies involves looking at how irrigation can remain economically advantageous for agriculture while coping with increasing water risks and reducing the potential impact on other users and the environment. A review of selected evaluations suggests that attribution and the modalities of policy change are usually taken into account, but not other factors. For instance, reviewed evaluations of irrigation policies increasingly factor in climatic changes during the period of inquiry, but typically do not account for the role of agricultural market trends in observed changes in irrigation use.

For management of diffuse nutrient pollution, the difficulty lies in uncertainties associated with the measurement of pollution and associated monitoring, due to incomplete and asymmetric information. Examples in this area, which encompass policy outcome monitoring and comprehensive policy reviews, suggest that uncertainties affect not only the measurement of possible policy results but also the possible role of other factors. In particular, it is difficult to measure the impact of a policy encouraging the adoption of better farm management practices on the concentration of pollutants in water bodies. In this context, an improved understanding of the functioning of a particular policy change may be a more realistic objective than reaching a broad estimation of the impact of a policy change on pollution.

Monitoring of agriculture and water could more explicitly consider both the type of progress and principles required, and the limitations and potential biases associated with particular approaches. The relationship between the three dimensions of policy progress defined in this report could be worth exploring further to support more comprehensive evaluations. New approaches taking into account the uncertainty associated with measurement may allow both a better sense of the risks and sufficient scope for future policy changes.

1. Policy evaluations act as beacons to navigate agriculture and water reform processes

Agriculture faces multiple water challenges, ranging from the sustainable use of available water resources, coping with water-related climate risks, and minimising its impact on water quality. Droughts that occur in multiple regions every year, and that are increasing in frequency and severity in some regions of the world, affect agriculture production more than any other sector (OECD, 2017[1]). More frequent episodes of heavy precipitation affect field and livestock activities (OECD, 2016[2]). Agricultural pollution of water is an environmental challenge shared by all OECD countries and a growing number of non-OECD countries, albeit varying in extents, scale and importance (OECD, 2019[3]). Given the high share of water consumption by agriculture, and the role farming plays as a key source of diffuse pollutants, these challenges generally largely exceed other water challenges in food supply chains (Ercin et al., 2011[4]; Chico, Aldaya and Garrido, 2013[5]; Ruini et al., 2013[6]). That said, they percolate through the food chain, contributing to the triple challenges facing food systems (OECD, 2021[7]), and threatening achievement of the Sustainable Development Goals (SDGs), especially SDG 2 (food) and 6 (water).

While the decisions of farmers in particular, and also of food companies, are important in tackling these challenges, agriculture and water policies have a significant role to play in steering their decisions in the right direction (OECD, 2017[1]). First, water used in agriculture is rarely a pure private or public economic good; in fact it is often a club good or a common pool resource, but irrigation competes with water uses other than agriculture (OECD, 2016[2]; OECD, 2015[8]). Second, water risks associated with extreme weather events often belong to the “catastrophic” risk layer, whereby private actions and market- based insurance are insufficient for farm actors to cope and rebuild (OECD, 2009[9]; OECD, 2020[10]). Third, diffuse or non-point source water pollution,[1] such as that associated with the runoff of agricultural nutrients, is a negative environmental externality of agricultural production that cannot be solved without public intervention (OECD, 2012[11]; OECD, 2017[12]). Equally, positive externalities associated with good soil and water management are not rewarded sufficiently to encourage upscaling (OECD, 2015[13]). Furthermore, many of the key issues for agriculture water management also face information constraints, from climate-related weather variables, to complex multilayer aquifers, and pollution depending on soil, water, crop uptakes, animal feed and the dynamic choices of multiple actors on a watershed that may constrain individual agricultural water management (Gruère and Le Boëdec, 2019[14]). Policy improvements in these areas are also needed.

At the same time, due to their important role, inadequate agriculture and water policies can aggravate the water resource and environmental challenges for the sector. Policies incentivising the use of water (and specifically groundwater) in dry areas or the use of potentially polluting inputs, can be harmful to water resources (Gruère and Le Boëdec, 2019[14]). More subdued policies, that encourage certain types of agriculture production directly or indirectly, subsidise insurance for marketable climatic risks, or agricultural exemptions from water regulatory requirements can also distort decisions of farmers in their use of water and management of agricultural inputs (OECD, 2020[10]; Gruère and Le Boëdec, 2019[14]). Moreover, given the context-specific nature of water challenges, policies that are working well in a particular context, may not be working in another context, due to the climatic or hydrological conditions, market structure characteristics, or unrelated factors (World Bank - OECD, 2018[15]).

Despite important reforms and policy upgrades in a number of countries, existing evidence shows that policy improvements are still needed particularly to address increasing water shortage risks and reduce the pressure of agriculture on aquatic ecosystems and other users (OECD, 2017[1]; Gruère, Ashley and Cadilhon, 2018[16]). Many OECD countries undertook significant policy changes from 2009 to 2019 (Gruère, Shigemitsu and Crawford, 2020[17]), but the intensification of water risks, growing competition for water with other sectors, and the persistence of pollution suggest that further efforts may be needed. The fact that reforms in water and agriculture take time and involve complex political processes suggests that early consideration of changes is necessary to address future water risks. Additionally, existing policies may not

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[1] The paper will refer to diffuse pollution, in consistency with the OECD Council Recommendation on Water (OECD, 2016[35]), but could alternatively be called non-point source pollution.

be effectively implemented, as reported, for instance, in cases of illegal water use mainly by irrigators (Loch et al., 2020[18]), or recent violations of nitrates regulations (Valo, 2014[19]; Stam, 2019[20]).

Identifying necessary policy changes or adjustments to achieve further progress requires sufficiently robust assessments of existing policies (Council of Canadian Academies, 2013[21]). Evaluations are necessary for effective reform processes, to motivate change, or indicate directions and adjustments on a reform pathway (Gruère, Ashley and Cadilhon, 2018[16]; Garrick et al., 2020[22]). A necessary condition for an effective reform process is to "support problem definitions, policy objectives setting and evaluations with robust evidence" (Gruère and Le Boëdec, 2019[14]); this encompasses diagnosing the situation at any particular stage and indicating where the reform is heading.

The aim of this paper is to identify general principles and practical options for governments to measure policy progress in agricultural water management. Building on the existing literature on applied policy evaluation and examples of policy assessments, the paper reviews different types of evaluations, identifies key principles for selecting evaluation methods and reviews possible approaches for policy makers. The analysis then considers specifically how to measure progress on two essential challenges: (i) managing water for irrigated agriculture under increasingly volatile climatic conditions in a sustainable manner, and (ii) controlling diffuse nutrient pollution to sustain water quality.

As a caveat, this paper does not aim to cover the breadth of evaluation methods used, nor discuss the advantages and limitations of each of the approaches. There is a broad and comprehensive economic literature on policy evaluation, including on the collection, use and statistical analysis of data. It also does not cover methods to assess potential future policy scenarios, whether via qualitative assessments, *ex ante* simulations or experimental approaches, as these approaches are generally not adequate to measure policy progress.[2] Instead, the paper focuses on general principles and approaches to be used principally by government agencies to assess their ongoing, recent or long term policy changes, with the view to helping guide their decisions on agriculture and water policy issues.

Part 2 discusses the different types of ways of measuring progress in agricultural water management and how these are applied by governments. Part 3 identifies key principles for these different areas, and Part 4 reviews practical options. Part 5 applies the principles to the challenges of managing irrigated agriculture sustainably under climate change and diffuse nutrient pollution control.

2. Measuring policy progress in agricultural water management: definition, typology and government rationale

Policy progress can be broadly defined as change in policy towards an objective (or expected policy result) over a certain period. Measuring policy progress involves analysing the extent of a policy-related improvement towards the overall objective or outcome from past to present (*ex post*).[3]

To gauge progress, policy makers may opt to monitor and/or evaluate a particular policy development. Monitoring policy progress over a certain period may involve looking at changes in an outcome or objective, but not necessarily explaining the role the policy might have had in the observed change.[4] In contrast, evaluating a policy change involves assessing the effects of this change without necessarily taking into

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[2] This does not imply that ex ante quantitative analyses cannot bring relevant elements for discussion. For example, Marshall et al. (2018[142]) and Ribaudo, Savage and Aillery (2014[143]) offer useful insights on policy options to control nutrient pollution in the Gulf of Mexico and the Chesapeake Bay, respectively. But they are not measuring policy progress per se.

[3] In a multi-dimensional policy context, assessment of progress may involve multi-dimensional analysis. Measuring the overall progress would then require an aggregation method. There are multiple tools offered in the utilitarian theory.

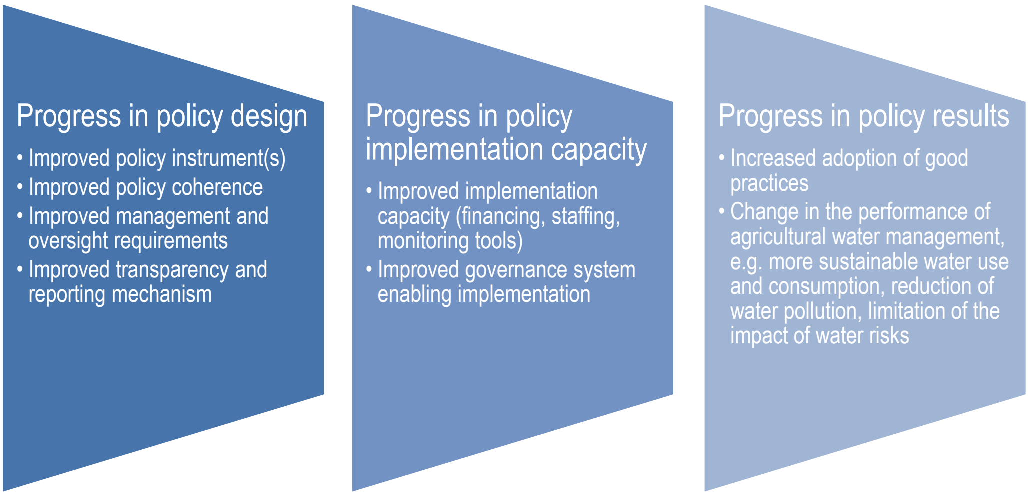
[4] Monitoring can also involve taking "snapshots" of a situation at different time to get an understanding of the changing landscape. For instance, the INEA research institute in Italy has conducted thorough assessment of irrigation systems in different regions such as Lombardy (Zucaro and Corapi, 2009[138]) or the Aosta Valley (Zucaro and Seroglia, 2013[139]).

account the evolution of its effects over time. Evaluating policy progress implies conducting regular evaluations consistently over time, to enable an understanding of how policy responds to changing conditions.[5] Iterative evaluations may also allow for adaptations, with adjustments in the measurement of progress to reflect changing uncertainty about data, and shifts in policy pathways (Gruère and Le Boëdec, 2019[14]).

Policy progress may pertain to the policy design, implementation capacity or results (Figure 1).[6] This typology applies, in particular, to progress in agricultural water management. For instance, a policy change may aim to control groundwater use in irrigation to limit aquifer depletion. Measuring policy progress in this area may involve (a) considering improvements in policy design (improved incentives, defined objectives, stakeholder consultation, reduced transaction costs) with respect to a past policy context; (b) considering changes from the initial situation in terms of implementation capacity, such as well monitoring, improved groundwater governance systems, or development of retention basins to facilitate recharge or (c) considering changes with respect to actual results, such as groundwater irrigation area, use, consumption or aquifer levels, via regular monitoring or a present to past comparison.

While these three types of progress can be sequenced, so that improved policy design may increase policy application and result in better outcomes, there is no guaranteed causality. Indeed there may be trade-offs and shifts in opposite direction; for instance, adopting a more sophisticated policy design may lead to impractical implementation and limited results.

Figure 1. Three types of policy progress



Source: Authors.

Furthermore, the purpose of evaluating the different types of progress may be different. A focus on policy design may be used when trying to identify policy gaps and consider how to orient further efforts in the medium to long term. An assessment of progress in implementation capacity may provide information on enforcement and funding gaps, while considering progress in policy results helps to gauge the effectiveness of a particular policy. Data or measurement limitations, either technical, or due to opposition by stakeholders, may limit assessment to a focus on policy design or application instead of considering results. Comprehensive measurement of policy progress would cover changes in design, capacity and (cost) effectiveness, and even consider how these are related.

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[5] In this report, one-off evaluations are considered as a means of measuring progress, just like policy progress monitoring or evaluation of policy progress.

[6] In the remainder of the paper, the third type of policy progress will be referred to as policy *results* evaluation, i.e. impact of a policy change. In contrast, *outcomes* are defined as changes in the environment that may or may not be due to policy changes.

There is a trade-off between the comprehensiveness, degree of accuracy, and robustness of an assessment and the time and efforts it requires. Ideally, all water basins facing water risks, including risks associated with agriculture, would be monitored carefully and frequently considering a wide range of factors. Such an exercise would enable a clear understanding of how water users behave, how policy and other factors influence agents and affect water resources. Yet, even in developed countries, despite sustained efforts, water consumption data is rare and only emerging, agricultural water use is only measured over long periods, aquifers and groundwater use are not all well-known, and diffuse pollution is still hard to track (OECD, 2019[3]; OECD, 2015[23]; OECD, 2017[12]).

In Italy, a dual information system strategy was developed to address some of the difficulties associated with the uncertainty of performance measurements and the measurement of policy progress. On the one hand, the National information system for the management of water resources in agriculture collects data and information on the use of water for irrigation; on the other hand, the National Database of investments for Irrigation and the Environment (DANIA) collects and shares information on investment projects for the sustainable use of water. The connection of these two databases supports the *ex-ante* identification of investments needs to address irrigation-related and environmental issues, and *ex post* evaluations of the effectiveness of the financed interventions.

At the same time, compromises between policy relevance and precision of assessment models are needed, as going further in precision may limit policy relevance (Borsuk, Stow and Reckhow, 2004[24]). Some evaluation methods, using Bayesian approaches, can be used to explicitly account for uncertainty (Brock, Durlauf and West, 2007[25]). For example, probabilistic graphical networks can incorporate analytical inaccuracies or the implications of imperfect information related to ecosystem interactions (Carriger, Barron and Newman, 2016[26]). These kinds of network approaches can also account for economic and non-economic factors, such as drivers of food sector and weather-related events.[7]

As in other policy areas, government efforts to measure progress in agricultural water management are commensurate with the importance of the issue among a broader set of priorities. Australia's Murray-Darling Basin Plan[8] is subject to frequent, in-depth review because of the critical importance of the Murray-Darling Basin's water resources to irrigators, communities, First Nation's people, industry, and water-dependent ecosystems in the driest inhabited continent on earth.[9] In contrast, agricultural water resource policies are rarely evaluated or monitored in countries that are relatively water abundant and where irrigation is done only for certain crops during particular seasons.

