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NOTE

INDICATORS AND MONITORING, REPORTING AND EVALUATION (MRE)- SYSTEMS FOR CLIMATE ADAPTATION AT NATIONAL LEVEL

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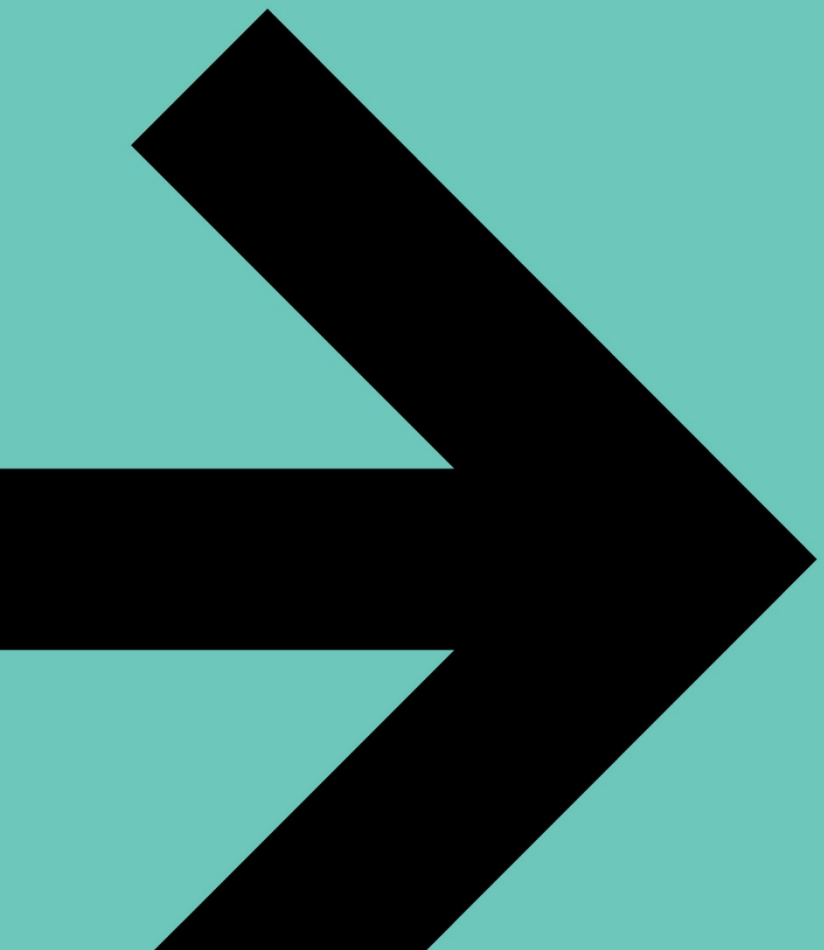

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KLIMA 2050

Indicators and monitoring, reporting and evaluation (MRE)-systems for climate adaptation at national level

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1 Introduction

1.1 Background

According to improved climate projections, many European regions will be facing an increase in the occurrence of climate-related extremes such as heavy precipitation, top wind speeds and storm surges [1]. In northern and north-eastern Europe, heavy precipitation events have increased over the last decades, and so have the occurrence of severe pluvial floods, flash floods and landslides. Particularly in winter, extreme precipitation events are projected to become more frequent all over Europe[1], increasing the risk for geo-hydrological hazards[2].
The built environment, transport infrastructures and human health are exposed to a substantial risk due to the increasing frequency and magnitude of extreme weather events. The economic losses related to such events accounted for almost EUR 400 billion in the EEA member countries over the period 1980-2013 [1].
Almost three quarters of Europe's population live in cities. According to the EEA, since the mid-1950s the total surface area of cities in the EU has increased by 78 %, whereas the population has grown by only 33 %. High soil sealing and limited spaces that allow for infiltration in combination with more extreme precipitation increase the risk for urban flooding and associated impacts such as moisture damage to buildings [1].
Mountainous regions are especially vulnerable when it comes to increasing risks for rapid-moving landslides triggered by severe rainfall events; fatalities and disruptions to transportation networks might be the consequence [2]. Critical infrastructure such as railways and roads in these areas are especially exposed due to limited routing alternatives [1].
The EEA reports an increase in the number of countries that have adopted a national adaptation strategy to reduce vulnerabilities and risks to human health, the natural and built environment and the economy. To date, 25 EU Member States have adopted a national adaptation strategy (NAS) and 15 have developed a national adaptation plan (NAP), but only a limited number of countries have started a monitoring, reporting and evaluation (MRE) process in order to investigate the progress of adaptation policies and actions [3]. Norway adopted a national adaptation strategy in 2013 [3].

In the framework of the Klima 2050 Centre: *Klima 2050 - Risk reduction through climate adaptation of buildings and infrastructure*, this report aims to give an overview over MRE approaches and indicator frameworks in other European countries, and to provide suggestions for further work towards a Norwegian indicator set with specific focus on the Klima 2050 categories.

1.2 Objectives

The main objective of this report is to review existing literature on climate adaptation indicators and MRE systems in other European countries. Sub-objectives are to

(i) give an overview over national initiatives and programmes concerning climate adaptation.
(ii) review types of indicators used to monitor climate adaptation.
(iii) review structures of established MRE systems, indicators and categories used in European countries.
(iv) review challenges related to indicator development and choice.
(v) suggest further work towards a framework for evaluating and monitoring climate resiliency in Norway.

