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UN Climate Technology Centre & Network

D2.3 Investigation of best practices of operating local climate information systems

CLIMATE RISK ASSESSMENT FOR SUBNATIONAL ADAPTATION AND ESTABLISHMENT OF A LOCAL CLIMATE INFORMATION SYSTEM FOR CLIMATE CHANGE ADAPTATION (LISA)

May 2023

Prepared for: **United Nations and MoE**
Prepared by: **ICEM**

icem

DISCLAIMER

This document was prepared for the United Nations Climate Technology Centre and Network (UN-CTCN) by an ICEM consultant team engaged to undertake the *Technical Assistance – Climate risk assessment for subnational adaptation and establishment of a local climate information system for climate change adaptation (LISA) in Cambodia.* The views, conclusions and recommendations in the document are not to be taken to represent the views of the UN-CTCN.

Prepared by	ICEM Asia
Prepared for	UN-CTCN, and MoE, Royal Government of Cambodia
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More information	www.icem.com.au | info@icem.com.au ICEM - International Centre for Environmental Management 26 Lane 86, To Ngoc Van Street, Tay Ho, Ha Noi Viet Nam
Front page image	Photo by ICEM
Project Team	Richard Cooper, Miguel Coulier, Pham Tran Minh, Lay Chanthy, Tous Sophorn, Joe Ogden, Truong Tung Hoa

ABBREVIATIONS

CCA	Climate Change Adaptation
CIS	Climate Information System
GFCS	Global Framework for Climate Services
ICEM	International Centre for Environmental Management
IT	Information technology
LISA	Local Climate Information System for Climate Change Adaptation
UN-CTCN	United Nations Climate Technology Centre and Network
WMO	World Meteorological Organization

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EXECUTIVE SUMMARY

The purpose of this report is to inform development and operation of a local climate information system for climate change adaptation (LISA) in Cambodia. To do this, the report examines international municipal climate information systems (CISs) that are operating at the highest standards and best practices, as well as academic literature to determine what an ideal CIS might include. This document includes a brief account of the need for climate services; developing end-to-end CISs; a review of how municipalities access climate information; and finally a series of recommendations for developing a concept for a web-based LISA. These recommendations will subsequently be discussed with national and subnational stakeholders to assess their utility for an application at the municipal level.

While there is no single definition for a CIS, for this report, a CIS is viewed broadly as a system that encompasses data collection, archiving, access, and dissemination of climate data and climate services, and a local CIS (or LISA) as one that informs end-users on climate resilient planning at subnational, municipal or local level.

The robustness of decision making will depend on the data and information available in a LISA, which may include access to future projections of climate change; historical records of past disaster events; identification of climate change hot spot areas by overlaying future projections of climate change threats and hazards on the assets of interest; analysis of exposure, sensitivity, impacts, adaptive capacities and vulnerabilities of each type of asset and per hazard; and provision of climate services where climate information has been tailored to address the adaptation requirements of a specific sector or group of end users.

Key capacity needs for facilitating use and sustainability of a LISA may require external support depending on the financial resources of the government authority. Capacity needs include those required to generate climate information products, for instance a multi-stakeholder working group may need to be established to inform spatial planning for adaptation; and the IT technical expertise to maintain the online web-based system.

A review of municipal CISs indicates that the existence of best practice municipal CIS in the Asia-Pacific region is very limited and often CIS are focused on the national-level. The review therefore has also looked at examples beyond Asia, including ‘best practice’ case studies for Amsterdam (Netherlands), London (United Kingdom), Pokhara (Nepal), Los Angeles (United States), Darwin (Australia), Toronto (Canada) and Singapore. Each of the case studies describes the key hazards affecting the city, their commitment to climate change adaptation, the presence of a CIS or other platforms or tools for accessing climate information, and the existence of a group of experts or technical working group supporting adaptation in the city.

Based on our examination of the official websites of municipal governments dedicated to climate change adaptation, it is clear that sharing of climate data and climate information products are not frequently available through these websites. While a small number of websites offer connections to the national meteorological agency where climate data may be visualized, there was little exchange of climate data among the municipal websites examined. However, all of the sites reviewed do share

webpages and/or links to adaptation plans and some provide more detailed documentation on adaptation measures for different sectors.

