PBL Netherlands Environmental Assessment Agency

DEVELOPMENTS IN MONITORING CLIMATE CHANGE ADAPTATION IN URBAN AREAS

Quick scan of experiences outside the Netherlands

PBL NOTE

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Developments in Monitoring Climate Change Adaptation in Urban Areas. Quick scan of experiences outside the Netherlands.

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Summary and Findings

Request for quick scan of developments in adaptation monitoring and evaluation outside the Netherlands

The Delta Programme on Spatial Adaptation is building a system for the monitoring and evaluation (M&E) of climate change adaptation in the Dutch urban environment. In this context, PBL has been asked to develop an indicator framework for the urban environment, and to update knowledge of M&E systems through a quick scan of developments in a selected number of countries and cities outside the Netherlands.

The main questions addressed in this quick scan are:

- What are the developments in the monitoring and evaluation (M&E) of climate change adaptation in various countries and cities abroad, in particular with respect to monitoring outputs, outcomes and the effectiveness of adaptation measures? Six European countries (Germany, United Kingdom and Switzerland in detail; Finland, France and Poland in general, and South Africa) were selected for this quick scan;
- What could the Delta Programme on Spatial Adaptation learn from these developments in other countries and cities abroad? Key interests of the Delta Programme are river and coastal flooding, pluvial flooding, urban heat stress, droughts in cities, and the level of vulnerability of vital and vulnerable functions, such as energy and ICT.

The results from the quick scan are based on a literature review, a short questionnaire and interviews.

The quick scan led to the following findings:

- Most countries and cities are still in the early phases of process monitoring. As adaptation strategy implementation is in its early stages in many countries and cities, output and outcome monitoring also is still in its infancy. Currently, there is hardly any monitoring of realised measures (output) and their impact (outcome) and the effectiveness of measures and strategy.
- Most countries and cities have adopted a participative approach in developing their adaptation strategy and monitoring and evaluation system. Given the complexity and context specificity in the physical, socio-economic and institutional environment, countries and cities adopt a variety of methods for monitoring their climate change adaptation strategy. There is no 'silver bullet' in approach, method and indicators.
- Available monitoring and reporting frameworks (such as those developed within the Covenant of Mayors for Climate & Energy — whose signatories form a network of more than 7000 cities across 57 countries around the world) provide a wide range of possible output and outcome indicators for urban areas. These indicators may be used as input for the development of indicators in the Netherlands.

Critical components for monitoring climate change adaptation

Given the complex challenges and range of sectors and stakeholders involved in climate change adaptation, many countries and cities follow a participative approach when developing M&E systems, often also with a focus on learning. Given the complexity, and acknowledging the adopted participative approach and the aim for creating a learning environment, the following three critical components can be identified for building an effective M&E system for spatial adaptation to climate change:

- Provide a basis for learning about the effectiveness of specific adaptation measures and actions contributing to adaptation, by:
  - defining the reference situation/baseline;
  - specifying the expected outcome of implemented adaptation measures and actions, on the basis of the available evidence;
  - measuring and monitoring of the realised effects of the implemented adaptation measures and actions, over time.

- Speed up learning: benefit from experiences, also those from outside the Netherlands. In the coming decades, many adaptation projects and actions will be implemented, in many countries and cities. To benefit from current and future adaptation knowledge, it will be important for the Delta Programme to:
  - make an assessment of available information on the effectiveness of measures in the urban environment;
  - systematically build an expanding knowledge base of Dutch adaptation projects;
  - effectively connect with international networks, especially those within Europe, and scan for examples and information relevant for the Netherlands.
- Build a long-term and consistent database for monitoring and evaluation that encompasses the implemented measures, expected effects, and eventual outcomes, in terms of crucial risks, such as weather-related damage, and the numbers of people and industries affected.

Monitoring and evaluation of adaptation is of increasing importance …
Monitoring and evaluation of climate change adaptation is an upcoming issue, as more and more countries —including many in Europe— have developed adaptation strategies and have embedded the commitments adopted in the Paris Agreement (2015) in their policy. Under the Paris Agreement, participating countries are requested to report on their adaptation progress. The agreement also stipulates a 'global stock take' (i.e. a review of adaptation effectiveness and progress made towards the global adaptation goal). As urban areas face significant risks from climate change and are responsible for large numbers of people, cities are increasingly active in formulating and implementing adaptation policies and actions. This is illustrated by the Covenant of Mayors for Climate & Energy (whose signatories form a network of more than 7000 cities across 57 countries around the world)[1], which aims to stimulate collaboration and the exchange of experience and information in building M&E systems, for both mitigation and adaptation.

… but is a complex challenge
Measuring progress in adaptation is complex and poses a number of challenges. Adaptation is scale- and context-specific, across many sectors, characterised by both short- and long-term time frames and large uncertainties, and needs to be integrated into sectoral policies rather than being considered a separate activity. Unlike mitigation, where the trend in greenhouse gases is a relatively easy-to-measure indicator, there are no off-the-shelf metrics for measuring progress or the success of adaptation. Responsible authorities at European, national, regional and local levels still face many conceptual, methodological and practical challenges. Therefore, participative approaches, involving a wide variety of stakeholders, are often used when building M&E systems for climate change adaptation.

Most countries and cities are in the early phases of process monitoring; output and outcome monitoring is still in its infancy
Many countries and cities in Europe and beyond are either developing or implementing adaptation strategies that include an M&E system for climate change adaptation (EEA, 2015, 2017; OECD, 2015, 2017). Most of these M&E systems are still in their infancy. The currently implemented systems mainly capture the *processes* of adaptation (e.g. integration of adaptation in policies and plans; adoption of targets; characterisation of measures). *Output* (i.e. implementation progress) is being monitored in only a few cases, as are outcome and effectiveness.

[1] http://www.covenantofmayors.eu/Adaptation.html; http://www.covenantofmayors.eu/The-Covenant-of-Mayors-going,2332.html

Several countries distinguish *strategic and operational levels* in their M&E systems, with the strategic level encompassing *process* monitoring and the operational level monitoring the *outputs* and *outcomes* of planned measures and actions. Also, in some countries, these systems focus on particular adaptation 'domains' (e.g. green infrastructure and heat stress in cities; vulnerability of the energy sector).

Some of the presented monitoring and reporting frameworks also provide a range of possible output and outcome indicators for urban areas (e.g. the German indicator '% loss of productivity', or '% change in storage of rain water' in the indicator system of the Covenant of Mayors, Annex IV). These indicators may be used as input for the development of indicators under the Delta Programme on Spatial Adaptation.

Within Europe, the United Kingdom is considered to be one of the frontrunners in the monitoring and evaluation of climate adaptation. It systematically provides information including *output* and *outcomes* of adaptation measures, on a national level. The United Kingdom was one of the first countries to adopt a Climate Change Act, which includes adaptation and has led to differentiation of responsibilities and the introduction of an M&E system, including a reporting obligation for sectors and municipalities. The UK's M&E system has five main indicator types to monitor progress under the National Adaptation Programme; four of these are related to adaptation actions in fields that are relevant to the Dutch Delta Programme, namely exposure, vulnerability, action (output) and realised impact (outcome). Examples of the indicators used include the number of households that are better protected from river/coastal flooding, the actual and planned investments in rail and strategic road structures, and the reduction in leakages from in public water infrastructure services.
A number of frontrunner cities, including Copenhagen, Rotterdam, Barcelona, Berlin and Helsinki, have started executing adaptation measures and implementing M&E systems.

Participative approach widely used in building monitoring systems
Given the complex challenges and range of sectors and stakeholders involved in climate change adaptation, many countries and cities, including in the Netherlands, follow a participative approach when developing M&E systems. It is widely acknowledged that a shared understanding of the challenges and possible solutions is of prime importance for effective adaptation. In their developmental processes, several countries have defined indicators that could be adopted by the Dutch Delta Programme, such as heat-related indicators (e.g. heat stress, heat in inner cities, heat islands, and heat casualties). Studies have shown that, when developing adaptation indicators to support learning and evaluation, there is a need to have *'a clear picture of objectives, the expected outcome, possible data sources, and the resources needed to build the required knowledge base'.* Identifying overlaps between policy domains and sectors (e.g. in spatial planning, water resource management, flood management and green infrastructure) may facilitate the development and use of indicators for also monitoring policy progress.

There are several approaches to gather data and/or information and monitor and evaluate adaptation. This includes self-assessment scorecards, surveys, interviews with experts, stakeholder dialogues (qualitative feedback), and in-depth analyses. Approaches vary per country and city. For each of these elements, indicators are needed to illustrate trends and evaluate progress and effectiveness.

Critical component: building a long-term database for monitoring and evaluation
OECD (2017) states that a critical component of monitoring progress and the outcome of adaptation policies is the creation of long-term data sets that encompass the implemented measures, the expected effects, and the eventual outcomes, in terms of changes in crucial risks (e.g. weather-related damage, and the numbers of people and industries affected). In combination with information about the trends in relevant climate drivers (e.g. precipitation extremes; heat; drought), this will provide a baseline for the analysis and evaluation of adaptation effectiveness, over time (Figure 1). As adaptation challenges are essentially context-specific, the targets and goals of adaptation policies and the required information underpinning the evaluation, over time, could be designed and developed in collaboration with relevant stakeholders. In addition, existing monitoring and data sets from stakeholders and parties could complement any dedicated adaptation data, wherever possible.

Combine and mainstream
For urban areas, M&E systems are used in many sectors and policy domains (e.g. spatial planning, water resource management, flood management, green infrastructure). Linking

with and learning from these M&E activities may stimulate the development of M&E systems for climate change adaptation and increase their applicability and acceptance.

Providing a basis for learning about effectiveness
Most countries have adopted participative working methods to implement their adaptation strategies and develop M&E systems. They also aim to create a learning environment. Attention should be given, particularly, to gathering adequate information for assessing the effectiveness of adaptation measures and actions. To provide a basis for learning, we suggest that:

- the reference situation/baseline is described in detail;
- the expected outcome is specified;
- over time, the realised outcome is monitored and recorded.

By comparing the expected outcomes of measures and actions, and providing information on realised outcomes, improvements could be made to both current and future adaptation strategies (Figure 1).

Given the multiple approaches and methods used across Europe for the monitoring and evaluation of climate change adaptation, the development of a common and widely accepted indicator-based system and knowledge base is of prime importance, as this, for example, would facilitate learning. Such development would require a shared view about definitions, objectives and measures (Figure 1).

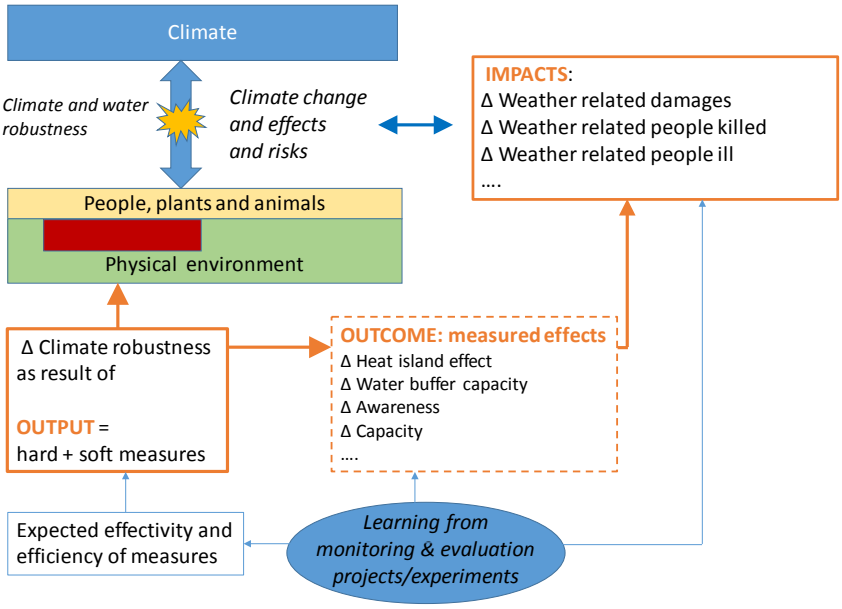


Figure 1. For learning and evaluation, it is important that stakeholders have a shared view about objectives, measures (outputs), expected effects of the measures, and that a knowledge base is developed containing measured effects and measured outcomes.

Speed up learning: benefit from experiences inside and outside the Netherlands
Over the coming decades, adaptation projects will be implemented in many countries and cities. These will build on an extensive and growing source of knowledge and experience on the subject of climate change adaptation. The Delta Programme may use this knowledge and experience to find effective strategies and solutions to deal with the projected consequences of climate change. An interesting example is the assessment of green infrastructural measures and their effect on heat in the urban environment in German cities.

To benefit from current and future adaptation knowledge, it will be of importance for the Delta Programme to:

- assess the information on the effectiveness of measures in the urban environment;
- systematically build an expanding knowledge base of Dutch adaptation projects;
- effectively connect with international networks and scan for examples and information relevant for the Netherlands.

As there is much information available on the urban environment, we recommend the Delta Programme to consider ways to make this information strategically and operationally useful, on a national level.

Bevindingen

Het Deltaprogramma Ruimtelijke Adaptatie moet ervoor gaan zorgen dat Nederland in 2050 op een zo waterrobuust en klimaatbestendig mogelijke manier is ingericht. Het programma is bezig een systeem op te zetten om de voortgang en effect (output en outcome) van die ruimtelijke adaptatie te monitoren. Het PBL is gevraagd om te verkennen of en zo ja in hoeverre dergelijke systemen al in het buitenland zijn ontwikkeld, waarbij de nadruk ligt op de stedelijke omgeving. De belangrijkste bevindingen op basis van deze quickscan zijn:

- De meeste landen en steden bevinden zich nog in de beginfase van de implementatie van hun adaptatiestrategieën en daarmee ook in de opbouw van hun monitoring-en-evaluatieprogramma's (M&E-programma's). De focus in de huidige M&E-programma's ligt op de monitoring van de uitvoering van procesafspraken, en nog beperkt op die van de realisatie van maatregelen (output), en de effecten en de effectiviteit daarvan (outcome).
- De meeste landen en steden volgen bij het ontwikkelen van hun adaptatiestrategie en opzetten van het M&E-systeem een participatieve aanpak en betrekken veel verschillende partijen, zoals overheden, bedrijfsleven en maatschappelijke organisaties. Gegeven de complexiteit van de adaptatieopgaven en de grote verschillen in fysieke, socio-economische en institutionele context gebruiken de landen en steden een grote variatie aan methoden voor de opbouw van hun M&E-systemen. Er is daarmee geen universeel toepasbaar M&E-systeem en geen universeel pakket te gebruiken indicatoren.
- Er zijn verschillende recente initiatieven voor mogelijke output- en outcome-indicatoren voor het stedelijk gebied. Zo heeft Duitsland binnen zijn nationale indicatorensysteem een indicator 'Verlies aan arbeidsproductiviteit door hitte in de stad', en heeft het Convenant of Mayors (waarbij meer dan 7000 steden in 57 landen zijn aangesloten) een outcome-indicator 'Extra vasthouden van neerslag' (zie ook Annex IV). Deze indicatoren kunnen een interessant vertrekpunt vormen voor het ontwikkelen van indicatoren binnen het Deltaprogramma Ruimtelijke Adaptatie.

Benodigde stappen voor het opzetten van een effectief M&E-systeem

Gegeven de complexiteit, de participatieve aanpak en het doel van het Deltaprogramma Ruimtelijke Adaptatie om een lerende omgeving te creëren, zijn er voor de bouw van een effectief M&E-systeem de volgende stappen geïdentificeerd:

- Voorzie in een basis om kennis te ontwikkelen over de efficiëntie en effectiviteit van adaptatiemaatregelen door:
  - de referentiesituatie/nulsituatie goed te definiëren
  - de verwachte effecten van de geplande maatregelen goed te beschrijven op basis van de beschikbare informatie, en
  - tijdig aandacht te besteden aan het meten en volgen in de tijd van het gerealiseerde/ daadwerkelijke effect van het beleid en geïmplementeerde maatregelen.
- Versnel het leerproces en profiteer van ervaringen en pilots binnen en buiten Nederland. Om goed te kunnen profiteren van bestaande en nog beschikbaar komende kennis is het van belang om:
  - een overzicht te maken van de bestaande informatie over de efficiëntie en effectiviteit van voor Nederland relevante maatregelen in de ruimtelijke adaptatie
  - systematisch te bouwen aan een groeiende kennisbasis van experimenten en uitgevoerde Nederlandse adaptatieprojecten en maatregelen en de efficiëntie en effectiviteit daarvan
  - een effectieve aansluiting op internationale netwerken te organiseren die zich met ruimtelijke adaptatie bezig houden en de mogelijk relevante ervaringen van projecten en maatregelen elders in Europa te scannen en benutten.

- Bouw aan een langetermijn-, consistente M&E-database met informatie over de uitgevoerde maatregelen, de verwachte en gerealiseerde effecten en de uiteindelijke veranderingen in klimaat-gerelateerde risico's.

Monitoring en evaluatie van klimaatadaptatie – quickscan van ontwikkelingen in het buitenland

Het Deltaprogramma Ruimtelijke Adaptatie (DPRA) moet ervoor gaan zorgen dat Nederland in 2050 op een zo waterrobuust en klimaatbestendig mogelijke manier is ingericht. Het programma is bezig een systeem op te zetten om de voortgang en effectiviteit (***output*** en ***outcome***) van die ruimtelijke adaptatie te monitoren. Het PBL is gevraagd om een analyse uit te voeren naar Monitoring (en evaluatie, M&E) van ruimtelijke elementen van klimaatadaptatie in het stedelijk gebied, en om zo een raamwerk te bouwen van adaptatie-indicatoren. Omdat monitoring van klimaatadaptatie nog een nieuw beleidsveld is, heeft het DPRA het PBL ook gevraagd om ervaringen in het buitenland te verkennen. In deze notitie beschrijven we de resultaten van de quickscan; het eigenlijke raamwerk van mogelijke indicatoren komt later in een aparte notitie aan de orde.
De vragen die in deze quickscan geadresseerd worden zijn:

- Welke ontwikkelingen zijn er in het buitenland op het gebied van M&E van klimaatadaptatie?
- Wat kan DPRA leren van deze ontwikkelingen voor het monitoren van klimaatadaptatie voor het stedelijk gebied? Hierbij staan de vier pijlers van Ruimtelijke Adaptatie centraal: waterveiligheid, wateroverlast, hitte en droogte en vitale en kwetsbare functies (zoals energievoorziening).

Zes Europese landen (Duitsland, Groot-Brittannië en Zwitserland alle in detail, Finland, Frankrijk en Polen in het kort) en Zuid-Afrika zijn geselecteerd voor deze quickscan. Deze landen worden beschouwd als koplopers als het gaat om de implementatie van klimaatadaptatie en bijbehorende M&E-systemen. In deze notitie is er ook aandacht voor koplopersteden in deze landen om te beschrijven hoe M&E van klimaatadaptatie in de praktijk werkt.

De quickscan is gebaseerd op literatuuronderzoek, een korte enquête in de landen en enkele interviews met betrokkenen.

Monitoring en evaluatie van klimaatadaptatie wint aan politiek belang …

Klimaatadaptatie wordt ook in het beleid steeds meer opgepakt. Steeds meer landen ontwikkelen of hebben nationale adaptatiestrategieën, en ook binnen het klimaatverdrag van Parijs (van eind 2015) is klimaatadaptatie – naast mitigatie – nu gereguleerd. Daarbij hoort ook M&E. Zo zijn landen door het Parijsakkoord verplicht om hun voortgang in adaptatiebeleid te rapporteren, inclusief de bijdrage aan de 'wereldwijde klimaatdoelen'. Omdat (vooral) steden steeds kwetsbaarder worden voor klimaatverandering, worden ook veel steden steeds actiever en gaan ze adaptatiebeleid en -maatregelen ontwikkelen en implementeren. Het Convenant of Mayors is een netwerk van meer dan 7000 steden in 57 landen over de hele wereld[2] dat zich onder meer richt op samenwerking en uitwisseling van ervaringen en informatie en het bouwen van M&E-systemen voor zowel klimaatmitigatie als –adaptatie (zie ook Annex IV).

… maar is een complexe opgave

Het monitoren en evalueren van de voortgang van klimaatadaptatie is niet eenvoudig. Zo zijn klimaatverandering en -adaptatie, en dus het monitoren en evalueren ervan, veelal omgevingspecifiek, worden ze gekenmerkt door grote onzekerheden, en verschillen ze tussen verschillende schaalniveaus en sectoren. Klimaatopgaven zouden dan ook (beter) afgestemd moeten worden met sectorale beleidsplannen. En in tegenstelling tot mitigatie, waar de trend in broeikasgasemissies een relatief eenvoudige outcome-indicator is, zijn er bij klimaatadaptatie geen methoden beschikbaar voor het monitoren van de voortgang en het succes van beleid. Vanwege deze uitdagingen worden momenteel veel participatieve benaderingen gebruikt – met belanghebbenden met een breed scala van achtergronden en interesses – bij de ontwerpen van M&E-systemen voor klimaatadaptatie

[2] www.covenantofmayors.eu/Adaptation.html; www.covenantofmayors.eu/The-Covenant-of-Mayors-going,2332.html

Monitoring klimaatadaptatie in veel landen in de kinderschoenen, veelal nog gericht op procesmonitoring
Diverse landen en steden zijn een M&E-systeem voor klimaatadaptatie aan het bouwen (EEA 2015; OECD 2017). Veel van deze ontwikkelingen staan echter nog in de kinderschoenen, bijvoorbeeld omdat zij meelopen met de implementatie van een recente Nationale Adaptatie Strategie (NAS). Hierdoor monitoren en evalueren veel landen en steden vooral het implementatie*proces* (bijvoorbeeld of er al dan niet integratie is van klimaatadaptatie in sectorale plannen, of er duidelijke doelen zijn vastgesteld, of de zachte en harde maatregelen duidelijk zijn gekarakteriseerd).

