DRR and economic instruments

Economic instruments, such as risk financing instruments, water pricing and water markets, private-public partnerships, taxes, and others, can produce incentivising behaviour and increase the uptake and efficiency of adaptation measures by MSPs. The effectiveness of these instruments at reducing risk is frequently debated in the policy and science spheres. Yet, the evidence base on their effectiveness remains limited (even for insurance-related instruments) and there are few conceptual and numerical analyses (Agrawala & Fankhauser, 2008; Kunreuther & Michel-Kerjan, 2009; Bräuninger et al., 2011). For example, the White Paper on the adaptation of the European Commission (EC; EC, 2009) calls for 'optimising the use of insurance and other financial services products, specialised Market-Based Instruments (MBIs) and public-private partnerships with a view to the sharing of investment, risk, reward and responsibilities between the public and private sector in the delivery of adaptation action'.

There is an increasing interest in the use of such economic instruments, which are currently at the heart of the debate on novel approaches to managing risk. The literature suggests that **risk transfer** could play an important role in risk reduction by incentivising the take-up of risk reduction measures (Herweijer et al., 2009; Maynard & Ranger, 2011). Risk transfer removes or reduces the risk of experiencing an uncertain financial loss. However, if designed and operated appropriately, it can also play a role in physical risk reduction and adaptation. There is a semantic challenge that one must consider when analysing the links between risk transfer and risk reduction on one hand, and adaptation on the other: stakeholders do not always speak the same language, and may use many terms in different contexts, such as loss prevention, risk engineering, risk reduction, vulnerability reduction, and climate adaptation. Assessing the effectiveness of a risk transfer scheme at incentivising risk reduction goes beyond pure economic cost-benefit analysis, and must include recognition of the different stakeholder objectives, such as vulnerability reduction, commercial viability, affordability, and the financial sustainability of a scheme in the context of changing risk levels. Measuring this effectiveness remains a challenge, particularly in the context of public-private partnerships because success or failure often only becomes evident after another risk event, and it requires in-depth data collection on the ground.

ENHANCE analysis identified three channels through which economic instruments can contribute to risk management: (1) direct risk reduction: for example, risk financing provides direct compensation payments, which reduce follow-on impacts from an event; (2) indirect risk reduction: incentives for risk management and increased resilience help to reduce and manage risks, (3) managing systemic risk: both down-and upside risk are managed; the insurance takes the down-side (bad risks) risks out of investment decisions, and focuses on harnessing upside risks (good risks).

ENHANCE examined the scope of different economic instruments for enhancing resilience and managing risk, and applied a common framework based on multi-criteria analysis to assess economic instruments in the case studies, in order to specify the suitability of those instruments. The criteria (and associated) indicators comprised the following aspects: economic efficien-

Introduction and overview

Economic instruments (EI), such as **subsidies**, **taxes** and **insurance-related options** are at the heart of discussions regarding novel approaches for managing risk and adapting to climate change, including in the context of multi-stakeholder partnerships (MSP) between the private and public sectors (Agrarwala and Fankhauser, 2008; Chambwera et al., 2014).

Although the attractiveness of reducing and managing disaster risk has long been demonstrated (e.g., Foresight, 2012), **there is underinvestment into disaster risk management** (DRM). A number of factors, such as a lack of comprehensive information and cognitive biases are important. In particular, financial constraints and moral hazard, i.e. adverse incentives provided by current arrangements for dealing with disasters play a large role (Chambwera et al., 2014).

In this line of thinking, instruments that provide a price signal for risk management and incentivise behavioural change hold high appeal by policymakers including in the EU (see Bräuninger et al., 2011). Yet, little is known about such economic instruments, their mechanics, links to risk management and concrete application in the field of disaster risk management (and climate adaptation) (see Chambwera et al., 2014). Knowledge gaps exist particularly with regard to conditions that create enabling environments for innovative market-based and risk financing instruments. Among these are, e.g., the attractiveness for stakeholders in the context of MSPs or institutional settings that are required to successfully and efficiently apply the EI.

This chapter discusses the **potential of EI for managing and incentivising risk management in the context of the ENHANCE project**. The analysis debates how economic instruments may support risk management, including new partnerships between the private and public sectors. Based on an inventory, it applies different assessment techniques to the most promising options by way of case studies, and finally gauges the potential of key economic instruments for incentivising risk management generally via multi-criteria assessment.

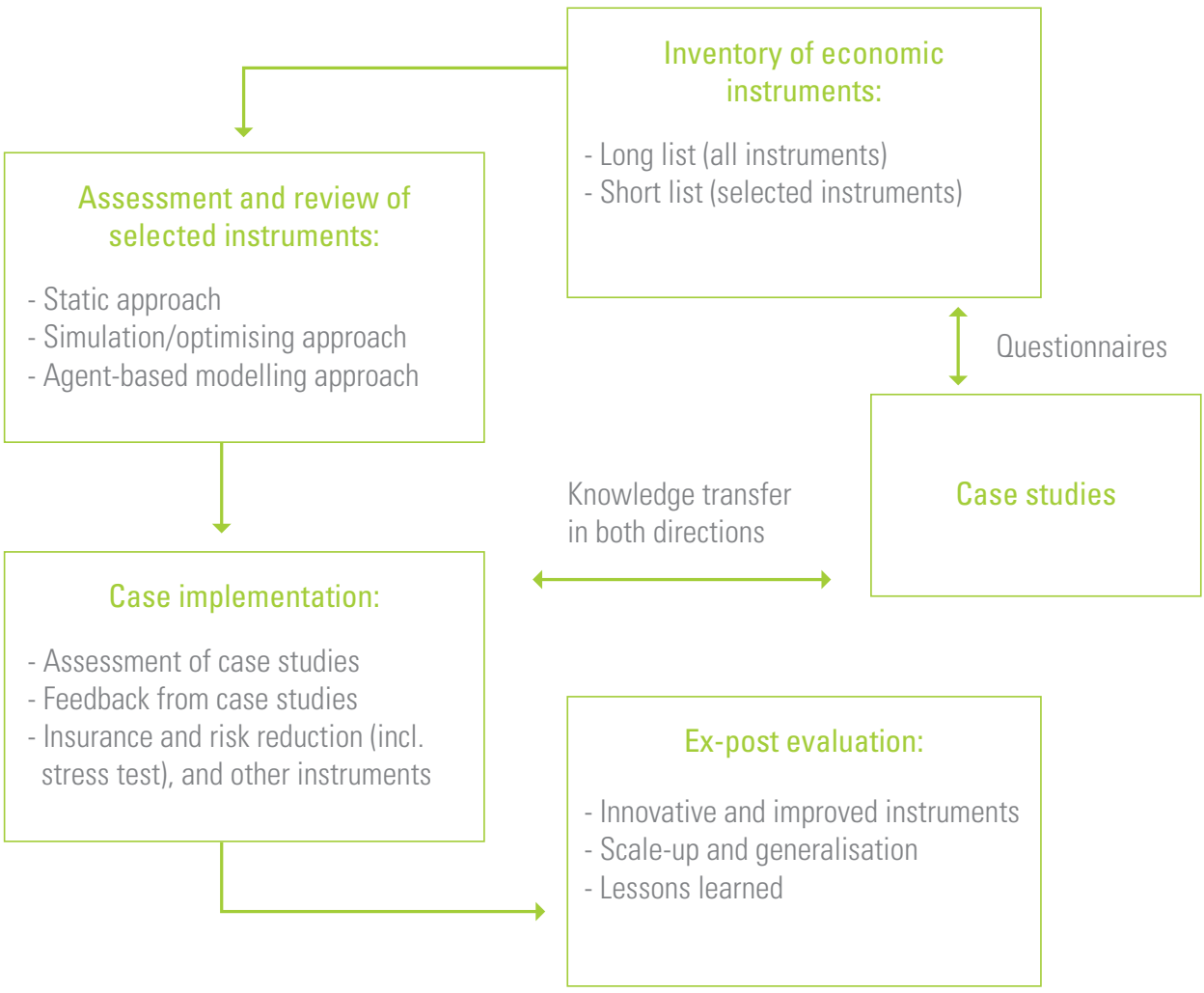
The guiding questions for this part of the ENHANCE project have been:

- What innovative economic instruments exist for managing disaster risk?
- How do they contribute to risk management?
- How do case studies discuss and assess economic instruments?
- What can be learned from the case study application using a common assessment framework?

Approach

Figure 4.1 shows the main tasks carried out for this line of work. A review of the available literature leads to a long list of potential instruments and their general applicability. Screening of anticipated uptake of the instruments in key ENHANCE case studies via a questionnaire submitted to our case study partners produced a short list of instruments, which were implemented and further assessed via modelling and empirical analysis. As the final step, a common framework based on multi-criteria analysis was applied to the case study instruments to assess their specific suitability.

Figure 4.1.
Workflow for assessing economic instruments for managing disaster risk in the ENHANCE project.



Review of economic instruments for disaster risk management

Private and public sector agents are tasked with managing disaster risks. While significant efforts of reducing and managing risk are being carried out throughout many regions, recent evidence suggests less than optimal adaptation levels to current hazards and future changes therein, e.g. through climate change (Agrawala and Fankhauser, 2008; IPCC, 2014) across all regions, sectors and societies. In fact, as discussed in IPCC (2014), given a diverse set of risks and manifold preferences, constraints and perceptions of risk, there is no such thing as 'optimal' adaptation. Yet, there is ample scope for 'better' adaptation and risk management. Risk management may happen autonomously or through policy intervention and policy instruments – the focus of our attention for this chapter.

Apart from insurance-related instruments, few adaptation instruments work ***directly*** via economic principles and using markets to adapt to impacts and risks. On the other hand, economic instruments can be used to ***indirectly*** incentivise behaviour and increase the uptake and efficiency of adaptation measures. As one important reference, Agrawala and Fankhauser (2008) distinguish the following incentive-providing instruments relevant for key sectors:

- insurance schemes (all sectors subject to extreme weather events);
- price signals / markets (water; ecosystems);
- financing schemes via Public-Private Partnerships or private finance (flood defence, coastal protection, water);
- regulatory measures and incentives (building standards, zone planning);
- research and development incentives (agriculture, health).

Synthesising this, and in line with recent literature, we consider two broad types of instrument categories (see also Chambwera et al., 2014; Bräuninger et al., 2011):

1. **Market-Based Instruments (MBI)** are instruments administered by government regulators that provide a monetary/economic incentive promoting risk management and adaptation. According to the EU white paper, the definition of MBI is broad (see EU Commission, 2009) and in the interpretation of this chapter it includes natural resource pricing, taxes, subsidies, marketable permits, payments for ecosystem services, licences, property rights and habitat banking.
2. **Risk Financing Instruments (RFI)** comprise all instruments that promote the sharing and transfer of risks and losses. They generally can be classified as pre-disaster arrangements, and comprise insurance, weather derivatives and catastrophe bonds, and many of those are indeed market-based as well.

Three channels through which EI can contribute to risk management can generally be identified (see Bräuninger et al., 2011; Chambwera et al., 2014):

1. **Direct risk reduction**: as one example, risk financing provides direct compensation payments, which reduce follow-on impacts from an event.
2. **Indirect risk reduction**: incentives for risk management and increased resilience help to reduce and manage risks.
3. **Managing systemic risk**: both down and upside risks are managed, i.e. insurance takes down-side ('bad risks') risk out of investment decisions, which overall focus on harnessing upside risks ('good risks').

Our inventory is presented in the form of a long list (see **Table 4.1**) and reflects instruments applied in the case studies. The EI are split up into the key groups mentioned above (see also Bräuninger et al., 2011).

Table 4.1.
Overview of economic instruments with applicability for managing disaster risk.