Based on the review of best practices literature and case studies, a series of recommendations were formulated for the development of the LISA platform, which include the adoption a whole-of-city approach by identifying and considering key climate threats to various sectors in the municipality; development of an end-to-end LISA, where feasible, by integrating data on future climate projections, maps of hazards, socio-economic indicators, identification of areas of highest exposure and vulnerability, and adaptation measures; development of expert groups to tailor climate services to each sector and advise on adaptation measures; and provision of capacity building for municipal staff to use LISA for planning and to support management (sustainability) of the platform.

1 INTRODUCTION

1.1 Overview of this report

This report is a deliverable under Output 2 of the *Technical Assistance on Climate risk assessment for subnational adaptation and establishment of a local climate information system for climate change adaptation (LISA) in Cambodia*. This *Report on the investigation of best practices of operating local climate information systems internationally* with a focus on municipalities aims to inform the development of the Cambodia LISA platform.

The TA is funded by the United Nations Climate Technology Centre and Network (UN-CTCN) and aims to design a web-based local climate information system (CIS), which can support adaptation decision making processes and provide services for climate information delivery at the subnational (local) level. The TA will be achieved through the following key activities:

- Identification of the current status of the CISs in Cambodia;
- Identification of stakeholder's needs and climate change risk assessment at the selected municipality; and
- Development of LISA at the selected municipality.

The purpose of this report is to provide information on how to develop and run a LISA in Cambodia. To do this, the report examines international municipal CISs that are operating at the highest standards and best practices, as well as academic literature to determine what an ideal CIS might include. This document provides a brief account of the need for climate services; developing end-to-end CIS; a review of how municipalities access climate information; and finally a series of recommendations for developing a concept for a web-based LISA. These recommendations will subsequently be discussed with national and subnational stakeholders to assess their utility for an application at the municipal level.

1.2 What is a climate information system?

Box 1: 'Climate information includes all aspects of climate, from observations and forecasts to application of this information for relevant segments of society' (Ropelewski 2003)

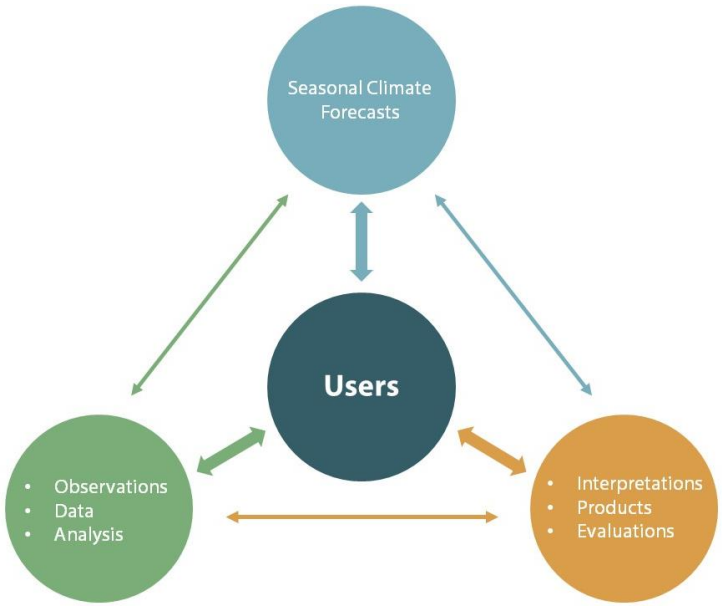
There is no single definition for a CIS. Broadly a CIS can be considered as a platform that can be used to share climate data and information, and may contain value-added information that is useful to inform decision-making for a given group of users or sector (Box 1). A CIS might be designed as an early warning system to alert communities of an imminent hazard, provide medium-term advisories to farmers, or in the long-term be used to identify areas at highest risk from climate hazards for prioritising investment planning.

According to Ropelewski (2003), the components of a CIS can include the following features (Figure 1):

- Robust real-time climate observations;
- Archives of climate data;
- Real-time analyses of current climate data;
- Climate forecasts from a range of sources;
- Comprehensible forecast products;
- Analyses of past forecast performance;
- Effective dissemination modalities of climate information to end users; and
- Engagement and feedback from end users.