In federal countries, the fact that water management is largely devolved to states or provinces can make it challenging for national government authorities to monitor national policies. For example, in Canada, jurisdiction over water is largely at the provincial or territorial level, which can create significant challenges in performing national-level assessments of progress.[10] In the absence of a federal agency with a mandate, monitoring water challenges, including for agriculture, may rely on consultation with provinces and territories with a variety of evaluation processes. Even federally-set water policies may face different monitoring systems at the state, province or territory level.

Some OECD country governments conduct evaluations because they are mandated to do so by their agriculture or water laws (Gruère, Ashley and Cadilhon, 2018[16]). For instance, the European Union's

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[7] Bayesian models have been successfully applied in the field of fisheries management and policy evaluation (Levontin et al., 2011[141]; Doll and Jacquemin, 2019[140]).

[8] The Murray-Darling Basin Plan was developed to manage the Murray-Darling Basin as a whole connected system, to bring the Basin back to a healthier and sustainable level, while continuing to support farming and other industries.

[9] In particular, a number of government organisations monitor and review the Murray-Darling Basin Plan, including the Murray-Darling Basin Authority; the Commonwealth Environmental Water Holder; the Department of Agriculture, Water and Environment, and Basin state and territory governments. Reviews provide the information needed for adaptive management of Basin resources. The Murray-Darling Basin Plan is also frequently studied because of the uniqueness of its water market policy design (Wheeler et al., 2020[135]).

[10] In 2020, the government of Canada announced that it will create a new Canada Water Agency to keep Canadian water safe, clean, and well-managed. This agency may play a role in monitoring progress in water policies.

Water Framework Directive mandates the evaluation of River Basin Management Plans every six years.[11] Under New Zealand's National Policy Statement on Freshwater 2020, regional councils must report relevant data yearly and report on the implementation of the statement at least every five years (New Zealand Government, 2020[27]). Such embedded evaluation can be a powerful means to ensure that policies can be changed and adapted over time if they do not fulfil their objectives.

Policy evaluations can also trigger the establishment of policy monitoring systems. For instance, in Australia, a 2011 independent evaluation of the National Water Quality Management Strategy (NWQMS)[12] recommended developing a small set of qualitative and quantitative performance measures that align with national objectives and priorities and implementing ongoing reporting at the national level (KPMG, 2011[28]). In 2018, the government released a monitoring and evaluation plan (Australian Government, 2018[29]). This plan provides performance measures that the Australian Government and state and territory governments can use to evaluate the performance of the NWQMS.

Public researchers, universities or international organisations also measure policy progress. They generate new knowledge on the effectiveness of agriculture and water management systems that can serve as additional or complementary sources of information. Non-governmental organisations and think tanks, and private companies, interested in greener or more resilient models can also develop data, tools, methods and produce evaluations that governments can also refer to (OECD, 2017[30]).

In the remainder of this report, it is assumed that "measuring policy progress" consists in observing an agriculture and water policy change over time, but that such change can be seen in terms of the policy design, its implementation capacity or its effects and that such observation can be made via different methods depending on the context.

3. Assessment principles and challenges of measuring progress in agricultural water management

This section discusses the main principles and key challenges to measuring progress in agricultural water management. Regardless of the type of policy progress, measurement requires setting a baseline and a reference or objective. The common challenge for all assessments reviewed in this report is how to define those sufficiently well.

At the same time, baselines and objectives or references are defined differently in the case of assessing policy design, policy implementation capacities or evaluating policy results, giving rise to different principles and challenges. Table 1 provides a synthesis view of the key principles and challenges. The following three subsections develop these points by type of progress.

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[11] Results of the 5th implementation report of the Water Framework Directive, released in early 2019, which evaluates the 2nd River Basin Management plans is available at: https://ec.europa.eu/environment/water/water-framework/impl_reports.htm

[12] Australia's National Water Quality Management Strategy (NWQMS) is a nationally co-ordinated framework supported by all Australian governments to facilitate water quality management for the productive and sustainable use of water resources.

Table 1. Measuring progress in agricultural water management: type of assessment, principles and challenges

Progress dimension	Type of assessment	Key principles	Key challenges
A. Progress in agriculture and water policy design	A.1. Screening a policy set to gauge alignment with a cross-cutting policy objective	Clear criteria that of alignment with the cross-cutting objectives	Ensuring that all main cross-cutting policy levers are considered
	A.2. Benchmarking a policy set to a reference policy design	Evaluation grid to match a set of policies with the reference design	Defining quantitative indicators, accounting for context, and for the limitations of the reference design
B. Progress in agriculture and water policy implementation capacity	B.1. Determining progress in implementation capacity	Comparing the implementation capacity with capacity needs or their potential to deliver outcomes	Limited data availability and knowledge on implementation needs
	B.2. Measuring progress in water governance conducive to improved implementation	Identification of multi-level governance gaps and their evolution	Setting the right level of analysis
C. Progress in agriculture and water policy results	C. Evaluating the results of agriculture and water policy.	Well defined outcomes and timeline Accounting for a plausible counterfactual Attributing the outcome to the actual policy change Cost-effectiveness determination	Setting the right scope of analysis (farm, watershed, region) Ensuring that all relevant factors are measured and accounted for. Including and determining the effects of all other relevant policy changes Measuring characteristics that could affect the policy change

Note: The indices indicate the relevant parts of this section.
Source: Authors.

A. Assessing progress in agriculture and water policy design

Assessing progress in agriculture and water policy design involves comparing the characteristics of the policy with a reference set of characteristics or policy design. There are two main types of policy design assessments: (1) those that focus on ensuring the alignment of a particular policy with a specific cross-cutting objective, and (2) those that compare the policy with a reference policy design, guidance or commitment. The next two subsections consider these two types of assessment.

A.1. Screening a policy set to gauge alignment with a cross-cutting policy objective

Screening can be used to ensure that environmental or social objectives are adequately included into government policies. In the agriculture and water area, a government could consider whether agricultural and water policies, such as water pricing and trading, or financial support for irrigation facilities and certain agricultural practices, are effectively helping and not hampering adaptation to climate change, or how they may impact greenhouse gas (GHG) emissions (OECD, 2014[31]).

Examples of screening approaches considering agriculture and water policies include evaluations of policy approaches encouraging a circular economy approach or policy integration in line with the water-energy-food nexus (Tsurita, Burnett and Orencio, 2017[32]; Water in the West, 2013[33]; Lindberg and Leflaive, 2015[34]). Assessment of policies affecting pollution may also cover agricultural policies and other economic policies to ensure that they do not favour additional pollution of nutrient in rivers or aquifers.

The main principle for effective policy screening is to identify clear criteria that define how existing policies may align with the cross-cutting objectives. These criteria can be a series of questions or a checklist, covering a sufficiently large scope of policies. An evaluation grid of some kind can then be drawn, for instance identifying synergies, trade-offs, and ambiguous interactions, by crossing the criteria and individual policies, or policy characteristics (Lindberg and Leflaive, 2015[34]).

Screening evaluations may involve reviewing formal policies and discussions with key stakeholders on agriculture and water. More advanced evaluation may involve developing a policy framework for evaluation and possibly complement the exercise with additional assessments. At the same time, the policy dynamics should be considered, either by comparing current and past policy design or by analysing how the alignment of a policy change with the cross-cutting objectives.

The main steps to follow this approach are to identify appropriate criteria and to ensure that they are effective means to gauge the alignment of policies with the cross-cutting objectives. The key challenge is to ensure that all main cross-cutting policy levers are considered, so the role of a particular policy is not exaggerated. Recommendations based on the results of the evaluation may differ depending on the level of sophistication.

A.2. Benchmarking a policy set to a reference policy design

Policy benchmarking involves comparing a policy change with a reference policy design. The reference policy design can be based on previous policies (*ante* reform), existing guidelines, characteristics recognised as necessary or important, principles to which the country adheres to, or international policy commitments. The assessment can help gauge the distance from the reference policy design, highlighting areas for further efforts.

In the agriculture and water area, such comparisons can be done to evaluate whether a water policy is comparable to that of other regions or countries. For instance, under the EU Water Framework Directive, Member States are required to limit pollution in all river basins in order to reach a good ecological status. But Member States can adopt different implementation strategies to fulfil these goals. Benchmarking a particular policy set with that of neighbouring states can help improve the design of policies.

For example, the OECD has been conducting a water policy benchmarking exercise with respect to the OECD Council Recommendation of Water (OECD, 2016[35]). OECD members that approved the Council Recommendation on Water in 2016 are encouraged to follow its guidance. The OECD Secretariat produced an implementation report to determine progress towards this Council Recommendation (OECD, 2020[36]).[13] A similar soft law commitment was taken by G20 Agriculture Ministers in 2017 in their Action Plan on Agriculture and Water. A first stocktaking discussion on efforts undertaken by governments and international organisations was made at a G20 Agriculture Deputies Meeting in January 2020.[14]

Conduct of such assessments involves developing an evaluation grid to match policies with the reference design. This may involve providing criteria such as the absence or presence of particular features of a policy or of its implementation modalities, developing a scale or indicators of closeness between the observed and reference policy design, or comparing policies in different jurisdictions with the same policy reference (pairwise for instance), which does not require using common metrics. At the same time, as for any measure of progress, dynamics matter, so a reference period and different state of the policy should be considered.

Comparing a policy change to a reference policy design, such as a commitment, is similar to determining the direction and length of vector with reference to a stable axis (Figure 2). A policy change can be determined by the difference between the initial policy status and the final policy status, or by one of these policy statuses and a measurement of the direction and amplitude of the policy change. This characterisation can then help draw inference about the alignment of the policy change with the international policy commitment (Gruère, Shigemitsu and Crawford, 2020[17]).

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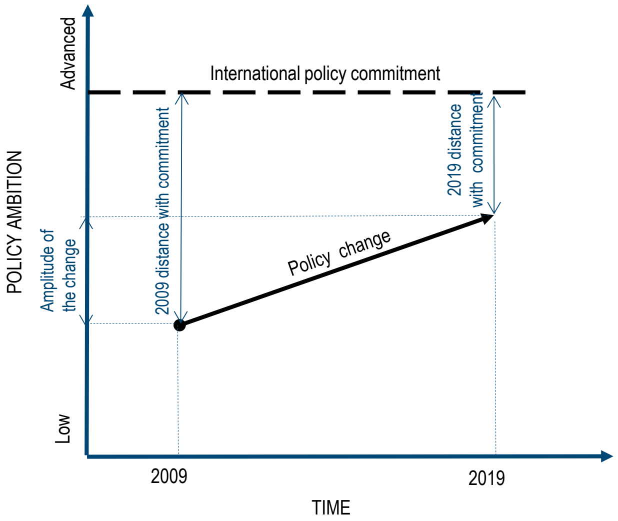
[13] Gruère, Shigemitsu and Crawford (2020[17]) was developed to contribute to this exercise focusing on agriculture and water policies. Details on their method is in Section 4, practical option P.O.3.

[14] See Gruère, Shigemitsu and Crawford (2020[17]) for results on policy efforts of the Action Plan by OECD G20 countries.

Figure 2. Measuring alignment of policy changes with an international policy commitment

Example of a policy change from 2009 to 2019



Note: this figure is unidimensional, however progress with respect to a reference is most often multidimensional with improvement in some areas and degradation in other areas (see, for instance, Figure 5).
Source: Gruère, Shigemitsu and Crawford (2020[17]).

These evaluation require a good characterisation of the reference policy document, the collection of sufficient information on policy changes, and the determination of distance between the two. This last step may involve comparing goals and objectives qualitatively, finding examples and outlining trends, or developing a scale determining the distance with the recommendation and quantitatively determining indices of alignment.

The key challenges reside in the fact that policies are not quantitative indicators, that the choice of policy and policy changes depend on the context especially on agriculture and water, and that the reference itself may not remain a plausible or ideal objective as the situation evolves and new options may emerge.

B. Assessing progress in agriculture and water policy implementation capacity

A policy may be adopted in the absence of sufficient implementation capacity, whether in terms of funding or governance. For instance, a policy that includes enforcement measures, but does not assign a sufficient budget to conduct monitoring and enforcement may lead to partial implementation. One reason for the partial result of the efforts of the government of Spain to register illegal wells (mostly on farms) was the insufficient funding allocated in view of the over 1.5 million wells to be checked (Fornés et al., 2007[37]). Governance gaps can also be problematic. The People's Republic of China's (hereafter "China") has set ambitious targets for water use in agriculture and for the reduction of water pollution. Yet implementation has been lacking in part because of the fragmented water governance system, and the divergent objectives of regional versus water basin authorities (OECD, 2018[38]).

Assessing progress in policy implementation capacity relies primarily on the determination of gaps in implementation capacity – technical, funding, or human – or in water and agriculture governance gaps that prevent the policy to be implemented at its intended level of application. Progress can be defined by changes that can reduce these gaps, therefore facilitating a better implementation of the policies.

The determination of the evolution of these gaps requires comparing changes in implementation capacity with predefined capacity needs or by considering their impact on implementation levels. This exercise may therefore be linked with assessments of progress in policy design (gaps in policies may result in implementation capacity gap) or in progress in policy results (gaps in implementation capacity will often lead to low implementation levels). The following two subsections look at the two different types of implementation capacity efforts and related limitations.

B.1. Determining progress in implementation capacity

The main principle of this type of assessment involves measuring the evolution of implementation capacity towards needed levels to achieve full policy implementation. The process to measure this evolution depends on the type of implementation capacity.