2 Climate change in Norway

On a map of the main biogeographical regions in Europe published by the EEA [1], Norway forms part of the Atlantic region (Western coastline from South to North), the Boreal region (mostly south-eats Norway) and mountain region (see Figure 1). The Boreal and Atlantic region are both projected to have stronger extreme precipitation events, winter and spring river flooding, urban floods, and associated impacts. Severe winter and autumn storms are expected to increase. Mountain ecosystem are described to be particularly vulnerable to climate change. Increasing risks to settlements and infrastructure from floods, landslides and rockfalls are expected here [1].

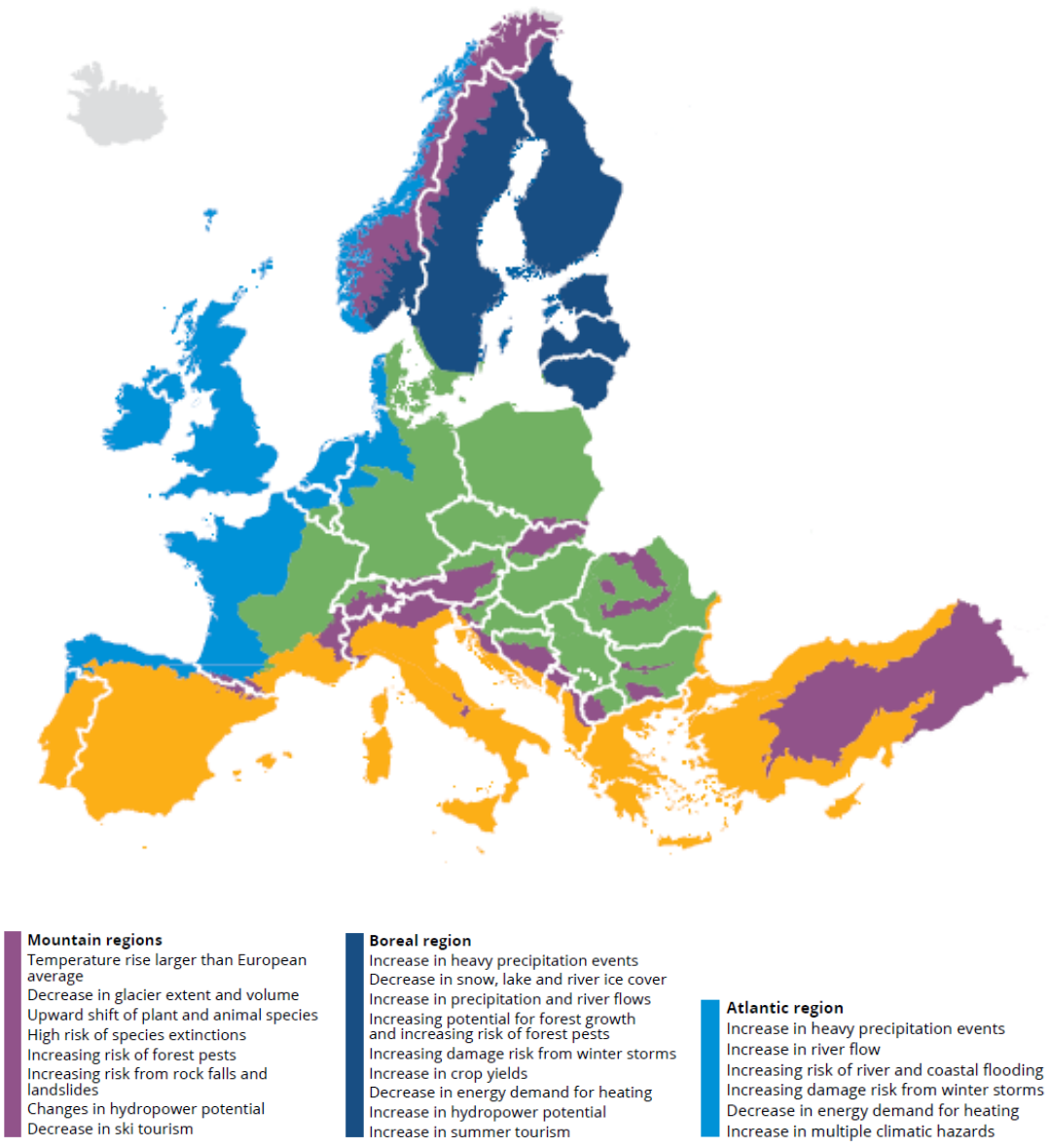

Figure 1: Division of Europe into main biogeographical regions according to EEA. Norway is divided into the three regions described above [1].

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The focus in "Klima 2050" is on the risk reduction through climate adaptation of buildings and infrastructure. Main threats to the built environment in Norway are expected to occur due to more frequent and extreme precipitation events and associated hazards such as pluvial floods, flash floods, urban flooding and geological instability and landslides. Central questions around this work are:

- How to monitor climate adaptation of buildings and infrastructure?
- How to assess the level of climate resiliency of Norwegian municipalities, cities, buildings and infrastructure?
- How to measure status and changes over time?

3 Use of indicators in climate adaptation

Indicators can help answering the questions stated above. They can serve a range of purposes such as tracking the implementation of adaptation strategies and policies, evaluating the effectiveness of adaptation measures, monitoring the spending of funding, communicating adaptation information to policy-makers, and comparing adaptation efforts across sectors and regions [4, 5].

3.1 Indicator choice

Indicators are a means to standardise, simplify and demonstrate complex data and information, they underpin assessments and result in knowledge [4]. When choosing indicators, the following should be considered carefully [5]:

- Does the indicator exist already and is appropriate data available?
- For new indicators: Is reliable data available?
- Does the indicator clearly communicate a specific assessment question?
- Is the indicator suitable for measuring the progress on the determining factor?