Figure 1: Schematic diagram of climate information system components

Source: Ropelewski, 2003



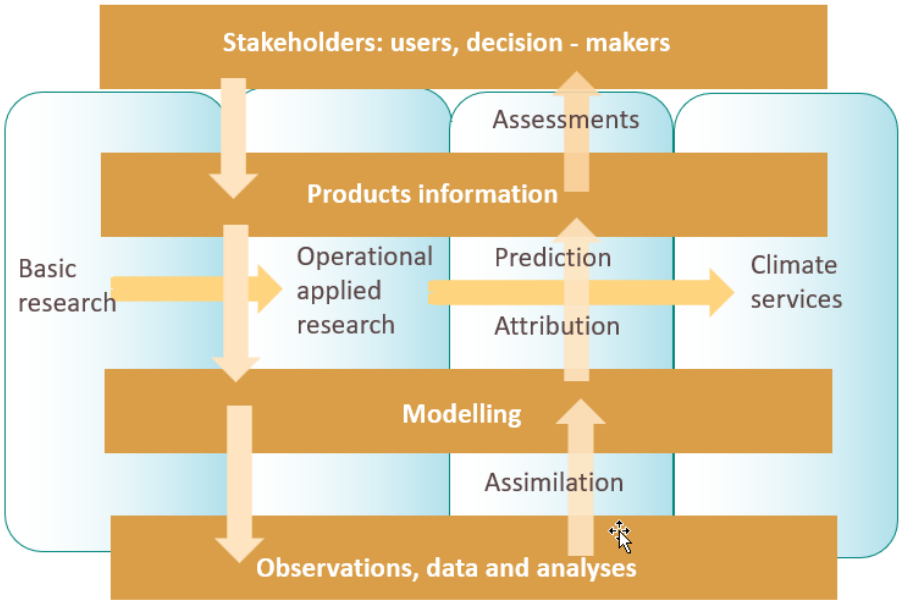
Trenberth (2016) advocates a similar 'end-to-end' design approach for CISs. An end-to-end system considers the entire process from provision of climate observations, data archiving, data access, to dissemination of climate services to end users and decision makers (Figure 2: Core features of an end-to-end climate information system

Source: modified from Trenberth (2008)

). Such a system is one that not only provides access to data but also data interpretation (Rood and Edwards 2014). For this report, a CIS is similarly viewed broadly as a system that encompasses data collection, archiving, access, and dissemination of climate data and climate services, and a local CIS as one that informs end-users on climate resilient planning at subnational, municipal or local level.

Figure 2: Core features of an end-to-end climate information system

Source: modified from Trenberth (2008)



1.3 Climate services

> *Box 2: Climate services are "climate information prepared and delivered to meet users' needs". (WMO 2011)*

Climate services are needed by decision makers to inform climate resilient planning and development, or 'climate smart development'[1], by ensuring that the most appropriate adaptation options are considered for addressing the future impacts of human-induced climate change. Hewitt et al. (2021) suggested a simple and generic definition of a climate service as "*the provision of climate information for use in decision-making*". Multiple sectors of the economy including those in the primary (agriculture, forestry, fisheries), secondary (industry, transportation, water, energy, housing) and tertiary (health care, tourism) sectors require the mainstreaming of climate change into decision making to bolster climate resilient development. The form of climate services will vary by sector. For instance, climate advisories are commonly used to inform medium-term agricultural planning, and may advise on appropriate crops and varieties, and diverse cropping patterns (WMO 2019). Regarding urban areas, heat stress is one potential adaptation concern, and climate services may include the creation of maps showing the number of heat wave days, and adaptation measures may include increasing surface coverage of green spaces and water (Giodano et al., 2020).