In enkele gevallen hebben landen en steden ook nog wel ervaring met het monitoren en evalueren van de *output*, oftewel de voortgang bij de uitvoering van maatregelen, zoals meer bewustzijn. De *outcome*, oftewel het effect van maatregelen, wordt slechts zelden gemonitord, en veelal genoemd in termen van verwachte outcome, gebaseerd op wetenschappelijk onderzoek en ervaringen elders. Zo heeft Duitsland binnen zijn nationale indicatorensysteem een indicator 'Verlies aan productiviteit door hitte in de stad', en is 'Extra vasthouden van neerslag' een outcome-indicator van het Convenant of Mayors. Er is nog weinig informatie beschikbaar over gerealiseerde outcome in de praktijk.

Sommige landen maken een onderscheid tussen het strategische en operationele niveau in hun M&E-systeem, waarbij het strategisch niveau vaak de procesmonitor is en het operationele niveau de monitoring omvat van de voortgang van geplande acties en maatregelen. Verder richten sommige landen zich op specifieke domeinen van klimaatadaptatie in hun M&E-systeem, bijvoorbeeld alleen op groene infrastructuur en hitteopbouw in steden, of op de mogelijke kwetsbaarheid van de energiesector.

Het M&E-kader zoals onlangs gepresenteerd binnen het Convenant of Mayors[3], biedt een breed spectrum van mogelijke output- en outcome-indicatoren voor het stedelijk gebied (zie ook Annex IV). Ook deze kunnen een interessant vertrekpunt zijn voor het ontwikkelen van indicatoren in Nederland.

Binnen Europa wordt het Verenigd Koninkrijk beschouwd als een van de koplopers die systematisch informatie verzamelt over de output en outcome van fysieke adaptatiemaatregelen op nationaal niveau. Dit kan het gevolg zijn van het feit dat het Verenigd Koninkrijk één van de eerste landen was met een klimaatwet inclusief klimaatadaptatie, waardoor verantwoordelijkheden duidelijk geformuleerd werden, en er een rapportageverplichting ook voor sectoren en gemeenten werd ingevoerd. Om dit te ondersteunen is een M&E-systeem met een duidelijke structuur ontwikkeld.

Het Britse systeem bevat vijf hoofdtypes indicatoren die gebruikt worden om de voortgang van hun nationale adaptatiestrategie te volgen; vier daarvan zijn voor onderdelen die relevant zijn voor het programma Ruimtelijke Adaptatie: blootstelling, kwetsbaarheid, actie (output) en *realized impact* (outcome). Gebruikte indicatoren zijn bijvoorbeeld: het aantal huishoudens dat (beter) beschermd is tegen overstromingen vanuit rivieren en zee, de geplande en werkelijke investeringen in spoor- en andere strategische infrastructuren, en vermindering van waterverspilling in het waternet.

Koplopersteden als Kopenhagen, Rotterdam, Barcelona, Berlijn en Helsinki zijn begonnen met de implementatie van maatregelen, en onderzoeken hoe M&E-systemen daarvoor kunnen worden ontwikkeld.

Een indicatorensysteem en kennisbasis zijn noodzakelijk voor een lerende omgeving
Vanwege de uitdagingen bij klimaatadaptatie inclusief de vele betrokken belanghebbenden in diverse sectoren, volgen veel landen en steden een participatieve aanpak in het ontwikkelen van een M&E-systeem. Zo kan de kennis van de risico's en mogelijke oplossingen breed gedeeld worden, iets wat van groot belang is voor adequate klimaatadaptatie.
Verder geven landen geregeld aan dat het van belang is om bij het ontwikkelen van indicatoren een duidelijk beeld te hebben van de doelstellingen van een maatregel, het verwachte resultaat, en van de middelen die nodig zijn om bijvoorbeeld de vereiste kennisbasis op te bouwen. Aansluiten bij ontwikkelingen in andere beleidsdomeinen en

[3] http://www.covenantofmayors.eu/IMG/pdf/Mayors-Adapt_Reporting_Guidelines.pdf

sectoren (zoals ruimtelijke ordening) kan de ontwikkeling en het gebruik van indicatoren voor klimaatadaptatie vergemakkelijken.

De ontwikkelingen in het buitenland laten ook zien dat er verschillende benaderingen gebruikt worden als het gaat om het verkrijgen van informatie, van 'zelfbeoordelings-scorelijsten', enquêtes en interviews (veelal expert judgements) tot stakeholderdialogen (met vaak kwalitatieve indicatoren) en diepgaande analyses (veelal geïnitieerd door wet- of regelgeving rond klimaatadaptatie). Voor al deze methoden blijken indicatoren waardevol te zijn om verwachte en waargenomen ontwikkelingen te signaleren.

Verschillende landen hebben bij hun ontwikkeling van een M&E-systeem ook indicatoren gedefinieerd die deels van nut kunnen zijn voor het Deltaprogramma Ruimtelijke Adaptatie. Voorbeelden zijn hitte-gerelateerde indicatoren zoals 'hitteopbouw in steden/warmte-eilanden', 'aantal hitte-gerelateerde slachtoffers' en 'areaal recreatiegebied in steden'.

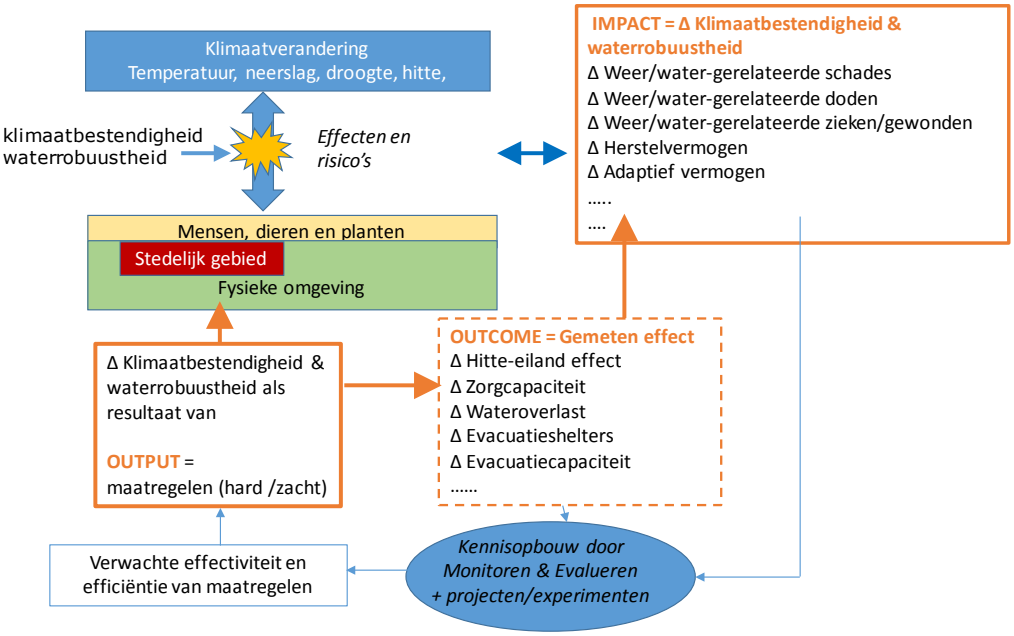
Vereiste voor monitoring en evaluatie: het opbouwen van een langjarige dataset
De OESO (2017) stelt dat het voor het succesvol monitoren en evalueren van adaptatiebeleid noodzakelijk is langjarige datasets te hebben. Hierbij gaat het ook om data van allerlei (verwachte) klimaateffecten, en van de eventueel bijbehorende risico's, zoals weer-gerelateerde schade en getroffen mensen. In combinatie met informatie over relevante weers- en klimaatinformatie (zoals frequentie van zowel extreme neerslag, hitte en droogte, waarvan veel landen al langjarige reeksen hebben), bieden dergelijke datasets een basis om het effect van adaptatiebeleid door de tijd te kunnen analyseren en evalueren (zie figuur 1). Aangezien klimaatadaptatie veelal omgevingsspecifiek is, zou het goed zijn om relevante stakeholders al in een vroeg stadium te betrekken bij het vaststellen van de doelen van het adaptatiebeleid en het hiervoor op te zetten M&E-systeem. Zo kan er dan, bijvoorbeeld, aangehaakt worden bij al bestaande monitoringactiviteiten en kunnen bepaalde datasets toegankelijker worden.

Benutten van andere M&E-systemen
Monitorings- en evaluatiesystemen worden ook ontwikkeld en toegepast in andere sectoren en beleidsterreinen binnen en buiten Nederland. Voorbeelden hiervan zijn stedelijke luchtvervuiling (relevant voor hitteopbouw in steden), ruimtelijke ordening (relevant voor bijvoorbeeld hitte en water in de stad) en klimaatmitigatie (relevant voor onder meer binnenklimaat in huizen). Bijvoorbeeld, meerdere steden in Duitsland rapporteren over hitte-gerelateerde adaptatiemaatregelen in combinatie met stedelijke luchtkwaliteit. Het koppelen aan en leren van deze activiteiten kan nuttig zijn bij het opzetten van een M&E-systeem voor klimaatadaptatie. Zo kunnen geschikte indicatoren worden overgenomen en kan gebruik van bestaande systemen de toepasbaarheid en acceptatie van het nieuwe M&E-systeem vergroten.

Een basis voor het leren over effectiviteit en efficiëntie
Veel landen hebben een participatieve methode gebruikt bij het opzetten en de implementatie van de adaptatiestrategie voor klimaatverandering en het ontwikkelen van een M&E-systeem, waarbij veelal gestreefd wordt naar een lerende omgeving. Hierbij zou ook expliciet aandacht gegeven moeten worden aan het opbouwen van een methodiek voor het beoordelen van de outcome (c.q. effect) van adaptatiebeleid en -maatregelen. Om dit te kunnen bereiken, is het nodig om:

- de baseline/nulsituatie goed beschreven te hebben
- het *verwachte* effect van het beleid en de maatregelen goed in beeld te hebben en
- aandacht te besteden aan het meten van het *gerealiseerde/daadwerkelijke* effect van het beleid en maatregelen.

Het vergelijken van de verwachte effecten van maatregelen in steden, en het tijdig verstrekken van informatie over het gerealiseerde resultaat, kan helpen bij het bijstellen en verbeteren van de adaptatiestrategieën. Gezien de diverse methoden die in Europa worden gebruikt voor het monitoren en evalueren van klimaatadaptatie en de rol van het 'leren' in deze, is het van belang om een gemeenschappelijk en breed geaccepteerd indicatorensysteem en kennisbasis te ontwikkelen. In het complexe domein van klimaatadaptatie vraagt dit ook om een gedeelde definitie over wat een effect en resultaat is en hoe dit gemeten kan worden (zie figuur 1).



Figuur 1 Voor het leren en voor het monitoren en evalueren is het van belang dat de belanghebbenden een gezamenlijk beeld hebben van de doelstellingen, de toegepaste maatregelen (= output), de verwachte effecten van beleid en maatregelen, en het opbouwen van een informatiebasis met de gemeten effecten en gemeten outcome.

Versnel het leren door aan te sluiten bij netwerken binnen en buiten Nederland
In de komende jaren en decennia worden in veel landen (inclusief Nederland) en steden projecten uitgevoerd die een voorbeeld en een potentiële bron van informatie kunnen zijn voor het Deltaprogramma Ruimtelijke Adaptatie. In Duitsland wordt bijvoorbeeld het effect van zogenoemde groene infrastructuren onderzocht; een netwerk van planten, bomen en andere groenvoorzieningen in de stad kan mogelijk de hitte-opbouw in steden beïnvloeden.

Om (beter) toegang te hebben tot en te kunnen profiteren van deze kennisopbouw doet het Deltaprogramma Ruimtelijke Adaptatie er goed aan om:

- een goed beeld te krijgen van de nationale en internationale informatie die beschikbaar is over de effectiviteit en efficiëntie van adaptatiebeleid en -maatregelen in de stedelijke omgeving
- een kennisbasis en dataset op te bouwen rond toekomstige adaptatiemaatregelen en -projecten in Nederland en
- aan te haken bij internationale stedelijke netwerken en daar te zoeken naar relevante voorbeelden voor Nederland.

Tot slot zou het Deltaprogramma Ruimtelijke Adaptatie kunnen zoeken naar manieren om de informatie, die veelal beschikbaar is op stedelijk niveau, te vertalen naar het nationaal niveau.

1 Introduction

Monitoring and evaluation of adaptation is of increasing importance …
Monitoring and evaluation (M&E) of climate change adaptation is an upcoming issue. More and more countries are developing adaptation policies, and actions (e.g. most countries in Europe have a National Adaptation Strategy (NAS)). The policy relevance of climate adaptation has strongly increased since the adoption of the Paris Agreement in 2015. Article 7 of the Paris Agreement highlights the importance of monitoring, evaluation and learning from adaptation practice. To demonstrate the level of progress made towards achieving climate resilience, individual Member States and the European Commission are required to produce adaptation progress reports (with an additional section on adaptation under the 'Monitoring Mechanism'). The Paris Agreement also stipulates a 'global stock take' that includes a review of adaptation effectiveness and progress made towards the global adaptation goal (enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change).
As cities face significant risks from climate change and are responsible for a large number of people, they are increasingly active in formulating and implementing climate change adaptation policies and actions. This is, for example, illustrated by the Covenant of Mayors, a framework encompasses around 7000 cities from around the world which is aimed at stimulating collaboration and the exchange of experience and information in building M&E systems for both mitigation and adaptation. For all of these reasons, reporting of adaptation progress has become more critical[4].

… but is a complex challenge
Measuring progress in adaptation is a challenge for several reasons. Adaptation is scale- and context-specific, transcends sectors, and needs to be integrated into sectoral policies rather than being considered a stand-alone activity.

With regard to scale, planning and implementing adaptation takes place primarily at the local or regional level, and often across different sectors. Climate change, however, is a systematic challenge that does not happen in isolation, but interacts with socio-economic factors. Regional and global trends in these factors add an extra dynamic. They include: geopolitics and conflicts; economic growth or decline; demographic changes such as an increase or decrease in population, age profile, social segregation and migration; further urbanisation and urban sprawl; and technological developments. All of these factors can change the vulnerabilities of cities (e.g. by having a greater number of elderly people, who are generally more vulnerable to extreme events, or placing people and assets in potentially risk-prone areas (EEA, 2016).

Sectoral complexity can be illustrated by the integrated dynamics of climate change and socio-economic developments, and associated uncertainties. And unlike mitigation, where the trend in greenhouse gases provides a comparatively easy measurable outcome, there are no off-the-shelf metrics for measuring the success of adaptation. Hence, at European, national, regional and local levels, responsible authorities face many conceptual, methodological and practical challenges. This is why, in many countries and cities, a participative approach involving a wide variety of stakeholders is often used when building an M&E system for adaptation (EEA, 2016).

The Dutch Delta Programme
The Dutch Delta Programme was established, in 2010, to tackle water-related risks in the Netherlands. The strategic goals of the Delta Programme are: (i) to protect the Netherlands from flooding; (ii) to ensure a sufficient supply of fresh water; and (iii) to facilitate a climate-proof and water-resilient spatial development (= spatial adaptation). In 2014, a number of

[4] http://www.covenantofmayors.eu/Adaptation.html

so-called Delta Decisions were approved, with policy targets for these three domains. The core aim of the Delta Decision on Spatial Adaptation is to ensure a climate-proof and water-resilient Netherlands, by 2050, and in such a way that any damage from heat stress, precipitation, drought and flooding will be kept to a minimum[5]. At the national level, the government will ensure better protection of functions that are of national significance or particularly vulnerable. These functions include public utilities, telecoms and IT, the sanitation chain, drinking water supplies, health care, pumps and drainage sluices, and road transport. Public authorities, including the provinces, municipalities and water boards, and the private sector and NGOs, together, are responsible for spatial adaptation in rural and urban areas.

Given that adaptation policies have been developed and are currently being implemented, a key challenge now is to devise a system to monitor progress with the implementation of decisions and associated measures, as well as their outputs and outcomes. Key questions for the Delta Programme include:

- Is the Programme *on track* to achieve both the short- and long-term objectives set out in the Delta Decision on Spatial Adaptation and meet its conditions (e.g. budgets)? Is it expected that the planned activities will be implemented and finalised on time?
- Are the *basic assumptions* still valid, given external developments?
- Are measures and actions being taken in an *integrated and participatory manner?*

Keeping track of adaptation in the Dutch Delta

Following a request from the Delta Commissioner, PBL developed an M&E framework for the Delta Programme, in collaboration with the University of Amsterdam and the Technical University of Delft. The framework is reported in the PBL (2016) report *Keeping track of adaptation in the Dutch Delta – Design of a reflexive monitoring and evaluation framework for the Delta Programme*.

A so-called reflexive approach was chosen as the basis for the elaboration of this framework, in line with the character of the Delta Programme. The following three perspectives form the basis of the framework:

1. *Learning through collaboration* in a participatory environment.
2. *Adaptive management* methods that can respond swiftly to changing conditions.
3. *Shared accountability* to keep track of the implementation of the Delta Programme, and to verify whether targets are being reached or should be revised, on the basis of experience.

The reflexive approach applies to the entire process of learning. Staying on course during implementation requires considerable insight into external and internal dynamics to enable a timely response to changes. This is visualised in Figure 1.1.

Reflexive monitoring and evaluation requires a joint effort by all stakeholders. This has the potential of improving the Delta Programme's policies during the implementation process, by engaging and feeding the energy and innovative drive of participating stakeholders. The design of an M&E framework based on the three perspectives mentioned above conforms to three ambitions of the Delta Programme:

1. *Participation and integration* – many stakeholders (government, provincial authorities, municipalities, water boards, private stakeholders, and social organisations) all working together.
2. *Adaptive delta management* – reflection on targets, instruments and problems (policy theory), and their significance in the light of changing circumstances are all part of adaptive management.
3. *Balancing learning and accountability* – on the one hand, accountability is crucial for the effectiveness and efficiency of the Delta Programme, whilst on the other, the energetic delta community needs to be encouraged and supported during an implementation phase that remains open in important ways. This can be achieved by organising accountability as a learning process, in which joint reflection is the main principle and interim results as treated as 'anchor points' that form a basis for decisions and adjustments.

[5] https://english.deltacommissaris.nl/delta-programme/contents/delta-decisions/spatial-adaptation-delta-decision

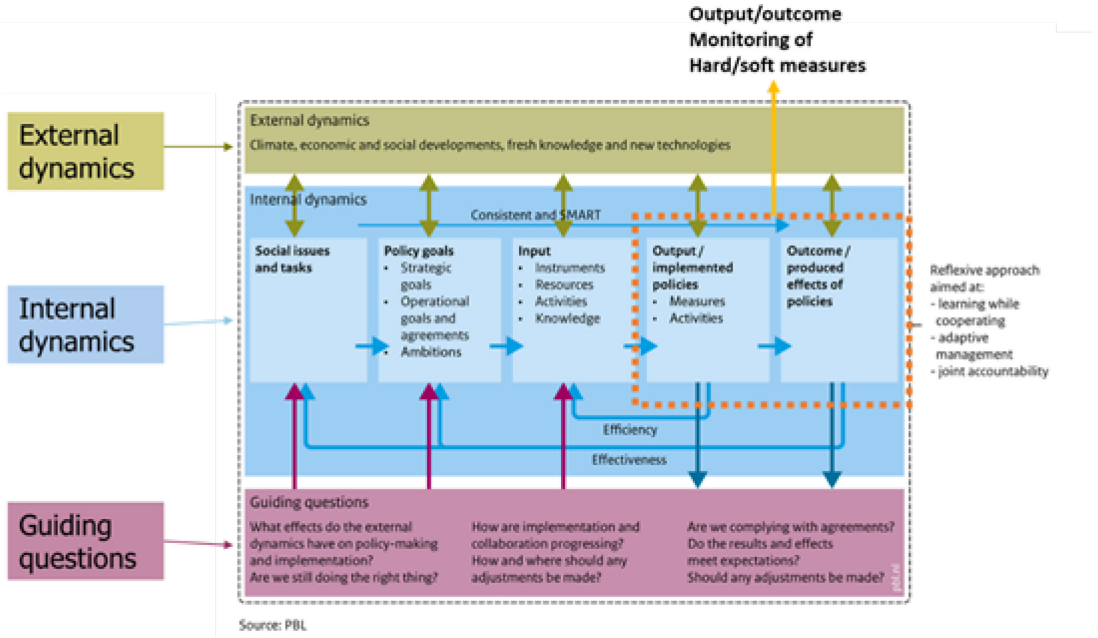


Figure 1.1. Conceptual framework for M&E of the Dutch Delta Programme based on a reflexive approach. The output and outcome are of particular importance as both are the results of the implementation of the adaptation strategy and determine success: 'Are we complying with the agreements?' 'Do the results and effects match the expectations?' or 'Should adjustments be made?'. (source: PBL, 2016)

Figure 1.1 shows that monitoring can focus on two sides of climate adaptation. One side of the focus includes the processes of policy-making, setting goals, formulating ambitions, and making sure that all the right instruments, resources, activities and knowledge are in place. The other side includes the results of these processes (e.g. the output of the measures and their outcome, in terms of making the country safer with respect to flooding, freshwater resource security, and heatwave-related health issues). The ultimate goal of such monitoring is to evaluate both output and outcome. As adaptation is still a relatively new policy field, it may take several years before the outcome of a measure can be observed, in practice, and is clear enough to be evaluated. In the meantime, monitoring of processes and output and investigating the effects of measures is a valuable method of progress monitoring.

Quick scan update

Monitoring and evaluation of adaptation in the urban environment

Following the above-mentioned development of an M&E framework for the Delta Programme (PBL, 2016), its sub-programme on Spatial Adaptation has asked PBL to develop an indicator framework for the urban environment. The first step is to provide a knowledge update on experiences with M&E systems by carrying out a quick scan of a selected number of other countries and cities in Europe and elsewhere. This briefing note presents the results of this quick scan; the results of the indicator development will be reported separately.

The main questions for the quick scan were:

- What developments exist in countries and cities regarding the monitoring and evaluation of climate change adaptation, in particular with respect to monitoring outputs, outcomes and the effectiveness of adaptation measures??
- What could the Delta Programme on Spatial Adaptation learn from these developments, in other countries and cities abroad? This includes approaches and indicators relevant to river and coastal flooding, pluvial flooding, heat stress and droughts in cities, and the vulnerability of vital functions such as energy and ICT.