The criteria deriving from the questions above can guide the development of a set of indicators and help to define limitations and uncertainties related to their use. Each set of indicators will have to be chosen according to the purpose and objective of the individual MRE system; there is no standard set that fits all. Also, similar climate events might impact societies in very different ways, depending on the location and timing of the occurrence, but also on available means and resources to respond [6]. However, it might be possible to agree on a set of core indicators that can be used for different settings and that enables the comparison of adaptation progress and resilience of different sectors, regions or even countries [7].

3.2 Types of indicators

Different types of indicators have been developed for different purposes. Depending on the focus of the climate change issue investigated, indicators might focus on risks, causes, impacts and vulnerabilities or adaptation [4]. Table 1 lists examples for indicator types and their definitions. Many MRE systems opt for a combination of indicators that provide information on climate hazards and impacts of climate change, adaptive capacity, adaptation processes and outcomes. Indicators that monitor the adaptation process are most commonly used, while adaptation outcome indicators are more difficult to track, although they play an important role in evaluating the progress and effectiveness of adaptation policies, strategies and actions over time [8]. A set with adaptation indicators may include social, economic, health and ecological indicators to track and understand vulnerability, identify adaptation needs and evaluate adaptation strategies and measures [4].

Table 1: Types of indicators to monitor climate adaptation (adapted from Vallejo (2017) [8]).

Type of indicator	Definition
Climate hazards	Observed climatic parameters that may adversely affect people and assets.
Climate impacts	Observed impacts of climate variability and change on socio-ecological systems.
Exposure	Presence of people and asses in areas that could be adversely affected by climate hazards.

Adaptive capacity	Capacity of exposed institutions, systems and individuals to adjust or cope with potential risks.
Adaptation process	Implementation of strategies and plans through policy action or allocation of financial and human resources.
Adaptation outcomes	Results of adaptation policies and plans on climate risks.

National approaches to adaptation monitoring and evaluation often favour process-based indicators, once policy goals become more targeted, outcome-based indicators tend to assume greater importance [8]. One reason for this might be that some actions can only be measured after a certain timeframe/number of years. The French government, for example, has established 84 adaptation actions over 20 different sectors in its NAP. These actions are further divided into 230 measures that are being followed up, mainly through the use of process indicators; only sometimes outcome indicators are used [9].

When it comes to indicators used to specifically monitor the adaptation policy process and not climate change in general, Mäkinen et al. [4] distinguish between four different types of indicators:

- Input indicators: providing a measure of resources needed for a particular adaptation action or programme.
- Process indicators: tracking progress in adaptation policy processes and actions.
- Output indicators: relating to the results of an adaptation policy or action without assessing the outcome.
- Outcome indicators: defining and assessing the result of specific adaptation measures.

Generally, a combination of qualitative and quantitative indicators as part of an MRE system is regarded as beneficial. Quantitative indicators can be measured in percentage values or absolute values. Qualitative indicators can be valued against a scale, e.g. from 0-10, each value representing a different level of adaptation or statements that can be answered with "yes" or "no" [7].

4 National adaptation initiatives and programmes in Norway

Norway adopted a national adaptation strategy (NAS) in 2013[10] outlining the national strategy, policies and guidelines for climate adaptation in Norway. According to the white paper, individuals, businesses and authorities are responsible for adaptation to climate change. The Norwegian Climate Change Act includes annual reporting requirements related to adaptation to climate change based on the national target set by the government:

"The Norwegian society should be prepared for and adapted to climate change."

This high-level target is currently measured through reporting only, indicators are only used to a limited extent in Norway's system [11]. Climate change adaptation in Norway involves many different authorities, such as the Norwegian Water Resources and Energy Directorate, the Norwegian Climate Service Center, the Norwegian Environment Agency, and the Directorate for Building Quality, just to name a few. Adaptation policy implementation, monitoring and evaluation is only led at the sectoral level and is not aggregated nationally [8].
All authorities are required to provide information to the public, municipalities and counties, which has resulted in several initiatives and programs concerning climate adaptation. In addition, research institutes and universities contribute to a continuously growing knowledge base on climate change and adaptation. In the following, some of the main national initiatives and programmes are presented. Table 2 gives an overview over identified governmental initiatives.

4.1 Governmental initiatives

4.1.1 Klimatilpasning.no

The Norwegian Environment Agency (Miljødirektoratet) is responsible for the overall coordination of climate adaptation in Norway [12]. Via their webpage, a list of adaptation measures, general information, rules, regulations and guidelines can be accessed organised by sector; in total ten sectors are included, covering national focus areas such as agriculture, natural environment, transport infrastructure, the built environment and others (see Table 4 for details) [13]. Information is also linked to webpages of other responsible authorities.

4.1.2 Norsk Klimaservicesenter

The Norwegian Centre for Climate Services provides climate factors for increasing amounts of precipitation and other climate and hydrological data. A climate factor is the factor that current values are multiplied with to get an estimate for future amounts of precipitation [14]. Climate factors should be used in all planning and dimensioning of new infrastructure that is or may become vulnerable to increasing amounts and intensity of precipitation towards the end of the century.

4.1.3 Seklima.met.no - Free climate and hydrological data

Increasing amounts of precipitation and more intense rainfall events will create challenges for storm and surface water management, especially in urban areas. Innovative solutions for stormwater management targeting infiltration, detention and safe flood ways in densely populated areas will be necessary. Through the webpage seklima.met.no, the Norwegian Meteorological Institute gives free access climate and hydrological data from historical to real time observations.