- *Technical capacity*: policies do not always define technical capacity needs. At the same time, technical upgrades in monitoring and enforcement that can reduce implementation costs or improve the effectiveness of monitoring efforts and results can be identifiable. This includes, for instance, the use of digital technologies to support the implementation agencies (OECD, 2019[39]), such as remote sensing tools measuring evapotranspiration to track water withdrawals by large number of farmers, or nutrient flow models that enable defining what the effort of a farmer should be to limit pollution in a watershed (OECD, 2017[12]). The adoption of such technologies, while not guaranteeing results, offers increase implementation means.
- *Financing capacity*: all policies involve public expenditures to cover essential transaction costs related to monitoring and evaluation, infrastructure investment, or funding for incentive based programmes (Loch and Gregg, 2018[40]). Financing needs can therefore be estimated early in the policy process, and possibly updated as implemented.[15] For instance, it is possible to estimate the required funding to set up water quality or quantity monitoring stations, to reinforce irrigation canals, or to offer agriculture extension services. The capacity gaps are defined by considering whether more funding is necessary to advance policy implementation towards its objective. Progress can be determined by computing the evolution of the distance between the actual and ideal implementation level and their respective costs, or alternatively by determining the total financing needs for full implementation and the evolution of actual expenditures to support the policy.
- *Human capacity*: policy reforms require a sufficient level of technicity and staffing for the implementing agency to operate effectively (Gruère and Le Boëdec, 2019[14]). Well-defined targets for human capacity development are not always defined in policies, so the assessment needs to consider the change in staff number and staff skills and how they may contribute to improved implementation.

The challenge of this type of assessment is related to the limited data availability and generally insufficient level of knowledge on implementation needs, particularly when considering agriculture and water policies (with the possible exception of water infrastructure).

B.2. Measuring progress in water governance conducive to improved implementation

Measuring progress in water governance conducive to improved implementation requires an understanding of the multi-level water governance system in place, as it relates to decision making in agriculture. Indeed, 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 (Gruère and Le Boëdec, 2019[14]).

Assessing a water governance system typically includes looking at the different institutions, their functioning, and co-ordination gaps at the relevant geographic levels (OECD, 2011[41]). In the case of agriculture and water policy, specific levels and institutions may be considered. For instance, the governance of water sanitation systems may not be relevant for agriculture and water policies, but how water resource is allocated or how water funding is decided may impact the implementation of specific irrigation policies. The role of federal, state and county level authorities in water decision making and their evolution overtime is also important to gauge policy implementation progress in federal countries like the United States, Canada, Germany or India.

There are three main options to conduct such assessment. First, a governance system may be evaluated with respect to good governance principles (OECD, 2018[42]), which is a similar process to the

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[15] Certain implementation costs may decrease over time, during the policy implementation phase (Loch and Gregg, 2018[40]).

benchmarking of a policy design with a reference policy (Section A.2). Second, a governance system may be evaluated with a structural evaluation grid identifying gaps (OECD, 2011[41]). This may rely on an analytical framework, such as a SWOT[16] analysis (Chan et al., 2016[43]), or an evaluation of the key water governance features of a policy change such as a water governance reform framework (Grafton et al., 2019[44]). These methods share similarities with the screening method discussed in the case of policy design above (subsection B.1). Comprehensive policy reviews, or surveys of policy users may also provide insights on the governance around a particular policy change.

The key challenges of this type of assessment is finding the right level of analysis. Assessing a water governance system is typically complex and requires a comprehensive understanding and analysis of all the different actors and their relationship, which may be difficult to do in the context of a policy evaluation. Yet a narrow governance analysis may fail to provide an understanding of the problems for policy implementation.

C. Evaluating the results of agriculture and water policy

Policy makers and agriculture and water stakeholders are most often interested in evaluating the results of a policy. Conducting an impact evaluation several years after introduction of the policy can be an essential tool to measure progress.

Such assessments may encompass a range of methods, that all require care to avoid a misleading interpretation of the possible relationship between a specific policy and an observed outcome. More than for the other two types of assessments, quantitative policy evaluations critically depend on accurate, robust and reliable data.

Generally, evaluating the result of a policy involves four key steps (Figure 3).[17] First, it requires defining progress (the result being sought) and the timeline of reference. Second, an accurate evaluation relies on determining a valid counterfactual, in other words, considering how existing policies, contextual and market conditions would have affected performance without policy changes during the reference period.[18] Third, it needs to consider what role the new policy change had relative to other policy changes, in other words how to attribute observed changes to the new policy. Fourth, if the role of the new policy is defined, the modalities of implementation need to be assessed to see if the policy was effectively driving change cost effectively.

Each of these four steps corresponds to a key principle for evaluation: (1) the studied result and timeline should be well defined; (2) it should account for the evolution of existing policies and other factors in the absence of policy changes; (3) it should also differentiate from the role of other policy changes; and (4) the degree and modalities of implementation, and cost-effectiveness of the policy change should be understood. The next few subsections explain these different criteria relating to agriculture and water policy changes.

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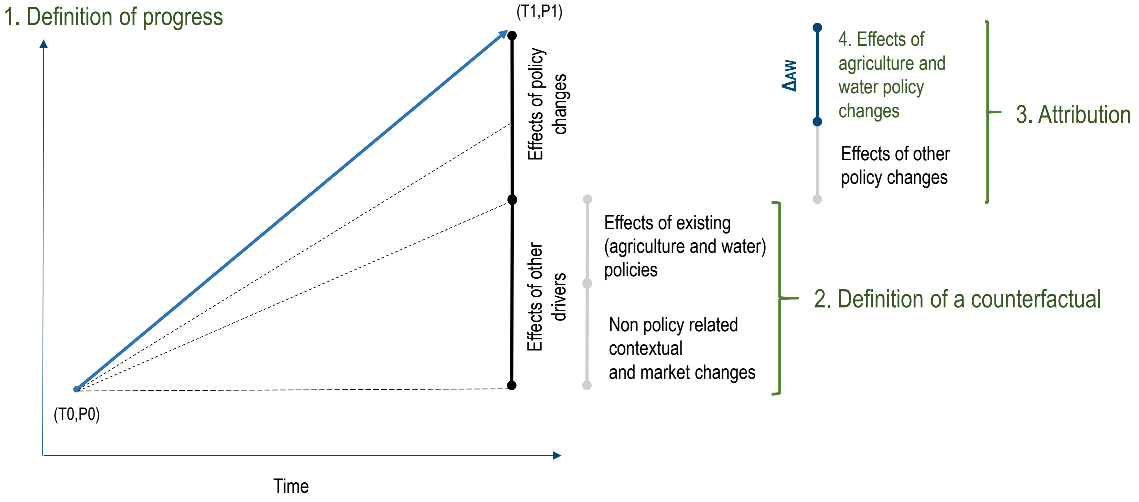
[16] SWOT stands for Strengths, Weaknesses, Opportunities and Threats.

[17] While the reference period data and method may vary, similar steps are necessary when considering an *ex ante* evaluation.

[18] Defining a counterfactual is also important in *ex ante* evaluation, in *ex post* evaluations it can be considered part of the “attribution” process.

Figure 3. Capturing the effects of a policy change



Note: The effects of the different factors are simplified for graphical purposes. In practices, they are not necessarily additive, nor are all contributing to any measurable progress. The evaluation is here defined with one dimension of progress, while evaluations may consider multiple outcome metrics.
Source: Authors.

(1) Defining progress and a timeline of reference

As noted earlier, progress is typically defined with respect to specific policy objectives or a broader policy outcome. Policy objectives may relate to the adoption of specific practices or technologies- such as the increased area in the use of pressurised irrigation or be directly or indirectly connected to specific outcome variables (water use or water consumption changes). There can be a wide range of possibilities between considering an outcome- or practice-based policy objective. Alternatively, broader policy performance, can be assessed by using aggregate or average indicators, for instance considering the state of water resources in a particular basin. For instance, Meals (1996[45]) studied the response of better management practices on watershed pollution levels in the US state of Vermont. The link between practices and broader performance indicators is not as strong but it can be useful at a wider scale.

Defining objectives is primordial in determining whether a policy change will deliver a positive outcome for agriculture and water (Giordano et al., 2017[46]; Scheierling and Tréguer, 2018[47]). Several studies have shown in particular how investments that focused solely on irrigation efficiency, without policies regulating water demand, have resulted in increased water consumption or accelerated groundwater depletion (Pérez-Blanco, Hrast-Essenfelder and Perry, 2020[48]; Grafton et al., 2018[49]; Perry, C J; Steduto, 2017[50]). Similarly, the adoption of certain practices does not guarantee an effective reduction in water pollution, as seen in the case of no till and phosphorus related eutrophication in lake Erie (Gruère and Le Boëdec, 2019[14]). A few examples of policy objectives and performance metrics for water quantity and water quality are shown in Table 2. Some water policies pursue long term overall objectives while adapting to changes over time; this can be important at the federal level, (see, for example, Canada’s Prairie Provinces Water Board in Box 1).

Table 2. Example of policy objectives and metrics to measure progress

	European Union's Water Framework Directive (2000)	Lake Taupo nutrient trading in New Zealand (2011)	California's Sustainable Groundwater Management Act (2014)	Canada-Ontario Lake Erie action plan to reduce phosphorus pollution (2018)
Main objective and period of implementation	Preventing deterioration of the aquatic environment and achieving a "good status" of all water bodies by 2015 (now by 2027)	Restore water quality to 2001 levels by 2080	Sustainable groundwater use by 2042, as applied by Groundwater Sustainable Agencies at basin levels[1]	Reducing phosphorus loadings to Lake Erie with the goal of decreasing the presence of harmful and nuisance algal blooms as well as the zones of low oxygen (hypoxia) that threaten both the ecosystem and human health (original targets 40% reduction from 2008 level to be updated)
Performance metrics	River and groundwater basins ecological and physical status indicators	Total nutrient discharge allowance among others	Absence of any "undesirable results" defined by 6 indicators	Track actions over time, including changes to phosphorous loadings

1. For some medium and high priority basins this goal must be met by 2040. Additionally, the State may grant up to 2 five-year reprieves if this objective is not met.

Source: Environment and Climate Change Canada and Ontario Ministry of Environment and Climate Change (2018[51]) ; European Commission (2017[52]); OECD (2015[53]); OECD (2018[54]).

Box 1. Canada's Prairie Provinces Water Board guides provincial water allocation policies and management

The provinces of Alberta, Saskatchewan, and Manitoba and the federal government of Canada created the Canadian Prairie Province Water Board (CPPWB) in 1948 to ensure water resources, including for irrigation and agricultural development, are shared fairly across the provinces.

Through the Master Agreement on Apportionment, which came into force in 1969, an intergovernmental framework was established to apportion or share water equitably between the Prairie Provinces and to protect transboundary surface water quality and groundwater aquifers.

The quantitative water metrics for progress in the CPPWB are minimum water flow rates for transboundary watercourses and lakes between provinces to ensure fair and equitable sharing. Water quality objectives for 12 interprovincial river reaches were also established in 1992 and new interprovincial water quality objectives were updated in 2015.

Source: https://www.ppwb.ca/about-us/what-we-do/1969-master-agreement-on-apportionment.

Because of the characteristics of water and agriculture issues, there can be a trade-off between the breadth of the objective and its usefulness in evaluation (Gruère, Ashley and Cadilhon, 2018[16]). For instance, looking at the performance of a policy change at farm level can provide a near-sighted understanding of the impact of any measure at the river basin or aquifer level. On the other hand, defining only policy outcomes at a high geographical scale offers a limited understanding of the impact of the policy for the individual actors, and whether the effort of some farmers may be masked by the counteracting actions of others at the basin level (Giordano, 2019[55]).

The timeline of evaluation is often defined as the period between the introduction of the policy change and the most recent date with available data. Yet regular evaluations may focus on shorter periods for instance. Alternatively, exogenous events, leading to a call for reform can call for evaluating policies covering a few years or a political cycle (Gruère, Ashley and Cadilhon, 2018[16]).

(2) Determining a plausible counterfactual

Defining a plausible counterfactual is essential to avoid underestimating or overestimating policy progress. The default strategy of considering no change from the initial situation can be problematic, as it considers "everything else being equal", which is rarely observed, unless the evaluation is done on a very short period or in a completely controlled environment.

Determining a counterfactual is also critical in determining the additionality of a particular policy intervention, or whether the policy intervention was necessary in achieving the desired result (OECD, 2012[56]). For instance, voluntary agri-environmental payment programmes for conservation seek to maximise additional environmental benefits by aiming to target farmers that would not change their practices towards improved environmental performance in the absence of the payment (OECD, 2012[57]).

A range of factors characterising the location or individuals can result in changes in observed progress and existing policies can affect the system during the period of interest. In the context of agriculture and water policy changes, the following factors may be worth considering:

- Changes in physical conditions, particularly climate related changes that affect water systems including in agriculture. For instance it is difficult to gauge the efficacy of a policy or allocation regime aiming to curb agricultural water demand in scarce conditions during relatively wet years.
- Changes in economic conditions for the agriculture and food sector, driven by markets or non-market factors, such as trade policies, market shocks, sanitary shocks, and energy and fuel prices. The COVID-19 crisis early on induced demand shifts for specific agriculture commodities, which may have impacted planting decisions (Lusk et al., 2020[58]). These decisions can have irrigation implications.
- Existing agriculture or water policies. New policies generally build on former policies and the effect of the new policy may therefore need to consider what policies were in place before. For instance, a policy aiming to reduce water pollution, via cost-share investments may be less effective in a context where farmers are encouraged to use pollution inducing inputs.

In the longer term, factors such as the structure of farms and of input, wholesale or retail firms, and the overall demand for water in a particular region may matter in determining changes in agriculture and water interactions. Trends in consumer demand may also play a role, especially if consumers opt for particular food products that may consume more water or increase the use of potentially polluting inputs. Social and demographical changes such as ageing of farmers and agricultural irrigation facilities, depopulation and urbanisation of rural areas may also create challenges for agriculture water management and limit drives for modernisation (OECD, 2020[10]).

The direction and amplitude of the effects of these factors on the defined outcome will vary, as will their potential omission. For instance, seasons with abundant rain may limit the use of water in agriculture, but may have ambiguous effects on agriculture's water pollution, increasing runoff, but also increasing the dilution of pollutants. An evaluation that ignores these factors may consider that agricultural water demand policies work better than they do, but conclude that pollution reduction instrument have an ambiguous impact depending on the selected indicator for progress (concentration of pollutants: exaggerated impact of policy, runoffs: undervaluation of the impact of the policy). At the same time, the omission of counterfactuals tends to exaggerate the impact of a particular policy.

An illustration of the importance of a valid counterfactual relates to the rebound effect. Several studies have shown that, when they have the freedom to do so, irrigators that benefit from irrigation efficiency support may react by switching to more water intensive crops or expanding their irrigation area (Ward and Pulido-Velazquez, 2008[59]; Pfeiffer and Lin, 2014[60]; Wheeler et al., 2020[61]). This may in turn increase water consumption (OECD, 2016[2]). These studies were able to fix all other relevant factors to assess the specific effect of the irrigation efficiency support. Indeed, a counterfactual that assumes no cropping area or production change from a previous situation may overestimate this effect, or conversely considering that other factors explain these change would underestimate this effect.