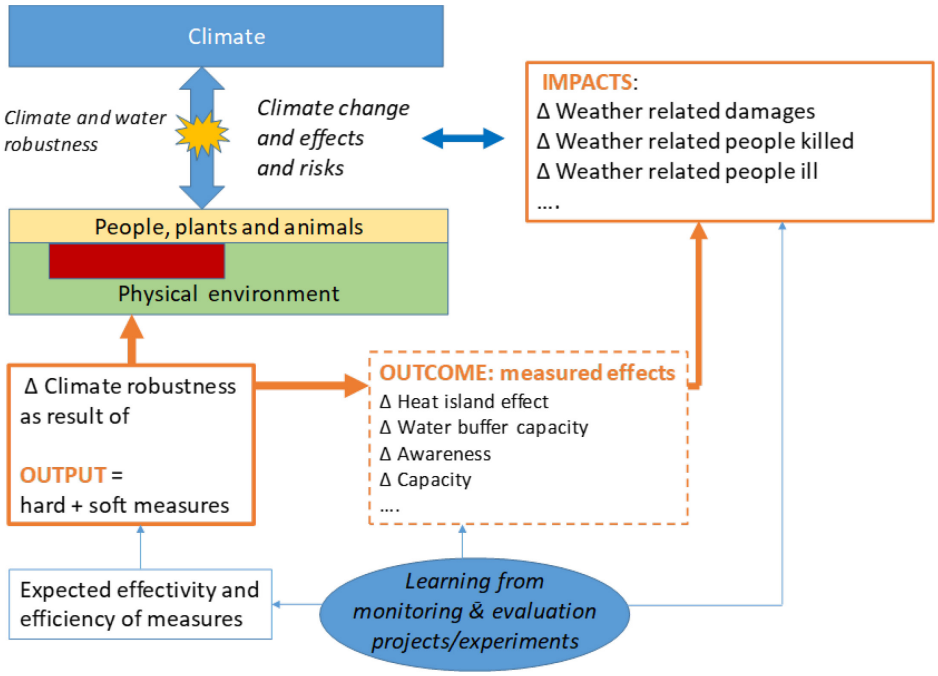


Figure 1.2. Climate change affects the living and physical environment. The output of soft and hard adaptation measures is expected to lead to a change in their resilience. Evaluating output and outcome shows whether these measures were effective and have reduced damage and the number of casualties due to climate change and weather extremes.

Set up of the briefing note

This briefing note presents an overview of the developments of M&E systems at two levels:

- Country level – exploring developments in six countries within Europe and in South Africa that are building/have built M&E systems for their NAS (Chapter 2). We present the systems in three countries in detail and a more general summary for the other countries. The assessment is based on the literature and on specialist input, including from the EPA Specialist Group on Climate Adaptation.
- City level – exploring developments based on city-orientated reports from the EEA and a more detailed look at specific cities (Chapter 3).

Given the short time available and the wide variety of approaches, methods and indicators adopted, it was not possible to process all the available information and to present the findings and developments in countries and cities in a comparable way. This quick scan thus gives an overview of the diverse developments and experiences as presented in the country and city documents; further specific details about the systems considered are part of the annexes.

2 Developments on country level

- Many countries are at an early stage in the development of an M&E system. Almost all countries in this note with an operational M&E system are in the phase of monitoring the *process* of implementation the progress of 'soft' measures and learning.
- Some countries (e.g. Germany and Switzerland) distinguish a *strategic and operational level* in their M&E system, where the strategic level encompassing the more process orientated M&E domain and the operational level encompassing the progress of measures.
- Given the present state, still little practical little information is available for most countries selected for this briefing note on most suitable indicators to monitor *output*, and realised *outcome* of physical measures that aim for reducing climate vulnerability. There is, however, information about the potential or expected effect of various adaptation measures, based on scientific research, and projects and experiments.
- Of the countries selected, the United Kingdom systematically provides information about output and outcome of adaptation measures at a national level in their M&E system. Output and outcome indicators cover heat, water shortage, rainfall and flooding and include for example: amount of actual and planned investments in rail and strategic road structures; reduction of leakage in public water infrastructure services; and number of households better protected from river/coastal flooding.
- Lessons:
    - The Dutch Delta Programme on Spatial Adaptation could benefit from the development of heat-related indicators, as included in most of the M&E systems in the selected countries (e.g. on heat stress, heat in inner cities, heat islands, heat casualties, urban recreational areas). In addition, drought-related indicators in the UK's M&E system might be of special interest.
    - Developments of M&E systems show that, for learning about the effect of the implementation of measures and actions, it is important to distinguish between:
        - Specifying the *expected* outcome, on the basis of the available evidence;
        - Measuring and monitoring the *realised* outcome, over time.
    - The OECD (2017) assessment and the M&E systems in the United Kingdom and Germany stress the importance of the need for long time series data, encompassing the implemented measures with expected output, the resulting effects and the realised outcome (impact) in terms of changing risks. In combination with information about the trends in relevant climate drivers (e.g. precipitation extremes, heat), this provides a baseline for analysis and evaluation of adaptation success, over time.

2.1 Introduction

As mentioned in the previous chapter, M&E of climate change adaptation is of increasing importance, but also complex. The Delta Programme on Spatial Adaptation requires an overview of experiences with currently implemented M&E systems. In this chapter, we provide details of our quick scan of M&E systems in six countries throughout Europe and in South Africa. We first summarise findings of international assessments relevant to M&E at national and local levels.

The selected countries are essentially frontrunners on M&E of climate change adaptation. The results from Germany, the United Kingdom, Switzerland and South Africa are based on literature surveys and expert contacts. Finland, France and Poland were studied in less detail, using either replies to a short questionnaire and/or literature surveys. For each country, we first introduce the adaptation policy process, including the governance structure. We then highlight the chosen priority sectors in the countries for which an M&E system has been developed, and subsequently assess the M&E systems by characterising different types of indicators. We conclude with some general findings.

2.2 Recent assessments: EEA and OECD

Interest in setting up monitoring and evaluation systems is increasing
The main purpose of adaptation M&E systems is tracking and reporting the progress and effectiveness of adaptation policy implementation, enhancing the knowledge base, accountability, and learning to improve adaptation policies, policy-making and practice (EEA, 2015). According to EEA (2016), M&E provides feedback on the effectiveness of adaptation action taken and progress achieved. Thus, it enables gaps to be identified, adjustments to be made, and future decision-making to be improved.

Indicators play a key role in adaptation M&E systems. In a number of countries, they have been created through an iterative and interactive process involving experts and other stakeholders. It is not necessarily the value of an individual indicator that needs to be considered, but whether or not the set of indicators provides a coherent and robust picture of adaptation progress (EEA, 2015).

In a recent paper, Pringle *et al.* (2017) highlighted transferable lessons learned that may inform M&E practice for climate change adaptation from evaluation communities working in the following three policy domains: biodiversity, adaptation and international development, and sustainability. The three domains were chosen following a two-stage review to identify policy areas that exhibit similar characteristics or face similar M&E challenges. They conclude that:

- Identifying overlaps between policy domains can facilitate knowledge exchange and support the use of common indicators for monitoring policy progress.
- Addressing cross-scale information needs can improve the utility and relevance of M&E outputs; this is by facilitating knowledge exchange and supporting the use of common indicators for monitoring policy progress.
- There is potential to enhance participation in M&E for adaptation and to incorporate a broader range of perspectives.
- Indicators are valuable in illustrating trends, but mixed approaches integrating various sources of information are needed to better capture the complexity of the systems.

These conclusions are also emphasised by the EEA (2015): '*Measuring progress in adaptation is challenging for several reasons; adaptation is context-specific and transcends sectors, is characterised by long time frames and uncertainty, does not have common aggregated metrics and is commonly integrated into other sectoral policies rather than being a stand-alone activity. Therefore, adaptation policy targets at European, national, regional or local levels cannot usually be monitored with a single or limited numbers of indicators or sources of information like in other policy domains such as climate change mitigation'*.

Governance and participation in monitoring and evaluation
Overall responsibility for M&E of adaptation often lies with ministries or government agencies coordinating adaptation policy. Horizontal and vertical coordination of M&E activities is often organised through committees involving multiple administrative levels and sectors. In few countries, the requirement for M&E is formalised in legislation, while in most cases it is voluntary. In many countries, it is a challenge to involve the municipal level in M&E of national adaptation policies (EEA, 2015).

State of the art and frontrunners
According to the EEA (2015), 14 European countries have systems for M&E of adaptation in place or under development. The evaluation of adaptations policies is at an early stage, often because the implementation of adaptation has only just begun. Progress on adaptation strategies and plans varies considerably and the same is true for M&E of adaptation.

OECD (2017) draws on insights related to current national approaches to M&E adaptation, and sets them in the context of international climate negotiations. Regarding definitions, the report highlights also the issue of adaptation indicators found in national adaptation M&E systems (Table 2.1). The report summarises a number of challenges in this respect:

- The long timescales of climate change adaptation, the uncertainty associated with the localised impacts, difficulties in setting baselines and targets, and the difficulty of attributing cause and effect.

- Identifying/developing relevant adaptation indicators as an appropriate tool for M&E; qualitative narratives or consultations can be useful in particular to assess adaptation from the viewpoint of the most vulnerable communities.
- Developing outcome indicators that can play an important role in evaluating adaptation effectiveness, over time.
- The lack of monitoring relevant data or developing data of sufficient quality, such as long and continuous time series at an appropriate level of disaggregation.

Table 2.1: Illustrative indicator types to monitor and evaluate adaptation at the national level (source: OECD, 2017).

Indicator type		Definition	Examples from existing systems
Climate risk	Climate hazards	Observed climatic parameters which may adversely affect people and assets	- Monthly precipitation - Change in annual precipitation, - Number of hot days per year (Mekong River Commission)
	Climate impacts	Observed impacts of climate variability and change on socio-ecological systems	- Percentage of total livestock killed by drought in a given year - Number of hectares of productive land lost to soil erosion (Kenya National Climate Change Action Plan)
	Exposure	Presence of people and assets in areas that could be adversely affected by climate hazards	Number of businesses, hospitals and households within most deprived communities located in areas at risk of flooding or coastal erosion (UK Adaptation Framework)
	Adaptive capacity	Capacity of institutions, systems, and individuals to adjust or cope with exposure or potential risks (and take advantage of opportunities)	- Percentage of municipalities with local regulations considering adaptation and vulnerability assessment results - Percentage of coastline under marine protection (Mexico Adaptation M&E system)
Adaptation process		Implementation of strategies and plans through policy action or allocation of financial and human resources (inputs)	- Percentage of transport infrastructure adapted to cope with climate change - Number of mechanisms identified which could potentially fund adaptation (French Evaluation of National Adaptation Plan)
Adaptation outcomes		Results of adaptation policies and plans on climate risks	- Increase in the number of small farmers and fisher folk who are credit-worthy - Water supply coverage of previously waterless communities (Philippines Results-Based Monitoring and Evaluation System)

2.3 Developments in selected countries

Germany

Introduction and adaptation governance
On 17th December 2008, the German Federal Cabinet adopted the *German Strategy for Adaptation to Climate Change*. This Strategy highlights areas already and likely to be affected by climate change, as well as basic options for a possible approach to, and requirements for, action in 15 action fields/sectors. To achieve these strategic objectives, it is considered essential to improve the knowledge base of all stakeholders. This for a better understanding of the opportunities and risks involved in climate change and to support decision-makers in shaping their adaptation strategy, setting priorities and planning the most appropriate actions to be taken. To improve the knowledge and information base, the German Government has developed two main tools:

- An indicator-based monitoring system to track developments in climate change impacts in 15 action fields of the strategy, and in the adaptation process. The first report was presented in 2015, and will be updated every four years. The indicator-based monitoring reports will provide basic information required for the evaluation process of the German National Adaptation Strategy, among other things.
- A vulnerability analysis, developed by a network of national authorities, on the basis of climate projections and socio-economic scenarios. The vulnerability analysis considers the impacts of climate change for the near future (the period from 2021 to 2050) and the distant future (the period from 2071 to 2100).

These tools contribute to the Progress Report on the German strategy (UBA, 2015b), which will be updated on a regular basis in future. The first progress report was published in 2015, focusing on the implementation and further development of the strategy. It also includes a reporting on the implementation of the first Adaptation Action Plans of 2011 (focusing on translating targets into specific activities) and its update in 2015.

Monitoring
The indicator system underlying the *Monitoring Report,* and the overall report itself, were one of the products created and agreed politically in an inter-ministerial process with the participation of experts from the competent sectors of agencies, and from scientific and private institutions. This theme-specific process took nearly six years.

The indicator system currently comprises 102 indicators (Figure 2.1). The indicators summarise the developments on the national level for climate change impacts and the manner in which adaptation proceeds in Germany. The indicators have been defined by using four main criteria (Van Rüth and Schöntaler, 2018):

- *Thematic focus*. In order to limit the effort expended on the development of indicators the first criteria for an indicator was that it needs to refer to one of these prioritised thematic fields and subthemes in the National Adaptation Strategy of Germany.
- *Causal relationship with climate change*. For this a pragmatic approach has been chosen: the influence of climate change must be assessed technically speaking as 'relevant'. This both for the impacts (i.e. observed changes are frequently discussed and described with respect to causal relationships with climate change) and response/adaptation (= expected outcome, i.e. they must help to reduce vulnerability or contribute to increasing the capacity for adaptation). This includes measures and actions that might be motivated from other interests
- *Data availability*: One prerequisite has been the availability of data sets which extend as far as possible into the past and, above all, will continue into the future to make sure that the times series can regularly be updated. This means, however, that the monitoring system cannot illustrate all essential developments.
- *Transparency and understanding* also for the general public

Furthermore, high standards were set and a documentation system to ensure the complete repeatability of calculations.

Among the 102 indicators, there are 15 which have been designed as so-called case studies (Figure 2.1), owing to a lack of data sources at Federal level or a complex data processing which could only be realised so far for single Länder. In addition, seven indicators were

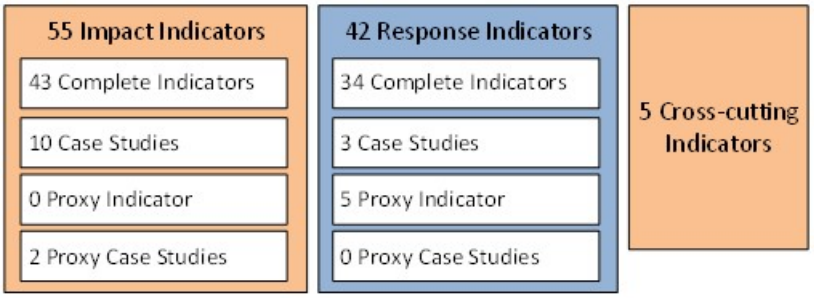


Figure 2.1. Composition of the Indicator Set in the Germany M&E system (source UBA, 2015a)

categorised as so-called proxy indicators (see also EEA[6]) which, in their proposed form, represent a mere approximation to the indicator subject, in the absence of more accurate or appropriate data or information. Proxy indicators need to be developed further.

An overview of the distribution of indicators over the German action fields and cross-sectional themes is given in Table 2.2. The first monitoring report (2015) provided reference points for various thematic areas, thus providing benchmarks against which the future development of climate change impacts can be assessed. It has also made it possible to trace back the efficacy of this political strategy.

In the first monitoring report of 2015 demonstrated that climate change was already happening in Germany. Impacts were often illustrated in the form of annual series (sometimes with map images) and trend analyses. Figure 2.2 provides an example of 'heat in inner cities'. Note that, for some areas, no trend in impacts has been observed, yet. This is partly due to the fact that adaptation measures or actions are already taken to impede adverse developments.

Table 2.2: Distribution of indicators over the action fields and cross-sectional themes of the German Strategy for Adaptation to Climate Change (DAS) (source: UBA, 2015b).

Action Fields and Cross-sectional Themes	Impact Indicators	Response Indicators	total
Human Health	6	3	9
Construction	2	3	5
Water Regime, Water Management, Coastal & Marine Protection	10	3	13
Soil	2	3	5
Biological Diversity	3	2	5
Agriculture	5	6	11
Woodland and Forestry	7	6	13
Fisheries	2	-	2
Energy Industry (Conversion, Transport and Supply)	4	4	8
Financial Services Industry	3	1	4
Transport, Transport Infrastructure	2	-	2
Trade and Industry	1	1	2
Tourism Industry	7	-	7
Spatial, Regional and Physical Development Planning	-	6	6
Civil Protection	1	4	5
Total	**55**	**42**	**97**
Overarching indicator	**5**		**102**

[6] EEA Glossary: Proxy data: data used to study a situation, phenomenon or condition for which no direct information – such as instrumental measurements – is available. [definition source: Kemp, David D. 1998. The environment dictionary. Routledge. London.]
http://glossary.eea.europa.eu/terminology/concept_html?term=proxy%20indicator

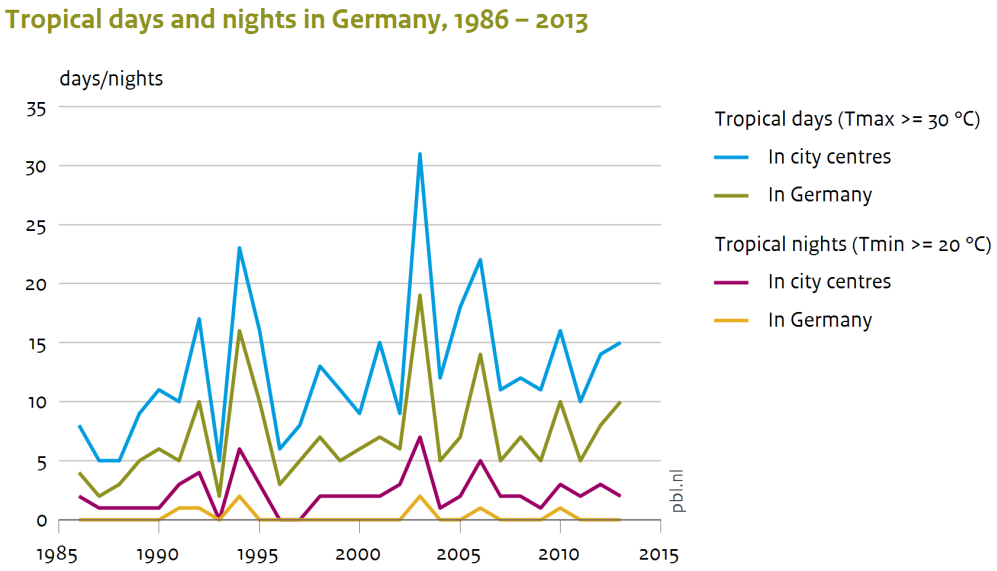


Figure 2.2 Heat in inner cities. The annual number of hot days (T_{max} > 30 °C) and tropical nights (T_{min} > 20 °C) in inner cities compared with the average for Germany as a whole.
Source: UBA, 2015a, based on DWD data (Climate Atlas Germany)

Note that the results are mostly presented at the national level. If there is a lack of national data, regional examples are presented. Most indicators are related to the physical system. Examples of heat- and flood-related indicators (relevant for the Delta programme) are:

- *Heat:* heat stress (day and night temperature); heat in inner cities; heat island effect; heat casualties; reduced labour productivity; following advice of the heat warning service; recreation area in cities; financing energy performance in homes; reduced power generation from power plants due to heat.
- *Flooding:* risk awareness of storm and high water levels; percentage of roads and homes that are likely to be affected by flooding once in every 100 years; damage by storm and hail; percentage of people insured against flooding and weather extremes.

Evaluation
Several products/reports as the aforementioned monitoring report are a basis for the evaluation of the German National Adaptation Strategy. Germany has prepared a methodology for this evaluation process. The methodology was discussed with relevant actors and approved by the inter-ministerial working group on adaptation. The objectives of the evaluation are broad: *Knowledge generation*, *learning* (e.g. identifying success factors and challenges regarding the implementation), *legitimation*, *controlling* (i.e. evaluating the adaptation process at the federal level and the implementation of measures in the second action plan), and *monitoring* (i.e. check whether the activities and instruments of the adaptation process are suitable to 'reduce vulnerability and improve the adaptive capacity of ecological, social and economic systems in Germany'). The evaluation will examine the adaptation process at the strategic and operational levels.

At the moment the first evaluation of the German adaptation strategy is ongoing. This evaluation focuses on insights for the advancement and improvement of the adaptation process in Germany, and will be reported in 2019.

The methodology is based on a model that allows the analysis of five levels of a process: input, implementation, output, outcome and policy impact. Required data and information will be collected by literature review (e.g. from the vulnerability assessment), several interview series and the analysis of indicators. Data will be analysed along defined criteria to ensure a comprehensible and transparent evaluation. In order to validate results, a Delphi survey will be conducted with central actors that are involved in the adaptation policy process.

Summary for and lessons from Germany

- Germany has developed a comprehensive M&E system for climate change impacts and adaptation. In this system monitoring and evaluation are separated processes.
- Monitoring assesses the past and present developments in 15 action fields, using 102 indicators. The Vulnerability assessment looks to present and future changes of these indicators, also using climate change scenarios. The evaluation includes input, implementation process, output, outcome and policy impact. Results of the first evaluation will become published soon.
- With respect to cities, relevant indicators are related to heat and flooding. For the Dutch Delta Programme on Spatial Adaptation in particular, the established heat-related indicators are relevant (e.g. heat stress, heat in inner cities, heat islands, heat casualties, recreation area in cities).

United Kingdom

Introduction and adaptation governance

The *UK's Climate Change Act (2008)* created a framework for both climate change mitigation and adaptation. Regarding adaptation, the UK Government is required to assess the country's climate-related risks and devise programmes to address them. Progress reports are statutory every two years, the first of which was published in 2015. A cyclical approach to risk assessment, planning and reporting will be repeated every five years. The second *Climate Change Risk Assessment (CCRA)* was published in 2017[7] and the second *National Adaptation Programme (NAP)* will be published in 2018.