4.1.4 Climate-proofing buildings

Information focusing on the consequences of climate change for houses, cottages and gardens with suggestions for measures to prepare properties for more extreme weather conditions is provided by the Directorate for Building Quality [15, 16]. To date, around 615

000 buildings are at high risk for rot damage; this number will increase to 2,4 million until 2100 [15, 16]. For the years 2017-2020, 42% of moisture damage in buildings can be related to increasing amounts of precipitation [17]. Moisture can also cause mould formation, which again can cause serious health issues.

4.1.5 NVE - Mapping risk prone areas

The Norwegian Water Resources and Energy Directorate is responsible for mapping the risk of landslides and flood prone areas and for calculations of flooding levels for use in designing infrastructure near water bodies. Flooding, landslides and rock fall due to heavy precipitation put pressure on critical infrastructure such as roads and railways, industry and housing areas, but also energy, water and waste water installations [10].

4.1.6 Miljøstatus – Achieving environmental goals

The Ministry of Climate and Environment has established 23 environmental goals for six focus areas [18]. Each goal has one or more associated indicators and is linked to a specific SDG. In total, 83 environmental indicators are included with the aim to measure changes and progress towards the individual goals. Sectors covered include (i) biodiversity, (ii) cultural heritage and cultural environment, (iii) outdoor life, (iv) pollution, (v) climate, and (vi) polar regions.
Under the climate sector, six goals are included; goal 5.6 "Political goal for society to be prepared for and adapted to climate change", has one associated indicator, which is describes as "Status of the incorporation of routines, measures, strategies and tools concerning climate adaptation in central sectors". Goals and indicators are quite broad, some are based on quantitative and some on qualitative data. There is no quality assurance of the data provided [18].

Table 2: Overview of governmental initiatives, networks and databases for climate adaptation

Name	Description	Organisation	Type of initiative
Menon report – MRE system og indikatorer for lokal klimatilpasning	Suggestions for an MRE system and indicators for local climate adaptation	Norwegian Environment Agency	Public
Klimatilpasning.no	Webpage [13]	Norwegian Environment Agency and others	Public
Naturfareforum	National platform for the prevention of natural hazards	Direktoratet for samfunnssikkerhet og beredskap (DSB), Norges Vassdrags- og Energidirektorat (NVE), Statens Vegvesen (SVV), Bane NOR, Landbruksdirektoratet (LDir), Kommunesektorens organisasjon (KS), Miljødirektoratet (MDir), Meteorologiske Institutt (MET), Kartverket og Fylkesberedskapssjefene (FM).	Public/private
Norsk klimaservicesenter (Norwegian Centre for Climate Services)	Making climate and hydrological data accessible for further use in climate change research and adaptation	Cooperation between the Norwegian Meteorological Institute, NVE, NORCE and the Bjerknes Centre for Climate Research	Public
"I front"-network	Municipal network for climate adaptation	Norwegian Environment Agency	Public

Seklima.met.no	Webpage with links to free climate and hydrological data	Norwegian Meteorological Institute	Public
NVE - Kartkatalog	Webpage with access to different tools and maps conc. risk prone areas etc.	Norwegian Water Resources and Energy Directorate	Public
Miljøstatus	Set of environmental goals with associated indicators	Norwegian Ministry of Climate and Environment	Public

4.2 Other initiatives

Apart from governmental initiatives, numerous climate adaptation initiatives with regional, national or international focus are taking part in Norwegian universities and research institutes.

Table 3: Overview of national research initiatives, centres and databases

Name	Description	Organisation	Type of initiative
Klima 2050	Network of public and private partners to reduce societal risks associated with climate change	Host institution SINTEF	Centre for research-based innovation
Indicator project with Trondheim municipality	Developing a set of adaptation indicators on a municipal level	SINTEF, municipalities	Research project
NORADAPT	Building knowledge on sustainable climate adaptation through a user-oriented approach	Lead institution: Western Norway Research Institute, seven associated research partners	Research Centre

5 Towards a national framework and indicator set for climate adaptation in Norway

In order to develop a framework for an MRE tool for the Norwegian context a thorough literature search and reviewing existing MRE frameworks and reporting schemes is necessary in order to establish a preliminary set of relevant climate adaptation indicators that can be used as a starting point. The following section gives suggestions for further investigation and steps towards a framework for a Norwegian indicator set. Examples are given referring to Klima 2050 focus areas.

While more general indicators might be sufficient on a national level, regional or local frameworks might require more detail. Flexibility of the framework, possibilities to adapt to different scales as well as to adjust to different contexts is therefore considered beneficial. Some municipalities or cities might even want to develop indicators for specific buildings or infrastructure and extent the indicator set accordingly.

The process of developing and agreeing on a set of national adaptation indicators can require significant resources both in terms of time and efforts to engage a broad range of stakeholders. Involvement of multiple key actors is necessary including authorities, the scientific community and data providers [4]. National focus areas and sectors for monitoring climate adaptation need to be clear and should be decided on prior to reviewing existing schemes and MRE frameworks and indicator sets. Sectors outlined in the NAS [10] or on "klimatilpasning.no"[13] can serve as starting point and can be adjusted if necessary. Austria, for example, based their indicator set on the sector covered in their NAP (see also Table 4), while Finland focused on key climate impacts to structure their MRE system and grouped indicators according to three main impacts (i) extreme weather conditions, (ii) temperature changes, and (iii) rising water levels [4]. Table 4 gives an overview over and compares focus areas covered in the NAS, klimatilpasning.no and the German and Austrian indicator systems.