Economic instrument	Description
I. Market-based instruments	
Subsidies	Subsidies can be defined as a financial support/incentive from a government to an entity for implementing a practice or performing a specified action.
Grants	Direct payments or grants constitute the purest form of a subsidy. An economic entity receives an amount of money, which is supposed to induce the recipient to undertake a specific action bound to that payment.
Price supports	Price supports belong to the group of indirect subsidies although some direct payment is usually associated with them. In its most common form, the government defines a price floor for a good and pays the differential amount to the producers of the good as soon as the market price falls or is below this minimum level.
Pricing (taxes and fees)	Besides generating government revenue allowing public expenditures e.g. for a public adaptation policy, taxes can also be used to direct private behaviour towards a socially optimal behaviour.
Land use taxes and fees	Land use taxes –we understand them as a tax on land and buildings – represent a payment either for the land ownership itself or for its kind of use. Land use fees are similar in nature, but they would by definition require some type of service from the collecting (public) institution in return.
Water pricing	Price to be paid for a certain amount of water or water/sanitation services. Double role, as financial instrument for cost recovery of water services and as economic instrument, acting as incentive for a more efficient water use. The EU Water Framework Directive requires the recovery of financial, environmental and resource cost of water services, considering the Polluter Pays Principle. The resource cost has been related with the opportunity cost (social welfare losses) of not using water for the most socially beneficial use. Efficient water pricing should incorporate a signal of the marginal value of water to the users. The design of the final tariffs for residential water supply involves the consideration of conditions of revenue sufficiency, efficiency, equity and affordability.
Licenses, permits and variations	Environmental markets are based on the generation of demand for tradable units through regulatory decision. This demand then triggers the supply of units.
Project-based offsets	A project-based adaptation offset could be generated by projects in regions where adaptation is relatively easy to generate, but where no governmental adaptation commitment exists.
Advance market commitment	The government guarantees a certain income to the entity providing a desired activity, making this instrument comparable to a subsidy.
Other market-based instruments	These instruments specifically address the problem of overuse of natural resources, partially picking up some of the broader concepts, like taxation.
Payments for ecosystem services	As long as the benefits from changing the ecosystem instead of conserving it are larger, a payment would be needed in order to avoid e.g. conversion of forests to pasture.

Water markets	An intensification of unevenly distributed water resources and extreme events such as droughts, together with increasing average temperatures, calls for the efficient use of scarce water supplies. Voluntary win-win trades of water can contribute to reallocate scarce resources to the high-value uses, improving the economic efficiency and promoting the adoption of water saving technologies. There is a broad range of options (permanent transfers, temporary transfers, option contracts, spot markets, etc.), and even water quality trading schemes.
Habitat banking	Habitat banking aims at conserving the ecosystem services of land, including biodiversity. Credits are given for the creation, restoration and enhancement of habitats, while debits occur when ecosystems are unavoidably degraded or destroyed.
II. Risk financing instruments	There are many instruments for dealing with the financial burden imposed by disasters. At the most general level, we distinguish risk financing from loss financing instruments. The important distinction is that risk financing is purchased/ organised by persons or a community at risk purposefully and in anticipation of risk, whereas loss financing is arranged by people, governments and the state, often ad hoc, after an event.
Insurance-related instruments	Insurance helps to finance losses caused by extreme events. Insurance has the potential to be useful for adaptation in incentivising and enabling and risk reduction as well as enabling recovery and economic development.
Catastrophe bonds	A catastrophe bond is an instrument whereby disaster risks are packaged (securitised) in the financial markets. The investor receives an above-market return provided a specified catastrophe does not occur during the contract, but sacrifices interest or part of the principal if the event does occur.
Weather derivatives	Weather derivatives are contracts where pay-outs are linked to physical 'triggers', e.g. number of days with temperatures below or above a specified threshold, or rainfall above or below a specified level.

Application to the case studies: instruments and methods

During the ENHANCE analysis a questionnaire was used to identify the type and scale of economic instrument use across the case studies. This was then refined through detailed discussions with case study partners about key instruments and the type of analytical methodologies applied in the different case studies. **Table 4.2** summarises the set of economic instruments and assessment methodologies used for the different case studies.

Table 4.2.
Overview of assessment of EI and methodologies used in case studies.

Economic Instruments	Empirical approach	Simulation and optimisation approach	Agent-based modelling approach
Grants, tax reductions	Santarém, tax-financed subsidies	--	London, subsidies for flood proofing Rotterdam, subsidies for flood proofing
Land use taxes & fees	Santarém, land-use tax	--	--
Market commitments	Santarém, market commitments	--	--
Water pricing/markets		Júcar, water pricing/markets	--
Property insurance, crop and forest fire insurance	Santarém, insurance Romania/Eastern Europe, sovereign and private market insurance market insurance	--	London, property insurance Rotterdam, property insurance, incentives for flood proofing
Sovereign insurance and related instruments	Romania/Eastern Europe/EU	EUSF	--

Simulation and optimising approach of water pricing and markets

Through simulation the economic impact of different policies/scenarios can be obtained for a particular set of a priori rules. In contrast, optimisation models directly provide the best solution in terms of the objective function and the constraints, recognising the opportunity costs and economic trade-offs inherent in any decision-making. This approach has been applied to the **Júcar River Basin drought case study** and focuses on water pricing and water markets as strategies for drought risk management (see also box below). It was also used for assessing **European-wide risk sharing via the European Solidarity Fund**.

Agent-based modelling approach

Agent-based models (ABM) are useful as they provide a bottom-up approach for understanding systems and their behaviour, and are advantageous for visualising the effects of changing behaviours. ABMs can be used to characterise different stakeholders in a risk sharing arrangement. Simulation of the hazard and losses can be used to assess the effect of different risk sharing options, and arrangements which encourage overall risk reduction. This approach has been applied to the **London and Rotterdam flooding case studies**, which focus on the role of insurance. These EI were found to be highly attractive for MSP stakeholders with a significant link to risk management. There is also a high level of experience and evidence with regard to their application for risk management and adaptation.

Mixed methods approach

Other cases used a mix of qualitative and quantitative empirical techniques. The **EUSF/Romania case study** focused on low-probability but high-consequence flood events and investigated the performance of the EUSF, including robustness, solidarity and risk reduction considerations. Beyond providing a detailed assessment of the Fund itself, the main goal was to explore if the formulation of an EU-wide multi-sector partnership that could enhance the financial resilience of the Community. The case study followed a probabilistic risks analysis method for assessing flood risk on the Pan-European level, leading into stress testing of the EUFS. Beyond the stress testing, the case study investigated the Fund's performance in terms of solidarity and promotion of disaster risk reduction by conducting a modelling exercise and a detailed analysis of relevant EU policies. The MSP of Chamusca and of Mação performed qualitative and a quantitative empirical analysis, which entailed identifying a long list of economic instruments, relevant criteria and a description for each criterion, and participatory deliberation with key the stakeholders of the MSPs.

Assessing water scarcity in the Júcar River Basin

Issue and instruments

The Júcar River Basin is a complex water resources system located in eastern Spain, highly regulated and with a high share of water for crop irrigation (about 83%), in which water scarcity, irregular hydrology and groundwater overdraft cause droughts to have significant economic, social and environmental consequences. The basin has been used as a test case to apply scarcity-based water pricing policies and water markets as potential instruments to manage drought risk. Scarcity-based water pricing policies are based on the marginal economic value of water (Pulido-Velazquez et al., 2013, Macian-Sorribes et al., 2015). When water storage is high, the marginal value of water is low, while low storage (drought periods) is associated with high marginal values.