The main challenges with this step is therefore to ensure that all key factors are accounted for, but also that these factors can be measured and that their evolution is observable during the defined period of interest.

(3) Attribution of the effects of the considered policy change

Evaluating policy progress based on results also requires attributing a result to the policy change under consideration. Other policies may have changed during the period of reference, some of which could influence the measurement of progress in agriculture and water. Sorting out the result of the policy of interest from that of other policy actions is necessary to avoid a biased interpretation of the progress in policy results.

There are multiple examples of other policies impacting agriculture and water. For instance, a change in agriculture support could affect the choice of activity in a particular country and therefore its water use. Deryugina and Konar (2017[62]) find that a 1% increase in insured crop acreage leads to a 0.223% increase in irrigation in the United States. A change in food policy, say encouraging fruits and vegetables could also result in changes in water uses (Canning et al., 2020[63]). Trade policy changes that affect the country of interest directly or indirectly may affect crop planting patterns, with impact on irrigation water use. Changes in energy prices might affect the price of fertilisers and the cost of groundwater pumping or of using agricultural machinery. Similarly, changes in water governance and management towards other water users could affect the resource pool available to farmers. More indirect effects may be observed from macro-economic policy changes which may affect farmers' financing options and consumers' behaviour.

The main challenges associated with attributing the result of a policy change is to ensure that all the relevant policy changes are known and that their effects on the performance can be determined.

(4) Cost-effectiveness determination

Investigating the modalities of change driven by the policy of interest is needed to understand whether the policy delivers a result relatively efficiently. In cases where a policy change decreases the performance measurement, the evaluation could determine why that is. While this step is not necessary to see whether a policy contributes to progress, determining the cost-effectiveness of a policy change can help identify further adjustments.

Factors limiting the effectiveness of an agriculture and water policy change include enrolment (and possible drop-outs) in voluntary programmes, the degree of compliance with mandatory regulatory requirements, the amplitude or intensity of change in production practices or behaviour and their evolution over time, and any unexpected compensation. Negative spill over effects may also be observed, for instance, in cases where farmers benefitting of support for irrigation efficient equipment use those to plant more water consuming crops or expand planting areas (Berbel et al., 2014[64]).[19] Costs include various factors related to policy implementation.

The main challenges associated with this step involve measuring characteristics that could affect the policy change. These require additional data collection and assessment efforts.

4. Practical options to measure policy progress

This section reviews selected practical options (noted PO) that can help measure agriculture and water policy progress. Some of these options can cover different types of assessments while others specialise in a particular type of assessment. Some options are specific to policy design assessment, others to policy result evaluation; while those covering policy implementation capacity are combined options. The type of use of each practical option is indicated at the beginning of the subsection. The section closes with a summary table of all options their corresponding evaluation types and principles.

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[19] This is discussed further in Section 5.1.

PO.1. Screening policies’ coherence with cross-cutting or governance objectives

Main uses

- A1. Screening a policy set to gauge alignment with a cross-cutting policy objective
- B2. Measuring progress in water governance conducive to improved implementation

Gauging the coherence of policies with cross-cutting goals is generally a qualitative exercise. It typically requires inventorying the relevant policies, and assessing their compatibility with each other or with cross-cutting goals, via a desk study and consultation with policy officers, recipients of policy programmes or other stakeholders.

This can be done by engaging into a structured and informed dialogue. OECD (2018[65]) identified recommendations on how to improve water, energy and land policies in Korea, based on a multi-step policy dialogue with authorities and relevant stakeholders that was informed by data received from a structured questionnaire. The dialogue involved water management experts from two other OECD countries, who could exchange on their experience with Korean authorities. The land and water interactions were mainly discussed in terms of reducing nutrient pollution from livestock units and field crops. The dialogue enabled not only discussing needed water policy and governance changes, but also how to make these changes happen in the Korean context.[20]

Some assessments explicitly define levels of coherence. For instance, OECD (2020[66]) looked at the coherence between land use, biodiversity and climate change policy plans in six countries (Brazil, France, Indonesia, Ireland, Mexico and New Zealand). The report assesses the coherence across national strategies and action plans, institutional co-ordination and coherence, and policy instruments relevant to the land-use nexus. Interactions between the different factors are characterised as synergies, trade-offs, or cases where the context affect whether they are in synergies or trade-offs.

A policy assessment framework can also be developed, allowing comparison across case studies. For instance, OECD (2020[10]) develops an extended framework on the resilience of agriculture and applies it to four case studies. OECD (2019[67])summarises the application of the OECD policy framework on innovation, agricultural productivity and sustainability (OECD, 2019[67]), to twelve OECD and G20 countries. The policy assessment includes the role of water policies on agriculture innovation, productivity and sustainability. In particular, the review of China encompassed a discussion of water policy and governance mismatch which may constrain further progress in this area (OECD, 2018[38]).

A full assessment of policy coherence may also look at existing institutional mechanisms and whether the results of policies do not create unwanted spill over effects (Figure 4). For instance, OECD (2016[68]) developed a framework to assess the coherence of policies towards sustainable development. The framework provides a list of questions, and possible outcome indicators, to track coherence of policies towards particular goals and associated SDGs, identify areas of synergies and trade-offs (Figure 4).

On the governance side, the use of frameworks can be used to decipher whether a policy change is compatible with the governance system and therefore enabling its proper implementation. For instance, Grafton et al. (2019[44]) propose a framework to look at the water governance compatibility of reforms, which includes seven strategic considerations in relation to water reforms and their implementation: (1) well-defined and publicly available reform objectives; (2) transparency in decision-making and public access to available data; (3) water valuation of uses and non-uses to assess trade-offs and winners and losers; (4) compensation for the marginalised or mitigation for persons who are disadvantaged by reform; (5) reform oversight and “champions”; (6) capacity to deliver; and (7) risk and resilient decision-making. The framework is used to screen the governance features of four water reforms, showing that it is possible to determine their strength and weaknesses.

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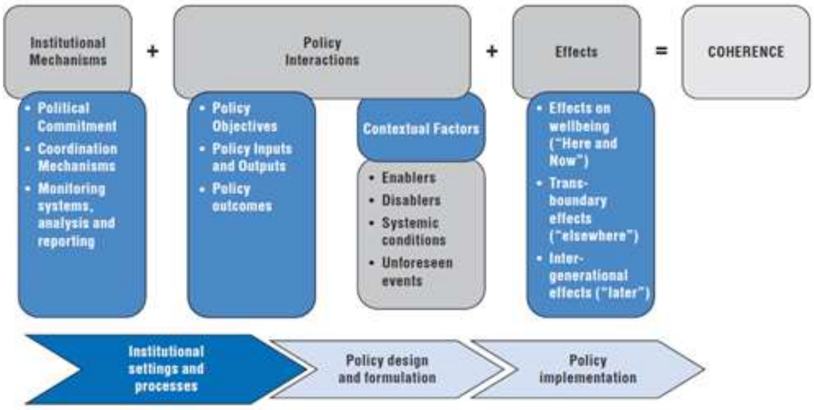
[20] Similar water policy dialogues were conducted in Brazil, Mexico, the Netherlands, or Peru, although they focused solely on water policy and governance. These and other country studies on water are available at https://www.oecd-ilibrary.org/environment/oecd-studies-on-water_22245081

The conclusion of these assessments can be depicted as +/- or synergy/trade-off tables, that describe how different policies are consistent with particular cross-cutting objectives or governance features. Areas for further progress are identified, including those that may present clear trade-offs. While studies tend to be done at a particular time, they typically look at the evolution of policies and aim to offer forward looking conclusions. Furthermore, the exercise can be repeated during multiple periods, to consider progress overtime in consistency.

The robustness of the assessment, depends on the comprehensiveness of the policy or governance coverage and on the rigor of the method used to define the criteria for consistency. Preparatory steps, before getting into a review of policies or governance, are therefore important, including the validation of the screening approach (questionnaire, framework or other).

Figure 4. Framework to track policy coherence for sustainable development



Source: OECD (2016[68]).

PO.2. Using modelling tools to evaluate the coherence of policy design with cross-cutting or broader objectives

Main use

- A1. Screening a policy set to gauge alignment with a cross-cutting policy objective

Modelling the impact of policy instruments on cross-cutting or broader objectives is another means to support policy design assessment. This requires a model calibrated on current conditions, and generally adding variables of interests that are not captured by the model. Policy shocks can be run to see whether it affects the cross-cutting objectives.[21]

In the agriculture and water area, farm level, watershed models, agriculture sector and economy-wide models can be used to model the consistency of a policy design with cross cutting objectives. For instance, the United States Department of Agriculture's Regional Environment and Agriculture Programming Model (REAP) was set to respond to "what if" questions, while considering different types of agriculture and environmental impact (Johansson, Peters and House, 2007[69]). Farm level and sector studies on the impact of particular characteristics of agriculture policies on environmental characteristics, including water quality can also be in this category (DeBoe, 2020[70]; Henderson and Lankoski, 2019[71]; Laborde et al., 2020[72]).

Such modelling can be used to provide complementary information to qualitative policy assessments. For instance, Lankoski, Ignaciuk and Jésus (2018[73]) combine a policy framework with two country case

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[21] While these simulations may help evaluate the policy design (Section 3.A), by considering the impact of policies, they also may contribute to some kind of results-based evaluation (Section 3.C).

studies and two applied economic simulations of alternative policy instruments to gauge how agricultural and environment policies are conducive to agriculture productivity, climate change mitigation and adaptation. They find that selected policy instruments have different implications for the three cross-cutting policy objectives.

Similar to the policy coherence screening option (PO.1), this method involves an assessment based on the current situation with forward looking progress insights. The validity of the assessment depends on the modelling structure and assumptions, data used, and choice of simulations. Any result is only usable in absolute value if there is a defined counterfactual, and with a proper characterisation of data. Unlike empirical models, simulations can fix all other variables, so there is no need to consider possible attribution biases.

PO.3. Measuring the alignment of a policy change with policy recommendations or guidance via the development of indicators

Main uses

- ➢ A1. Screening a policy set to gauge alignment with a cross-cutting policy objective
- ➢ A2. Benchmarking a policy set to a reference policy design
- ➢ B2. Measuring progress in water governance conducive to improved implementation

Developing and updating alignment indicators can help assess the changing distance between a policy change and a reference policy design. This method involves creating a correspondence between the reference and observed policy set. It therefore requires considering the details of the reference policy design, which can be complex, but there are practical means to do so, including in the agriculture and water area.

For instance, Gruère, Shigemitsu and Crawford (2020[17]) developed indices of alignment to relevant sections of the OECD Council Recommendation on Water and the 2017 G20 Agricultural Ministerial Action Plan. These indices were built on responses from agriculture and water policy questionnaires conducted in 2009 and 2019 for 38 countries, allowing progress in alignment to be tracked by theme, country, and specific section of the two international reference policy documents. A correspondence table was developed between questions in the policy survey and specific articles of the recommendations, offering means to measure relative policy alignments and their progress overtime. Complementary data was used to measure policy alignment with specific articles of the Council Recommendation on Water. This process allows to derive 0-1 indicator variables matching each question to an article of the Recommendation (differentiating status and evolution). These variables are averaged by article of the recommended text and by country to create continuous relative alignment indices between 0 and 1. For instance, Figure 5 shows the average progress in alignment of OECD countries' agriculture and water policies with specific chapters of the Council Recommendation on Water.

The development of indicators of progress towards the OECD Water Governance Principles provides an example that allows both to evaluate policy design and a method to support the assessment of progress in implementation (OECD, 2018[42]).[22] The progress measurement framework includes 36 water governance indicators and a checklist containing 106 questions on water governance covering the 12 OECD principles on water governance. The framework aims to be used as a self-assessment tool to collectively identify whether water policies and related institutions are following the principles and if the water governance system is properly functioning based on a multi-stakeholder dialogue. The evaluation therefore includes questions on the means and modalities of implementation of specific governance principles, but it also considers the degree of confidence of this assessment among the consulted stakeholders (Figure 6).

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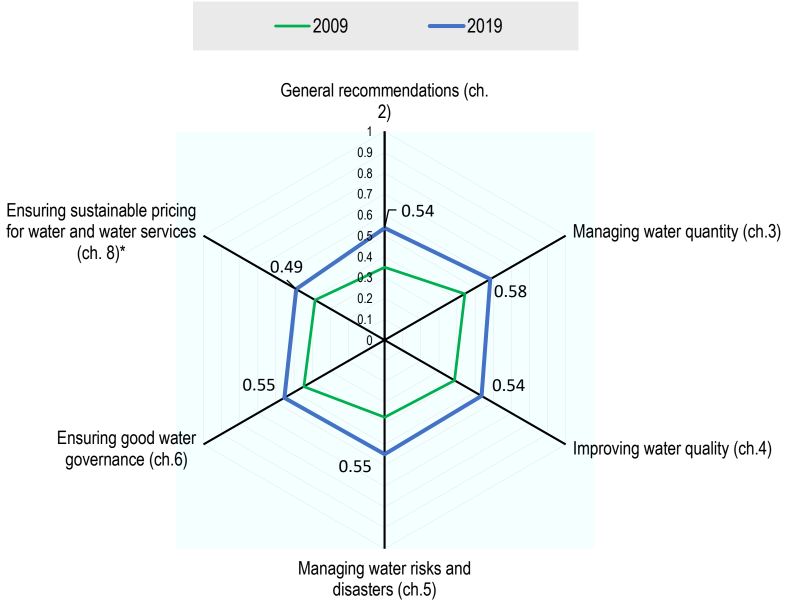
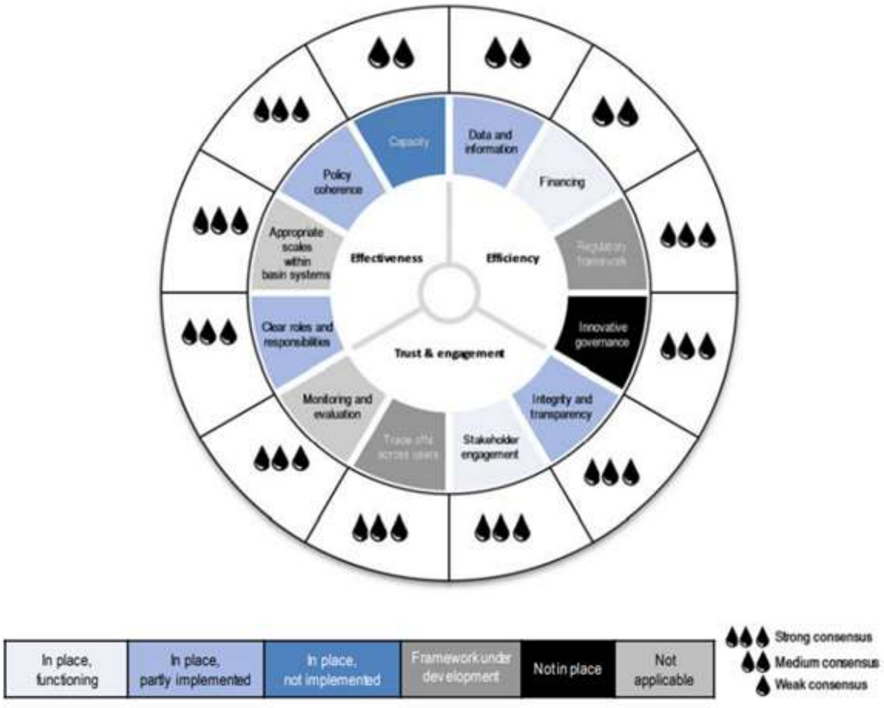
[22] OECD (2018[133]) offers another example of alignment study by assessing the implementation of the 2014 OECD Recommendation of the Council on the Governance of Critical Risks, which encompasses water risks, based on country responses to an OECD survey.