Table 4: Sectors or focus areas covered in the national adaptation strategy of Norway and on "klimatilpasning.no" compared to sections included in Germany's and Austria's indicator systems.

	NAS Norway	Klimatilpasning.no	DAS	Austria	Sectors directly relevant to Klima 2050 Focus area
	Nature management	Natural environment (Naturmiljø og friluftsliv)	Soil (Boden)	Ecosystems and biodiversity	
			Biodiversity (Biologische Vielfalt)		
	Agriculture and Forestry	Agriculture (Landbruk)	Agriculture (Landwirtschaft)	Agriculture	
			Forestry (Wald und Forstwirtschaft	Forestry	
	Fisheries and auqaculture	Fisheries and marine environment (Fiske og havbruk)	Fisheries (Fischerei)		
	Health	Health (Helse)	Human Health (Menschliche Gesundheit)	Health	
	Buildings and other infrastructure	Buildings and construction (Bygg og anlegg)	Building industry/built environment (Bauwesen)	Construction and housing	yes

	The business sector	Business/trade (Næringsliv)	Industry (Industrie)	Business/industry/trade	yes
		Vann og avløp	Water supply, water economy, coastal and marine protection (Wasserhaushalt, -wirtschaft, Kuesten- und Meeresschutz)	Water resources and water management	
			Tourism industry (Tourismuswirtschaft)	Tourism	
			Power industry (Energiewirtschaft)	Energy	yes
		Civil defence (Samfunnssikkerhet og beredskap)	Civil defence (Bevölkerungsschutz)	Protection from natural hazards	yes
				Disaster risk management	yes
			Financial industry (Finanzindustrie)		
		Infrastructure (Infrastruktur og samferdsel)	Traffic and transport infrastructure (Verkehr, Verkehrsinfrastruktur)	Transportation infrastructure and selected aspects of mobility	yes
			Land use planning, regional and building planning (Raumordnung, Regional- und Bauleitplanung)	Spatial planning	yes
				Cities with a focus on urban green and open spaces	Yes
			Overlapping action fields (Handlungsfeldübergreifend)		yes
		Cultural heritage and cultural environment (Kulturminner og kulturmiljø)			
Total number of sectors	6	10	16	14	

5.1 International initiatives and MRE frameworks

Adaptation monitoring and evaluation demonstrate whether actions have taken place and can enable lessons learnt from practice to guide future adaptation action. As such, MRE systems are increasingly recognised as an important component of national adaptation practices. Evaluation is in many ways more methodologically challenging than just monitoring, because adaptation strategies and plans often lack measurable targets or clearly defined expected outcomes [8]. This might be part of the reason why experience in MRE activities and the development of robust and comprehensive sets of adaptation indicators on a national level is still not common [19]. Only few European countries have operational sets of indicators in place, including e.g. Finland, France and Germany [20]. Concerning the status in Norway, the following has been reported on the European Climate Adaptation platform Climate-ADAPT on November 19, 2019:

"The Norwegian Climate and Environment Ministry is responsible for monitoring and evaluating climate change policy in Norway including adaptation progress. In Norway, each

sector agency is responsible for integrating climate change adaptation (CCA) in their sector and may have their own systems for monitoring and evaluating progress. A national system for MRE has not yet been developed or implemented, but a brief assessment regarding possibilities for developing national climate change adaptation indicators and systems for reporting has been carried out." [21].

Indicator sets are being developed from different starting points and with different objectives. National context matters greatly in defining whether indicator development is primarily driven by policy, data, or nature of climate change impacts. These different driving forces along with available resources, influences the entire development of indicator sets [4]. The themes or sectors covered by different national assessment schemes seem to be governed by variations in geographical and socio-economic contexts. Indicator sets are also put together in different ways, largely influenced by country-specific priority areas, National Adaptation Strategies and differences in adaptation approaches [4]. The number of sectors and topics covered in European MRE systems varies as well. This might be due to different limiting factors such as availability of data and resources, and progress in sector-specific adaptation measures. MRE systems have been developed on many levels: national, sub-national, programme and project specific. National-level systems generally have a broader scope in terms of sectors, climate hazards, geographic area and adaptation measures considered, compared to systems that operate on a smaller scale [8]. Table 5 presents a collection of identified MRE frameworks and initiatives but should by no means be considered complete.

Table 5: Examples of identified international MRE frameworks and initiatives

Name	Description	Organisation	Country of origin	Reference
RESIN Adaptation Options Library	Climate resilient cities and infrastructures	Horizon 2020 - European research project with consortium of partners	Europe wide	Resin-cities.eu
MONARES	Modular Resilience-Indicator Set tested in German cities	Adelphi, IREUS, Universität Gießen, Dialogik	Germany	[22-24]
German Strategy for Adaptation to Climate Change (DAS)	DAS monitoring indicator system (102 indicators); 40 indicators are planned in addition	Federal Government of Germany	Germany	Schönthaler et al., 2015); [4]
ND-GAIN-Notre Dame Global Adaptation Index	Helping countries and cities counter the risks of a changing climate	University of Notre Dame	USA	http://www.gain.org
TAMD – Tracking Adaptation and Measuring Development	Tracking adaptation and measuring development	International Institute for Environment and Development (IIED), Department	UK	http://iied.org

		for International Development (DFID)		
French National Climate Change Adaptation Plan	Monitoring adaptation actions from the NAP	National Observatory on the effects of Global Warming (ONERC)	France	https://www.ecologie.gouv.fr/adaptation-france-au-changement-climatique
EU Covenant of Mayors for Climate and Energy	Climate adaptation in cities - Network	EU	Europe wide	https://www.covenantofmayors.eu/en/
Climate-ADAPT	European Climate Adaptation Platform	European Commission and European Environment Agency	Europe wide	https://climate-adapt.eea.europa.eu/

5.1.1 Indicator sets from international framework

Both, the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) and the 2030 Agenda for Sustainable Development (SDGs) contain a set of indicators as part of their monitoring and reporting system. The SFDRR has a set of 38 indicators, while the SDG contain 232 indicators.