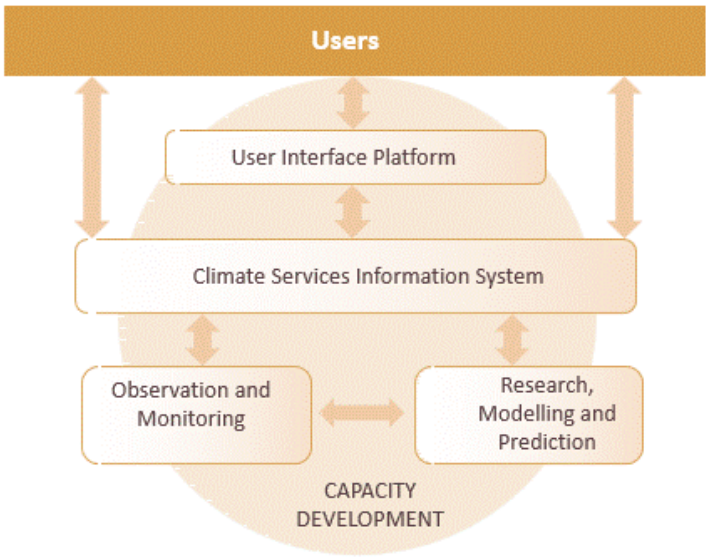
At the global level, the World Meteorological Organization (WMO, 2009) established the Global Framework for Climate Services (GFCS) to support climate-resilient planning.[2] The purpose of the GFCS is to support regional, national and local governments in mainstreaming climate change into decision-making in priority areas such as health, water, agriculture, energy and disaster risk reduction.[3] The climate service information systems is the central mechanism of the GFCS and comprise institutes and centres responsible for collecting, analysing, archiving, and sharing climate information data and services (Figure 3).

[1] https://gfcs.wmo.int/what-are-climate-services
[2] https://www.gfcs-climate.org/overview/
[3] https://www.gfcs-climate.org/partnership/

A series of eight principles were proposed to guide the implementation of the GFCS including the third principle which states that "activities will address three geographic domains - global, regional and national", with the most important aspect being the implementation at subnational and local levels (WMO, 2018). Engagement between producers of climate information and its end-users is also stated as critical to mainstreaming climate change into decision-making.

Figure 3: Five pillars of the Global Framework for Climate Services

Source: adapted from WMO, 2014



1.4 Key requirements for a local climate information system

1.4.1 Data and information content

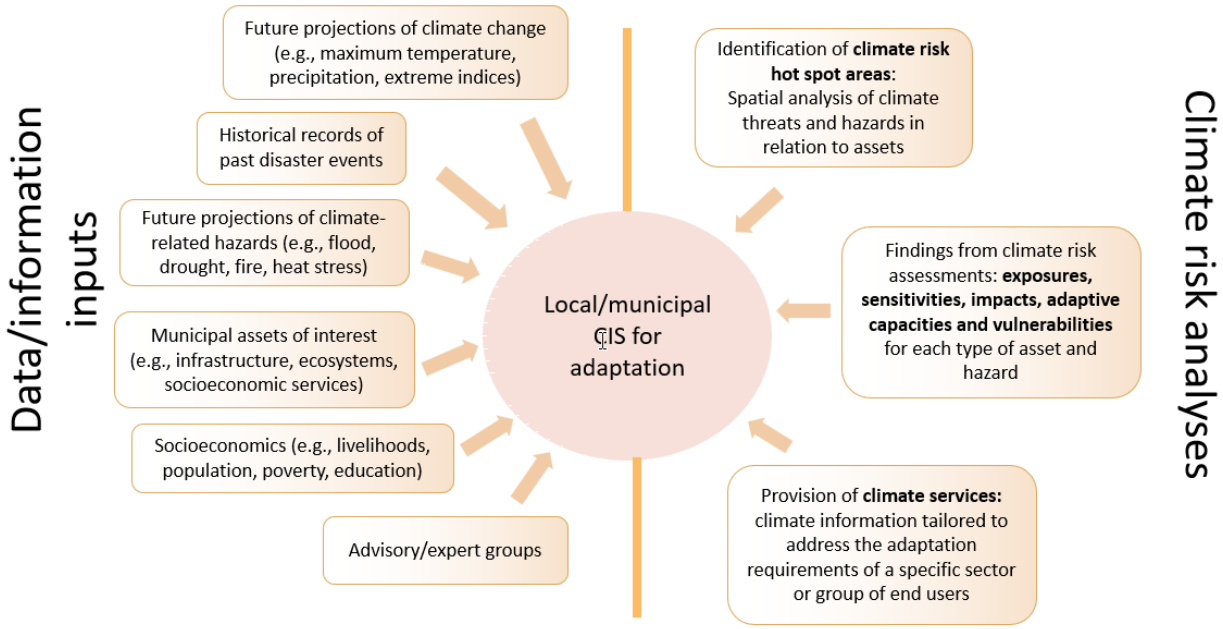
The key purpose of the proposed LISA is to inform urban planning in the context of climate change. The LISA should be of relevance to Cambodia's climate change response strategies and plans, such as spatial planning at city, district, or municipality level; vulnerability assessment to support development of climate change strategic plans; and strengthening of climate resilient cities.