Figure 5. Measuring progress in alignment: the case of OECD agriculture and water policies with the Council Recommendation on Water



Source: Gruère, Shigemitsu and Crawford (2020[17]).

Figure 6. Visualisation of the traffic light on water governance indicators: What is the current situation?



Note: the dynamic element of this indicator- are changes expected in three years' time? - is not presented here.
Source: (OECD, 2018, p. 68[42]).

Overall, these methods offer indications of whether policy designs are approaching or getting further away from reference policy designs. The limitations they face is that even with common metrics that link the reference policy with the observed policy set, indicator values are only meaningful relative to a comparator. In some cases, the specific indicator value is determined by the persons that conduct the analysis, and could be given another value with a different set of graders. Alignment indicators are therefore good at giving trends in progress towards particular policy reference but not necessarily adapted to an accurate assessment. At the same time, given the leeway to interpret any policy text, it would be difficult to have a perfect correspondence between two legal texts.

PO.4. Monitoring policy progress towards an outcome with indicators of performance

Main use

- C. Evaluating the results of agriculture and water policy

The use of indicators to monitor policy progress is more common in results-based evaluations. By setting and updating indicators, governments aim to want to know what their current status in selected variables is and to track progress towards specific objectives.

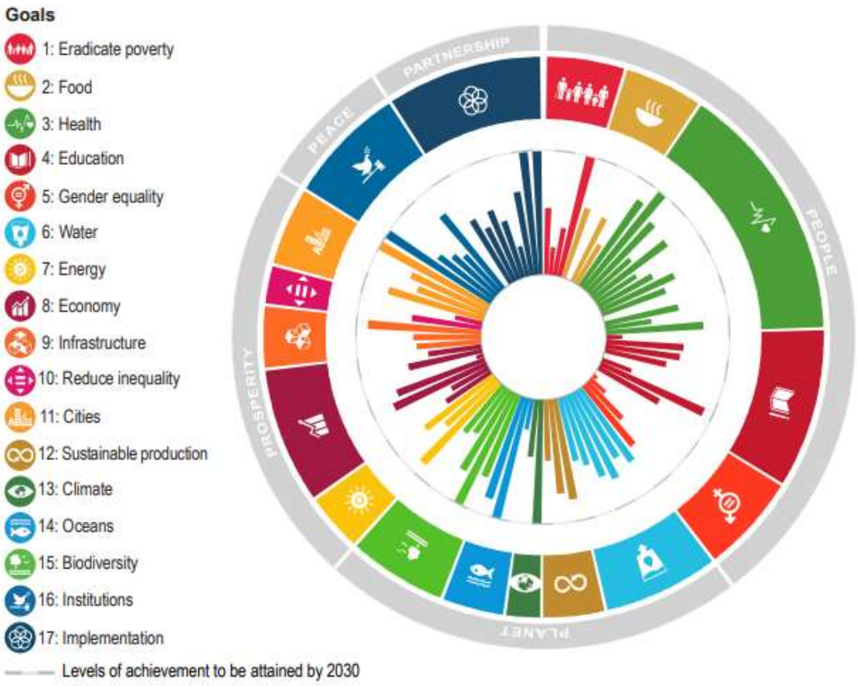
This type of exercise is being conducted by the United Nations to help UN member states seek progress towards the 17 Sustainable Development Goals (SDGs). While a system of a larger number of indicators is being discussed corresponding to subsections of the SDGs, OECD (2019[74]) found a sufficiently wide range of relevant statistics, aligned with the 17 goals, to assess the distance of particular OECD member states with these goals (Figure 7). Sub-indicators for SDG 2 include for instance the prevalence of undernourishment, obesity rates, nutrient balances, and proportion of local breeds, while sub-indicators for SDG 6 include the proportion of population with access to improved drinking water sources, GDP unit per freshwater abstraction, water stress or average annual change in water surface. The indicators are built by setting target levels for each variable and determining the standardised difference of the observation with the target- or number of standard deviation between a normalised value of the variable and the target value.

Also at the international level, PAGE (2017[75]) uses a combination of indicators to measure progress in the application of UN green economy measures. Progress in indicators are evaluated overtime by gauging their performance compared with the 10% best performing countries within classes of countries sharing similar human development index. Comparators for each indicator, called thresholds, are calculated with respect to planetary boundaries.

Indicators of performance can also be used in the absence of target levels to rank progress in a composite score, accounting for intra-regional differences in water policy performance. NITI Aayog (2018[76]) develop a composite water index to evaluate the performance of Indian states in terms of water management. To do so it combined data reported on 28 variables, grouped under nine themes associated with water management performance (ranging from irrigation area, resource status, with practices, or policy and governance status). Each variable is normalised between 0 and 1 using data from all states, so the best performing state is rated 1 and the worst 0 (or for presence question, the presence of a feature is rated 1 and the absence 0). These variables are averaged by state and theme, and a weighted average of variables, with attributed weights by theme provide a composite index by region. The use of data from 2015-16 and 2016-17 enables to track progress in these indices, and switching ranks across states.

Composite indicators can also be developed at farm or water management levels. The principles are the same, specific outcome indicators are selected, standardised with respect to a reference and aggregated via a weighted average, although the determination of targets and weights may differ. For instance, Kefayati et al. (2018[77]) evaluate the sustainability effects of inter-basin water transfer in Iran, encompassing variables for economic, environmental and social sustainability parameters. Gómez-Limón and Sanchez-Fernandez (2010[78]) evaluate the agriculture sustainability of rainfed versus irrigated farms in the River Duero valley in Spain.

Figure 7. Monitoring progress towards the SDGs: OECD countries' average distance from achieving SDG targets



Note: The chart shows how far OECD countries (on average) are from achieving each target for which data are available. The longer the bars, the shorter the distance to be travelled by 2030; target levels are represented by the outer dotted circle. The inner circle represents a score of 3 or more standardised distances away from target, which most OECD countries have achieved on most targets.
Source: (OECD, 2019[74]).

Composite indicators can also be developed at farm or water management levels. The principles are the same, specific outcome indicators are selected, standardised with respect to a reference and aggregated via a weighted average, although the determination of targets and weights may differ. For instance, Kefayati et al. (2018[77]) evaluate the sustainability effects of inter-basin water transfer in Iran, encompassing variables for economic, environmental and social sustainability parameters. Gómez-Limón and Sanchez-Fernandez (2010[78]) evaluate the agriculture sustainability of rainfed versus irrigated farms in the River Duero valley in Spain.

The main advantage of performance indicators approaches is the ease of understanding and use. They provide rapid and obvious signals to policy makers to see where the problem may be and how it should be considered.

However, these methods rely on existing proxy variables that may not be fully accurate nor sufficiently comprehensive. Furthermore, they do not fulfil the four principles of evaluations for a comprehensive and reliable policy progress evaluation. While they enable monitoring progress on outcomes, and can be used in any timeline, no specific policy change is outlined and there is no counterfactual. No effort is made to consider the result of existing policies nor to attribute the observed outcome to any policy change or to analyse the modalities and cost-effectiveness.

In other words, without complementary information or analysis, the indicator approach provides a direction for change which may be associated to many factors, but cannot be used to justify, question or refute any particular policy change.

PO.5. Comprehensive assessment combining qualitative and semi-quantitative information

Main uses

- C. Evaluating the results of agriculture and water policy
- A1. Screening a policy set to gauge alignment with a cross-cutting policy objective
- B1. Determining progress in implementation capacity
- B2. Measuring progress in water governance conducive to improved implementation

Perhaps the most common method used by governments in the area of agriculture and or water policy is the use of comprehensive assessments combining quantitative indicators of performance with extensive qualitative information. This type of exercise discusses primarily the results of policies, but can also analyse their design and progress in implementation capacity. It is not a quantitative evaluation, in that it does not assesses the specific results of a particular policy change. Instead it observes the change in environmental outcomes and explains why this change may have happened and what role policies may have had in this change.

A key example in this area for OECD countries is the reporting required under the EU Water Framework Directive (WFD). The WFD requires river basin districts in each EU Member State to set river basin management plans, and to identify and monitor water resources (European Environment Agency, 2018[79]). The goal of the Directive is for all water bodies to achieve "Good status" in terms of ecological status and chemical status of surface water bodies and chemical and quantitative status of groundwater bodies (Figure 8).[23] The status of body refers to its compliance with ecological health indices, quality standards (chemical status) or with specific objectives set in the Directive (groundwater balance above zero for quantitative status). EU Member States are monitored for every management plan cycle, every six years (2009-2015, 2015-2021 and 2021-2027), on the governance and implementation of their plans and the status of these variables. The assessment discusses progress in policy design, looking at the evolution of policies and policy measures, policy implementation, considering the application of monitoring sites, and policy results, via the status indicators (European Commission, 2019[80]). Measurement of outcomes also consider the proper establishment of a baseline, and changing hydrological conditions are considered in the assessment. While the purpose is not to determine the progress of a particular policy, but how the overall policy impetus provided by the EU WFD has contributed to progress in a particular cycle of reviews.

Comprehensive policy assessments are also conducted at the country level. In Australia, under the Basin Salinity Management 2030 Strategy agreed in 2015, auditing occurs biennially to align with the comprehensive reporting by jurisdictions and the Murray–Darling Basin Authority. The latest report of the auditors, the Independent Audit Group for Salinity (IAG-Salinity), was released in January 2020.[24] In the European context, Van Grinsven, Tiktak and Rougoor (2016[81]) evaluated the implementation of the Nitrates Directive, the Water Framework Directive and the national emission ceilings Directive in the Netherlands. This encompassed a review of policy instruments implemented to reduce nitrogen, phosphorus and ammonia emissions from agriculture since the 1980s. Their assessment provides a report on the achievement of targets under the three directives, via trends in application and outcome indicators, and discusses how policies helped or not to get there, assessing the cost and benefits of policies. Lallouette, Magnier and Barreau (2016[82]) reviewed the implementation of the EU Nitrates Directive in France from 2012-15, looking at trends in regional water quality indicators, policy changes, but also enforcement measures and their progress.

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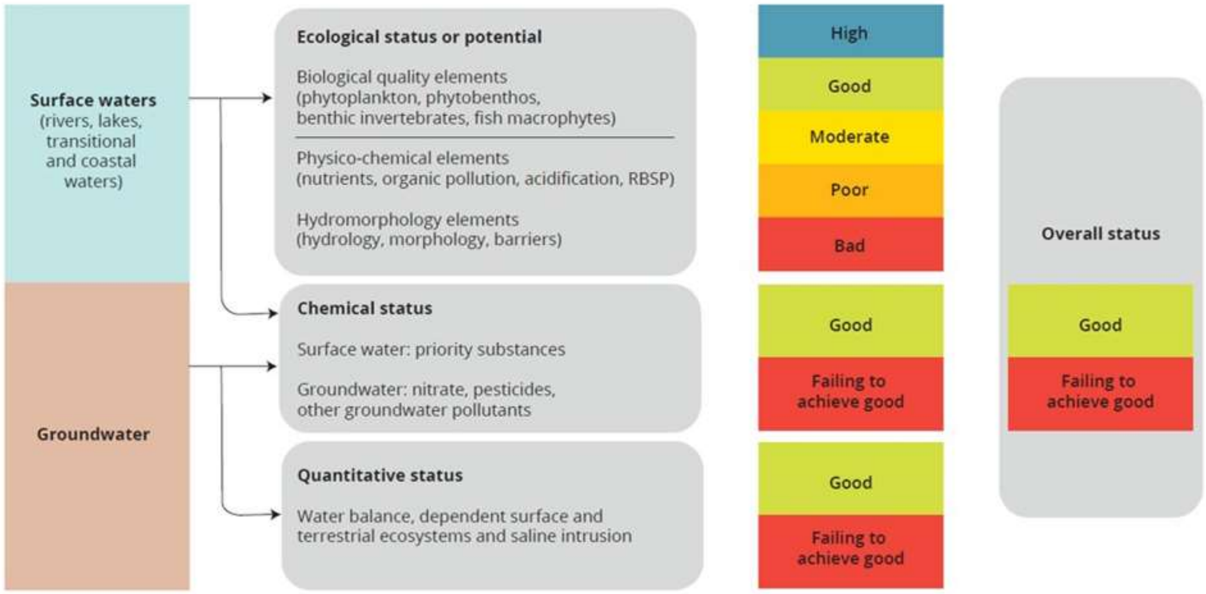
[23] Initially the goal was to reach this status by 2015, with exceptions going to 2021 and potentially 2027.

[24] Pannell and Roberts (2010[134]) offered an earlier retrospective assessment of Australia's National Action Plan for salinity and water quality. The review was based on a combination of inputs from existing government and external reviews, published research, comprehensive stakeholder consultation and existing data on achievement of the targets.