Some of the indicators included in these frameworks are directly relevant for adaptation processes and can be linked to monitoring climate change adaptation [4]. Norway has adopted the Sendai Framework and started reporting on the indicators in 2018 [21]. Adaptation monitoring and evaluation is also considered important in the Paris agreement 2015 under Art.7 §9 (d) [25]. Developing and/or integrating indicators from these frameworks might offer opportunities through shared indicators, joint implementation, capacity building and mutual support in policy implementation [4]. Table 7 gives an overview over indicators included in the SDGs and SFDRR that are of relevance for Klima 2050 focus areas.

Table 6: Indicators with relevance for adaptation in the Klima 2050 focus areas included in the SDGs and SFDRR, adopted from [4].

Indicators relevant for Klima 2050 focus areas	Covered in SDG	Covered in SFDRR	Klima 2050 Focus area
Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population	11.5.1; 13.1.1		Flood, landslide and rockfall, moisture damage
Direct economic loss in relation to global GDP, damage to critical infrastructure and number of disruptions to basic services, attributed to disasters	11.5.2		Flood, landslide and rockfall, moisture damage
Damage to critical infrastructure attributed to disasters (including health and educational facilities damaged or destroyed and		D-1	Flood, landslide and rockfall, moisture damage

critical infrastructure units and facilities)			
Direct economic loss attributed to disasters in relation to global GDP (including losses from agriculture, housing sector, productive assets, critical infrastructure and cultural heritage damaged or destroyed)		C-1	Flood, landslide and rockfall, moisture damage
Direct economic loss attributed to disasters in relation to GDP	1.5.2		Flood, landslide and rockfall, moisture damage
Number of disruptions to basic services attributed to disasters (including educational, health and other basic services)		D-5	Flood, landslide and rockfall, moisture damage
Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction	13.1.3		Flood, landslide and rockfall, moisture damage
Degree of integrated water resources management implementation (0-100)	6.5.1		Flood, landslide and rockfall
Progress towards sustainable forest management	15.5.1		Flood, landslide and rockfall

5.1.2 National adaptation indicator sets and development processes across Europe

Some countries have already put into place indicator sets for national MRE systems, e.g. Germany, Austria, Finland, Scotland and the UK [4, 20]. Different countries might share similar challenges or approaches and reviewing the process how indicators were developed and chosen in other countries will help to identify possible synergies. Learning about limitations observed in relation to indicators can give guidance for the development of an own indicator set.

The German Strategy for Adaptation to Climate Change (DAS) developed by the German government includes 15 action fields ("Handlungsfelder") of which 13 are addressing specific sectors and two are focusing on cross-sector issues. The action field "building industry/built environment", for example, includes nine different indicators, four of them focusing on the impacts of climate change and five adaptation indicators. Table 5 lists indicators relevant for the Klima 2050 focus areas from the DAS action field "building industry/built environment". Other indicators in this action field focus mainly on increasing temperatures and related impacts or adaptation measures [26], which might not be as relevant in the Norwegian context.

Table 7: Indicators covered in the DAS action field "Building industry/built environment" relevant for the Klima 2050 focus areas [26].

Indicators relevant for Klima 2050 focus areas	Type of indicator	Indicator Nr.	Klima 2050 Focus area
Heavy precipitation in residential areas	Impact indicator	BAU-I-4	Flood, moisture damage

Claims expenditure in property insurance	Impact indicator	BAU-I-5	Flood, landslide and rockfall, moisture damage
Green roofs on federal buildings	Adaptation indicator	BAU-R-2	Flood, landslide and rockfall, moisture damage
Subsidies for climate-adapted building and rehabilitation	Adaptation indicator	BAU-R-4	Flood, landslide and rockfall, moisture damage

5.2 Indicators drawn from European reporting requirements

European reporting requirements can support national adaptation in terms of indicator selection and development. The EU adaptation scoreboard provides a broad range of process-related-indicators concerning adaptation strategy and policies [27]. The Water Framework Directive (EU, 2000) entered into force in Norway in 2008, simultaneously, Norwegian authorities issued a corresponding water regulation (Vannforskriften) that ensures the national implementation of the directive.
Relevant for Klima 2050 is also the EU Floods Directive [28]; requirements for the consideration of climate change adaptation have been added in river basin management and flood risk management planning processes [4].

Other context-specific sectors can be identified, and European reporting schemes can be scanned for suitable indicators. Sectoral reporting requirements usually include specific quantitative indicators and might even be helpful in choosing focus areas for a country's MRE system. The French national MRE system, for example, relies to a great extent on data extracted from existing sectoral monitoring systems with an emphasis on easy-to-access data and simple information [9]. Easily available data, allocated resources and regular monitoring will make a robust indicator.

6 Challenges identified from the literature

- Iterative nature of indicator development

Some countries have reported an extensive process concerning the development of indicators for their national MRE systems due to the iterative nature of indicator development. Germany, for instance, conducted three consecutive studies accompanied by consultation processes. In addition, the German monitoring system is supplemented by national, cross-sectoral vulnerability assessments to continuously evaluate climate risks and identify adaptation needs [29]. In the UK, indicator sets have been further developed and revised based on experience applying them, revisions are likely to be needed. Finland identified more indicators than they included in their initial set; due to data availability issues these "extra" indicators require further development for future use [4]. This highlights the fact that adaptation is a continuous process that requires a flexible framework and continuous evaluation.