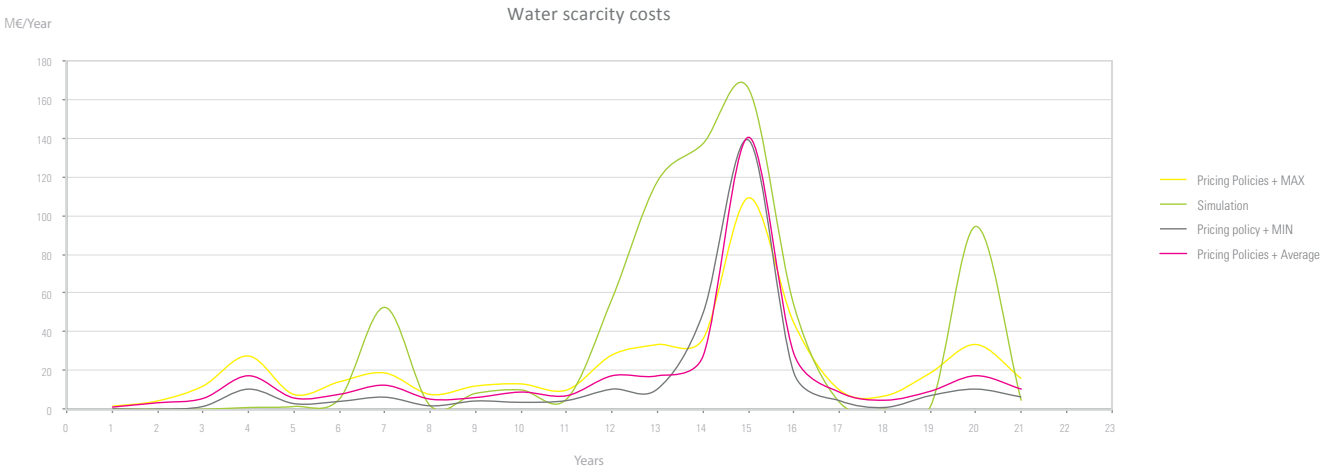
Models and methods

In order to assess the impacts of these economic instruments, two new tools were developed and applied to allocate available water resources through simulation and optimisation approaches. The **simulation tool** (SIMGAMS) allocates water resources according to system priorities and operating rules, evaluating the scarcity costs through economic demand functions. The **optimisation tool** (OPTIGAMS) allocates water resources to maximise net benefits (or minimise total water scarcity cost plus operating cost at river basin scale). SIMGAMS allows for simulating incentive-based water pricing policies based on water availability in the system (scarcity pricing), while OPTIGAMS is used to simulate the effect of ideal water markets by economic optimisation.

As the Júcar River Basin has a high share of water use for crop irrigation (around 80%), we also assessed the impact of drought on irrigated agriculture production using an **econometric approach** (Lopez-Nicolas et al. 2015). For this purpose, a two-stage approach has been applied (Gil-Sevilla et al., 2010 and 2011): first, an econometric model has been fitted to explain the impacts of water resource availability and crop price volatility on the agricultural production value. Monte-Carlo algorithms are then used to consider the contribution of the variability of the hydrology on drought risk and impacts.

Lessons and insights

The results show the potential of applying economic instruments to deal with drought risk management. Water pricing policies and water markets have a positive impact on drought risk management, reducing the total scarcity cost during drought periods. Scarcity-based water pricing policies send a scarcity signal to water users (when the storage decreases water price increases). So this works as an incentive towards a more efficient water use, promoting high-value uses during



MCA assessment of economic instruments for adaptation

Overview of synthesis assessment using MCDA framework

In choosing an approach to assess the costs and benefits of a number of economic instruments, four major decision-techniques can be identified: cost benefit analysis (CBA), cost effectiveness analysis (CEA), multi-criteria decision analysis (MCA), and robust decision-making approaches.

We utilise an MCA methodological framework in this work to discover and quantify stakeholder and decision-maker considerations about various non-monetary factors in order to compare different courses of action (Huang et al. 2011). As described by Belton and Stewart (2002), MCA approaches **'seek to take explicit account of multiple criteria in helping individuals and groups explore decisions that matter'**.

MCA is appealing and practically useful as it tries to take account of multiple conflicting criteria, provides a model that can serve as a focus for discussion, and a process which leads to rational and explainable decisions (ibid). MCA methods are desirable for analysing complex problems, as they deal with a mixed set of both quantitative and qualitative data, including expert and stakeholder opinion. The process of application is structured to enable collaborative planning and decision-making, as it accommodates the involvement of multiple experts and stakeholders (Mendoza & Prablu 2003). While there are numerous MCA methods, they all follow a similar basic approach. For any alternative, its total value score is calculated as a linear weighted sum of its score across several criteria. Alternative approaches have hierarchical structures, which break dimensions into several sub-dimensions (criteria to indicators) (Keeney and Raiffa, 1976).

Regardless of the specific MCA approach, the selection of criteria and indicators for assessment is vital, and we build on analysis conducted by Bräuninger et al. (2011), which defined and populated a set of indicators to assess economic instruments for the EU, based on qualitative scoring and expert opinion. The criteria are outlined below, with the introduction of a fourth, which deals with the environmental dimension of economic instruments.
Regardless of the specific MCA approach, the selection of criteria and indicators for assessment is vital, and we build on analysis conducted by Bräuninger et al. (2011), which defined and populated a set of indicators to assess economic instruments for the EU, based on qualitative scoring and expert opinion. The criteria are outlined below, with the introduction of a fourth, which deals with the environmental dimension of economic instruments.

Table 4.3.

Criteria used in MCDA analysis of economic instruments, and motivating questions and indicators for analysis.

Economic criterion: Efficiency	Social Criterion: Equity	Political and institutional applicability	Resources, biodiversity and sustainability
What is the balance between costs and benefits?	What distributional consequences will arise? Will they be negative, i.e. regressive? Will the instrument be affordable and cover a high percentage of those affected?	Which types of adaptive activities can be incentivised by the instruments?	Does the measure reduce the quality or quantity of resources?
What transaction costs will accrue?	Are there any specific barriers or conditions that are not covered?	Have policymakers applied similar instruments? What have the experiences been?	Does it incentivise more sustainable management of resources, or encourage biodiversity protection?
How well does the instrument incentivise disaster risk management?		Are interest groups likely to oppose such instruments?	Do measures decrease negative externalities related to human health? Do they encourage the use of linked resources?