England's first NAP[8] (TSO, 2013) covers 6 policy areas (built environment, infrastructure, healthy and resilient communities, business, agriculture and forestry, natural environment), 31 adaptation objectives derived from the first CCRA, and 371 adaptation actions – the last are 'owned' by a range of different organisations. A cross-cutting area (local government) is also included. Of the 6 policy areas, 4 areas and 22 associated adaptation objectives are relevant to the urban environment (built environment, infrastructure, healthy and resilient communities, and business) (Table 2.3). (details in Annex I).

Monitoring and evaluation

The Adaptation Sub-Committee of the Committee on Climate Change is a statutory body with responsibility for evaluating the NAP every two years. In its assessments, the ASC poses three questions for each adaptation objective:

1. Is there a plan?
2. Are actions taking place?
3. Is progress being made in managing exposure and/or vulnerability to climate risks?

Multiple indicators have been used in the UK Adaptation Sub-Committee's 2015 and 2017 progress reports, across a number of adaptation objectives. Table 2.4 proves some examples from the 2015 report, all details can be found in Annex I. These indicators can be categorised into five main indicator types: Exposure, Vulnerability, Action, Realised Impact, and Realised Opportunity. Impact indicators are collected. Note that it takes a very long time to observe a trend in impacts, and that there are issues in attributing impacts to different causes. Therefore, the ASC focuses more on whether progress is being made in reducing exposure and vulnerability to climate-related risks. Information on these indicators can provide information on the output and outcome of measures and actions. Except for 'Realised Opportunity', the indicator types are of particular relevance to adaptation M&E in relation to flooding, droughts, and heat-related impacts in urban areas. Those might be used in monitoring and evaluating climate change adaptation in the Dutch urban environment.

[7] www.theccc.org.uk/uk-climate-change-risk-assessment-2017

[8] While the NAP is formally just for England, the analysis and lessons here are applicable to the UK as a whole (Fankhauser et al. (2013): An Independent National Adaptation Programme for England – Policy brief March 2013).

Table 2.3: Policy areas and their adaptation priorities and number of indicators that are relevant for climate change adaptation in the urban environment (source: TSO, 2013).

Policy areas	Adaptation priorities	Indicators*
Built Environment	1. Community-scale flood alleviation	6 indicators (4 A, 2 RI)
	2. Surface-water flood management	7 indicators (2 V, 3 A, 2 RI)
	3. Avoid inappropriate development in flood-prone areas	7 indicators (2 E, 4 A, 1 V)
	4. Residual flood risk to existing buildings	2 indicators (2 A)
	5. Heat-related health impacts (covered under Healthy & Resilient Communities)	(See below)
	6. Water demand in the built environment	2 indicators (1 V, 1 A)
Infrastructure	1. Design and location of future infrastructure	3 indicators (1 E, 1 V, 1 A)
	2. Resilience of energy infrastructure services	5 indicators (2 A, 1 E, 2 RI)
	3. Resilience of public water infrastructure services	5 indicators (4 A, 1 V, 1 RI)
	4. Resilience of ports and airports infrastructure services	1 indicator (1 RI)
	5. Resilience of road and rail network infrastructure services	4 indicators (1 V, 2 A, 1 RI)
	6. Resilience of digital infrastructure services	1 indicator (1 RI)
Healthy & Resilient Communities	1. Public understanding of climate risks	2 indicators (2 V)
	2. Heat-related health impacts	15 indicators (1 E, 2 V, 7 A, 5 RI)
	3. Cold-related health impacts	5 indicators (3 V, 2 RI)
	4. Pathogens, air pollution and UV radiation	12 indicators (4 E, 4 A, 3 RI, 1 V)
	5. Ability of people to recover from flooding	9 indicators (3 V, 2 A, 4 RI)
	6. Capability of emergency planning system	5 indicators (3 RI, 2 A)
Business	1. Business impacts from severe weather events	8 indicators (2 E, 4 A, 2 RI)
	2. Supply chain interruptions	3 indicators (1 E, 1 RI, 1 A)
	3. Water demand from industry	5 indicators (1 V, 1 E, 2 A, 1 RI)
	4. Business opportunities from climate change	3 indicators (3 RO)

Table 2.4: Examples in the UK's M&E system of action/output and realised impact/outcome indicators of direct relevance to flooding, droughts and temperature-related impacts (see Annex 1 for total overview)

Built Environment		
Adaptation priority	**Indicator**	**Indicator type**
1. Community-scale flood alleviation	Number of households better protected from river/coastal flooding	Action
	Fraction of EA flood defence asset systems maintained each year in accordance with identified needs	Action
	Number of properties lost to coastal erosion	Realised impact
2. Surface-water flood management	Area of permeable concrete or block paving (domestic/commercial)	Action
	Number of properties affected by sewer flooding	Realised impact
Infrastructure		
Adaptation priority	**Indicator**	**Indicator type**
2. Resilience of energy infrastructure services	Number of major electricity substations in areas of high river/coastal flooding with site-level protection measures implemented	Action
	Amount of electricity generation capacity (MWh) lost due to temporary abstraction restrictions	Realised impact
3. Resilience of public water infrastructure services	Reduction in leakage (ml per year)	Action
	Number of interruptions to water supply due to severe weather	Realised impact
4. Resilience of ports and airports services	Annual number and length of delays to: a) port, b) airport transport caused by severe weather	Realised impact
Healthy and Resilient Communities		
Adaptation priority	**Indicator**	**Indicator type**
2. Heat-related health impacts	Number of air conditioning units (domestic/commercial)	Action
	Number/area of green roofs installed in urban areas	Action
	Number of local authorities implementing heatwave plans	Action
	Number of heat-related deaths	Realised impact
	Number of heatwave alerts issued by Met Office	Realised impact
5. Ability of people to recover from flooding	Number of households located in areas susceptible to river/coastal flooding signed up to flood warnings	Action
	Number of working/school days lost from flooding/severe weather events	Realised impact
	Average length of time between flooding events and people returning to their homes	Realised impact
Business		
Adaptation priority	**Indicator**	**Indicator type**
1. Business impacts from severe weather	Number of businesses with insurance against flooding events (weather damage and business interruption insurance)	Action
	Losses to businesses from flooding events (direct and indirect)	Realised impact
	Insured losses from severe weather events	Realised impact

Summary for and lessons from the United Kingdom

- The *UK's Climate Change Act (2008)* has been an important trigger to develop adaptation policy in the United Kingdom, including an adaptation M&E system.
- Objectives should be specific and measurable when developing indicators.
- The UK's M&E system includes a broad set of about 200 indicators. Of the five main indicator types defined to monitor progress with the NAP, four[9] are of relevance to adaptation actions related to flooding, droughts, and heat-related impacts in urban areas: Exposure, Vulnerability, Action (output), and Realised Impact (outcome). As such, the UK's M&E system also includes indicators to assess the outcome of adaptation policies and actions.
- Climate change adaptation is complex and has multiple dimensions. For the M&E system in the United Kingdom, this has been included by: (1) prioritising the highest risks, the most pressing objectives, and the most effective actions; and (2) focusing on a core set of policies and actions that will address these most urgent risks, with each having specific goals, responsibilities and timescales.
- Revisit the monitoring regularly, and reassess policies in order to improve effectiveness of M&E systems.
- When revisiting the monitoring, emphasise particular risks and objectives/set priorities at national and sub-national levels.

Switzerland

Introduction and adaptation governance

The revised *CO_2 Act* which entered into force in January 2013 provides the legal basis for adaptation in Switzerland. According to Article 8, the Swiss federation shall coordinate and provide the basis for adaptation measures. The coordinating body is the Federal Office for the Environment (FOEN). For the implementation of the legal mandate, FOEN developed an adaptation strategy together with federal offices from other ministries.

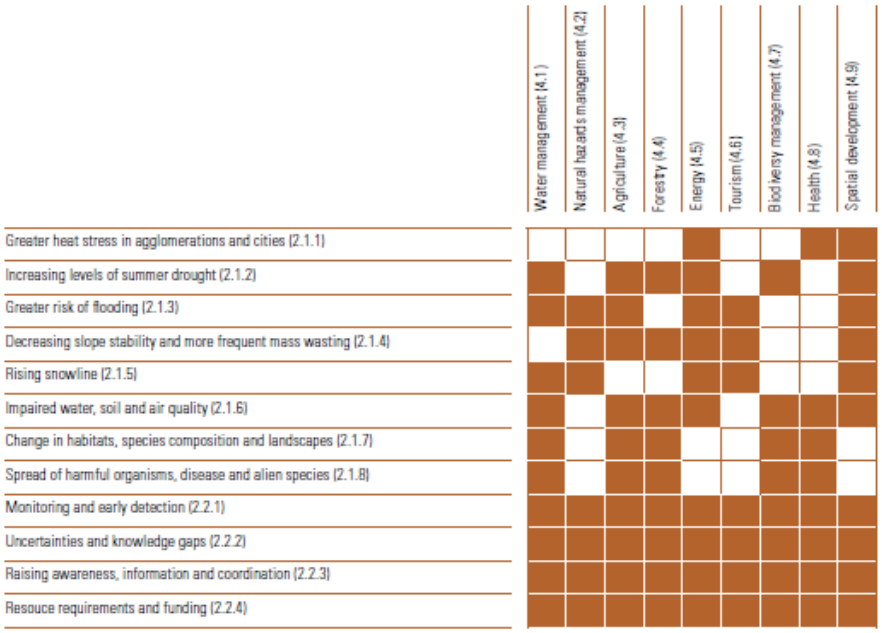
The adaptation strategy consists of two parts. The first part of the strategy, adopted by federal council in 2012, contains objectives and principles, a definition of fields of action and a description of cross sectoral challenges. Table 2.5 shows Switzerland's 12 greatest challenges in adapting to climate change. Eight challenges result directly from the effects of climate change on the sectors. The other four challenges are intended to improve the basis for implementing adaptation measures.

The action plan 2014–2019 (2nd part of the strategy) consists of 63 adaptation measures and was adopted by federal council in 2014. 54 of these measures refer to the nine sectors mentioned in Table 2.5: Water management (11 measures); Hazard control (7); Agriculture (6); Forestry (4); Energy (8); Tourism (2); Biodiversity management (7); Health (4); Spatial planning (5). These adaptation measures are implemented within the different sectoral policies. The nine other measures are cross-sectoral and refer to scientific basis, coordination and awareness raising.

A frequent process-orientated action is 'knowledge development', frequent impact-reducing actions are 'setting up early warning systems' and 'changes in management/diversification' (in water management, agriculture, forestry, tourism, and biodiversity). Changes in legislation are mentioned for energy, biodiversity, and spatial planning.

[9] All except 'realised opportunities'

Table 2.5: The challenges in adapting to climate change in Switzerland (source: BAFU, 2012).



Monitoring and evaluation

With the adoption of the action plan, the FOEN was mandated to report on the progress made and the effectiveness achieved in adaptation in Switzerland. The progress of implementation of adaptation measures was monitored in 2015 and 2017. A survey with the federal offices responsible for development and implementation of these measures shows the current state of implementation at the federal level (2017, Figure 2.3). Most of the measures are fully implemented or in an advanced or early stage of implementation, while the implementation of only nine measures is suspended.

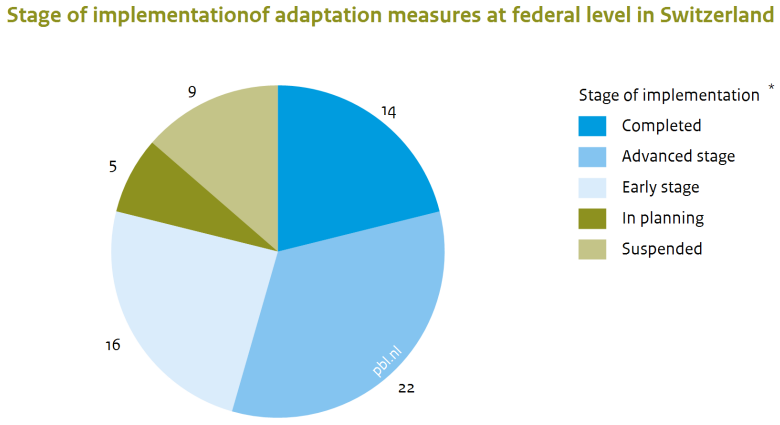


Figure 2.3. State of implementation of adaptation measures at federal level in Switzerland in 2017. (source FOEN, 2017)

The effectiveness of the adaptation strategy (both in terms of increased adaptive capacity and changes in risks), and of the coordination work of FOEN[10] were externally evaluated in 2017[11]. This evaluation focuses on the following three challenges in adapting to climate change in Switzerland: greater heat stress in agglomerations and cities, increasing levels of summer drought and rising snowline. For each of these challenges an impact model with the

[10] Legal duty: CO_2 Ordinance, Section 6, Article 15: Coordination of Adaptation Measures
[11] https://www.bafu.admin.ch/bafu/de/home/themen/klima/fachinformationen/anpassung-an-den-klimawandel/strategie-des-bundesrates-zur-anpassung-an-den-klimawandel-in-de/vollzugs--und-wirkungsanalyse-der-anpassung-an-den-klimawandel.html

main evaluation objects was developed (based on impact model on climate change adaptation, Figure 2.4). Among others the evaluation analysed the added value of the adaptation strategy (concept) and the suitability of the organisational structure on federal level in order to tackle the challenges in adapting to climate change (implementation/output). The latter includes the evaluation of the 63 actions (outcome/impact).

For *output*, three questions dealt with the implementation level of the actions, their usefulness ('doing the right thing'), and the need and availability of resources. Regarding *outcome and impact*, questions dealt with changes in adaptive capacity (e.g. through better knowledge and awareness) and vulnerability (i.e. opportunities seized and risks reduced) due to the actions taken. The evaluation was based on qualitative, face-to-face interviews with stakeholders from federal, cantonal and communal levels and third parties, as well as on workshops with scientific board and cantonal representatives, literature review, literature studies and empirical evidence checks by scientists. No quantitative indicators were developed or applied.

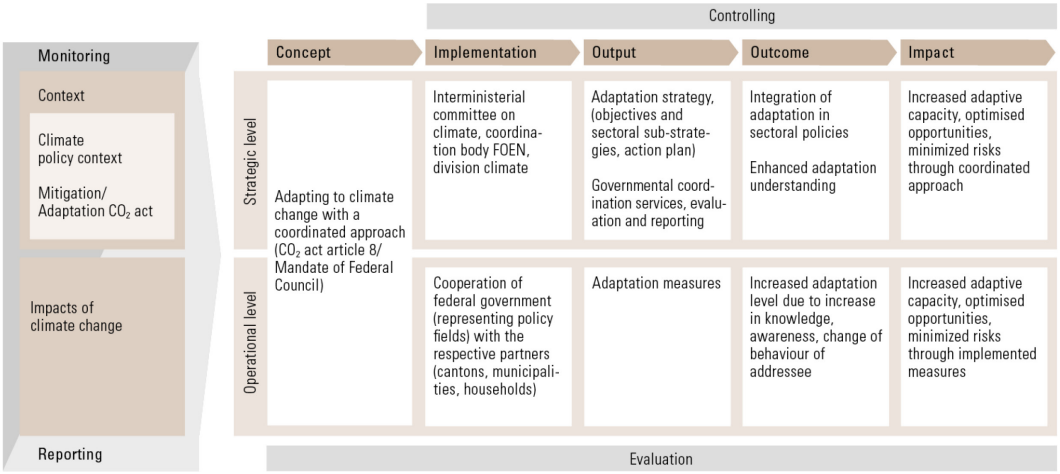


Figure 2.4. Impact model of climate change adaptation (source: BAFU, 2012).

Summary for and lessons from Switzerland

- Switzerland has a clear approach to monitor and evaluate the implementation (output) and effect of 63 measures and actions.
- Switzerland is using stakeholder engagement methods and empirical evidence for its adaptation M&E.
- Progress report shows that many adaptation measures and actions have been taken and either fully or partly implemented.
- Also, the evaluation of output, outcome and impact has recently been finalised.

Finland[12]

Introduction and adaptation governance

The National Strategy for Adaptation to Climate Change of Finland was issued in 2005 (Ministry of Agriculture and Forestry, 2005). The starting point of the strategy was national and sector-specific. The strategy contained over 200 actions for 15 sectors. In addition, the strategy included joint actions for different administrative areas. The evaluation of Finland's *National Strategy for Adaptation to Climate Change* (Ministry of Agriculture and Forestry, 2013) provided an assessment of how the strategy had been applied in the sectors since 2005 and recommendations for updating the strategy. The report also provided an overview of the adaptation of regions and municipalities and a summary of the assessments of Finland's adaptation strategy, EU adaptation policy and the latest research results. In 2015 a national plan for adaptation to climate change (NAP) was approved by the Government. It has superseded the strategy as an overall guiding document for adaptation activities.

[12] Based on 'Evaluation of the Finland's National Strategy for Adaptation to Climate Change 2013'

The adaptation strategy and plan aim at making adaptation an integral part of normal planning, operations and follow-up. In most sectors, the consequences of climate change are known, at least at the indicative level. The evaluation in 2013 concluded that adaptation measures have been identified, the implementation of the strategy's actions has started in almost all sectors, and progress has been made compared to the mid-term assessment of 2009. The integration of adaptation into daily practice, however, has started in very different ways within the different sectors. Most progress was made for sectors that are traditionally weather and climate dependent. Vulnerability to climate change varies from one sector to another, and the effects of climate change and the necessary adaptation measures relate to different periods of time. The majority of sectors have not made any systematic analyses of how climate change should be taken into account in their goals, governance and operations.

The management of uncertainties in climate change requires governance and planning decisions that can be adapted to different situations. The strategy, being sector-specific, contributed to its application and follow-up, but did not initially spur the sectors to a sufficiently broad collaboration. A need was identified to better integrate of regional and local adaptation efforts into the implementation of the national adaptation strategy. The strategy contributed to adaptation by initiating R&D that has led to practical tools for planning. These have included methods and approaches for assessing and managing climate risks, as well as assessing costs and benefits. Raising the level of knowledge through communication, counselling and education has been seen as a prerequisite for the adaptation efforts, both for government decisions and autonomous adaptation by private actors. In particular, efforts have been made to provide information in a form that can also serve the general public.

Ongoing research projects also take into account other elements of change, in addition to climate change. The global reflexive effects of climate change on Finland are being investigated and their significance for decision-making is being explored. A need for additional research on the economic impacts of climate change and adaptation measures has been identified. There is also a need for studies of vulnerability and long-term effects and impacts on society's vital functions as well as analyses of the preparedness for, for example, a faster climate change.

Monitoring and evaluation
Finland was one of the first countries to implement a system for monitoring and evaluation of adaptation. Monitoring is one of the elements of the country’s legislation on climate (the Climate Act of 2015). The M&E activities are expected to provide feedback for the implementation of adaptation policies and actions. It will also serve the reporting requirements under the EU MMR Article 15, and the development of national communications under the UNFCCC (see also EEA, 2015). Apart from learning and improving adaptation processes, the M&E is also expected to ensure accountability of adaptation action in the longer term.

An inter-ministerial National Monitoring Group, coordinated by the Ministry of Agriculture and Forestry (which is responsible for the adaptation process), is responsible for overseeing adaptation activities and developing the M&E system. The National Monitoring Group facilitates cross-sectoral and vertical coordination in order to ensure the M&E system becomes widely accepted.

The M&E system is largely based on self-assessment approaches to assess progress and has also involved government officials and other stakeholders. Additional data have been collected through thematic interviews, focusing on adaptation measures in specific sectors. The aim is to ensure that the M&E system uses the available monitoring data and processes (e.g. from human and animal health sectors).

Summary for and lessons from Finland
- Embedding M&E in legislation had been helpful in implementing the system.
- M&E has multiple objectives; feedback to implementation, future planning and learning are particularly important.
- Having a specially appointed group for the monitoring of the national adaptation plan has helped in identifying useful M&E processes. It has also strengthened horizontal and vertical coordination in the public sector and also helped to engage stakeholders.
- Linking to currently implemented monitoring systems in other fields/sectors can be an efficient and effective way of creating commitment to the M&E.

France

Introduction and adaptation governance

In France, a *National Adaptation Strategy (NAS)* was adopted in 2006. The objectives of this strategy are to underpin all recommended measures concerning adaptation to climate change, namely: Act for public safety and health; Take account of social inequality; Limit costs and take advantage of benefits; and Preserve the natural heritage (Ministry of Ecology, Sustainable Development and Energy, 2013). A first *National Adaptation Plan (NAP)* was adopted in 2011. This document describes 240 prioritised measures, covering the 20 themes of the plan, including a theme on cross-cutting actions (Ministry of Ecology, Sustainable Development and Energy, 2013). The first NAP was evaluated at the end of 2015. A second NAP is under construction.

In these documents, three challenges have been identified for successful adaptation: (1) Lack of feedback and measurement units (metrics); (2) Attributing responsibilities; and (3) Long timescales and climate change uncertainty. Because of these challenges (especially long timescales and uncertainties), climate change is considered a dynamic, ongoing process and adaptation policy has to be implemented in an unstable and particularly uncertain context. Adaptation, therefore, requires: (i) an initial vision of the potential and observed consequences of the future climate and its consequences, and (ii) strategic flexibility (ADEME, 2013).

In addition to activities at the national level, several actions have been taken at a more regional level. It was recognised that local actors are often ill-equipped for decision-making in a changing climate. Therefore, regional impact, vulnerability and adaptation studies have been carried out to develop and implement sub-national adaptation planning policies.

Monitoring and evaluation

To enable action when faced with uncertainty and maintain a certain degree of flexibility and reversibility, adaptation actions should be robust, no regret, flexible/reversible, in synergy with attenuation objectives and other environmental policies, and/or favouring financial and institutional local authority mechanisms that are less costly and carry less inertia in the face of uncertainties (e.g. in the face of flood risks, prefer to develop an early warning and evacuation system rather than building dykes).

To tackle this challenge, France has developed a methodology for M&E of adaptation policies. The proposed methodology will be accessible to all communities (on national, regional and local levels). It offers a vision of what is desirable for the territory or a given sector in terms of adaptation. The system is designed as a toolbox/guide that provides methodological advice to organise, develop and successfully implement its M&E system.

The main objectives of the French M&E system are to: (i) enable authorities to locate and monitor the progress of their policy and evaluate performance with a view to continuous improvement and policy consistency; and (ii) promote the exchange of experience and collective learning in the field of still largely ’exploratory‘ public policies.