- Variations in approach and indicators chosen

Different countries structure their indicator sets in different ways [19], showing the need for flexibility in MRE systems. Both schemes and indicators need to be tailored to national or context-specific circumstances. Some countries develop indicators based on policy needs, others on the relative importance of different climate risks or impacts. The importance of individual sectors also differs between countries, which will influence the choice of indicators. France opted for a pragmatic solution for their MRE system by basing their choice of indicators on easily available data from, e.g. sectoral reporting [9]. Variations in evaluation approaches and choice of indicators might prevent the comparability of various national systems between each other to a certain extent. However, adjusting to local context and available data and resources is crucial for developing functioning indicators on a national level.

- Availability of data and high costs of data collection

Ideally, indicators should be developed that enable the use of data that can be extracted from already existing monitoring and evaluation systems for different sectors. This practice is common to several of the existing national MRE system that were reviewed for this report [4, 9, 29]. Easy-to-access-data and simple information will facilitate the evaluation process. However, to obtain a complete picture of certain adaptation processes and actions, it might be necessary to collect new types of data, potentially over long time periods. Before establishing such an indicator, one should investigate the feasibility in terms of data acquisition, associated costs and whether the additional information obtained justifies the implementation of the indicator. The Finnish national MRE system includes several "sleeping" indicators that are considered important but are not yet in use. More data or investigations are needed, before they can be part of the "functional" set of indicators [4].

- Time frame

Measuring progress using indicators must take into consideration that it might require long periods of time before the outcomes of adaptation interventions are known. Climate change is a long-term process, and the impact of climate change adaptation might not be visible over an extensive time span. Both impacts and outcomes might not be visible and, hence, not measurable, over several years.

- Capacity and resource constraints

Capacity and resource constraints might be additional limiting factors to building national systems for adaptation, monitoring and evaluation [8]. The need for resources, including both personal and financial, depends very much on the individual approach to develop a national MRA system and the ambitions associated with it. Extensive involvement of experts, policymakers and stakeholders will facilitate the development of a strong indicator

set that can meet both scientific and political requirements but will most probably entail higher costs and personal resource needs. Involving research activities and financing will be beneficial, but care must be taken that findings are transferred to public authorities that have the capacity and knowledge to continue and maintain the process when a scientific project period ends. The German MRE system was developed over a five-year period. Resources were mainly provided through government-funded research projects that were supported by government officials that conducted the work as part of their regular duties [29]. The development of the French system, on the contrary, has been reported as "not very resource intensive" [9]. However, the two approaches to evaluating climate adaptation progress in the two countries differ greatly, and direct comparisons are difficult.

7 Conclusion

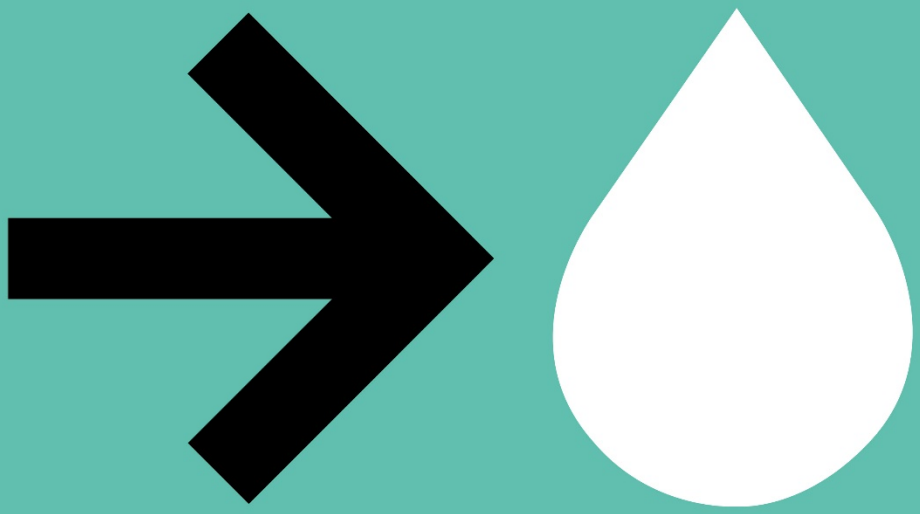
Just like all European countries, Norway will be facing an increase in the occurrence of climate-related extremes such as heavy precipitation, top wind speeds and storm surges. Adaptation as a response to climate change is vital and more and more countries are interested in evaluating effectiveness and cost-efficiency of policies and measures relating to climate change adaptation. In this context, MRE activities are gaining more interest, as they can help to make more targeted and justified decisions. Developing a robust set of national climate adaptation indicators can be described as an iterative and on-going process that requires the involvement of multiple key actors, including authorities, the scientific community, data providers and potential end-users. Existing indicator sets from international frameworks, such as the Sendai Framework for Disaster Risk Reduction, the 2030 Sustainable Development Agenda with the Sustainable Development Goals as well as existing MRE systems from other European countries can provide a starting point for developing indicators related to monitoring adaptation to climate change in Norway. There needs to be a consent on the focus areas of the MRE tool and the goal should be to establish a long-term and holistic MRE system with clear roles and responsibilities and secured resources. Climate change is a long-term process, and the impact of climate change adaptation might only be visible after relatively long periods of time.