Figure 8. Ratings system for water bodies under the EU Water Framework Directive



Source: European Environmental Agency (2018[79]).

Some of the evaluations are conducted in response to a request by government agencies, often under a legal mandate, and focus on a particular law, regulation or programme. For instance, the Chilean National Irrigation Commission (2019[83]) evaluated programmes for small and medium water irrigation works and the promotion of irrigation in Chile from 2015 to 2018. The report reviews the objective of these programmes, and assesses progresses in the dimensions they include as objectives. It also discusses the justification of the programme, and its degree of application during the three years it was implemented. Epypsa (2010[84]) evaluated the programme for the promotion of sustainable agriculture production (PFAS) in Costa Rica for the Ministry of Agriculture and Livestock, which requires beneficiaries to reduce water pollution by half among other, and includes a number of water-related practices. The evaluation reviews the achievement of the targets and looks at enrolment and the economic and environmental efficiency of the measures.

Some evaluations have used innovative means to measure the effectiveness of programmes using qualitative and quantitative information. For instance, McCoy, Holmes and Boisjolie (2018[85]) develop a four tier accounting framework to evaluate the efficacy of the Columbia Basin Water Transactions Program, a voluntary mechanism intended to restore flows and improve the aquatic ecological system in the Columbia River (Northwest United States). The framework encompasses looking at transactions' compliance with the programme, their effect on the hydrological system, how such change may affect natural habitat and ecological responses. The framework is then applied using data on transactions, the characteristics of returned water flows to a case study with habitat restoration.

The advantages of this approach are multiple, and they can cover different types of assessments, but they do not fulfil all the principles for policy result evaluation. These assessments are adaptable to data, usually robust in gauging outcome changes, and can involve a comprehensive stakeholder consultation, which allows assessors to understand how a policy change may have operated. On the other hand, they may not always account for the counterfactual or for other policy changes. Absent these considerations, they may exaggerate the result of particular policy changes, or provide a broad assessment that does not allow drawing conclusions on the impact of the policy change.

PO.6. Quantitative *ex post* evaluations of policy application via surveys of users

Main uses

- C. Evaluating the results of agriculture and water policy (most common)
- B1. Determining progress in implementation capacity (possible)
- B2. Measuring progress in water governance conducive to improved implementation (possible)

When data can be collected directly, *ex post* evaluations of users' impact can help assess policy progress. This can be done by conducting surveys of farmers, water managers or other agents targeted by the policy after a sufficient period post-introduction.

For instance, Sanchis-Ibor, García-Mollá and Avellà-Reus (2017[86]) employed a survey of water user associations (WUAs) to assess the impact of policies promoting drip irrigation in the Valencia region of Spain. The survey obtains information on the impact of the policy but also on how the policy programme acted and on changes in water using operations (covering implementation capacity). Greiner (2015[87]) conducts an *ex post* evaluation of the water quality tender programme in the Lower Burdekin river area in the Great Barrier Reef region of Australia. This programme, implemented in 2007-08, offered funding for the adoption of on-farm practices to improve water quality based on a competitive tender process. The survey, focusing on tending participants, helps assess the legacy of the tender programme and provides insights on whether such programmes could be improved. Rouillard and Rinaudo (2020[88]) analyse the impact of the 2006 Water Law in France in the devolution of irrigation quota allocation decision to groups of users, combining available data and legal and governance analysis with responses from a survey of irrigators and board members.

The advantage of these methods, which can be implemented as an element of broader evaluation studies, lies in their capacity to provide a quantitative understanding of the policy impact. As the questions focus on the policy change, they may not be subject to significant attribution biases, and counterfactual elements may be part of the survey. Furthermore they offer the possibility of looking at modalities of the programme implementation, potentially identifying gaps or weaknesses in policy implementation.

On the other hand, they cannot be used to provide a definitive understanding of the impact of a policy (on application of practices or environmental outcome), and may actually conclude that further evaluation is necessary.

PO.7. Quantitative *ex post* evaluations of the impact of policy changes

Main use

- C. Evaluating the results of agriculture and water policy

Quantitative *ex post* evaluation of policies and programmes, using statistical data analysis are the most sophisticated means of measuring policy progress. They are typically run by researchers, often affiliated with universities or research centres, but only remain sparsely used by government officials in the agriculture and water policy area.

Relatively few economic studies have evaluated specific agriculture and water policy initiatives, with research questions typically looking at policy effectiveness in changing farmers' practices or behaviour. On water quality, Goodwin and Smith (2003[89]) used national county level data pre and post adoption of the USDA Conservation Reserve Program (in 1982 and 1992) to assess its effect on erosion, using econometrics regression. Dupont (2010[90]) studied the effectiveness of Ontario's Rural Water Quality Program for the Grand River in encouraging the adoption of best management practices to protect watershed sources in Eastern Canada. The study uses a two-step estimation method, studying enrolment and application of best management practices by farmers and assessing the effect of the level of incentives. Newburn and Woodward (2012[91]) assessed the cost-effectiveness of the water quality trading programme in Ohio, United States, using data from the reverse auction process on nutrient reduction bids. Sohngen et al. (2015[92]) analysed the role of nutrient prices on nutrient concentrations in agricultural watersheds of the US Midwest. The study derives price elasticities of nutrient emissions suggesting the possible impact of increasing the prices faced by farmers. Claassen et al. (2014[93]) studied the additionality of conservation programmes in the United States using propensity score matching to estimate what farmers did with the programme versus what they would have done had they not received payments.[25]

Irrigation studies generally focus on the adoption of particular practices associated with policy incentives with several exceptions. For instance, Pfeiffer and Lin (2014[60]) use a rich dataset of 10 000 wells to study the impact of increased efficient irrigation on water resources in Western Kansas, United States. They find that encouraging efficiency resulted in increased water use in that region. Li and Zhao (2018[94]) use the same dataset to evaluate the role of groundwater rights in curbing the rebound effect associated with more efficient irrigation practices. Wallander and Hand (2011[95]) use panel dataset to assess the impact of the Environmental Quality Incentives Program (EQIP) on irrigation efficiency and water conservation. The study uses difference in difference estimators, and finds observable impact. However the programme is not randomly assigned. This is controlled with a matching estimator that does not confirm the results. Multiple studies look at the on farm impact of irrigation efficiency investments that mostly are done as technology evaluation (Pérez-Blanco, Hrast-Essenfelder and Perry, 2020[48]).[26]

Evaluations in this area rarely assess the economic benefits of policy progress, focusing instead on the policy objective. Measuring the benefits of improved water quality or the opportunity cost of saved water requires additional data and estimation procedures. For instance, Keiser and Shapiro (2018[96]) estimate the impact of water quality improvements due to grants and investments following the US Clean Water Act from 1972-2001. They then estimate some of the economic benefits of observed water quality improvements by measuring the hedonic value for residences located nearby water courses, and find that 25% of the cost are already recovered by the value of residence.

With sufficiently robust and comprehensive data, and a sound application of statistical techniques, quantitative data analyses can fulfil all the identified principles for evaluation. They can fix changing variables, attribute a change to a policy, measure the economic welfare implications, consider uncertainty and even explain observed results. At the same time, they require comprehensive data collection covering multiple periods, which is often only possible at a limited scale, and a greater level of technicity for the assessment.

Comparison of the reviewed options and applications of the principles

Table 3 compares the main advantages and disadvantages of the different reviewed options, using the key principles as criteria. In particular, it shows that some options are more flexible than others in assessing the different types of progress. At the same time, the more specialised evaluations can get more robust results in particular dimensions of policy progress. It also shows that there is no perfect model for policy evaluation.

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[25] Other empirical studies focus on land use change or the use conservation practices, which do not help track impacts of policies on results (Garnache et al., 2016[132]).

[26] A number of studies consist in pilot studies of policies, and therefore do not effectively offer measures of policy progress. For instance, Wang, Zhang and Huang (2016[136]) conducts a survey to measure the impact of an irrigation pricing scheme in China.

Table 3. Comparing the options for evaluation

	A. Assessing policy design		B. Assessing progress in implementation capacity		C. Evaluating progress in policy results				Other advantage or constraint
Principles Practical options (PO)	Clear criteria of alignment with the cross-cutting objectives	Evaluation grid to match a set of policies with the reference design	Comparing the implementation capacity with capacity needs or their potential to deliver outcomes	Identification of multi-level governance gaps and their evolution	Well defined outcomes and timeline	Accounting for a plausible counterfactual	Attributing the outcome to the actual policy change	Cost-effectiveness determination	
PO.1. Screening policies' coherence	Yes			Yes if focused on governance					Broad assessment, robustness depends on rigor of the assessment grid
PO.2. Modelling tools to evaluate policy coherence	Yes								Rigorous assessment but limited in scope
PO.3. Measuring policy alignment with indicators	Possible but rarely done	Yes		Yes with governance indicators					Developing a common metric is complex but necessary
PO.4. Monitoring policy progress with indicators					Yes	Not possible	Not reliably	Not possible	Tracks the overall performance, not the link with policies
PO.5. Combined qualitative and semi-quantitative evaluation	Possible but rarely done		Possible	Possible	Yes	Possible but often limited	Possible but often limited	Yes	Provides robust snapshot, but may exaggerate the impact of policies
PO.6. *Ex post* evaluation of policy application			Possible with semi quantitative results	Possible, but often limited	Yes	Possible	Yes but limited to application	Yes	Offers a good understanding of policy functioning
PO.7. *Ex post* evaluation of the impact of policy changes					Yes	Yes	Yes	Possible	Most advanced, but requires good data and robust estimation

Note: grey cells indicate that the relationship does not apply.
Source: Authors.

5. Application to the sustainable management of water for irrigation and water pollution reduction

The above-listed principles and methods need to be adapted to the specific policy challenge. This section considers two of the key growing problems for water managers in agriculture: managing irrigation sustainably under climate change, and controlling diffuse pollution from agriculture.

It should be noted that these two challenges are not the only ones for agriculture. In relatively more water abundant countries, managing drainage and flood protection can be more important. For instance, the greatest potential for managing water resources for agriculture in Sweden lies in ensuring capacity in the groundwater reservoir through soil structure and drainage. Drainage is also important in managing excess water, which is the predominant problem for agriculture in a number of countries around the world.

5.1. Measuring progress in the sustainable management of water for irrigated agriculture under climate change

5.1.1. Problem definition and consequences for monitoring policy progress

Managing irrigated agriculture sustainably under climate change requires acting on three main characteristics of irrigated agriculture: the benefits it can generate, the risks it can face, and the environmental and resource problems it can create. Climate change is expected to increase the importance of all these three irrigation features, while inducing broader uncertainty.

First, irrigation plays a key role for agriculture especially under arid and semi-arid areas, enabling farmers to be more productive and less dependent on rainfalls (OECD, 2017[1]). It can also play a complementary role in regions with varying rainfalls, and is likely to be increasingly important in many regions of the world. Renewable groundwater resources that are less affected by variability in precipitation can provide an important reservoir under increased climate volatility (OECD, 2015[23]). Watered fields, whether via rain or surface water irrigation, can contribute to aquifer recharge, which could then be used in future periods by agriculture or other users (Ibid).

Second, irrigated agriculture in many countries is competing for water with other water users and facing increasing climate-related risks. For instance, in China water demand is expected to be driven by other sectors, reducing the availability of water for agriculture (OECD, 2017[1]), while irrigated agriculture in the US Southwest is projected to decline in the future due to increasingly limited resources (Cooley et al., 2016[97]). At the same time, intense water-related extreme events, particularly intense droughts over multiple year, limit the viability of irrigation, sometimes irreversibly. While field crops can be fallowed, some horticulture activities depend on minimum access to water. Permanent culture, such as fruit trees may be unable to recover from a consistent lack of water.

Third, irrigation remains a major water consuming sector in countries where it is used significantly. In the absence of well-defined allocation systems, intensive irrigation can exert pressure on other water users and aquatic ecosystems. This pressure is particularly important in regions where agriculture activities remain the first water using sector, but where water is scarce.

Measuring policy progress in this area should therefore account for these three characteristics. Evaluations should assess whether and how policies are able to ensure that farmer can benefit from irrigation, that they can limit water risks and that they can minimise potential impacts generated by irrigation under a changing climate. Considering only one or two of these three objectives, even if they are not all as important in each location, may lead to a partial and potentially misleading definition of progress. Abstaining from considering changing climatic conditions and their impacts on the water cycle may also limit the long term utility of the evaluation. In practice, there are multiple variables that can help measure progress in terms of policy design, implementation and results (Table 4).

Table 4. Possible factors to measure policy progress on irrigation management under climate change

	Economic benefits of irrigated agriculture	Risks faced by irrigated agriculture	Impacts of irrigated agriculture	Climate change
Policy design	Agriculture production and income featuring in the objective of the policy	Risks for irrigation explicitly considered in the objective and modalities of implementation	Inclusion of the possible impacts of irrigation and of means to tackle those in the policy	Climate change and its potential impacts are discussed in the policy text
Policy implementation	Financing system is sustainable to maintain irrigation infrastructure, technical assistance is available	Governance system reactive to risk for irrigated agriculture, financing for degradation of irrigation canals	Means to monitor water use and water level are included in the budget	Implementation modalities allow policy officers to train farmers to adapt their irrigation practices to climate change.
Policy results	Agriculture productivity impact, positive externalities of irrigation (where relevant)	Volatility of crop yields, irrigation and water costs, prices, and market operations	Water consumption, surface water and groundwater levels, economic impacts of irrigation	Scenario simulations, sensitivity analysis or discussion of results includes the impacts of climate change

Source: Authors.

5.1.2. Examples of policy evaluations

If specific irrigation projects are often evaluated (Scheierling and Tréguer, 2018[47]), policies managing irrigation are not as widely studied. It is also difficult to find specific examples of policy evaluations that explicitly and rigorously account for climate change and irrigation. At the same time, climate change is increasingly considered in policy evaluation on irrigation.

Three sets of examples are presented below, focusing on water resource policy reviews in Australia, water pricing studies and groundwater management studies.