Monitoring will take place continuously during policy implementation. Evaluation generally intervenes at two key moments: midway through the policy cycle and at the end of the process (ex-post evaluation). At the midway point, evaluation aims to assess the initial outcomes and good governance and possibly redirect the strategy. At the end of the process, it provides a comprehensive strategic overview of the effects of the policy, so the next cycle can be prepared on the basis of a philosophy of continuous improvement.

The French M&E system for climate change adaptation is based on a system for territorial policies and projects, already being used by different French authorities, especially in the context of evaluating their Agenda 21. The framework uses a five-step approach (Figure 2.4):

1. Assess the current *situation and data* on which the local authority wishes to act.
2. Formulate the desired medium and long-term strategic (*adaptation) goals and objectives.*
3. Formulate measures and actions that lead to the desired outcomes (including *operational outcomes)*.
4. Identify *success factors* for achieving the objectives.
5. Choose *indicators* for measuring the achievement or otherwise of objectives and outcomes and to monitor actions (maximum two or three indicators per intervention level).

Associated with the last step in the M&E system, different types of indicators can be defined (see also Figure 2.5):

- *Effect indicators* to evaluate the policy effects on the main goals of any local adaptation policy, including adaptive capacity (e.g. number of involved agents; prevention and safeguard plans in place) and vulnerability of a region/society (e.g. extent of flood prone areas; yield reduction percentage in dry years).
- *Strategic impact indicators* to monitor changes flowing directly from a policy in each main strategic policy field (e.g. number of farmers with insurance against extreme weather events; number of hotels adapted to future summer conditions).
- *Operational outcome indicators* to measure the level of achievement. There are generally two types of outcome indicators: (i) sectoral indicators (e.g. number of flood protection works ; lines of elevated dykes (km); and (ii) coverage indicators that relate to transversal actions or that have a territorial dimension (e.g. number of actors; number of trained agents)
- *Achievement indicators* on the actions implemented to produce the expected outcomes (e.g. number of environmental restoration sites).
- *Input indicators* to measure the technical, human, financial or other inputs for the adaptation policy (e.g. cost of works; full-time equivalent involvement).

Each indicator should be made as concrete as possible by specifying the indicator, the quantitative objective (e.g. at least 50% of clean-up service teams), the qualitative objective (e.g. show improvement in the adaptation to climate change) and the time horizon (e.g. within a certain number of years), and by defining the spatial coverage where possible (in all intercommunal associations).

Summary and lessons related to France

- France has a clear five-step adaptation M&E system.
- Distinction between strategic and operational levels is needed in a M&E system, as the levels require different measures and indicators to measure the associated level of success.

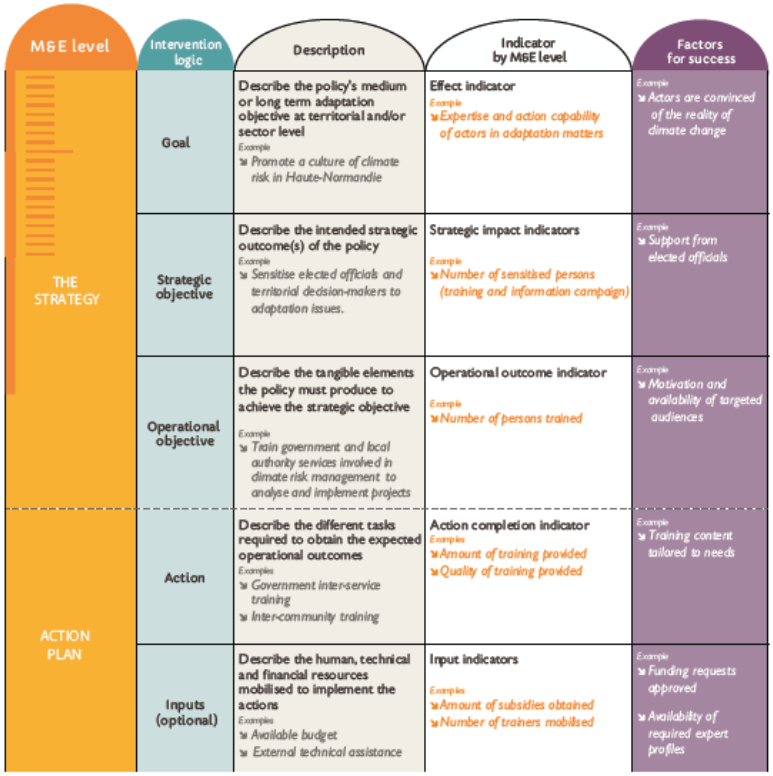


Figure 2.5. Standard French logical framework matrix for adaptation M&E (source: ADEME, 2013).

Poland

Introduction and adaptation governance

Poland's national adaptation policy is formulated in its *National Strategy for Adaptation to Climate Change (NAS 2020)* (Ministry of the Environment of Poland, 2013). The Ministerial Council adopted the NAS 2020 in 2013.

The NAS 2020 covers 10 sectors and regions and formulates rules, governance, monitoring and control of implementation of the adaptation strategy at the national level. Regional authorities adopted regional development strategies that include the most relevant elements of adaptation. Five programmes have been established to develop urban adaptation to climate change.

For example, the main goal of the ADAPTCITY project is reduction of negative impacts of climate changes for Warsaw. In the project a questionnaire was prepared to assess the degree that Polish cities are prepared for climate change, how they prepare for climate change, and what else remains to be done. The study was completed in 2015 and will be repeated in 2018.

Another project, called MPA, is aimed at preparing urban adaptation plans in 44 cities with over 100,000 inhabitants. It is carried out under supervision of the Ministry of the Environment and coordinated by the Institute of Environmental Protection. The major objective of the project is to assess the sensitivity of these largest Polish cities to climate changes, and to monitor adaptation activities appropriate for the identified risks. The project started in 2016 and will be completed in 2019. Meanwhile, a similar project (CLIMCITIES) for five cities, each with a population of over 50,000 (Bełchatów, Ostrołęka, Nowy Sącz, Siedlce, Tomaszów Mazowiecki) was completed in 2017.

Monitoring and evaluation
The Government Centre for Security is building an effective and comprehensive system of crisis management. The objective is to prevent crises and, in case they do occur, to minimise their impact by taking professional actions.

The impacts of extreme events, such as forest fires, droughts and other natural hazards related to the atmosphere and hydrosphere) are monitored in Poland. Adaptation measures have been cited in sectoral strategic documents; monitoring their implementation is also part of these strategies. The sectoral monitoring system falls under the responsibility of different ministries. Urban adaptation strategies will be subject to periodic assessments in terms of achieving their goals and implementation of adaptation actions. Four broad types of adaptation monitoring have been defined:

1. Led by the Ministry of Environment on the basis of the Polish National Strategy for Adaptation to Climate Change (NAS 2020).
2. Led by various institutions whose competencies are to prevent the impacts of extreme events and to implement preventive actions.
3. Conducted by municipal authorities responsible for implementation of urban strategies.
4. Conducted as part of research activities such as ADAPTCITY.

A number of process indicators are being used to monitor adaptation (e.g. adaptation plans that are in place for cities with more than 100,000 residents). For these indicators, the 2010 baseline and the 2020 expected value are provided, together with possible data sources.

Summary for and lessons from Poland

- Monitoring of climate change adaptation is part of more sectoral monitoring systems.
- The M&E system in Poland focuses on monitoring process and progress/output; outcome is not yet considered.

South Africa

Introduction and adaptation governance
South Africa is developing a system for monitoring and evaluating climate change adaptation. The country's *National Climate Change Response White Paper*[13] presents a vision for an effective response to climate change. Its objective is to address the immediate and observed threats to society, the economy and the environment through policies and interventions to reduce vulnerability and build resilience. In terms of adaptation, this will largely be delivered through policies, plans and actions stimulated by national governmental and sectoral strategies and by international agreements (notably the adaptation goals set out in South Africa's *(Intended) Nationally Determined Contribution* (A-INDC goals) under the UNFCCC Paris Agreement).

The *White Paper* states that robust M&E is essential to assess progress towards climate resilience. The South African system is based on so-called *Desired Adaptation Outcomes* (DAOs), which have been devised to facilitate, inform and focus monitoring and evaluation. DAOs identify desired states that, individually and in combination, will contribute to climate resilience in the short to medium term (i.e. over the next 5 to 20 years). They aim to provide clear insights into climate change adaptation in South Africa and to help capture the country's unique circumstances to aid reporting on adaptation. They also provide a means of assessing the capacity of 'at risk' sectors and their stakeholders to adapt to climate change and whether the measures being taken are appropriate, efficient and effective.

Nine generic DAOs (Table 2.6: G1–G9) have been developed, each of which of cross-cutting and cross-sectoral relevance and outlining a desired state that will enhance South Africa's transition towards climate resilience. These DAOs can be divided into 2 distinct groups: 6 DAOs (G1–G6) describe the 'inputs' (e.g. processes, resources and capacities) that need to be in place to enable effective climate change adaptation; and 3 DAOs (G7–G9) describe the key 'impacts' of adaptation interventions and associated measures (e.g. reductions in the vulnerability of human and natural systems).

13 https://www.environment.gov.za/sites/default/files/legislations/national_climatechange_response_whitepaper.pdf

Table 2.6: Generic Desired Adaptation Outcomes in the South African approach to M&E climate change adaptation.

Desired Adaptation Outcomes (DAOs)	
'Inputs' to enable effective adaptation	
G1	Robust/integrated plans, policies and actions for effective delivery of climate change adaptation, together with monitoring, evaluation and review over the short, medium and longer term.
G2	Appropriate resources (including current and past financial investments), capacity and processes (human, legal and regulatory) and support mechanisms (institutional and governance structures) to facilitate climate change adaptation.
G3	Accurate climate information (e.g. historical trend data, seasonal predictions, future projections, and early warning of extreme weather and other climate-related events) provided by current and future monitoring and forecasting facilities/networks (including their maintenance and enhancement) to inform adaptation planning and disaster risk reduction.
G4	Capacity development, education and awareness programmes for climate change adaptation (e.g. informed by adaptation research and with tools to utilise data/outputs).
G5	Newly developed and adapted technologies/knowledge and other cost-effective measures (e.g. nature-based solutions) used in climate change adaptation.
G6	Climate change risks, impacts and vulnerabilities identified and addressed.
'Impacts' of adaptation interventions and associated measures	
G7	Systems, infrastructure, communities and sectors less vulnerable to climate change impacts (e.g. through effectiveness of adaptation interventions/response measures).
G8	Non-climate pressures and threats to human and natural systems reduced (particularly where these compound climate change impacts).
G9	Secure food, water & energy supplies for citizens (within the context of sustainable development).

Monitoring and evaluation

A simple pragmatic approach has been developed to monitor and evaluate the progress being made in achieving individual DAOs. The approach uses traffic light colours as a scoring system to summarise progress, for example:

- Legal frameworks, plans/strategies, policies, programmes and projects are not based on risk and vulnerability profiles that include climate risks and impacts (red).
- Legal frameworks, plans/strategies, policies, programmes and projects are based on risk and vulnerability profiles that include climate risks and impacts (amber).
- Legal frameworks, plans/strategies, policies, programmes and projects – based on risk and vulnerability profiles that include climate risks and impacts – are implemented to reduce vulnerability in risk and vulnerability profiles, and enhance the capacity to respond to climate change impacts (green).

Responsibility for delivering individual adaptation outcomes will rest with a range of stakeholders operating at different spatial scales (i.e. national, provincial and municipal). Some stakeholder groups may have systems and indicators in place to monitor their activities, others have not. This approach will enable all stakeholders to gather basic data and information, from which a cumulative 'score' of progress can be derived. Stakeholder groups will be informed on the needed data/information and of the time period for which these are required. The data/information collected from individual groups will be aggregated to provide a total 'indication' of progress for that DAO. A summary of progress for the specified time period will then be presented graphically. Table 2.7 illustrates the approach by providing a 'hypothetical' summary of progress towards a sub-set of generic DAOs.

Table 2.7: 'Hypothetical' summary of progress towards a subset of generic DAOs.

DAO	Summary of progress (for a specified time period)
G1	
G6	
G7	
G8	

By comparing progress summaries for successive reporting periods, the effectiveness of adaptation policies, plans and actions in addressing adaptation priorities and, therefore, delivering climate resilience can be determined.

Reliable, readily available and long-term data and/or information are required to monitor South Africa's transition towards climate resilience. This should enable progress in achieving individual DAOs to be accurately and repeatedly monitored, over time, and provide an understanding of their effectiveness in reducing vulnerability and enhancing resilience to climate change. Consultations have been undertaken with key sectoral and provincial stakeholders to gain ownership and acceptance of the DAO concept, to fine-tune the DAOs, to consider the data needed to track progress towards their achievement, and to identify potential data sources.

Summary for and lessons from South Africa

- Climate change adaptation in South Africa will largely be delivered through policies and actions stimulated by national governmental and sectoral strategies and by international agreements.
- The concept of *Desired Adaptation Outcomes* (DAOs) has been devised to facilitate, inform and focus M&E of progress towards climate resilience.
- Nine generic DAOs have been developed, each of which is of cross-cutting, cross-sectoral relevance and describes a desired state that will enhance climate resilience.
- A simple pragmatic approach, using traffic light colours as a scoring system, has been developed to monitor progress in achieving individual DAOs and for which reliable and readily available data and/or information are required.
- Responsibility for delivering DAOs rests with a range of stakeholders operating at different spatial scales; consultations with key sectoral and provincial stakeholders have identified the data needed to track progress and potential data sources.

3 Developments on city level

- Much progress on the monitoring and evaluation of climate adaptation has been made on a national scale; nevertheless, several cities are in the process of also developing such a system. Only a few of these, mostly larger, cities already use an M&E system for climate adaptation monitoring implementation and progress. All this can be a source of information when developing indicators to monitor the effectiveness/outcome of policies and actions (see also Annex II-V).
- Given the attention currently being given to adaptation in cities, knowledge on urban adaptation is expected to grow rapidly. During the coming years and decades, numerous projects in many countries and cities will build an enormous potential source of knowledge and practical experience of adaptation measures in the urban environment. This calls for an effective connection of the Delta Programme on Spatial Adaptation (DPSA) to the international networks of cities, thereby providing opportunities for learning and obtaining valuable and relevant information about adaptation in the urban environment.
- At the cities level, the Covenant of Mayors Initiative on Climate Change Adaptation (now integrated into the Covenant of Mayors for Climate & Energy) includes:
  - A monitoring and reporting framework
  - An e-learning module on adaptation, including an overview of case studies and examples of good practices
  - Funding for integrated climate projects.
- The M&R framework of the Covenant of Mayors provides a wide range of suggested output, effect and outcome indicators, including for urban areas

3.1 Introduction

Cities play an important role in climate change adaptation and the development of systems for M&E. This was highlighted in an EEA report (2016); the most relevant findings of this report are summarised in Section 3.2. This section also addresses the indicators presented by the Covenant of Mayors Initiative on Climate Change Adaptation (now integrated into the Covenant of Mayors for Climate & Energy, a global network of more than 7000 cities across 57 countries[14]) that aims for an effective M&E system for climate change adaptation.

In Section 3.3, we present the results of our quick scan on M&E activities in a number of cities in the countries included in the previous chapter. These cities are frontrunners in their country and provide literature and/or additional information on their adaptation activities. The cities chosen provide good examples that could be of use in the Delta Programme on Spatial Adaptation (DPSA).

3.2 Recent initiatives at European level

The EEA 2016 report on Urban adaptation

Three different approaches to urban adaptation
In 2016, the EEA published *Urban adaptation to climate change in Europe 2016; transforming cities in a changing climate*. This report provides an overview of actions that can be taken to adapt cities in Europe and includes tools, reports and initiatives on urban adaptation. The report addresses three different adaption approaches (coping, incremental, transformative) and related complementary benefits.

State of the art and frontrunners
According to the EEA, hundreds of cities have started to assess their vulnerability to climate change over the last few years, and have developed plans and strategies to adapt. Frontrunners, such as Copenhagen, Rotterdam, Barcelona and Helsinki, have moved from

[14] http://www.covenantofmayors.eu/Adaptation.html; http://www.covenantofmayors.eu/The-Covenant-of-Mayors-going,2332.html

developing strategies and planning adaptation to putting the first measures into practice. Only a few larger cities are beginning to think about M&E adaptation efforts and how to develop monitoring schemes.

Apart from specific adaptation measures, many cities have implemented measures that can support adaptation too, but are not labelled as such. These include reducing the risk of disasters, managing water and creating urban green space. Whether or not these in fact contribute to adaptation depends on their specific design – will they work not just in the current climate and according to past risk levels but also under future climate change? The challenge is to find ways to close the gap between the few frontrunner cities and the many cities that have just – or not yet – begun (EEA, 2016).

Knowledge on urban adaptation is weak and fragmented
A main conclusion of the EEA report is that knowledge on urban adaptation is growing rapidly. Researchers and knowledge providers can fill gaps, but only the effective co-creation of knowledge with practitioners, the communities affected and business ensures that knowledge will be relevant and applicable. To create the knowledge base for transformative adaptation, research must pursue much more systematic approaches and integrate the socio-economic and demographic dimensions of urban development.

Monitoring and evaluation is one of five challenges
The EEA report also defines five areas of action needed for implementing effective adaptation and transforming cities into well-adapted and vital places. One of the five areas is monitoring, reporting and evaluation. This provides feedback on the effectiveness of adaptation action taken and progress achieved. Thus, it enables gaps to be discovered, necessary adjustments to be made and future decision-making improved. However, only a few cities have developed and used M&E for adaptation. Nonetheless, their experiences are valuable for national-level assessments of adaptation progress and for providing learning to help other cities. Such learning includes the development of indicators, which are needed to better understand the effectiveness of adaptation actions. Establishing robust criteria for choosing indicators is important. Learning also helps cities with certain characteristics in common to conceptualise and manage policies within the policy cycle.

The developments in cities are useful to become aware of some specific pitfalls and as such why it may be necessary to adjust M&E approaches. For example, the developments show the dynamics and uncertainties around climate change adaptation and as such that it can be difficult to monitored how adaptation policies and actions are implemented. Complicating factors include the long time horizons involved, the cross-sectoral relationships complicating an accurate baseline, the attribution to adaptation measures when observing certain changes in impacts, and the lack of appropriate data. In addition, because of the cross-sectoral relationships, M&E needs to track the integration and effectiveness of climate change adaptation into related policies and practices.

The Covenant of Mayors Initiative as a source for adaptation indicators at local level
At the European level, a monitoring and evaluation framework has been developed. It was initially started under the umbrella of the *Covenant of Mayors Initiative on Climate Change Adaptation*[15], which has since been integrated into the Covenant of Mayors for Climate & Energy (a global network of more than 7000 cities across 57 countries[16]. This framework includes *Guidelines on Sustainable Energy Action Plan and Monitoring* and gives minimum requirements for each step[17]. The framework distinguishes between indicators to monitor process by using a scoreboard (e.g. frequency of reporting; list of possible actions; available resources) and changes in vulnerability, impact and outcome/adaptation action (see Table 3.1 for outcome indicators, and Annex IV for entire list). The latter is quite similar to the 'realised impact' indicators used in the United Kingdom (e.g. percentage change in sealed surfaces; percentage change in crop yield due to adaptation measures).

[15] http://www.covenantofmayors.eu/Adaptation.html
[16] http://www.covenantofmayors.eu/Adaptation.html; http://www.covenantofmayors.eu/The-Covenant-of-Mayors-going,2332.html
[17] http://www.covenantofmayors.eu/IMG/pdf/Mayors-Adapt_Reporting_Guidelines.pdf

Table 3.1: Outcome indicators as given in the M&E framework of the Covenant of Mayors Initiative on Climate Change Adaptation to monitor the process of climate change adaptation *(the indicators encompass a wide range of topics, including urban environment, agriculture, forestry and tourism).*

Sector	Outcome-related indicators	Unit
Buildings	Public, residential or tertiary buildings retrofitted for adaptive resilience	%
Transport, Energy, Water, Waste, ICT	Transport, energy, water, waste or ICT infrastructure retrofitted for adaptive resilience	%
Land-use Planning	Change in green & blue infrastructure/areas	%
Land-use Planning	Change in the spatial connectedness of green and blue areas	%
Land-use Planning	Change in sealed surfaces / soil moisture level	%
Land-use Planning	Change in rainwater runoff from floodplains (due to changes in soil condition)	%
Land-use Planning	Change in shading (& related change in the Urban Heat Island effect)	%
Land-use Planning	Coastline designated for managed realignment	%
Water	Change in water loss (e.g. due to leakages from the water distribution system)	
Water	Change in storage of rainwater (for reuse)	%
Waste	Change in solid waste collected / recycled / disposed of / incinerated	
Environment & Biodiversity	Habitat restoration / species protection	%
Agriculture & Forestry	Change in crop yield due to adaptation measures	%
Agriculture & Forestry	Change in water consumption for agriculture/irrigation	%
Agriculture & Forestry	Additional forest restoration	%
Tourism	Change in tourist flows	%
Tourism	Change in tourism activities	%
Other	Change in restoration and reconstruction costs associated with extreme climate events	%
Other	Investment in adaptation research (e.g. soil conservation, water/energy efficiency) by the city/other stakeholders	€
Other	Investment in education/medical & emergency services by the city	€
Other	Number of awareness-raising events for citizens and local stakeholders	
Other	Number of training sessions for staff	
Other	Number of direct stakeholders involved in adaptation process through community participatory activities	

3.3 Developments in selected cities

Berlin (Germany)

Adaptation to the consequences of climate change
The consequences of climate change for Berlin and the city's adaptation policy have been reported in detail by Reusswig *et al.* (2016). The following issues are discussed in the report:

- Climate change and climate scenarios
- Regional climate scenarios for Berlin in 2050 and 2100
- Sector vulnerability and measures
- Selected cost-benefit aspects
- Synergy and conflicts regarding climate change adaptation
- Monitoring concept
- Communication

The report states that the way climate changes and the impacts that can be observed in Berlin need to be monitored, continuously. The report makes suggestions to this end, on the basis of the OECD's monitoring system, which distinguishes between indicators on state, impact and response (resonance).