For this assessment, we strongly relied on expert opinion, i.e. on ENHANCE analysts' perspectives on the pros and cons of the different instruments, while involving stakeholder views where possible. Scoring was jointly taken forward by the team involved in this line of work of the ENHANCE project in order to give broader insight into the instruments as they are supposed to support DRM. Several issues emerged while doing the analysis. These include level of generalisation of the results across case studies as well as questions regarding the context-specific nature of each case and instrument, as well as differences in relevance of the criteria and indicators. The comparability of results across different cases remains very questionable, and therefore the results should not be necessarily viewed as a comparison across case studies but of viewing the case study in a more holistic manner.

MCA analysis of instruments: results

The MCA analysis covered five case studies, of which four dealt with insurance-related instruments, and one, the Júcar case, with water markets and pricing. We present results separately for the analysis of water markets and water pricing as well as insurance cases.

Water markets and scarcity-based water pricing in the Júcar River Basin

Two instruments were compared in the Júcar River Basin case for dealing with water scarcity: water markets and scarcity-based dynamic water pricing. The following section provides a qualitative comparison of the two options assessed, followed by results of the MCDA process (see Figure 4.2).

Economic criterion

In theory, both water pricing policies and water markets move water to the highest-valued uses, providing an efficient water allocation with a positive impact on drought risk management, reducing the total scarcity **cost** during drought period. Water pricing would also reduce the demand in scarcity periods increasing the storage in drought conditions, which could avoid potentially larger future losses.

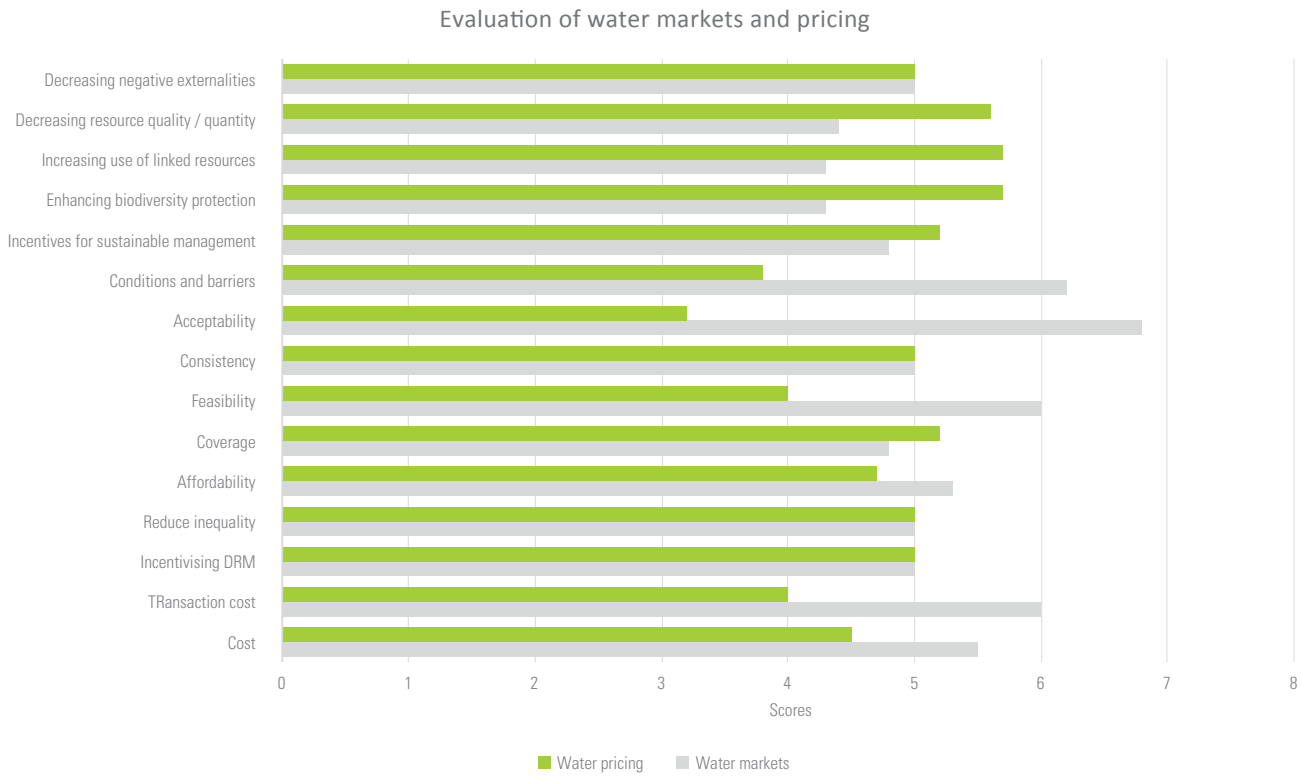
Scarcity-based water pricing policies are pricing policies linked to water availability in the basin (represented by available storage) that integrate the marginal value of water (MROC), sending the users a signal of the economic value of the resource and the opportunity costs. When water storage is high, the MROC is low, while low storage (drought periods) will be associated to high MROC and therefore, higher prices. So this works as an incentive towards a more efficient water use, promoting high-value uses during drought periods, reducing the total water scarcity cost (forgone benefits due to deficits in water deliveries). The results for the Júcar Basin show that a significant reduction of water scarcity can be achieved with an efficient scarcity-based water pricing policy, up to a 60% reduction of total scarcity cost (see Box above).

A perfect water market (results provided by the optimisation) could further reduce the total scarcity cost of the system. Results for the Júcar basin show transfer of resources from low to high value uses during drought conditions, although with implications on environmental conditions that should be regulated in order to prevent this. Transaction costs might hinder the efficiency of water markets.