Monitoring progress in water resource policies: the case of Australia

Australia's water resource management policies are subject to periodic evaluations by federal and state and territory authorities. Under the Commonwealth Water Act 2007 (Cth), the Productivity Commission[27] is required to undertake three-yearly inquiries into the progress of reform in Australia's water resources sector. The first inquiry by the Productivity Commission (2017[98]) reviewed the implementation of the National Water Initiative of 2004, the Water Act 2007 (Cwth); a second inquiry is expected in mid-2021 (Box 2). Under the Water Act 2007 (Cth), the Productivity Commission is required to undertake five-yearly assessments of the effectiveness of the implementation of the Murray-Darling Basin Plan and state and territory water resource plans. Evaluations are also conducted at the subnational level; the South Australian Murray-Darling Basin Royal Commission also conducted an inquiry of the Murray-Darling Basin Plan that highlighted the urgent need to strengthen understanding of climate change and its likely effect on the Basin's water resources (South Australia and Murray-Darling Basin Royal Commission, 2019[99]).[28]

These two evaluations monitoring progress in Australia's water resource policies, which go beyond irrigation, cover at least partially irrigation benefits, risks and impacts, and they discuss climate change. They employ a comprehensive policy assessment combining qualitative and semi quantitative information (PO.5) that encompass a large set of features of the policy in response to a specific mandate. They involve agricultural and non-agricultural stakeholder consultations, policy research and consideration of relevant research to arrive at their conclusions and recommendations. At the same time, these reviews may not

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[27] The Productivity Commission is the Australian Government's independent research and advisory body on a range of economic, social and environmental issues affecting the welfare of Australians (Australian Government, 2021[147]).

[28] OECD (2019[144]) provides a review of the environmental performance of Australia, including on water, using a comprehensive assessment methodology, going not as deep into country specific institutions, but providing international benchmarking and recommendations developed with peer-reviewing environmental policy officials from other OECD countries.

always define an explicit baseline scenario. Policy changes are evaluated in comparison to no policy changes without considering how past policies and other factors might have influenced the situation.

Monitoring progress in water pricing initiatives

Another example is that of the evaluation of water pricing, an instrument that affects benefits for irrigators, but may be used to limit risks and impacts. Berbel et al (2019[100]) look at irrigation tariffs and taxes and their evolution in Europe, reviewing the different instruments and their development in accordance with the Water Framework Directive. The study focuses on policy design evaluation and reviews the different properties of pricing schemes in a structural way (similar to PO.1).[29] However the report does not look at policy results. A similar exercise is run by European Environmental Agency (2013[101]) considering all cost recovery measures including in agriculture and referring to the literature on the impacts of these policies. Bar-Shira, Finkelshtain and Simhon (2006[102]) study the impact of block-rate versus uniform water pricing, using data from Israeli agricultural communities between 1992 and 1997 to estimate water demand elasticities and simulate water demand with a uniform pricing rate. Still, quantitative evaluations of pricing are difficult to find, perhaps due to limited application of developed pricing schemes in the irrigation context. Several studies look at the potential impact of pricing via simulations using current data (Liao et al., 2008[103]), however these do not measure progress.

At the same time, quantitative studies of water pricing in irrigation have highlighted the inelasticity of water demand especially under scarce conditions (Hendricks and Peterson, 2012[104]; Scheierling, Loomis and Young, 2006[105]). This means that introducing small price signals will rarely have a significant impact on water withdrawals, and even less on water consumption. This implies that under these circumstances, water pricing -beyond cost-recovery- may limit benefits without reducing risks and impacts. This also means that attributing the result of a water pricing policy is even more difficult than for other measures. The same result has been observed with respect to changes increasing the cost of energy and its impact on groundwater withdrawals (Pfeiffer and Lin, 2014[106]).

Box 2. Reviewing water policies in Australia: Ongoing and future assessments by the Productivity Commission

The Productivity Commission is required to undertake inquiries into the progress of water reforms in Australia. The Second inquiry is looking at the progress in achieving the objectives, outcomes and timelines of reform directions proposed in the 2004 Intergovernmental Agreement on a National Water Initiative (NWI). A draft report of the inquiry was published for comment in February 2021 (Productivity Commission, 2021[107]). The Inquiry includes an assessment of the extent to which the NWI reforms are adequate to support government responses to emerging or changing water management challenges such as climate change. The Commission will also consider the interaction of water policy with other policy areas such as climate and the policy ramifications of emerging climate change impacts on water resources.

Each review of the Commission is very comprehensive. For instance, in its review of the NWI, the Commission will assess the progress of jurisdictions towards adopting the principles set out in the NWI, consider the outcomes (including benefits and opportunity costs) of reform efforts, consider the extent to which the NWI reforms help address emerging challenges faced by Governments, water providers and water users, such as climate change or changes in economic circumstances, and make recommendations on future reform priorities, and ways in which the NWI could be improved.

Under the Water Act 2007 (Cth), the Productivity Commission is also required to undertake five-yearly assessments of the effectiveness of the implementation of the Murray-Darling Basin Plan and state and territory water resource plans. The first assessment report was released in 2019 (Productivity Commission, 2019[108]). It covered four questions: how actions of governments to implement the Basin Plan are tracking against the set timeframes; the extent to which management arrangements will deliver on the objectives of the Plan and enable its impacts and outcomes to be evaluated; whether actions to implement the Plan have been effective and efficient; and the

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[29] Similarly, but using economic theory, Becker (2015[137]) looks at the development of pricing in Israel.

institutional and governance arrangements for implementation. The Commission noted that the Basin Plan is scheduled to be reviewed in 2026 and that this review will need to be forward looking and consider emerging risks (such as climate change). Planning for the 2026 review needs to commence soon and the Commission expects to see demonstrable evidence of this planning when it next examines the implementation of the Plan in 2023. This includes establishing a process to identify and address any knowledge gaps that may hinder the 2026 review.

In its inquiries, the Productivity Commission consults widely including establishing stakeholder working groups, inviting public submissions, holding public hearings, and releasing draft reports for public comment. The Commission consults with relevant Australian Government, state and territory government agencies, key interest groups and affected parties.

Source: Referenced reports.

Measuring progress in groundwater management for irrigation

Aquifers constitute key water reserves that can help adapt to climate volatility if groundwater use is managed sustainably (Akam and Gruere, 2017[109]). Monitoring progress in this area can measure the impact of agriculture and risk reductions, which are intrinsically linked in largely exploited groundwater basins, and maximise benefits for irrigators (with water on demand). Naturally, evaluations require good hydrological information, and wells monitoring (Gruère and Le Boëdec, 2019[14]).

A number of comprehensive assessments have looked at groundwater issues (OECD, 2015[23]). For instance, Frija et al. (2015[110]) assessed the performance of groundwater management policy instruments (regulatory, economic and local governance) in the agricultural sector in Tunisia. They considered the overall groundwater evolution and held broad consultations to understand whether each of the policies they looked at contributed to the increased productivity of agriculture, reduced groundwater withdrawals, whether these instruments were accepted and their implementation levels and costs. Many research reports and publications analyse groundwater management policies and approaches in Spain, with institutional, legal, qualitative and semi-quantitative policy analyses (De Stefano and Llamas, 2012[111]).

Quantitative ex post analyses are rarer, in part because they require groundwater use and resource data that are not universal. These exercises are also one time evaluations. Badiani and Jessoe (2019[112]) measure the impact of electricity subsidies on groundwater levels and agriculture in India. They find that the subsidies increase groundwater use and the area cultivated with water intensive crops. Drysdale and Hendricks (2018[113]) evaluate the adaptation of irrigators to a locally adopted water pumping restrictions in the US state of Kansas in 2013. It uses a panel of groundwater pumping, rights and characteristics in the targeted location and neighbouring area. Estimates comparing before and after show that irrigators reduced their water use by 26% compared to the absence of this restriction, controlling for other factors. [30]

5.2. Measuring progress in controlling diffuse nutrient pollution

5.2.1. Problem definition and consequences for monitoring policy progress

Inputs to agricultural lands such as nutrients are widely recognised as major causes of deteriorating water quality. Agricultural diffuse nutrient sources – nitrogen and phosphorus – remain the principal polluters of water bodies in OECD countries (Gruère, Shigemitsu and Crawford, 2020[17]). For example, in the Mississippi River Basin in the United States, which spans 31 states and drains into the Gulf of Mexico, nutrient run-off from row crops and concentrated animal feeding operations (CAFOs) contribute the most nutrient pollution (EPA, 2012[114]). In European countries, the agricultural use of nitrogen in organic and chemical fertilisers has been a major source of water pollution and farming remains, responsible for over 50% of the total nitrogen discharge into surface waters (EU, 2010[115]). Globally, nitrogen used as a fertiliser

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[30] A number of sophisticated groundwater policy analyses use hydro-economic models, calibrated to local conditions, to assess the effect of particular policy options such as Kuwayama and Brozovic (2013[146]) or Hrozencik et al. (2017[145]). However, these are essentially ex-ante assessment, therefore not characterising policy progress per se.

per cropland area increased eightfold where phosphorus use increased threefold since 1961 (Lu and Tian, 2017[116]).

Controlling diffuse nutrient pollution management is therefore increasingly important, but difficult to do, due to the presence of asymmetric and incomplete information (OECD, 2012[11]). Most OECD countries have monitoring networks to measure the state of water quality of water bodies and farm nutrients have been recorded in more detail and with greater frequency than other agricultural pollutants (Gruère, Shigemitsu and Crawford, 2020[17]). Still, monitoring diffuse nutrient pollution from agriculture is more difficult and therefore less common than monitoring of other pollutants in OECD countries (OECD, 2017[12]).

Furthermore, despite technological progress, assessing the compliance and effectiveness of regulations and policies remains difficult. For instance, checking compliance with the use of best management practices requires multiple activities, such as the monitoring of nutrient management plans; bookkeeping for fertilisers, manure management on farms; nutrient accounting; and soil analysis (FAO, 2018[117]). Some countries have developed farm models to estimate runoffs from animal waste and fertilisers (OECD, 2017[12]).[31] Others rely on models to localise water pollution hotspots (Gruère and Le Boëdec, 2019[14]).These modelling tools, which can effectively support decision making, need to be calibrated to a wide range of climatic variability, and cannot provide viable enforcement mechanisms.

The dispersion of impacts associated with nutrient use, which constantly vary over time and location, are difficult to observe and almost impossible to track in multiple farms. This contributes to the characterisation of the management of nutrient as a “wicked problem” for policy makers (Shortle and Horan, 2017[118]). OECD countries have favoured voluntary incentive programmes in many cases, which have generally not led to water quality improvements (Ribaudo and Shortle, 2018[119]). Still, some policy initiatives that have shown results in terms of water quality improvements, whether via highly targeted regulatory mechanisms, extensive training programmes covering a large number of farms, urban-rural or watershed partnerships, or via the use of water quality trading mechanisms (Shortle, 2010[120]; Gruère and Le Boëdec, 2019[14]).

Progress in terms of controlling diffuse nutrient pollution can be defined relative to a reference concentration level, a nutrient balance objective, a maximum nutrient load, or a relative reduction of any of these variables. The duration of the monitoring exercise needs to be sufficiently long to observe a meaningful result, especially in the case of groundwater pollution. The level of application for evaluation matters significantly; smaller scope can limit the potential problems of diffuse pollution tracking. For instance, Bishop et al. (2005[121]) used sophisticated data analyses to assess the effect of best management practices on Phosphorus load in a small reservoir serving New York City, limiting the region of interest. At the same time, measuring progress for any policy in this area needs to account for remaining uncertainties associated with the measured outcome and reported link between a policy and a particular outcome.

5.2.2. Examples of policy progress monitoring

Monitoring pollution levels in the European Union

The European Union conducts regular evaluations of policy progress and pollution level, as part of its periodical reporting to assess whether implemented policies are effective in reducing nutrients loads from agriculture. Specifically, the Nitrates Directive (91/676/EEC) was set up aiming to reduce and prevent water pollution caused by nitrates from agricultural sources such as setting Nitrate Vulnerable Zones, in which nitrate action programmes must be implemented and minimum requirements of nitrogen fertiliser use needs to be respected.

In order to evaluate whether the countries meet the Directive’s objectives, article 10 of the Nitrates Directive requires EU Member States to submit a national monitoring and progress report on the implementation of the Directive to the Commission every four years with information on (1) the preventive action related to codes of good agricultural practice, (2) a map of surface and groundwater affected by nutrient pollution and the location of the designed vulnerable zones, (3) the water quality monitoring results, (4) the implemented action programmes. EU Member States are also mandated to conduct an analysis of nitrate

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[31] In particular, New Zealand is expanding its use of the OVERSEER tool (OECD, 2017[12]).

concentration levels and trophic state by setting up monitoring networks for ground, surface and marine waters (Articles 5 and 6) (EU, 2018[122]).

The European commission then publishes a report based on the information received by the countries (under Article 11). For the 2008-2011 and 2012-2015[32] reporting periods, all 27 Member States submitted data, which enabled the European Commission to observe trends and changes of policies and effects and to identify necessary policy design improvements. For example, the latest report found that freshwater and groundwater quality slightly improved during the period 2012-2015 based on the data on nitrates concentration. It also shows variation across the European Union, identifying Member States where action programmes are yielding good results and Member states where further actions to reduce and prevent pollution are needed (EU, 2018[122]).

This type of evaluation is another example of comprehensive assessment combining qualitative and semi-quantitative information (PO.5). It provides information on policy progress, based on the evolution of water quality variables, but also reports on the specific policy changes and programmes undertaken by each Member State. While overall reporting exercises are structured, heterogenous monitoring processes prevent the report from enabling a valid comparison of progress across Member States.The monitoring period and objectives are well defined, but the results of the policy evaluation and description of programmes, are well substantiated but not sufficient to support a result based-assessment of policy progress.

Just like other comprehensive assessments, this assessment offers a thorough analysis of programmes and their modalities. At the same time, the exercise may underestimate the role of other factors in observing the results (counterfactual), although the inclusion of regional and local analyses may provide some contextual factors, such as the price of fertilisers and trends in animal and dairy markets. The fact that it concentrates on nitrate regulation and programmes facilitates policy understanding, but leaves out the potential role of other policy changes.[33]

A structured evaluation of nutrient control policies in the Baltic Sea

The Baltic Sea is one of the most polluted seas in the world, mainly due to eutrophication induced by nutrient loads originating from agriculture and urban waste water. The problem is transboundary, as the Baltic Sea is bordered by eight EU Member States (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden) and the Russian Federation.