The purpose of LISA is to ensure that adaptation options implemented by decision makers are based on science – i.e., scientific evidence that addresses the specific climate threats and climate-related hazards in the municipality. The robustness of decision making will depend on the data and information available, which may include the following (Figure 4):

(i) Access to future projections of climate change (e.g., changes in temperature or precipitation) and climate-related hazards (e.g., flood, drought, fire, heat stress);
(ii) Historical records of past disaster events;
(iii) Identification of climate change hot spot areas by overlaying future projections of climate change threats and hazards on the assets of interest (e.g., infrastructure, ecosystems, socioeconomic measures). This is considered a key requirement to help identify hotspot locations that are particularly exposed to climate threats and hazards.
(iv) Analysis of exposure, sensitivity, impacts, adaptive capacities and vulnerabilities of each type of asset and per hazard;
(v) Provision of climate services where climate information has been evaluated by experts and tailored to address the adaptation requirements of a specific sector or group of end users.

These sources of information may be integrated into and shared directly from the local CIS or the CIS may link to external resources, a national atlas for instance.

Figure 4: Key data and information sources for a local climate information system to inform resilient planning



While financial resources may preclude conducting thorough vulnerability analyses of all assets and hazards and the generation of sector-based climate services, the development of a LISA platform should aim to integrate available data and information where practicable to improve science-based decision making within the municipality. Relevant sources of information may be available from regional or national government agencies, universities, or NGOs.

1.4.2 Capacity needs

Depending on the size and resources of a government authority, it may not be financially feasible to employ climate change adaptation experts in-house to generate climate information products, and external consultations may be required with experts from academia, NGOs or the private sector. The provision of climate information products in a local CIS should also not be seen as a one-time analysis. There should also be scope for climate information in the CIS to be revised based on new climate data, such as generated from more recent data analyses (e.g., from downscaled data, the use of different climate models, projections, and bias corrections or from participatory data collection). A multi-stakeholder working group may need to be established to inform spatial planning for adaptation.

The operation of a CIS at local level also needs to be considered from a system management perspective to ensure its sustainability. For instance, a CIS that contains climate data should enable some degree of analysis from the user, through integration of a map viewer to enable spatial overlaying of climate and other data to better identify those areas at greatest risk to climate threats and hazards. This kind of system would be more complicated for hosting and maintenance than a simple website or content management system. Alternatively, climate information if presented visually in simple HTML web pages or in PDF reports could be readily accessible from a simple website and the system would be consequently easier to maintain. However, whatever the complexity of the software system, a local government agency needs to have the IT capacity, both hardware and trained staff, to effectively manage the site, including the future updating of data and information.

2 REVIEW OF MUNICIPAL CLIMATE INFORMATION SYSTEMS

A few criteria have been applied for this review to define 'best practice'. The first consideration to selecting a municipality as potential 'best practice' is to determine if the local authority has demonstrated a commitment to climate change adaptation. Relevant evidence of such commitment would include conducting a climate risk assessment at municipality level, the preparation of a climate change adaptation plan, or declaring a climate emergency. The second consideration is that the municipality has developed some sort of web-based platform, website, or local CIS for visualising and disseminating climate information, including on adaptation planning. A third and final consideration is if there is an advisory group or group of experts established to support municipal adaptation.

The existence of best practice municipal CIS in the Asia-Pacific region is very limited and often CIS are focused on the national-level, for example in the case of the Cambodia *Platform for Real-time Impact and Situation Monitoring* (PRISM) or the Ministry of Environment Department of Climate Change's *Cambodia Climate Change Data Portal*[4]. Notwithstanding the few good examples of national-level CIS in the region, often supported by development partners under specific projects, disseminating climate information publicly is often limited to sharing strategies, plans or publications on Government websites. As shown in Table 1, even the national Government's weather forecasting websites have a limited integration of climate projections or information on climate risks and adaptation.