Transaction costs associated with water pricing vary across methods and locations, and involve a fixed component (installing measuring devices, setting up administration etc.) and a variable component that increases with water proceeds (monitoring and collection) (Tsur, 2000). Beyond administrative costs, others can be substantial and difficult to value (Johansson et al., 2002), and may render pricing policies unfeasible. Since water scarcity pricing is based on marginal water values and use, accurate pricing would require assessing volumetric use, which may not be implemented for some uses (e.g. agricultural demands for use in irrigation), resulting in higher costs. While generating insufficient revenue is obviously not sustainable in the long run, strategies can be implemented to guarantee revenue sufficiency. Markets also involve transaction costs, and can bring costs due to the economic and environmental externalities the transfer can generate. Generally, transaction costs of water markets are higher than of pricing policies, as it might require developing new infrastructure to transfer water between sellers and buyers. When considering bargaining and information costs (also transaction costs), water markets might become more appealing.

In terms of **incentivising DRM**, instruments were not assessed to have a large direct effect, although scarcity-based water pricing policies may indirectly provide an incentive towards more efficient use of water resources by promoting high-value uses during drought periods, and providing users with a signal of the economic value of the resource and opportunity costs. Economy wide macroeconomic impacts of water pricing (e.g. effects on GDP or GVA) are difficult to account, but there are some examples in the literature using input-output tables or computable general equilibrium models (e.g. Perez-Blanco et al., 2016).

Figure 4.2.
Unweighted scoring of water pricing and water markets in the Júcar River Basin case.



Social criterion

Both instruments, pricing and markets, would contribute to the reallocation of resources to high value uses during water scarcity periods. Additional revenues generated by water pricing could be used to **compensate low-value users for some of the losses** they might face due to the price increase during drought periods using financial compensation mechanisms (e.g., Tilmant et al. 2009). The additional financial resources generated could be also employed to **develop adequate infrastructure** to increase water security (for example, by financing desalination plant that reduces water scarcity). Water exchange in water markets is voluntary and represents a win-win situation for both buyers and sellers, but control mechanisms need to be implemented in order to avoid third party effects.

Political and institutional criterion

Both approaches lead to high scores in terms of addressing political and institutional criteria, as they are legally and administratively **feasible** in the setting of the case study, although some legal and institutional reforms are required for implementation in other contexts. Both instruments are **consistent** with other regulatory or incentive-based instruments. However, in some cases water markets might face **physical barriers** to implementation, as it may be necessary to construct additional infrastructure connecting users. Scoring diverges in regards to **acceptability** by other interest groups. In the case of scarcity pricing, acceptability will depend upon the perceived equity and the affordability of the rate structure. Water markets are expected to be more easily acceptable for farmers, since they would increase their income by buying and selling the water, while water pricing policies would penalise them. But it is also true that experience shows that water markets face many practical challenges for their implementation.

Environmental criterion

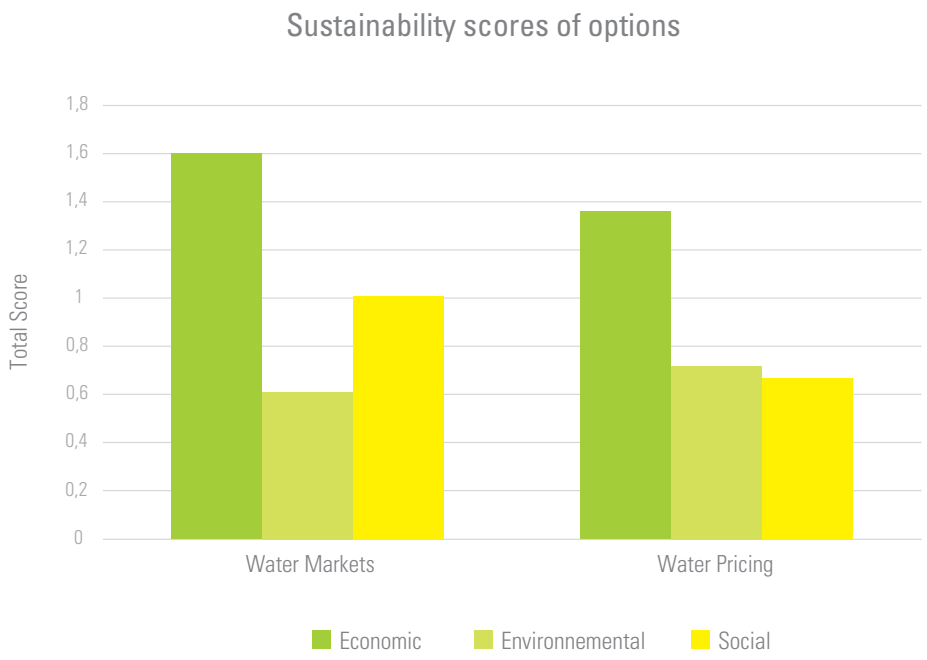
Both instruments score high in regards to environmental indicators; scarcity-based water pricing policies work to promote **more efficient water use**, enhancing **high-value uses** during drought periods. In this way, water pricing can contribute to improving economic efficiency and social equity and, by using less of the resource more efficiently, lead to environmental enhancement. However, we can be more efficient and use more water as well

Photo by Tobias Arhelger/Shutterstock.

(as have been discussed in the case of the modernisation of irrigation systems, Ward and Pulido, 2008), and therefore, have a negative environmental impact. Water markets can also lead to a more **sustainable use of water** through **water reallocation** to (1) more productive soils in more suitable locations, (2) more efficient water users, (3) higher-valued uses, and (4) new developments and the consolidation of water into more viable units, increasing employment and economic activity, and producing environmental benefits (Bjornlund, 2004). However, unless explicit consideration is given to non-market uses or reserves set aside for the public good, markets may not deliver on broader societal goals, requiring to include adequate information on environmental needs, delivering water to meet these needs, and designing an adaptive process to manage these requirements with changing conditions and circumstances (Grafton et al., 2011). Scarcity-based water pricing policies, by reducing water demand and reallocating water use, can also have an impact on environmental flows that need to be considered in the design of the pricing policy.

Results of MCDA analysis

Figure 4.3.
Average sustainability scores of water markets and water pricing for the Júcar River Basin case.



Results of this analysis are shown in **Figure 4.3**, which displays a breakdown of the scores in what it terms 'sustainability scoring', assessing options by separating indicators into economic, social, and environmental factors.[1] **While water pricing is scored as being slightly better in terms of environmental effects, water markets are seen to outperform water pricing in terms of both social and economic indicators**. In any case, this evaluation only refers to the specific pricing policy (scarcity-based marginal cost pricing) and water market scheme that was considered for the Júcar River Basin case study. There are many alternative options for pricing and water trading with many different economic, environmental and social implications. This comparison does not intend to be exhaustive nor can be further generalised. Moreover, the two instruments are not necessarily exclusive and can act as complementary options for mitigating drought impacts.