The European Union has implemented multiple policy initiatives to limit nutrient pollution in the Baltic Sea. For example, under Article 13 of the EU2008 Marine Strategy Framework Directive (2008/56/EC), EU Member States are called to co-operate within regions and sub-regions to achieve a good environmental status of marine waters, where practical and appropriate, using the structures already in place under the regional sea conventions. The 1974 Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area requires the reduction of nutrient loads from its contracting parties (the nine coastal countries and the European Union). In 2007, the Baltic Sea action plan (BSAP) to restore the Baltic Sea to a good environmental status by 2021 was adopted by the signatory countries of the Helsinki Convention. On the agriculture side, the European Agricultural Fund for Rural Development has supported rural development programme measures which may have a direct or an indirect impact on water quality.

As part of its mandate, the European Court of Auditors (ECA) examined whether the EU actions have been effective in reducing nutrient loads into the Baltic Sea In particular, the ECA questioned the role of EU agriculture-related actions in reducing nutrient pollution into the Baltic Sea. [34] To do so, it examined (1) the effectiveness of the implementation of the requirements under the Nitrates Directive in relevant EU member states, including the appropriateness of follow-up by the European Commission; (2) the effectiveness of cross-compliance mechanism introduced in 2005 to the Common Agriculture Policies

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[32] 28 Member States including Croatia for the first time.

[33] This may be less problematic during the 2012-15 cycle, as the Common Agriculture Policy remained unchanged.

[34] Other questions include (1) Have Member States been successful overall in reducing nutrient inputs into the Baltic Sea? (2) Have EU actions regarding urban waste water been effective in reducing nutrient pollution into the Baltic Sea? (3) Has the EUSBSR provided added value as regards existing actions for the reduction of nutrient inputs into the Baltic Sea?

which links the payments received by farmers to their compliance with environmental requirements; and (3) the effectiveness of EU co-financed rural development measures aimed at water protection are effective as regards nutrient reduction.

To evaluate progress in these areas, the ECA examined the EU actions to reduce agricultural pollution by visiting Finland, Latvia and Poland and it sent questionnaires to the five Baltic Sea EU Member States that were not visited (Denmark, Germany, Estonia, Lithuania, and Sweden) concerning their plans for enforcing the Helsinki Convention nutrient reduction targets. It also analysed documents, data, and conducted interviews with the European Commission staff, the Helsinki Convention Commission Secretariat, experts from the Baltic Nest Institute and representatives from the Estonian Audit Office, which carried out a similar audit in Estonia. The questionnaires were developed based on existing legislation, Commission guidelines and the Helsinki Convention agreements, as well as from previous audits in the field of water protection (ECA, 2016[123]).

The ECA review is an example of comprehensive evaluation that aims to assess a policy design and its compliance with rules (PO.3), while considering the effectiveness of the policies (PO.5). It combines a qualitative exercise with a structured analysis of compliance of the EU Commission’s budget spending and programmes, while considering the effectiveness of the policy and programmes, using a range of qualitative and quantitative information. On the one hand, the part of the review that assesses the policy design is based on well-defined criteria and an evaluation grid. On the other hand, the policy result assessment is not as comprehensive. It relies on existing evidence in the five countries, instead of a policy result assessment. It is difficult to know whether all uncertainties are accounted for. Given the scope of policies discussed, the question of attribution may not be as much a problem as in other evaluation. At the same time, the review would need to take into account non-policy factors that may exacerbate the water condition in the Baltic Sea to provide a more robust assessment of policy progress.[35]

Nutrient pollution policy reporting, tracking and evaluation in the United States

In the United States, the Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters and for regulating quality standards for surface waters (US EPA, 2021[124]). Under the CWA, the US Environmental Protection Agency (EPA) approves water quality standards (WQS) set by state or federal laws (US EPA, 2021[125]). These standards define quantitative nutrient criteria, the desired condition of a water body, and the means by which that condition will be protected or achieved. Numeric nutrient criteria are critical tools for protecting and restoring a waterbody's designated uses related to nitrogen and phosphorus pollution. They also enable the effective monitoring of waterbodies in relation to their objectives.

The EPA publishes and updates a table that shows the progress of numeric nutrient criteria implementation and nutrient levels by US state (Figure 9) (EPA, 2020[126]). Specifically, the table indicates the adoption of current and past EPA-approved numeric nitrogen and phosphorus criteria based on state-provided information. The table also shows the presence of nitrogen and phosphorus criteria by water type (lakes, reservoirs, rivers, streams and estuaries) for each state. This information is translated into indices. The degree of policy implementation and water quality are measured by scale of one to five; from level 1: absence of nitrogen and/or phosphorus criteria to level 5: complete set of nitrogen and phosphorus criteria for all water types. The table also includes pollution levels by state.

While the pollution level and the adoption of quantitative criteria are not necessarily correlated, having these two indicators can help clarify the effectiveness of setting a target and encourage potential improvements. Moreover, the time series makes it possible to see changes and progress with respect to past periods and allows state by state comparisons, encouraging more countries to set up pollution criteria and abiding by those. Focusing on policy choice and outcomes also limits the risk of incorrect conclusion, or biased correlation. It enables the observer to consider the role of specific policy changes (including the adoption of a criterion) and other policy changes and factors.

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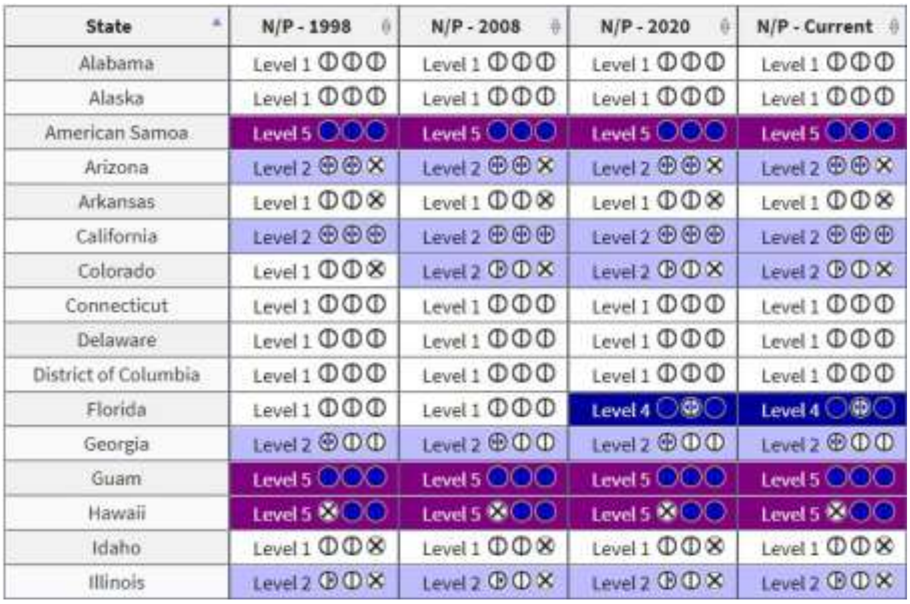
[35] For example, increased sea temperatures due to climate change offer a more conducive environment for the growth of algal blooms, as well as a prolonged growing period. Shorter and wet winters will lead to less snow and ice cover and thus to greater run-off from rivers’ catchment areas. This will result in increasingly high nutrient loads entering the sea, which will likely aggravate eutrophication.

Figure 9. Nutrient criteria status and progress for selected US States and years



State	N/P - 1998	N/P - 2008	N/P - 2020	N/P - Current
Alabama	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶
Alaska	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶
American Samoa	Level 5 ●●●	Level 5 ●●●	Level 5 ●●●	Level 5 ●●●
Arizona	Level 2 ⊕⊕✕	Level 2 ⊕⊕✕	Level 2 ⊕⊕✕	Level 2 ⊕⊕✕
Arkansas	Level 1 ⦶⦶⊗	Level 1 ⦶⦶⊗	Level 1 ⦶⦶⊗	Level 1 ⦶⦶⊗
California	Level 2 ⊕⊕⊕	Level 2 ⊕⊕⊕	Level 2 ⊕⊕⊕	Level 2 ⊕⊕⊕
Colorado	Level 1 ⦶⦶⊗	Level 2 ⊕⦶✕	Level 2 ⊕⦶✕	Level 2 ⊕⦶✕
Connecticut	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶
Delaware	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶
District of Columbia	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶
Florida	Level 1 ⦶⦶⦶	Level 1 ⦶⦶⦶	Level 4 ○⊕○	Level 4 ○⊕○
Georgia	Level 2 ⊕⦶⦶	Level 2 ⊕⦶⦶	Level 2 ⊕⦶⦶	Level 2 ⊕⦶⦶
Guam	Level 5 ●●●	Level 5 ●●●	Level 5 ●●●	Level 5 ●●●
Hawaii	Level 5 ⊗●●	Level 5 ⊗●●	Level 5 ⊗●●	Level 5 ⊗●●
Idaho	Level 1 ⦶⦶⊗	Level 1 ⦶⦶⊗	Level 1 ⦶⦶⊗	Level 1 ⦶⦶⊗
Illinois	Level 2 ⊕⦶✕	Level 2 ⊕⦶✕	Level 2 ⊕⦶✕	Level 2 ⊕⦶✕

Note: This illustration presents a truncated version of the table on the US EPA website. In each cell, the three circles stand for lakes/reservoirs, rivers/streams and estuaries, respectively. Each circle in split in two parts with the left part representing criteria for N, the right part for P. The more the circles are filled the more complete is the criteria decision process; a cross indicates the absence of the type of water body.
Source: EPA (2020[126]).

These criteria can also help in the development of Total Maximum Daily Loads (TMDLs), which are pollutant reduction targets for any water body that enable the allocation of necessary load reductions necessary by pollutant. TMDLs have been a key component of the nitrogen and sediment controlling efforts in the Chesapeake Bay (OECD, 2017[127]). A complex model determined that nitrogen needed to be reduced by 25%, phosphorus by 24% and sediment by 20% by 2025 to restore water quality in the Bay. The model attributed the particular targets by states and river basins based on their pollution contribution (Ibid.). These targets need to be reached government agencies in the six states, whose waters flow into the Bay with implementation plans progress compiled in Watershed Implementation Plans (WIPs). These plans, which are other examples of comprehensive assessments (PO.5), provide reviews of activities and progress towards the targets; they cover eight elements from the pollution status to tracking protocols, plans to address gaps, and contingency plans. There are three plurennial phases for WIPs development. The latest phase of these plans was in 2019 (US EPA, 2020[128]).

Going one step beyond criteria, targets and outcome, the United States Nutrients Working Group (NWG), a partnership between Water Administrators and the US EPA, measures progress of state nutrient reduction (ACWA, 2017[129]). The Nutrients Reduction Progress Tracker was created to improve the robustness of national metrics and demonstrate state actions and policies taken to reduce nutrient loads in conjunction with the development of nutrient criteria. The Tracker is composed of five sections: Part I covers state-wide strategy, monitoring, assessment and observed changes in water quality; Part II asks information about nonpoint source pollution; Part III requests information about point source pollution; Part IV concerns drinking water; and Part V reports any other efforts conducted to reduce nutrient pollution.

The tracker measures outputs and outcomes from various programme areas. The 2017 tracker includes responses from 31 states, including the District of Columbia in addition to national data by the EPA. The responses report specific actions undertaken by state authorities to reduce nutrient in their waters. Collected responses from the 2017 tracker can be used as a baseline from which to measure progress in nutrient reduction nationwide.

This example can be considered an intermediate option between outcome indicator monitoring (PO.4) and comprehensive assessments using semi-quantitative and qualitative information (PO.5). It is a monitoring tool that tracks changes in policies and pollution, without conducting an actual evaluation of the links between the two. Yet, this tool does more than just track outcome indicators by reporting policy responses; it provides data that can be the basis for further analysis.

Focusing in particular at the effect of conservation programmes, the Conservation Effects Assessment Project (CEAP) led by the Natural Resources Conservation Service of the US Department of Agriculture, evaluates the environmental effects of agricultural practices, including nutrient runoffs, at different scales in the United States. Osmond et al. (2012[130]) draw lessons from 13 CEAP projects to protect water quality in agricultural watersheds, noting that sediment reduction has been effective, while they did not observe much evidence of progress in nutrient reduction. They also identify requirements for future conservation programmes to be more effective. White et al. (2014[131]) report findings from the CEAP project on nutrients delivery from the Mississippi River to the Gulf of Mexico. The project modelled nutrient loads in the watersheds. They then use the model to estimate the impact of conservation practices in the watershed, finding that their adoption reduced 20% of the nutrient runoffs to the Gulf of Mexico.

This type of modelling assessment offers an alternative to quantitative *ex post* evaluations where information and data are difficult to measure. It compares current nutrient flows with a situation without conservation practices (and related policies). By keeping all other variables constant it can capture the complex hydrology of a watershed, yet it also relies on data and assumptions that may simplify the complexity of links between a policy lever, the adoption of practices, their effects on field and on the watershed.

5.3. Lessons from the two case studies

A few lessons can be drawn from comparing the characteristics and challenges of the two case studies (Table 5).

Table 5. Comparison of the case studies

	Sustainable management of irrigated agriculture under climate change	Controlling diffuse nutrient pollution
Goal	Higher Irrigation benefits, lower risks, lower environmental impacts	Lowering pollution loads from agriculture activities.
Types of policy progress assessed	All types	General principles can be used for design, difficult to assess implementation capacity needs and results.
Mainly used practical options	PO. 5 and PO. 7	PO. 4 and PO. 5.
Progress (objective) definition	Weighing the three dimensions may be difficult, risk resilience objectives are harder to set	Multiple definition of pollution and uncertainties in measurement makes it difficult for precise definition.
Baseline or counterfactual definition	Often imperfectly done. Water use and risks depending on climate change. Other factors are not always considered.	Challenging associated with the characterisation of diffuse pollution flows.
General challenges	Limited data or understanding on water flows, incorporating uncertainties, capturing behavioural responses to policy, addressing economic and environmental trade-offs.	Challenges in assessing pollution flows and in measuring policy outcomes, no reference solution to this wicked problem.

Source: Authors.

Both cases highlight the difficulties associated with uncertainties, imperfect data and measurement that constrain the capacity to measure progress. At the same time, the irrigation case study underscores the problem of coping with multiple objectives. Progress achieved, whether in terms of policy design, implementation capacity, or policy results, is not likely to be uniform across multiple objectives. For instance, achieving groundwater sustainability by reducing long term overdraft can be opposed to ensuring the viability of the irrigated sector. The nutrient pollution case shows the difficulty of measuring the effect of better farm management practices on the concentration of pollutants in water bodies. In this context, an improved understanding of the functioning of a particular policy change may be a more realistic objective than reaching a broad estimation of the impact of a policy change on pollution.

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