In addition to observation of the urban climate, the climate-sensitive health status of the population, the various effects on 'natural balance' and urban infrastructure are to be monitored and assessed continuously. This will partly make use of existing or planned monitoring activities. Assessment of the impact of measures taken by policy, administration and private parties is a separate task, which requires consideration of all types of indicators, as well as a separate expert assessment. Such a monitoring system is important in order to make adaptation itself adaptable and flexible.

The monitoring system is described in Part 1 of the report. In Part 2, indicators are further elaborated (e.g. who collects the data). The following tables are taken from Part 1 (see Annex II):

- Table 30 summarises the type of indicators with a brief explanation.
- Table 32 summarises part of the 'state' indicators.
- Table 33 concerns 'impact' and 'response' indicators (a small part of the table is reproduced and shows which fields of action ('Handlungsfeldern') have been considered).

Munich (Germany)

Adaptation policy
The city of Munich has elaborated on the following aspects (Wirth et al., 2016):

- Impacts of climate change, the prioritisation of these impacts affecting Munich, and where the city is particularly affected.
- Fields of action, goals and framework conditions: How can Munich prepare for climate change? Is there need for action?
- Development of measures to adapt to climate change.
- Development of an action-related monitoring concept.

Whilst the monitoring concept for the city has been developed, a set of indicators has, as yet, not. Munich uses 'pragmatic monitoring' to follow the development and implementation of measures for five 'fields of action' by checking:

- Whether the proposed adaptation measures have been implemented.
- Whether the measures implemented have the expected result.
- Whether objectives have been achieved by implementing the measures.

It is necessary to check whether the implemented measures are having the expected effect and whether the defined objectives are being achieved. Unlike an evaluation of a single activity at a given time, this concept is a continuous process of monitoring whether or not the desired targets are being realised with the resources provided, over a certain period of time. Monitoring is seen as a task in which reliable data are collected from which it should be possible to estimate whether the measure is successful or not.

The monitoring concept, which is supposed to support the everyday work of stakeholders, especially those from the city council and urban society, should not require new data to be gathered, but rely on available data and easy-to-determine action-based indicators. These indicators and any accompanying documentation are the starting points for a pragmatic monitoring approach.

Table 3.2 shows monitoring concepts used by others cities in their adaptation strategies (e.g. Solingen and Remscheid). For each of the 28 measures from 5 fields of action, successive indicators were identified that determine the level of goal achievement. Indicators can be both quantitative (e.g. renatured shore length) and qualitative (e.g. evaluation of best practice examples; an information flyer was created; or GIS analysis completed: yes / no).

Table 3.2: Urban development and green spaces: measures, indicators and documentation (source: Wirth et al., 2016) (in the source document, tables for 'city green and buildings', 'precipitation and water', 'land use and nature development', and health' are included).

Measures	Success indicators	Documentation
Integration of climate function into urban planning	a. More restrictions for large-scale developments that could limit air circulation; b. Demand assessment in relation to climate surveys in city planning (number of cases): * Checks in relation to the climate function map * Deeper appraisal and appropriate investigations carried out * Results included in spatial planning - tender text for urban competition - explanatory text of the development plan - climate function maps in checklist for construction plan	a. Description and spatial reservation of measures and action that stimulate air circulation b. Meta-information of measures, including names of relevant experts
Further integration of climate adaptation into urban planning instruments	Checklists for integration created; Climate adaptation considered (where legally possible and subject to technical considerations) in formal and informal planning (e.g. stipulations in the development plan, anchoring in urban development competitions)	Description of measures and action, and evaluating the level of integration into urban planning instruments
'Stadtbaukasten' as an exemplar adaptation toolkit for cities to tackle climate-related challenges in urban areas[18]	Tendering coordinated with planning and construction; Micro-climatic expert opinions on city climatic problems available; Planning recommendations developed	Description of the measures and actions, and of their integration in urban planning tools
Vulnerability and resilience analyses of urban structures	Monitoring carried out	Monitoring is carried out at IHKM (Integriertes Handlungsprogramm Klimaschutz München)

Leicester City (United Kingdom)

Climate risks and responses

Leicester City Council began the development of its *Climate Change Adaptation Plan* in 2006. Following extensive consultation with stakeholders, potential climate-related risks to the city's people and places were identified and an adaptation risk register was developed. These risks were then scored using a risk assessment methodology. Three significant risks requiring immediate action were identified: (1) flash flooding; (2) heatwaves and prolonged periods of increased average temperatures; (3) reduced water availability in summer.

The *Climate Change Adaptation Plan* has been updated regularly since its inception and reflects an evolving emphasis on adaptation within the City Council. The most recent plan was published in 2015. It lists a series of response actions to address the key risks to City Council services and infrastructure (see Annex III for details). *Leicester's Sustainability Action Plan (2016–2019)* reiterates the city's commitment to climate change adaptation and cites a number of actions in response to the risk of flooding and drought. These include:

[18] See http://www.climate-service-center.de/products_and_publications/toolkits/stadtbaukasten/index.php.en

- Reduce the flood risk to 2000 properties along the River Soar (by 2018).
- Develop a drought plan for the city (by 2018–2019).
- Continue to communicate the 'Do you know your flood risk?' campaign to raise awareness of and increase preparedness for flooding (by 2018–2019).

A number of projects have been defined for these three commitments/objectives. Most of these are process-orientated (e.g. to develop community engagement plans), with few more on physical infrastructure (e.g. gully replacement programme). A status report captures the progress made in initiating and implementing these projects (i.e. outputs); information on the effect of the projects (i.e. outcomes) is lacking.

Glasgow (United Kingdom)

Climate Ready Clyde's 'vision' for Glasgow City Region
Scotland is taking a strategic 'partnership-focused' approach to climate change adaptation across policy, practice and research. This is echoed in Climate Ready Clyde's vision for climate resilience across the city of Glasgow and the Clyde Valley (Glasgow City Region). The vision acknowledges the threats that climate change (i.e. increasing precipitation and temperature, and sea level rise) poses to the health and well-being of people and the environment, to social inequality (exacerbating it), and to business and economic investment opportunities. The Glasgow City Region has a vision about its role in adaptation, addressing potential impacts (e.g. urban heat stress, riverine, coastal and surface water flooding), and making the City Region a good place to live, work and do business. Following on from the vision, 11 different partners, including 6 municipalities, health sector, transport providers and universities are now developing a strategy and action plan to coordinate and drive forward adaptation measures. This work is overseen by a board comprising an independent chair and a representative from each of the funding organisations.

People are at the heart of the vision, which will require a coordinated response from across the Glasgow City Region, with leadership provided by the public sector, businesses and communities. The city region has a long history of partnerships working to address sustainable development challenges. *Climate Ready Clyde* is drawing on these strengths and bringing together a diverse range of organisations and stakeholders to deliver its vision.

Climate Ready Clyde has published a three-year work programme (2017–2020) for adapting Glasgow and the Clyde Valley to the impacts of climate change. The work programme provides a high-level set of actions to assess climate risks and vulnerabilities to provide a shared understanding from which the City Region can develop an Adaptation Strategy and Action Plan. This first programme identifies seven outcomes/objectives under two themes for 2020, with actions, outputs and indicators for each. These are split between those which are being led by the initiative, and those where the initiative has identified it needs to work with others to adapt. Details on this are given in Annex IV. Objectives are, for example: '*Glasgow City Region has a shared understanding of climate change risks and opportunities, and is taking action to adapt to them*' (outcome 1) and '*Governance for adaptation in the city region is coordinated*' (outcome 4). The proposed actions are mainly related to 'soft' initiatives, such as integrating governance structures needed for adaptation into policy and training in the city region

Durban (South Africa)

The city of Durban is responding to climate change by setting targets to both reduce its emissions of greenhouse gases (mitigation) and adapt to its impacts. To address this challenge, the eThekwini Municipality (2014) has developed the *Durban Climate Change Strategy* (DCCS) as part of its Municipal Climate Protection Programme. The aim of the DCCS is to define a citywide approach to climate change adaptation and mitigation.

The DCCS includes a section on observed and projected changes in climate for Durban, including temperature increase, increasing numbers of heatwaves, increase in annual rainfall (e.g. up to 500mm per year, by 2100), increase in year-to-year rainfall variability of between 30% and 100%, and more intense rainfall events with increased erosive effects.

As a result of the impacts of these climatic changes, and of compounding indirect or non-climate effects (e.g. population growth rate), there are a number of risks that Durban is likely to face:

- Year-to-year changes in water availability, impacting also water quality and sanitation.
- Damage to infrastructure due to flash flooding, droughts and coastal storms (exacerbated by sea level rise).
- Threats to biodiversity and ecosystems, including an increase in invasive alien species.
- Impacts on agriculture and food security, posing a significant threat to food security.
- Health impacts – warmer and wetter climatic conditions could result in increased incidences of heat stress, heat-related vector-borne and water-borne diseases (e.g. malaria and cholera), and respiratory and food-related illnesses.
- Higher energy consumption – increases in temperature and the number of heatwaves could necessitate increased cooling needs.
- Economic impacts, including impacts on already poor communities.

Ten themes were identified in the development of the DCCS, each including a set of goals, and actions/responses. For example, for the water theme the goal is to '*effectively manage Durban's water resources and infrastructure in a way to ensure optimal protection from climate change impacts*'. Associated responses are orientated towards processes (e.g. facilitate cooperation; incorporate climate change into municipal planning), and towards actions on the ground (e.g. implement management measures to reduce water demand). In addition, six short-term Durban Flagship Programmes will be implemented to ensure that both mitigation and adaptation interventions take place as soon as possible (see also Annex V):

1. Water Conservation and Demand Management Flagship Programme
2. Renewable Energy Flagship Programme
3. Energy Efficiency and Energy Demand Management Flagship Programme
4. Transport Flagship Programme
5. Waste Management Flagship Programme
6. Adaptation Flagship Programme

The goals and responses related to the 10 themes form the core of the DCCS (Annex V). A number of the themes are not mutually supportive, with some responses for a specific theme having a potentially negative impact on the objectives of another theme. In order to limit such conflicts, a cross-sectoral approach is encouraged in the strategy's implementation, where partnerships and robust decision support mechanisms are used to enable informed and defensible actions. There are also several cross-cutting issues that are relevant for multiple themes. For example, the water, sea level rise, biodiversity, food security, economic and transport themes include responses that reference the need for effective 'land-use planning and management' as a means of adapting to climate change impacts and minimising greenhouse gas emissions. Similarly, the water, sea level rise, health and energy themes include responses that reference the need to adapt 'infrastructure and buildings' to climate change impacts.

An M&E system for the DCCS will be developed to track progress in reducing climate vulnerability and in transitioning to a low-carbon city. This will include information on processes, outputs and outcomes. The development of the M&E system will draw heavily on, but not pre-empt, the Implementation Framework. It will also link, where appropriate, with South Africa's national climate change response M&E system (including Desired Adaptation Outcomes – see Section 2.3 on South Africa) to ensure consistency and facilitate ease of reporting.

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Annex I: Indicators for flooding, droughts and heat-related impacts, in the United Kingdom's M&E system

Different indicators have been defined in the M&E system in the United Kingdom, specified for the four policy areas and their adaptation priorities. The indicators are of particular relevance to monitoring and evaluating climate change adaptation in relation to flooding, droughts and heat-related impacts in urban areas. Those might be used in monitoring and evaluating climate change adaptation in the Dutch urban environment.

Built environment		
Adaptation priority	**Indicator**	**Indicator type**
1. Community-scale flood alleviation	Number of households better protected from river/coastal flooding as a result of: (a) construction of new defences, (b) enhancement of current defences (increased crest height), (c) renewal/refurbishment of current defences (same crest height)	Action
	The capital & revenues spent on flood risk & coastal erosion management, derived from: a) grant-in-aid, b) taxes levied by the regional flood and coastal comittees, c) other public-sector contributions, d) private-sector contributions	Action
	Fraction of EA flood defence asset systems protecting high consequence areas in target condition	Action
	Fraction of EA flood defence asset systems maintained each year in accordance with identified needs	Action
	Number of properties damaged by river/coastal flooding	Realised impact
	Number of properties lost to coastal erosion	Realised impact
2. Surface-water flood management	Fraction of built-up areas with impermeable surfaces	Vulnerability
	Gain/loss in area of urban green/blue space	Vulnerability
	Area of permeable concrete or block paving (in residential and commercial areas)	Action
	Implementation of Sustainable Drainage Systems (SUDS) in existing built-up areas	Action
	Fraction of planning applications proposing SUDS	Action
	Number of properties affected by sewer flooding	Realised impact
	Number of properties affected by surface water flooding	Realised impact
3. Avoid inappropriate development in flood risk areas	Number of future residential properties located in areas: a) highly prone to river/coastal flooding; b) highly susceptible to surface water flooding	Exposure
	Number of existing and future residential properties in areas at risk of coastal erosion	Exposure
	Fraction of local authorities in highly flood-prone areas, who have adopted Local climate action Plans post 2012	Action
	Fraction of local authorities undertaking strategic flood risk assessments	Action
	Fraction of planning applications approved for areas at risk of flooding/coastal erosion, also taking specific EA conditions into account	Action
	Number of planning applications within areas of flood risk: a) approved contrary to sustained EA objection, b) not carrying out satisfactory flood risk assessment	Vulnerability

4. Residual flood risk to existing buildings	Number of households in flood risk areas retrofitting property-level flood protection measures	Action
	Number of properties covered by Flood Re (flood insurance)	Action
5. Heat-related health impacts	These impacts are described below, under 'Healthy and Resilient Communities'	
6. Water demand in built environment	Not applicable in this analysis	
Infrastructure		
Adaptation priority	**Indicator**	**Indicator type**
1. Design and location of new infrastructure	Number of Nationally Significant Infrastructure Project applications in areas: a) at high/medium/low likelihood of river/coastal flooding, b) susceptible to 1-in-30/1-in-100-year mid-depth surface water flooding, c) highly susceptible to groundwater flooding, d) at risk of coastal erosion	Exposure
	Number of NSIP applications: a) approved contrary to EA objection, b) not carrying out satisfactory flood risk assessment, c) not satisfactorily applying sequential test	Vulnerability
	Number of NSIPs approved with EA conditions	Action
2. Resilience of energy infrastructure services	Number of major electricity substations in areas of high river/coastal flooding with site-level protection measures implemented and number of customers at reduced risk	Action
	Amount of actual and planned investment in resilience measures by electricity transmission and distribution companies	Action
	Amount of electricity generation capacity (MWh) lost due to temporary abstraction restrictions	Realised impact
	Number of customer minutes lost due to severe weather	Realised impact
3. Resilience of public water infrastructure services	Amount of actual and planned investment in resilience measures by water companies	Action
	Reduction in leakage (ml per year)	Action
	Number/length of water company sewer networks in poor condition	Vulnerability
	Amount of actual and planned investment in renewals of sewer networks	Action
	Number of interruptions to water supply due to severe weather	Realised impact
4. Resilience of ports and airports infrastructure services	Annual number and length of delays to: a) port, b) airport transport caused by severe weather	Realised impact
5. Resilience of road and rail network infrastructure services	Number of rail and strategic road structures (earthworks, bridges, tunnels, culverts, sea walls) in poor condition	Vulnerability
	Amount of actual and planned investment in drainage measures for: a) rail network, b) strategic road network, c) local highways	Action
	Amount of actual and planned investment in renewals of rail and strategic road structures	Action
	Annual number and length of delays to: a) rail, b) strategic road network caused by severe weather	Realised impact
6. Resilience of digital infrastructure services	Annual number and length of delays to ICT and data services caused by severe weather	Realised impact

Healthy and resilient communities		
Adaptation priority	**Indicator**	**Indicator type**
1. Public understanding of climate risks	Fraction of people living in floodplains unaware of flood risk	Vulnerability
	Fraction of healthcare workers unaware of risk from heat stress	Vulnerability
2. Heat-related health impacts	Number of hot days per year (days exceeding 1993–2006 93rd percentile of 2-day maximum temperature)	Exposure
	Area of urban greenspace	Vulnerability
	Number of air conditioning units bought or fitted (domestic/commercial)	Action
	Number of buildings retro-fitting passive cooling measures	Action
	Number of planning applications with: a) conditions requiring passive cooling measures, b) implementing conditions in final development	Action
	Number/area of green roofs installed in urban areas	Action
	Number of hospitals/care homes/GP surgeries implementing heatwave plans	Action
	Number of local authorities implementing heatwave plans	Action
	Fraction of hospitals/care homes/schools/work places affected by overheating	Realised impact
	Fraction of homes affected by overheating	Realised impact
	Number of heat-related deaths	Realised impact
	Number of heat-related hospital admissions	Realised impact
	Number of heatwave alerts issued by Met Office	Realised impact
3. Cold-related health impacts	Fraction of households in fuel poverty (per county)	Vulnerability
	Number of homes with a damp or mould problem	Vulnerability
	Number of cold-related deaths	Realised impact
	Number of cold-weather-related hospital admissions	Realised impact
4. Pathogens, air pollution and UV radiation	Concentrations of ground level ozone, particulate matter and N_2O	Exposure
	Implementation of measures to reduce ground-level ozone, particulate matter and N_2O	Action
	Number of air quality warnings issued	Action
	Number of deaths from respiratory illnesses linked to air pollution	Realised impact
	UVR levels	Exposure
	Implementation of public awareness measures on UV risks	Action
	Number of deaths related to UVR exposure	Realised impact
	Average time population stays indoors/outdoors	Vulnerability
	Distribution/spread of pathogens or disease vectors	Exposure
	Number of incidents of harmful algal blooms in water bodies	Exposure
	Investments in monitoring of new/emerging pathogens	Action
	Number of deaths attributable to vector-borne diseases or other pathogens linked to climate change	Realised impact
5. Ability of people to recover from flooding	Number of households in deprived communities located in areas with high likelihood of flooding	Vulnerability
	Number of hospitals/care homes/emergency service stations/GP surgeries in areas with high likelihood of flooding	Vulnerability
	Number of schools/pupils in areas with high likelihood of flooding	Vulnerability

	Number of households located in areas susceptible to river/coastal flooding signed-up to flood warnings	Action
	Number of working/school days lost from flooding/severe weather events	Realised impact
	Number of people suffering mental health problems following flooding/severe weather events	Realised impact
	Average length of time between flooding events and people returning to their homes	Realised impact
	Number of hospitals/care homes/emergency service stations/GP surgeries/schools flooded	Realised impact
6. Capability of emergency planning system	Number of flooding incidents attended by fire services as a share of total incidents attended	Realised impact
	Local authority expenditure on emergency planning and response	Action
	Annual economic losses from flooding/ weather events	Realised impact
	Number of deaths from flooding/ weather events	Realised impact
Business		
Adaptation priority	**Indicator**	**Indicator type**
1. Business impacts from severe weather	Number of new non-residential properties in areas: a) highly prone to river/coastal flooding, b) highly susceptible to surface water flooding	Exposure
	Number of existing and future residential properties located in areas at risk of coastal erosion, where policy is: a) hold-the-line, b) no active intervention, c) managed realignment	Exposure
	Number of businesses located in areas susceptible to river/coastal flooding, who have signed up to receive flood warnings	Action
	Fraction of businesses at risk of flooding, which have business continuity plans in place	Action
	Fraction of businesses at risk of flooding, which have taken property-level flood protection measures	Action
	Number of businesses with flood insurance	Action
	Business losses from flooding events	Realised impact
	Insured losses from severe weather events	Realised impact
2. Supply chain interruptions	Fraction of goods imported from countries at high risk from climate change	Exposure
	Business losses due to supply chain disruptions caused by severe weather events	Realised impact
	Fraction of companies that have assessed the risks to supply chains from severe weather and reduced water availability.	Action
3. Water demand from industry	Number of water-intensive industries abstracting from catchments with limited water availability	Exposure
	Implementation of water efficiency measures by water-intensive industries	Action
4. Business opportunities	Not applicable in this analysis	

Annex II: Indicator information, Berlin (Germany)

Table 30: Indicator types and categories of AFOK in overview

Indicator type	Explanation	Use in AFOK
State indicators	State indicators include frequent climatic monitoring (temperature, rainfall, wind), ideally within the framework of long-term measurement series with small-scale (city-specific) differentiation.	S: these are 14 indicators
Impact indicators	Impact indicators include monitoring of the impact of the weather parameters.	I: these are 43 indicators
Response indicators	Resonse indicators include monitoring of the progress or achievement of specific adaptation measures. Response indicators can also be divided into two groups: - The process indicators reflect the extent to which adaptation measures are implemented without affecting the actual reduction in the impact of climate change. These include the initiation or adoption of political decisions, process indicators are the most common case of response indicators. - The outcome indicators that assess a measure's actual impact. In some cases, the outcome indicator is identical to the impact indicator and is therefore not dealt with, separately.	A: these are indicators which are measurable at regular intervals as well as free of charge. These 47 indicators form the basis of the AFOK's monitoring program. B: These are 3 indicators which serve as a supplement to the indicators. C: These are 24 binary indicators, which are only checked if a measure has been carried out. These are, above all, measures which, for example, A study or the setting up of a monitoring program. D: These are 20 indicators of quality, they describe an evaluation of the measure after a selected number of years by means of a report.

Table 32: Overview of complex state indicators

State indicators	Unit	Discription of indicators	Calculating method
Heat days	d/y	Day with maximum temperature (Tmax) above 30 ^{0}C	Annual number of days beyond limit
Ice days	d/y	Day with minimum temperature (Tmin) below 0 ^{0}C	Annual number of days beyond limit
Snow	mm/y	Precipitation on days with Tmin less than 1 ^{0}C	Total amount of precipitation on days with temperatures below 1 ^{0}C
0 C passage	d/y	Day with Tmax> 0 ^{0}C and Tmin <0 ^{0}C	Number of days per year, on which both conditions apply
Max. precipitation in 5days period	mm/y	Sum of 5 days of rain	Highest 5 days total precipitation within a year
Heavy rain days	d/y	Day with 10/20 mm of precipitation or more	Number of days when limit value exceeded
Dry period	d/y	Longest period with precipitation less than 1 mm	duration of cohesive days with less than 1 mm precipitation; determine the longest period within a year
Dry spells	d/y	Longest period with on average over 20 ^{0}C medium temperature and less than 1 mm of precipitation	Determining the longest period, in one year, for which both conditions apply.