It is suggested to take advantage of already existing MRE frameworks in other European countries, international reporting requirements and international frameworks that have established indicator sets to create a preliminary set of indicators as a starting point for a Norwegian MRE system. Involving both government agencies, the research community and stakeholders will contribute to the development of a sound indicator set to monitor and evaluate climate adaptation. Apart from national benefits and opportunities for more targeted climate adaptation actions, the outputs of national adaptation MRE systems could contribute to the assessment of the collective progress towards the global goal on climate adaptation [8].

References

1. European Environment Agency, *Climate change, impacts and vulnerability in Europe 2016. An indicator-based report*. 2017, Publications Office of the European Union: Luxembourg.
2. Gariona, S.L., Guzzetti, F., *Landslides in a changig climate.* Earth-Science Reviews, 2016. **162**: p. 227-252.
3. EEA. *Number of countries that have adopted a climate change adaptation strategy/plan*. 2019; Available from: https://www.eea.europa.eu/airs/2018/environment-and-health/climate-change-adaptation-strategies.
4. Mäkinen, K., Prutsch, A., Karali, E., Leitner, M., Völler, S., Lyytimäki, J., Pringle, P., Vanneuville, W., *Indicators for adaptation to climate change at national level - Lessons from emerging practice in Europe.*, in *European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation (ETC/CCA) Technial paper 2018/3.* 2018.
5. European Topic Centre on Air and Climate Change, *Development of Adaptation Indicators - ETC/ACC Technical Paper No 2009/6*. 2009.
6. Engle, N.L., De Bremond, A., Malone, E.L., Moss, R., *Towards a resilience indicator framework for making climate-change adaptation decisions.* Mitigation and Adaptation Strategies for Global Change, 2014. **19**: p. 1295-1312.
7. Food and Agriculture Organization of the United Nations, *Tracking adaptation in agricultural sectors - Climate change adaptation indicators*. 2017.
8. Vallejo, L., *Insights from national adaptation monitoring and evaluation systems - Climate Change Expert Group, Paper No.2017(3).* 2017, Organisation for Economic Co-operation and Development.
9. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GMBH, *France: Monitoring and Evaluation of the French National Adaptation Plan*. 2014.
10. Norwegian Ministry of Climate and Environment, *Meld. St. 33 (2012–2013) Report to the Storting (white paper) - Climate change adaptation in Norway*. 2013.
11. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GMBH, *Norway: Learning by doing for measuring progress in adaptation.* 2014.
12. Direktoratet for samfunnsikkerhet og beredskap, *DSB's Climate Change Platform*. 2017, Norwegian Directorate for Civil Protection.
13. Miljødirektoratet. *Klimatilpasning*. 2020; Available from: https://www.miljodirektoratet.no/myndigheter/klimaarbeid/klimatilpasning/.
14. Verpe Dyrrdal, A., Førland, E.J., *Klimapåslag for korttidsnedbør - Anbefalte verdier for Norge*. 2019, NCCS.
15. Norwegian Centre for Climate Service, *Climate in Norway 2001 - a knowledge base for climate adaptation*. 2017, Norwegian Environment Agency (Miljødirektoratet).
16. Gjensidige. *Slik sikrer du boligen mot ekstremvær*. 2020 [cited 2020 24.11.2020]; Available from: https://www.gjensidige.no/godtforberedt/content/slik-gjor-du-boligen-mer-klima-trygg?utm_id=lgoq&utm_source=email_nyhetsbrev&utm_medium=dialog&utm_campaign=contentmarketing2020_nb1-20.
17. Bunkholt, N.S., Kvande, T., *Mer regn, men bedre bygningsregelverk.* Byggeindustrien, 2020. **19**.
18. Miljøstatus. *Norges miljømål*. 2020 7.12.2020]; Available from: https://miljostatus.miljodirektoratet.no/miljomal/.
19. EEA, *National adaptation policy processes in European countries - 2014*. 2014, European Environment Agency.

20. Adaptation Community. *Examples of National M&E systems*. 2021; Available from: https://www.adaptationcommunity.net/monitoring-evaluation/national-level-adaptation/examples-of-national-me-systems/.
21. ClimateADAPT. *Sharing adaptation information across Europe*. 2019 6.12.2020]; Available from: https://climate-adapt.eea.europa.eu/countries-regions/countries/norway.
22. Feldmayer, D., Wilden, D., Kind, C., Kaiser, T., Goldschmidt, R., Diller, C., Birkmann, J., *Indicators for monitoring urban climate change resilience and adaptation.* Sustainability, 2019. **11**.
23. MONARES, *Ergebnis AP1: Framework für urbane Klimaresilienz*. 2020.
24. Kaiser, T., Feldmayer, D., Goldschmidt, R., Wilden, D., Hauer, M., Sauter, H., Wendnagel-Beck, A., Küpfer, K., Kind, C., *Leitfaden zur Unterstützung bei der Evaluation von Maßnahmen zur Steigerung der Klimaresilienz.* 2020.
25. United Nations, *Paris agreement 2015*. 2015.
26. The Federal Government, *German Strategy for Adaptation to Climate Change*. 2008.
27. ClimateADAPT. *Scoreboard indicators*. [cited 2021; Available from: https://climate-adapt.eea.europa.eu/eu-adaptation-policy/strategy/scoreboard-indicators.docx/view.
28. European Union, *DIRECTIVE 2007/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2007on the assessment and management of flood risks*. 2007.
29. deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GMBH, *Germany: The Monitoring System of the German Adaptation Strategy*. 2014.



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