[1] Political and institutional factors are not discussed separately as they would lead to the same scores for both instruments, as discussed above.

Insurance-related instruments

The following section assesses insurance instruments analysed by the case studies of Portuguese forest fires, Rotterdam and UK flooding, and the EU Solidarity Fund. Instruments were assessed qualitatively according to each criterion, with **Table 4.4** providing a short overview (see annex for a more detailed version, outlining the specifics of each case study) of instruments using the criteria defined previously to structure analysis. The table uses a colour shading system to indicate the strength or weakness of an instrument with regards to the given indicator, as assessed by expert judgment, i.e. building on researchers' insights using quantitative and qualitative analysis. Green indicates that an option is perceived as scoring highly for a given criterion, with yellow indicating moderate ability to meet the ambition set out by the respective indicator, and red being very little or no ability. Grey indicates areas of ambiguity or indicators that are not applicable to the option.

Due to the diversity of cases and analytical tools the findings should not be seen as a comparison between different cases, but rather as a stand-alone analysis of each case.

Table 4.4.

Synthesis assessment of insurance instruments for DRM (see Annex for a more detailed version, outlining the specifics of each case study).

Criteria	Indicator	London Flood Insurance	Fire Insurance and market commitments	Rotterdam property insurance	EU Solidarity Fund
Economic	Cost	Ambiguous	Low	Ambiguous	High
	Transaction cost	Ambiguous	N/A	Moderate	Moderate
	Incentivise DRM	Moderate	High	Ambiguous	Moderate
Social	Reduce inequality	Moderate	Low	Low	Low
	Affordability	Moderate	Low	Moderate	High
	Coverage	Moderate to high	Low	Low to moderate	Moderate to high
Political and institutional	Institutional feasibility	N/A	Moderate	High	High
	Consistency	Moderate	Low	Ambiguous	High
	Acceptability	High	Moderate	Ambiguous	Moderate
	Conditions and barriers	Ambiguous	High	High	Low
Environment dimension	Decrease resource quality	N/A	High	Low	N/A
	Decrease resource quantity	N/A	Moderate	Low	N/A
	Incentivise sustainable management	Moderate	High	Moderate	N/A
	Enhance biodiversity protection	N/A	High	Low	N/A
	Decrease negative externalities	N/A	High	Low	N/A
	Increase use of linked resources	N/A	High	Low	N/A

Economic criterion

Most cases diverged widely in their assessment of economic indicators; the **cost** indicator - indicating how costly experts regard the instrument to be for the economy - varies on a case-by-case basis. The expansion of insurance can promote the growth of the insurance sector or facilitate the development of economic activity; in which case it is a boon. The Rotterdam ABM shows that strengthening the link between DRM and insurance can result in the number of households buying insurance increasing by up to 63%, a rapid expansion of the sector (Haer et al., 2015). As insurance is a transfer of resources from one economic agent to another in a mutually acceptable trade, a high premium cost is not a cost to society, as the price of the premium sends a viable signal of risk, allowing potential policy holders to make a more informed decision regarding the risk faced. However, insurance schemes tend to require (in)direct government support, which can be quite expensive, as vouchers to correct for unaffordability could cost billions of euros if offered at the national level (Hudson et al., 2016). These burdens may be balanced out with lower overall risk faced by society. For instance, in France and Germany the risk reduction potential of all households by 2040 would exceed the costs of providing insurance vouchers to correct for unaffordability (Hudson et al., 2016).

Beyond the cost of the instrument, cases generally reported moderate or low **transaction costs** for the general provision of insurance, due to the well-developed insurance markets in which most of the cases operate. However, the aspects of the cases involving a greater connection to risk would possibly entail higher transaction costs due to the increased costs of monitoring DRM activities that specific policyholders conduct[2]. Private insurers commonly state transaction costs as a major reason for not strengthening the direct link between premiums and DRM (Hudson et al., 2016). Competitive markets can help to keep transaction costs as low as possible. Moreover, in a period of increasing risk the insurers must keep increasing their reserves to meet legal solvency requirements; resulting in more resources being invested in liquid assets with higher management costs.

Most of the measures assessed showed a moderate ability to **incentivise DRM**, even though in some cases, it was not part of the initial design of the instrument, and is seen as being very context dependent. For instance, the ABM in Rotterdam shows that premium discounts could increase the share of households employing DRM by, up to, 55% (Haer et al., 2015). On the whole, the incentivising ability is ambiguous and context dependent, as highlighted by the UK flood insurance mechanism which emphasises that depending on its design and implementation, an insurance scheme can send signals to policy makers in support of flood risk management policies which would address risk levels, e.g. via changes in the planning system and building regulations. The new Flood Re scheme does not enhance this policy link nor the incentivisation of home resilience, which is a missed opportunity (Jenkins et al., 2016). The Portugal forest fire case provides a slight juxtaposition to the other cases, as experts asserted a high amount of incentivising DRM, since insurance application requires a Forest Management Plan and a Plan for Forest Fire Defence. The EUSF also found that recent reforms better linked the Fund to DRM measures, but only for flood risk, leaving more potential for strengthening the link to DRM.

Social criterion

The finding from most cases was that insurance had little to no effect on social indicators such as **inequality reduction**. The Rotterdam case emphasised that it is not a role of insurance to directly reduce inequality; insurance may have a minor role in preventing the worsening of inequality by providing compensation payments but this would only come into play after a disaster, limiting the role of instruments in this regard. Both the Portuguese and EUSF cases also saw minimum potential to reduce inequalities, with the former instrument only benefitting owners of large properties, with no subsidies in place for support, with similar results for the EUSF, as significantly more aid is allocated to countries most able to withstand a disaster's financial impacts. However, for the Flood Re instrument the scheme is shown to alleviate unaffordable premiums, which has a marginal effect on the number of instances in which mortgage payments become unaffordable and houses are repossessed (foreclosed) by the bank (Jenkins et al., 2016), thus slightly influencing inequality.