Table 33: Impact (category I) and response indicators (categories A and D) for the fields 'building environment' and 'health care'. This table is supplemented by impact and response indicators for the fields of tourism, culture and sports, environment and nature, industry and finance, transport and infrastructure, water management, energy and waste management, and education.

Field of action	Impact indicators	Response indicators
Building environment, and green and open spaces	Climatic exposure on cities Green infrastructure Sealed surfaces	Decrease/increase in public and private well-being; Decrease/increase in climatic relief space; Report on the implementation of pilot projects for the testing of climate adaptation measures; Report on the development of strategies for the climatic decoupling of new construction projects; Report on paradigm shift rainwater management in 'Schwammstadt'; Report on the integration of climate adaptation into existing planning instruments; Report on the climate vulnerability of the city; Report on sensitisation and information; Report on the resilience of the city green space.
Health and Civil protection	Deaths from cardiovascular and respiratory diseases Pollen season and occurence of ragweed species Water quality at bathing sites Blue algae occurance Emergency response	BMI per age group of the population Prevalence of allergenic plants Prevalence of ticks, infected mosquitos, etc Presence of fountains and other locations with accessible drinking water Average amount of time required for the arrival of emergency services Percentage of the population that has become informed Number of warning messages Number of heat-related work accidents Number of heat-related hospitalisation admissions and casualties

Annex III: Adaptation actions that address key climate risks for the city of Leicester (UK)

Reducing the impact of flooding		
Project	**Description**	**Progress (2015)**
1. Surface Water Management Plan (SWMP) delivery phase	The evidence produced as part of the SWMP process will be used to identify options for managing flood risk in the city, bring forward flood risk management initiatives, and improve the City Council's responses to flooding.	Areas identified as being at increased risk of flooding are under further investigation. Three areas were identified as being at risk of surface water flooding and detailed analyses are underway to determine options to manage or reduce these risks.
2. Local Flood Risk Management Strategy (LFRMS)	As a lead local flood authority, the City Council has responsibility for developing a LFRMS for their area covering local sources of flooding.	A strategy has been developed, outlining current and future actions that the City Council proposes to take to manage flood risk in the city. Following public consultation on the draft document, their feedback and views were incorporated in the final strategy. A key objective of the strategy is to build good links with the Environment Agency and Severn Trent Water Ltd.
3. Develop community engagement plans	One of the responsibilities of a lead local flood authority is to ensure that communities who live in areas that could potentially be affected by flooding are informed and understand how they can prepare for and become more resilient to flooding.	The City Council and partners developed a community engagement 'toolkit', which was tested in community engagement events in three flood risk areas of the city. The programme is now being extended to include other areas at risk of flooding and is involving local residents in organising and promotion the events.
4. Develop an action plan on the basis of the recommendations within the SWMP	There are a number of actions in the SWMP final report that detail how Leicester can improve its response to flooding. An action plan will be developed that incorporates these recommendations.	The action plan forms an essential part of the wider LFRMS. Work to deliver the plan's short-, medium- and long-term actions is underway and partnerships are being built with the Environment Agency and Severn Trent Water Ltd to help deliver these actions.
5. Establish arrangements for the approval and adoption of Sustainable Urban Drainage Systems (SUDS)	As a result of the Flood and Water Management Act 2010, the City Council will become responsible for approving, adopting and maintaining drainage plans and SUDS schemes that meet the national standards for sustainable drainage.	Further consultation with Defra suggested that SUDS will be built into the existing planning system. Changes to planning policy are expected to come into force in Spring 2015.
6. Host SUDS training events	To encourage water management methods that reduce flash flooding and damage to the environment.	These events will be run throughout the year, both within the City Council and for developers in the city.
7. Manage development to reduce erosion caused by surface water flooding	Devise standards for using tools to minimise erosion caused by floodwater (e.g. locations of green areas around new housing developments that are at risk of flooding)	Sustainable drainage will be promoted in all new developments. Retrofitting will be considered where surface water flooding and erosion are identified as particular issues, such as in the SWMP.

8. Buildings risk assessment analysis	To create a picture of which buildings within the city council's stock are most vulnerable to climate change.	The methodology for assessing which buildings are most at risk from climate change is being revised.
9. Develop design codes for Ashton Green	To inform the development of Ashton Green (2500 homes), two documents will be drafted: a Green Infrastructure Strategy and Design Guidance. Both will build on the vision of Ashton Green being a sustainable place to live and provide details of how the design will reduce its impact on the environment and adapt to climate change.	Work to produce an energy strategy and carbon reduction design guidance document for Ashton Green is on-going and will seek to incorporate both the initial vision for the development and government changes to building regulations.
10. Map of drainage assets	Create a city-wide map of all drainage assets (culverts, gullies etc.). Once complete, this will allow a more effective review of the drainage maintenance scheme.	Most highway gullies in the city have been mapped. The majority of these are connected to sewers in the public network, for which Severn Trent Water Ltd is responsible for maintenance. However, some gullies are connected to more local drainage networks. These networks should also be identified and mapped.
11. Improvement to storm sewer network	Improvements are sought, where possible, to the storm sewer network to increase capacity to accommodate higher flow rates.	The SWMP has highlighted areas where the storm water sewer network needs to be improved. This information is being shared with Severn Trent Water Ltd, which is responsible for the sewer network, and the Environment Agency. Through closer working with partners, management of the interface between respective areas of responsibility and coordination of maintenance services will be improved.
12. Emergency response to flooding	Ensuring that a procedure to cover the emergency response to a major flood event affecting the city-wide road network is included in the City Council's Business Continuity and Emergency Plan.	A corporate flooding emergency plan and a flood action plan for highways are available. Community engagement exercises have illustrated how the City Council can work with other organisations, such as the Environment Agency and the Local Resilience Forum, to respond to the risk of flooding and help local communities become more prepared and resilient when flooding events occur.
13. Roadside maintenance	Review maintenance regimes for clearance of roadside gullies, culverts and the drainage network and amend, as necessary, to cope with the changing climate. This can only take place once the city-wide drainage assets have been mapped and flooding 'hotspots' identified.	The gully replacement programme is well under way, with over 500 having been replaced over the last 12 months. Work is continuing with the installation of in-cab electronic data capture and retrieval systems to improve the efficiency and effectiveness of gully maintenance. A focusing on rigorous maintenance regimes at flooding 'hotspots' should reduce the number of reactive maintenance visits.

Reducing the impact of summer heatwaves and increased average temperature		
Project	**Description**	**Progress (2015)**
14. Shading the urban environment	Review the opportunity for the provision of trees to shade and cool urban areas through evapo-transpiration as part of the City Council's tree strategy.	The City Council is working with stakeholders to produce a tree strategy, which will highlight the benefits of trees for reducing the urban heat-island effect and take this into account when developing strategic objectives.
15. Develop a heat vulnerability map	The heat vulnerability map will highlight the areas in Leicester that are most vulnerable during heatwaves. The map will contain overlays of areas with several indicators of vulnerability (built and green space coverage, areas of social deprivation etc.). The resource will be immensely useful to the City Council and community partners when prioritising areas in the greatest need of resources during heatwaves. It can also be used to plan adaptive responses in the long term (e.g. planning green infrastructure projects).	A mapping tool published *Climate Just* can help identify the most disadvantaged areas in relation to climate impacts (flooding, heat vulnerability, etc.). The tool will be used by the City Council to support planning its responses to climate change.
16. Influence the urban design of the city to include adaptation tools	Developments can incorporate climate change adaptation into their design through the implementation of green infrastructure, Sustainable Urban Drainage Systems (SUDS) and green roofs.	A SUDS guidance document for developers, published by the City Council, explains the issues and gives real examples of sustainable drainage used in new housing development across the city. The Green Infrastructure Strategy (see 17, below) includes a section on green roofs and how these might increase the city's resilience to climate change.
17. Publish a Green Infrastructure Strategy	A Green Infrastructure Strategy will demonstrate how sustainable management of our natural environment can deliver benefits to residents (e.g. improved air quality, reduced flood risk, increased biodiversity).	The Green Infrastructure Strategy has been developed and will be publicly available. The document highlights how resilience to climate change can be improved through natural interventions and integrating a network of green and blue spaces with the urban environment.
Reducing the impact of lower summer water availability		
Project	**Description**	**Progress (2015)**
18. Tree stock inspection	Regular inspection and maintenance to be carried out of the tree stock, to reduce the risk of damage to private property from subsidence.	Both tree stock inspection rates and associated record keeping have improved as the number of sites from which information has been collected has increased. At some locations, it has been possible to record a wider range of detail, but it is unlikely that this level of activity can be maintained due to increased pressure on resources.
19. Consideration of tree locations	Specialist advice should be sought and careful consideration given to	Anyone involved with tree planting in the City Council is asked to seek advice

	the species and location of new trees to be planted by the City Council. This should ensure that they are at a sufficient distance from existing buildings and infrastructure, and reduce subsidence risk to an acceptable level.	from in-house specialists. Although the majority of tree planting proposals are passed to specialists for comment, some planting schemes have been approved without prior consultation. The process requires review and inclusion in the new tree strategy.
20. City-wide drought plan	Develop a Leicester-specific drought resilience plan.	Due to a shortage of resources, the drought plan has been on-hold, although action is imminent. The drought resilience plan will aim to encourage water use to be reduced to sustainable levels.
21. Develop Leicester City Council-specific emergency drought measures	Ensure that certain City Council services have measures for drought preparedness in their business continuity plans (BCPs).	Some City Council services will be more affected by drought than others, and their BCPs should include specific drought measures. This would include details of how to respond during drought events.
22. Adopt SWIMS (Severe Weather Impacts Monitoring System)	Each City Council service will log the impacts of, and its responses to, severe weather events onto an online data capture facility. This will provide an invaluable database and a clear picture of how the City Council as a whole is affected by severe weather. This will be used to monitor good practice and enable better planning for future events.	This is being piloted with Leicestershire County Council. Each local council will run the system individually, with data then shared across the Local Resilience Forum.

Source: Leicester City Council services and infrastructure

Annex IV: Adaptation themes and outcomes under the Climate Ready programme of the city of Glasgow (UK)

Theme 1: Activities led by the Climate Ready Clyde secretariat (in conjunction with partners)		
Outcome 1: Glasgow City Region has a shared understanding of climate change risks and opportunities, and is taking action to adapt to them		
Actions	**Due date**	**Outputs/indicators**
Review evidence to identify gaps on how climate change will affect the city region	June 2017	Evidence gaps for the city region
Use workshops /expert evidence to identify the relative vulnerability of sectors to climate change	December 2017	Sectoral synthesis reports
Develop and publish a climate risk and vulnerability assessment to inform a regional adaptation strategy and action plan	September 2018	Climate risk and vulnerability assessment
Commission research to address evidence gaps highlighted by the climate risk and vulnerability assessment	September 2018	Data sets and evidence reports
Agree monitoring and evaluation through high-level objectives and metrics for target sectors	October 2018	Metrics for the strategy and action plan
Undertake a Strategic Environmental Assessment (SEA) and revise the strategy objectives	December 2018	SEA
Scope actions to be included in the strategy and action plan	March 2019	List of potential adaptation actions
Assess whether the actions offer value for money through a cost-benefit analysis	September 2019	Cost-benefit analysis actions
Consult organisations and individuals to ensure the strategy and action plan meet local priorities	June 2019	Action plan – consultation draft
Revise the strategy and action plan	December 2019	Action plan – final draft
Publish and launch the strategy and action plan	March 2020	Launch event
Outcome 2: Decision-makers in the city region make climate just, climate-friendly and climate-ready decisions		
Actions	**Due date**	**Outputs/indicators**
Embed adaptation into the governance/ assurance framework of the City Deal's 'Land Use and Sustainability Portfolio'	Quarterly	
Raise awareness of climate change issues within the city region through an ongoing media presence	Ongoing	Press releases and media coverage
Plan and launch Climate Ready Clyde at the European Climate Change Adaptation conference	June 2017	Launch event
Outcome 3: Organisations and individuals have access to the skills, tools, and guidance to support them to adapt		
Actions	**Due date**	**Outputs/indicators**
Provide support on best practice approaches to the development and implementation of adaptation for partners	Ongoing	
Produce a toolkit to support partners identify climate adaptation issues in major projects and developments	December 2017	Toolkit for use across the city region

Compile a database of tools and guidance to support adaptation in different sectors and share with partners	September 2017	Tools database
Outcome 4: Governance for adaptation in the city region is co-ordinated		
Actions	**Due date**	**Outputs/indicators**
Ensure coordination and oversight of ongoing work through Climate Ready Clyde board meetings	Quarterly	Approved work programme
Raise awareness and coordinate activity with others by attending partnerships and meetings	Ongoing	
Ensure that adaptation activity is visible, accountable and transparent by producing and publishing an annual report	March 2018	Annual report
Theme 2: Influencing the work of others across the city region		
Outcome 5: The city region has a shared understanding of climate change risks and opportunities, and is taking action to adapt to them		
Actions	**Due date**	**Outputs/indicators**
Identify options to address projected sea level rise in the Firth of Clyde by bringing stakeholders together and using an adaptation pathways' approach	From May 2018	Adaptation pathways report on sea level rise
Position the city region as a demonstrator for research into the implementation of climate change adaptation, including through UK Research Council fellowships	Ongoing	Evidence and data sets
Understand the current and future exposure of the city region's infrastructure to flooding to inform the risk and vulnerability assessment and future spatial land use strategies	October 2017	Data on current and future exposure
Outcome 6: Decision-makers in the city region make climate just, climate-friendly and climate-ready decisions		
Actions	**Due date**	**Outputs/indicators**
Provide consultation responses to regional, national and international plans and strategies that support the city region to become more resilient, on behalf of local partners	TBC	*Ad-hoc* consultation responses
Adequately account for sea level rise impacts in the regional marine plan	TBC	Regional marine plan
Outcome 7: Organisations and individuals have access to the skills, tools, and guidance to support them to adapt		
Actions	**Due date**	**Outputs/indicators**
Train key individuals from 10 organisations to better adapt to climate change through the 'Adaptation Learning Exchange' programme	May 2017	Partner outputs, local climate impact profiles, briefing notes and project assessments
Ensure a comprehensive baseline of climate impacts for the city region by producing updated local climate impacts profiles	May 2017	Local climate impacts profiles
Provide further capacity to organisations, improve the climate change evidence base and give real world experience to students by developing a programme of placements	December 2017	Student placements into other organisations

Annex V: Durban Climate Change Strategy: adaptation themes, goals, objectives and responses

Theme 1: Water	
Goal A: : Effectively manage Durban's water resources and infrastructure to ensure optimal protection from climate change impacts.	
Objectives	**Responses**
A.1: Minimize the impacts of climate change on the secure, clean and safe supply of water to Durban.	A.1.1: Facilitate cooperation between relevant agencies to jointly manage climate change impacts on catchments that supply water to Durban.
	A.1.2: Implement watershed management that responds to projected climate change impacts to optimise yields of clean freshwater and storage capacity of reservoirs created by dams
	A.1.3: Implement water demand management measures to reduce water demand in the face of projected climate change impacts.
	A.1.4: Adopt and enforce simple, innovative, adaptive engineering approaches to water treatment that respond to projected changes in water quality as a result of climate change.
	A.1.5: Recognise, make use of and manage the role of open spaces, natural areas and agricultural land in providing flood and storm water protection services.
	A.1.6: Prioritise water supply systems for communities that are most vulnerable to projected climate change impacts, such as water scarcity and health risks.
	A.1.7: Plan for projected increases in drought cycles that result from climate change and introduce appropriate measures to maintain an acceptable assurance of water supply.
	A.1.8: Incorporate projected climate change impacts into proactive planning of the municipal water supply.
	A.1.9: Adopt a risk-averse approach to water quality protection by imposing stringent controls on water polluting land uses and activities to ensure that the impacts of climate change are not exacerbated.
A.2: Limit the impact of amplified flooding and increased storm water levels that result from climate change through risk-averse planning and appropriate infrastructure, building standards and enhancement of ecological infrastructure.	A.2.1: Adopt and enforce a risk-averse approach to spatial, land use and infrastructure planning and development controls that respond to potential climate-change-amplified flood risks.
	A.2.2: Incorporate research on changes in projected rainfall and flood lines into guidelines that are used when designing, planning and implementing all types of infrastructure. Considerations should include the location for new infrastructure, infrastructure design and choice of materials.
	A.2.3: Adopt and enforce adaptive engineering approaches that are flexible and can evolve in response to changing threats and levels of flooding.
	A.2.4: Identify and relocate critical infrastructure from flood-prone areas to areas of lower risk.
	A.2.5: Identify and prioritise relocating or upgrading informal and low-income settlements that are vulnerable to flooding.
	A.2.6: Retrofit and modify infrastructure and public spaces using adaptive engineering approaches to provide protection against future water-related climate impacts.
	A.2.7: Monitor the effectiveness of storm water systems and, where necessary, upgrade them to accommodate variability in precipitation events and the projected increases in volumes of waste water.
	A.2.8: Incorporate the possibility of extreme water-related climate change events into the operational plans for basic services provisioning, such as public transport, water, electricity, wastewater management and refuse collection, in order to prevent any long-term disruption of services and pollution of water bodies.

Theme 2: Sea level rise	
Goal B: Maintain, restore or enhance Durban's protective coastal ecological infrastructure —where possible— to provide a buffer against sea level rise and coastal storms. Where needed, protect Durban built environment along the coast, and discourage further development in high risk areas.	
Objectives	**Responses**
B.1: Limit the impact of sea level rise through risk-averse planning and appropriate infrastructure, building standards and enhancement of ecological infrastructure.	B.1.1: Adopt and enforce the provincial coastal management line and risk zones to manage current and future development in the face of climate change.
	B.1.2: Develop a coastal management policy for the built environment, in the face of climate change.
	B.1.3: Adopt and enforce a risk-averse approach to spatial, land use and infrastructure planning and development control that responds to all potential coastal flooding and other coastal risks.
	B.1.4: Research, review and adapt infrastructure and building design standards to accommodate to current and future sea levels and coastal storm risks.
	B.1.5: Adopt and enforce adaptive engineering approaches that are flexible in response to changing threats and coastal erosion risk.
	B.1.6: Prioritise the relocation or upgrading of informal and low-income settlements that are vulnerable to sea level rise, coastal storms and coastal erosion.
	B.1.7: Rehouse municipal offices in high risk zones to buildings in areas of lower risk, when current buildings reach the end of their life cycle, or when these have become severely damaged by storms.
	B.1.8: Retrofit and modify buildings and infrastructure to provide protection against future sea level rise and increased coastal storms.
	B.1.9: Recognise and utilise, where possible, the coastal dunes' natural defence system to provide protection against sea level rise, coastal storms and coastal erosion.

Theme 3: Biodiversity	
Goal C: Durban's biodiversity and associated natural capital are protected and enhanced to deliver ecosystem services that facilitate protection from and mitigation of climate change.	
Objectives	**Responses**
C.1: Ecosystem functioning and connectivity are enhanced through integrated planning and effective action to reduce climate change impacts on biodiversity and maximise the delivery of ecosystem services.	C.1.1: Maximise the extent and enhance the habitat representativeness of Durban's network of public and private open spaces across a range of environmental gradients, to sustain viable species populations and to increase heterogeneity of species populations in order to improve resilience of species to climate change impacts.
	C.1.2: Adopt and enforce integrated planning approaches and development controls that protect the integrity and enhance the functionality and resilience of Durban's biodiversity and natural capital to withstand climate change impacts.
	C.1.3: Design and manage the built environment to contribute positively to the supply of ecosystem services, minimise pollution and degradation of the natural environment, contribute towards biodiversity conservation and the sequestration of carbon dioxide.
	C.1.4: Ensure that linkages between open spaces are conserved and maintained to allow for poleward and altitudinal movement of plant and animal populations to ensure that gene flow and diversity are maintained, and that species are able to adapt to climate change impacts where such potential exists.
	C.1.5: Actively manage the spread of alien invasive species in freshwater, marine and terrestrial habitats to protect against the increased spread of these species as a result of climate change.
	C.1.6: Restore and manage degraded natural open spaces through government, business and community efforts to improve resilience of ecosystems to climate change impacts.
	C.1.7: Acknowledge that there will be changes in biodiversity due to climate change and implement measures to manage the negative effects and enhance the benefits of these changes.