Responses on the **affordability** of instruments were mixed. Evaluators considered the Solidarity Fund as quite easily affordable for most member states, as they contribute based on economic performance, while for forest fire insurance, the instrument is affordable only for large properties with strong economic standing. The Rotterdam and London cases also showed mixed results; in Rotterdam, affordability can prove problematic for some (potential) policyholders if the link with risk is increased as proposed then high-risk households (with risk adverse insurers) will face

[2] German insurers, for instance, find the transaction costs of offering and monitoring household level DRM are sufficiently high to prevent an active insurer based financial incentive for DRM (Hudson et al., 2016).

very high premiums (Hudson et al., 2016). However, the increased use of risk-based pricing means less cross-subsidisation and lower insurance premiums for those at lower risk. In the UK, Flood Re is understood to achieve the provision of affordable insurance. As technical risk prices increase (reflecting increased flood risk), Flood Re reduces average premiums from approximately £650 to £280 in the baseline scenario. Even under future climate change scenarios average premiums are limited to £450 - £550 by year 30. Experiments without Flood Re illustrate much higher and steeper increases in average flood insurance premiums, upwards to £1700 under the 2050 high scenario. However, this also presents a clear challenge for the aim of using Flood Re as a temporary measure, before allowing risk based pricing after 25 years. As the technical price and the subsidised price for insurance are expected to diverge more and more it remains highly unclear how the system would lead to affordable risk based premiums after Flood Re stops its operation.

Institutional and political criterion

In terms of institutional and political indicators, cases varied widely. Insurance can score highly on aspects such as **feasibility**, and several countries have developed the required institutions for a viable insurance market with risk-based premiums. The EUSF, for example, is fully feasible and is in operation, whereas the Flood Re scheme is not yet operational, so its feasibility cannot be adequately assessed. In Portugal, a legal framework for fire insurance exists, but is not associated to any support from EU or domestic institutions to decrease premium costs.

However, cases diverged on how their instruments were scored with regard to **consistency**. The Rotterdam case emphasised that assessing consistency is ambiguous as it is dependent on the link with DRM. The stronger the overall link with DRM, the more able insurance is to increase resilience against natural hazards. The London case observed that investment in sustainable drainage system (also in combination with property-level protection measures) can help to stabilise insurance premiums over time – a clear indicator that surface water risk management is essential to maintain the viability of flood insurance.

The overall **acceptability** of instruments can be regarded as mostly high and moderate among cases, with some caveats. The Flood Re instrument study highlighted that both property developers and the local government could contribute to flood risk reduction, but are not part of the flood insurance MSP. One aspect that warrants further investigation is how Flood Re could be strengthened or expanded to contribute more significantly to flood risk reduction. The Portuguese fire insurance instrument was seen to have high acceptability among other interest groups besides the current users, contingent on the lowering of premiums. For the Solidarity Fund, acceptability was viewed as only moderate, due to strong concerns from some stakeholders, namely the insurance industry. The Rotterdam property insurance instrument was more ambiguous. Possible reforms will result in certain premiums increasing (and others reducing), thus limiting (or improving) the acceptability of the reform.

The case studies saw a number of different **conditions and barriers** to introduction of the EI, as in Rotterdam where the potential height of insurance premiums forms a strong barrier. Moreover, insurance reforms tend to be highly politically contentious between major stakeholders, which can limit stakeholder buy-in without considerable time and patience being expended. In regards to fire insurance, the absence of reliable information on risk, and limited incentives for coverage to small properties was seen as detrimental to encouraging insurance companies to provide coverage.

Environmental criterion

For most **environmental considerations**, for the majority of instruments there was not a good match with the indicators. Generally speaking, the Rotterdam case emphasised that while insurance was not directly tied to an environmental criterion, there may be some negative implications, as property insurance can facilitate economic activity that may lead to an increase in the magnitude of externalities. Conversely, incentivising DRM can also **encourage sustainable management**; agents are made aware of the risk and only locate economic activity in risky areas if it is worth the risk or cost of insurance. Greater interaction between insurers and planning agencies can provide guidance on the land use management strategies that would alter the overall risk in an area, highlighting the benefits of public-private partnerships.

The only instrument which consistently scored beneficial in this regard was Portuguese fire insurance, which is projected to increase quality of resources, due to adequate forest management resulting from those participating in the instrument being required to submit forest management plans. The instrument can also encourage the

protection of biodiversity via improved protection against wildfires due to management plans and the application of the Plan for Forest Fire Defence, and has the potential to reduce human impacts due to wildfires via fire defence plans, as well as increasing most ecosystem services through the application of forest management plans.

Photo by cohdra/Morguefile.

Conclusions

This chapter presented the findings from several ENHANCE case studies with regards to the use economic instruments for disaster risk management in the EU. After an overview of the different instruments in operation we reflected briefly on the different analytical tools applied across the cases. We presented lessons and insights from each case and synthesised these via a common framework, using an MCA-based approach. We conclude by reflecting on the use of MCA, observations from the synthesis of case instruments, and general recommendations for further policy and research.

Use of MCA in assessing economic instruments

While MCA approaches have proven useful time and again in terms of assessing options and decision-support, full use of MCA was limited in scope within this work. Detailed MCA is time-consuming and requires common understanding by participants of all options being assessed, as well as the criteria and indicators being used to 'grade' such options. This is usually done via a set of participatory process of workshops and communication.

We found the initial use of an MCA tool to rank insurance options to be associated with a number of problems, of which two factors are particularly relevant: (1) the context-specific nature of each insurance instrument, which differs widely from case to case, as well as (2) differing understandings of what each indicator was supposed to mean, e.g. the participants' understanding of what is included when considering a cost or transaction cost ranking for an instrument. An MCA ranking of insurance options also led to imply that the options were similar enough to be compared, whereas experts felt they were all rather local and context-specific to be assessed in such a way as would imply their similarity or substitutability.

However, there was generally a belief that the MCA process was suitable for the assessment of water markets and pricing in the Santarem case, as two options to address a single problem in a single location were being assessed by the same group of experts and stakeholders. In this case, the use of MCA can be seen as more robust, and the results more meaningful, as the problems listed above for the insurance options were not that relevant for this case.

Even though we identified a number of challenges for the entire MCA process when evaluating the various insurance mechanisms, the study team considered the consistent framework of criteria and indicators as useful to lead to some common understanding and base for assessing each instrument. Instead of using a quantitative scoring system, **we took a more qualitative approach forward which allowed for greater understanding of each case instrument**. In addition, **it helped to synthesise the different instruments by providing a common framing and ability to compare** where certain instruments perform better than others, keeping in mind, however, the limits to comparability across cases.