	C.1.8: Promote consideration of climate change impacts in the Environmental Impact Assessment process where it is likely that the development will affect the resilience or adaptive capacity of species, habitats or ecosystems to climate change.
	C.1.9: Identify mechanisms for incentivising land owners to protect and manage natural environments on their properties to maximise ecosystem functioning and resilience in order to withstand climate change impacts.
	C.1.10: Prioritise the restoration, protection and management of habitats and ecosystems that are most vulnerable to the effects of climate change.
	C.1.11: Prioritise the restoration, protection and management of ecosystems that play a key role in alleviating the impacts of climate change on vulnerable communities or infrastructure.
	C1.12: Prioritise the restoration, protection and management of ecosystems that contribute towards mitigating climate change through carbon sequestration and storage.
C.2: Improve current understanding of climate change impacts on biodiversity through knowledge generation and stakeholder participation.	C.2.1: Identify climate-sensitive indigenous species and develop appropriate strategies to protect and conserve these species under changing climate conditions.
	C.2.2: Adopt and enforce a precautionary or least-regrets approach where climate change impacts are not yet currently understood, while continuously striving to improve the understanding of climate change impacts.
	C.2.3: Generate knowledge (including indigenous knowledge) of projected climate change impacts on biodiversity and ecosystem functioning through focused research, monitoring and evaluation.
	C.2.4: Identify already present or new invasive alien species that are likely to benefit from climate change, and implement a control strategy to offset future impacts on biodiversity.
	C.2.5: Identify commercially and socially important species and develop a plan to conserve these in response to changing climate conditions.
	C.2.6: Develop local biodiversity and ecosystem conservation and management plans in a participatory manner with local stakeholders. The plans should address optimisation of carbon storage in ecosystems, protection of scarce or vulnerable species and habitats, and optimise and sustain ecosystem services supply under conditions of climate change.
Theme 4: Food security	
Goal D: Durban has a robust and resilient food security system that ensures availability, equitable access to and efficient utilisation of food in the context of both climate variability and climate change.	
Objectives	**Responses**
D.1: Durban has robust local food production systems that are able to withstand future climate threats and provide for the poor.	D.1.1: Develop and enforce polices and by-laws that reserve space for local food production.
	D.1.2: Encourage innovative local food production within urban development projects.
	D.1.3: Localise food production and distribution through the establishment and preservation of agricultural hubs and small-scale local community farming efforts.
	D.1.4: Promote ecological and sustainable farming practices as an overarching approach to protecting local food production against climate change impacts.
	D.1.5: Make use of indigenous knowledge in combination with latest research to educate communities and farmers about alternative, locally appropriate crops and farming techniques in order to continue producing food in Durban's changing climate.
	D.1.6: Encourage and support cooperation amongst small-scale growers so they are able to jointly respond to climate change challenges to food production.
	D.1.7: Research the impacts of crop improvement technologies in the face of a changing climate.
D.2: Durban has adequate food distribution and	D.2.1: Promote the decentralisation of the fresh produce marketing system through a system of distribution hubs that can supply small traders more effectively and efficiently.

marketing networks in place to adapt to climate change.	D.2.2: Establish food markets at transport hubs and centralised gathering points with local and other farmers supplying local communities.
	D.2.3: Provide support to informal traders in the food sector by conducting an analysis of what their potential needs are (i.e. micro-credit, shade, trading facilities) that take account of climate change.
	D.2.4: Provide refrigeration facilities at decentralised marketing hubs where small traders can pay for and store refrigerated food, thereby increasing the shelf life of foods and increasing the overall amount of food in storage.
	D.2.5: Encourage large retailers to link directly to local and community producers, where possible.
	D.2.6: Investigate methods to improve the efficiency, adaptability and reduce the carbon footprint of food transport systems into and within Durban.
D.3: Durban residents have economic access to food in the face of climate change.	D.3.1: Investigate methods of increasing economic food access for climate vulnerable communities.
	D.3.2: Maximise the distribution to and utilisation of good quality left-over food waste by climate vulnerable communities.
D.4: Durban residents are able to utilise foods appropriate for a changed climate in the best possible manner.	D.4.1: Educate people about the utilisation and preparation of crop types that may be more appropriate for production under changed climatic conditions.
D.5: Durban is able to supply its residents with adequate food during climate-related disasters or events.	D.5.1: Link with food banks and promote the establishment of more food banks.
	D.5.2: Consider a system of smaller, localised food banks or fresh produce hubs that are able to effectively supply food locally to extreme weather disaster affected households. Establish emergency rations storage at such facilities.
	D.5.3: Identify alternative methods for bringing food into Durban and for distributing food within Durban under emergency conditions that disrupt normal transport channels.
	D.5.4: Investigate modern emergency ration food preservation technologies/suppliers and promote a local industry around these.
Theme 5: Health	
Goal E: Durban promotes public health and safety and the prevention of diseases in the face of a changing climate. Durban's public health system is resource efficient and climate smart.	
Objectives	**Responses**
E.1: Promote healthy communities, populations and living environments that are prepared for the full range of climate change impacts.	E.1.1: Design new and retrofit existing infrastructure, development, public spaces and services to protect users from climate-change-related health impacts. Considerations include the appropriate location of new infrastructure, infrastructure design (such as improved shade at public places and transport nodes, building new houses that are thermally efficient and have cross-ventilation, providing access to water at public spaces) and choice of materials to provide insulation from heat.
	E.1.2: Identify communities that are vulnerable to high temperatures, flooding and other climate-related events and develop and implement appropriate plans to reduce the vulnerability of these communities.
	E.1.3: Identify and profile the sub-population groups most vulnerable to health impacts of climate change (i.e. those who cannot take care of themselves, such as the aged, youth and persons living with disability).
	E.1.4: Provide a support network for the aged, persons living with disability and any other sub-population groups that may require extra care and assistance as a result of climate change impacts.

	E.1.5: Recognise, make use of and manage the role of open spaces and agricultural land in providing protection from urban heat islands and other climate impacts.
E.2: Strengthen and promote emergency management services to better handle emergency and disaster situations related to climate change and health.	E.2.1: Develop community emergency plans in response to possible climate-related disasters that include use of early warning systems with associated public health advice.
	E.2.2: Equip local health facilities to handle climate-related emergencies and extreme weather events in order to prevent or lessen referrals to tertiary health facilities. Ensure health facilities are able to function under climate-related disaster conditions (e.g. potable water reserves, electricity generation back-up and access even during flooding).
	E.2.3: Establish adequate stockpiles of medications, medical supplies, assistive devices and other resources that may be required during climate change-related disasters and events.
E.3: Surveillance and monitoring of climate-related diseases and associated vectors.	E.3.1: Introduce, enhance and integrate surveillance systems to monitor changes in climate and climate-related diseases. Systems should include a weather watch system/early warning systems and surveillance and accurate record keeping of climate-related illnesses, such as heat-related illnesses and vector-borne, water-borne and food-borne illnesses.
	E.3.2: Community burden of diseases data should be updated where possible. This is particularly applicable for co-morbidities for climate-sensitive health outcomes.
	E.3.3: Monitoring for conditions (e.g. tree cover, improved housing development, etc.) that reduce vulnerabilities/enhance community resilience.
	E.3.4: Integrate surveillance systems across departments and those of private organisations to provide a holistic view of climate change and health vulnerabilities within the city.
E.4: Climate change and responses take into account air quality and human health.	E.4.1: Ensure local energy generation projects conform to the Air Quality Management Plan and implement a range of mitigation measures to reduce impacts on local air quality.
	E.4.2: Incorporate potential increases of mono-nitrogen oxides (NOx) and volatile organic compounds (VOCs) as a result of increased temperatures into Durban's Air Quality Management Plan.
Theme 6 : Energy	
Goal F: Durban has a thriving sustainable energy sector. Where appropriate, renewable energy supplies a significant share of Durban's energy needs, and energy is used efficiently by all sectors. All sectors have access to safe and affordable energy sources.	
Objectives	**Responses**
F.1: 40% of Durban's electricity consumption is supplied from renewable energy by 2030 in line with the national long-term mitigation targets.	F.1.1: Develop and implement a road map for the supply of 40% of electricity from appropriate renewable energy technologies by 2030. A minimum of 10% of the electricity supplied from the national grid will be derived from renewable sources.
	F.1.2: Implement viable small-scale renewable energy generation, such as micro-hydropower, roof-top solar photovoltaic and anaerobic digesters within municipal assets.
	F.1.3: Create an enabling environment for local energy generation that allows for connection of local generators to the grid.
	F.1.4: Introduce rebates and incentives to encourage electricity users to implement renewable energy technologies.
	F.1.5: Develop a Sustainable Energy Sector Development Plan to advance the sustainable energy sector of the green economy within Durban.
	F.1.6: Develop dedicated institutional structures and capacity within the municipality that can support the implementation of renewable energy.
	F.1.7: Introduce a renewable portfolio standard to increase production of energy from renewable sources.
	F.2.1: Residents adopt a range of energy efficiency measures within their own homes:

F.2: Energy in Durban is used efficiently by all sectors.	- By 2020, 50% of mid to high income households have implemented efficient water heating technologies. - By 2017, 50% of mid to high income households use gas or induction cookers. - By 2020, 90% of residential lighting is energy-efficient.
	F.2.2: Businesses adopt a range of energy efficiency technologies, with 90% of lighting, heating, ventilation, cooling and water heating equipment within facilities becoming energy-efficient by 2030.
	F.2.3: Municipality adopts a range of energy efficiency technologies, with 90% of lighting, heating, ventilation, cooling, distribution systems, water and waste water treatment, and water heating equipment within facilities becoming energy-efficient by 2030.
	F.2.4: Promote programmes to implement energy-efficient technologies in buildings and development beyond the current national building regulation standards.
	F.2.5: Introduce a range of mechanisms that reduce electricity consumption during peak hours.
	F.2.6: Facilitate the implementation of energy efficiency incentives by energy users in Durban.
	F.2.7: Develop and implement a range of programmes and competitions to promote large-scale behaviour change towards energy efficiency in Durban.
	F.2.8: Promote the use of energy-efficient technologies to reduce the heat island effect in Durban's urban nodes.
F.3: All Durban's energy users have safe (physical and social) access to suitable energy forms to meet their needs.	F.3.1: Encourage a 'basket' of energy services to meet the energy needs of poor households and reduce the 'energy burden' or cost of energy.

Theme 7: Waste and pollution	
Goal G: Durban has effective air, water, solid waste and waste water management systems in which resources are focused on reduction, re-use and recycling strategies that effectively reduce greenhouse gas (GHG) emissions in all economic sectors, divert waste from landfill, and create employment opportunities. Waste infrastructure is also designed appropriately to adapt to the impacts of climate change.	
Objectives	**Responses**
G.1: Greenhouse gas emissions from waste and pollution generated in Durban are minimised.	G.1.1: Establish and integrate waste and pollution statistics collection systems relevant to greenhouse gas emissions.
	G.1.2: Identify and control large emitters and polluters. Enforce the National Environmental Management: Air Quality Act (Act No. 39 of 2004) and Atmospheric Emission Licences.
	G.1.3: Enforce waste, water and air pollution legislation that assists in regulating greenhouse gas emissions.
	G.1.4: Reduce waste at source through innovative reduction approaches, such as making changes to the design of packaging in order to reduce the greenhouse gas emissions associated with waste along the value chain.
	G.1.5: View waste as a resource and proactively identify opportunities for waste re-use by organisations and industries in order to achieve emission reduction targets.
	G.1.6: Research the full lifecycle greenhouse gas emissions across the range of waste recycling and re-use options with a view to identifying the options that maximise emission reductions.
	G.1.7: Operate a separation-at-source recycling service that creates multiple job opportunities and is supported by well-distributed recycling drop-off stations.
	G.1.8: Provide waste collection services in all residential areas to avoid the burning of waste and to prevent the pollution of natural resources.

	G.1.9: Minimise methane emissions through implementing the recovery of energy at landfill sites and waste water treatment plants, where viable, that conforms to environmental and air pollution standards. Methane that cannot viably be used for energy generation or transport should be flared.
Theme 8: Transport	
Goal H: Durban provides an integrated climate smart, low-carbon transport system for passengers and freight.	
Objectives	**Responses**
H.1: Durban's spatial planning is integrated with transport planning to reduce the need for travel.	H.1.1: Develop economic nodes and mixed-use zones in existing and planned neighbourhoods and communities where residents have access to shops, services and entertainment, thus reducing the need for extensive travel.
	H.1.2: Improve transport linkages that enable access to goods and services between neighbourhoods, communities and economic nodes.
	H.1.3: Encourage densification within nodes and along public transport routes (and that respects the carrying capacity of the natural environment) to achieve economies of scale. Development outside of these nodes, public transport routes and the Urban Development Line should be discouraged.
H.2: All Durban's transport users have access to safe, affordable, carbon efficient and climate resilient transportation.	H.2.1: Provide and maintain efficient, high quality and safe road and rail infrastructure that supports low-carbon, climate-smart public transport options.
	H.2.2: Maintain and extend high quality infrastructure that allows for safe movement by non-motorised transport.
	H.2.3: Continue with the implementation of the integrated rapid public transport network in Durban to provide an affordable, high quality, clean and safe form of public transport that enables seamless movement between modes.
H.3 Greenhouse gases from transport in Durban are minimised and the energy efficiency of transport is improved.	H.3.1: Discourage private car use through a range of travel and trip demand management measures and behaviour change interventions.
	H.3.2: Explore the adoption of a range of alternative fuels and fuel-efficient technologies that are less carbon intensive.
	H.3.3: Explore the local potential for adoption of energy-efficient transport technologies.
	H.3.4: Prioritise the use of and promote the purchase of low-carbon and energy-efficient vehicles.
	H.3.5: Optimise port operations by implementing a range of energy efficiency measures.
	H.3.6: Optimise freight rail systems and construct new infrastructure, as required, to improve rail accessibility and efficiency, in order to shift freight from road to rail.
Theme 9: Economic development	
Goal I: Durban transitions to a low-carbon economy that is socially responsible and environmentally sustainable, provides diverse economic opportunities, and increases the capacity to adapt to the impacts of climate change.	
Objectives	**Responses**
I.1: In the long-term, Durban develops a low-carbon economy that is socially responsible and environmentally sustainable.	I.1.1: Establish a platform, with an associated community of practice, to explore the climate change and economic development nexus.
	I.1.2: Develop an understanding of the possible climate change scenarios and the potential roles which the economy may play (positive and negative) in each scenario.
	I.1.3: Identify priority municipal responses through undertaking a risk and opportunities analysis for a range of climate change scenarios.
	I.1.4: Define a set of policy outcomes that will achieve a low-carbon and climate-resilient economy that is socially responsible and environmentally sustainable.
	I.1.5: Develop a suite of positive economic incentives that when applied will achieve the policy outcomes mentioned in 1.1.4.

	I.1.6: Develop municipality-wide indicators of progress to i) evaluate the efficacy of policies in achieving a low-carbon and climate-resilient economy, and ii) measure the welfare of the citizens of Durban.
	I.1.7: Conduct research into the relationships between potential economic growth options for Durban and the impacts of climate change, and what these relationships mean for a future Durban.
I.2: In the short-term, Durban will implement a range of known interventions that can contribute to low-carbon economic development.	I.2.1: Educate and promote the concept of localised production and the 'circular economy' within business where resources are preserved and re-used in the economy.
	I.2.2: Create an enabling environment whereby businesses can network to establish symbiotic relationships with regards to the re-use of effluents, waste materials and other resources by other businesses.
	I.2.3: Create income generation and commercial opportunities for vulnerable communities in the built environment in the restoration, protection and management of ecosystems through key partnerships.
	I.2.4: Support the development of green products, services and industries sectors in eThekwini Municipality.
	I.2.5: Promote low-carbon micro-scale organic food businesses to provide economic opportunities to communities and reinforce food security.
	I.2.6: Promote the efficient use of current space, infrastructure and resources in Durban, where brownfield development is prioritised.
	I.2.7 Ensure that the potential impacts of climate change are taken into account when considering large-scale infrastructure projects.
Theme 10: Knowledge generation and understanding	
Goal J: Durban has an engaged climate change research sector that generates regionally and locally relevant knowledge that is widely disseminated to all sectors in Durban for informed decision-making and action.	
Objectives	**Responses**
J.1: High quality, innovative local climate change research is conducted on an on-going basis.	J.1.1: Establish a multi-disciplinary forum to promote the exchange of knowledge, cross-sectoral research, and innovative local responses to climate change.
	J.1.2: Research the full range of projected climate change impacts on natural resources, infrastructure and human well-being and appropriate adaptation measures for Durban.
	J.1.3: Research the ecological thresholds of Durban's ecosystems to proactively define acceptable limits of human/settlement impacts on these systems in the context of climate change.
	J.1.4: Conduct Mitigation Potential Analysis and develop Desired Emission Reduction Outcomes for each sector and sub-sector of the economy.
	J.1.5: Host an annual climate change research day.
	J.1.6: Engage in knowledge-sharing exchanges with other cities and local authorities to promote collective learning, sharing lessons learnt and best practice.
	J.1.7: Provide opportunities for students to undertake research and gain qualifications that can contribute to the pool of knowledge necessary to respond optimally to climate change in Durban.
J.2: People of Durban improve their under-standing of climate change, its likely impacts and opportunities, as well as possible adaptation and	J.2.1: Develop a range of audience-appropriate and innovative educational and awareness-raising resources to explain climate change, its potential impact on Durban, methods for reducing greenhouse gas emissions, and how to adapt to changing conditions.
	J.2.2: Develop a school-specific package of audience-appropriate information explaining climate change in the Durban context that links to the syllabus and can be presented in an enticing manner.
	J.2.3: Develop and implement a targeted educational campaign for communities that are most vulnerable to the projected impacts of climate change.

mitigation measures relevant to their lives and their work areas.	J.2.4: Ensure eThekwini Municipality's departments and technology sectors understand the impacts of climate change and that staff are equipped to develop and implement appropriate adaptation and mitigation responses.
	J.2.5: Educate business, civil society and residents about the impact of climate change on their businesses and communities, and provide them with the tools and knowledge to respond optimally to these impacts.

Annex IV: Possible indicators for adaptation defined by the Covenant of Mayors

The indicators provided here serve as a source of inspiration. The list below provides examples of indicators of vulnerability, impact and outcome.

(see also http://www.covenantofmayors.eu/IMG/pdf/Mayors-Adapt_Reporting_Guidelines.pdf)

Vulnerability indicators

Vulnerability type	Vulnerability-related indicators	Unit
Climatic	Number of days/nights with extreme temperature (compared to ref. annual/seasonal temperatures)	Days/nights
Climatic	Frequency of heatwaves/cold waves	average per month/year
Climatic	Number of days with extreme precipitation (compared to ref. annual/seasonal precipitation)	days
Climatic	Number of consecutive days without rainfall	days
Socio-economic	Current population versus projections for 2020/2030/2050	inhabitants
Socio-economic	Population density (compared to national/regional average in year X in country/region X)	people per km^2
Socio-economic	Share of vulnerable population groups (e.g. elderly (65+)/young (25-) people, lonely pensioner, low-income/unemployed households) compared to national average in year X in country X	%
Socio-economic	Population living in areas at risk of, e.g., flooding, drought, heatwaves, wildfires	%
Socio-economic	Areas unaccessible to emergency services	%
Physical & environmental	Change in average annual/monthly temperature	%
Physical & environmental	Change in average annual/monthly precipitation	%
Physical & environmental	Length of transport network (e.g. road/rail) located in areas at risk of, e.g., flooding, drought, heatwaves, wildfires	km
Physical & environmental	Length of coastline/rivers affected by extreme weather conditions/soil erosion (without adaptation)	km
Physical & environmental	Low-lying or high-altitude areas	%
Physical & environmental	Coastal/riverine areas	%
Physical & environmental	Protected ecologically and/or culturally sensitive areas	%
Physical & environmental	Areas (e.g., residential, commercial, agricultural, industrial, or tourist) at risk of, e.g., flooding, drought, heatwaves or wildfires	%
Physical & environmental	Current energy consumption per capita versus projections for 2020/2030/2050	MWh
Physical & environmental	Current water consumption per capita versus projections for 2020/2030/2050	m^3

Impact-related indicators

Sector	Impact-related indicators	Unit
Buildings	Number or % of public, residential, or tertiary buildings damaged by extreme weather conditions/events	per year / over a certain period
Transport, Energy, Water, Waste, ICT	Number or % of transport, energy, water, waste or ICT infrastructure damaged by extreme weather conditions/events	per year / over a certain period
Transport, Energy, Water, Waste, and Emergency Services	Number of days of public service interruptions	days
Transport, Energy, Water, Waste, and Emergency Services	Average length of public service interruptions (e.g. energy or water supply, public transport, traffic, health, civil protection, emergency services)	hours
Health care	Number of people injured/evacuated/relocated due to extreme weather events (e.g. heatwaves or cold waves)	per year / over a certain period
Health care	Number of deaths related to extreme weather events (e.g. heatwaves or cold waves)	per year / over a certain period
Emergency Services	Average response time of emergency services, in case of extreme weather events	minutes
Health care	Number of water quality warnings issued	number
Health care	Number of air quality warnings issued	number
Environment & Biodiversity	Area affected by soil erosion / soil quality degradation	%
Environment & Biodiversity	Habitat losses due to extreme weather events	%
Environment & Biodiversity	Change in number of native species	%
Environment & Biodiversity	Native animal or plant species affected by diseases related to extreme weather conditions/events	%
Agriculture & Forestry	Agricultural losses due to extreme weather conditions/events (e.g. drought, water scarcity, soil erosion)	%
Agriculture & Forestry	Livestock losses from extreme weather events	%
Agriculture & Forestry	Change in crop yield and grassland productivity	%
Agriculture & Forestry	Livestock losses from pests/pathogens	%
Agriculture & Forestry	Timber losses from pests/pathogens	%
Agriculture & Forestry	Change in forest composition	%
Tourism	Change in tourist flows / tourism activities	%
Other	Direct economic losses (e.g. in commercial, agricultural, industrial, tourism sectors) due to extreme weather events	euros/year
Other	Financial compensation received (e.g. insurance)	euros/year

Outcome-related indicators

Sector	Outcome-related indicators	Unit
Buildings	Public, residential or tertiary buildings retrofitted for adaptive resilience	%
Transport, Energy, Water, Waste, ICT	Transport, energy, water, waste or ICT infrastructure retrofitted for adaptive resilience	%
Land-use Planning	Change in green & blue infrastructure/areas	%
Land-use Planning	Change in the spatial connectedness of green and blue areas	%
Land-use Planning	Change in sealed surfaces / soil moisture level	%
Land-use Planning	Change in rainwater runoff from floodplains (due to changes in soil condition)	%
Land-use Planning	Change in shading (& related change in the Urban Heat Island effect)	%
Land-use Planning	Coastline designated for managed realignment	%
Water	Change in water loss (e.g. due to leakages from the water distribution system)	
Water	Change in storage of rainwater (for reuse)	%
Waste	Change in solid waste collected / recycled / disposed of / incinerated	
Environment & Biodiversity	Habitat restoration / species protection	%
Agriculture & Forestry	Change in crop yield due to adaptation measures	%
Agriculture & Forestry	Change in water consumption for agriculture/irrigation	%
Agriculture & Forestry	Additional forest restoration	%
Tourism	Change in tourist flows	%
Tourism	Change in tourism activities	%
Other	Change in restoration and reconstruction costs associated with extreme climate events	%
Other	Investment in adaptation research (e.g. soil conservation, water/energy efficiency) by the city/other stakeholders	€
Other	Investment in education/medical & emergency services by the city	€
Other	Number of awareness-raising events for citizens and local stakeholders	
Other	Number of training sessions for staff	
Other	Number of direct stakeholders involved in adaptation process through community participatory activities	