Table 1: Overview of national weather information platforms and their integration of climate information

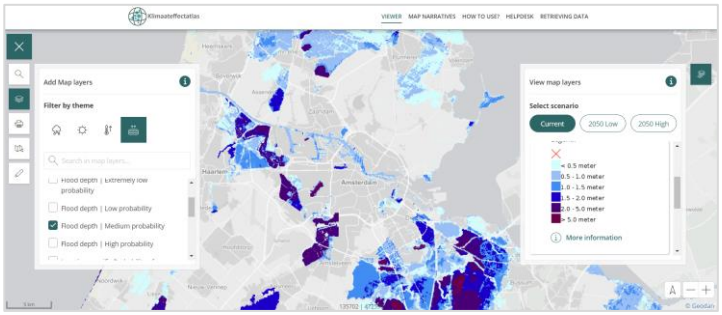
Country	National agency and website for weather information	Does it contain climate projections and other climate information?
Cambodia	Ministry of Water Resources and Meteorology, Department of Meteorology - http://www.cambodiameteo.com	No
Vietnam	Ministry of Natural Resources and Environment, National Centre for Hydro-Meteorological Forecasting - https://nchmf.gov.vn/	No – But contains a link to the website of the Institute of Meteorology, Hydrology and Climate Change - https://imh.ac.vn/
Lao PDR	Ministry of Natural Resources and Environment, Department of Meteorology and Hydrology - https://dmhlao.la/	No – The Department has a Climate Division, but there is no climate information shared on the website
Thailand	Ministry of Information and Communication Technology, Meteorological Department - https://www4.tmd.go.th/	Yes – Includes a range of static climate information products: http://climate.tmd.go.th/
Malaysia	Ministry of Natural Resources, Environment and Climate Change, Malaysian Meteorological Department - https://www.met.gov.my/	Some - but limited to data on extreme weather events.
Philippines	Department of Science and Technology, Philippine Atmospheric, Geophysical and Astronomical Services Administration - https://bagong.pagasa.dost.gov.ph/	Yes - Including an interactive map viewer[5]

The review therefore has also looked at examples beyond Asia. The tables below include 'best practice' case studies for Amsterdam (Netherlands), London (United Kingdom), Pokhara (Nepal), Los Angeles (United States), Darwin (Australia), Toronto (Canada) and Singapore. Each of the case studies describes the key hazards affecting the city, their commitment to climate change adaptation, the

[4] https://ncsd.moe.gov.kh/dcc/data-portal
[5] See: https://bagong.pagasa.dost.gov.ph/climate/climate-change/dynamic-downscaling/climap

presence of a CIS or other platforms or tools for accessing climate information, and the existence of a group of experts or technical working group supporting adaptation in the city.

Table 2: 'Best practice' case studies for Amsterdam (Netherlands)

Criteria	Review findings
AMSTERDAM (Netherlands)	
Key hazards	▪ Heat, drought, extreme rainfall, floods.
1. Commitment to climate change adaptation	▪ Declared a climate emergency. ▪ Established a climate adaptation programme in 2019 and developed an adaptation strategy in 2020: *Strategy for Climate Adaptation Amsterdam*.[6]
2. Development and operation of web-based municipal climate information system	▪ Not one integrated CIS, but various platforms and tools. ▪ National 'Climate Adaptation Knowledge Portal' developed in 2014, containing all available policies and programmes, tools and relevant publications, covering multiple sectors: https://klimaatadaptatienederland.nl/en/ - Has a specific page with an overview of adaptation measures implemented locally: https://klimaatadaptatienederland.nl/en/examples/ ▪ Several climate information products in the form of maps available: o National level bilingual interactive map viewer covering various cities and containing a lot of data layers: socio-economic information, natural systems, hazards and climate change (Figure 5, Figure 6 and o Figure 9), and impacts: https://www.klimaateffectatlas.nl/en/ o City level map viewer for Amsterdam (Figure 7 and Figure 8): https://maps.amsterdam.nl/klimaatadaptatie/?LANG=en **Figure 5: 1-in-100 year fluvial flood in Amsterdam**  **Figure 6: Drought susceptibility in Amsterdam**

[6] Available at: https://assets.amsterdam.nl/publish/pages/867626/climate_adaptation.pdf

Criteria	Review findings
AMSTERDAM (Netherlands)	

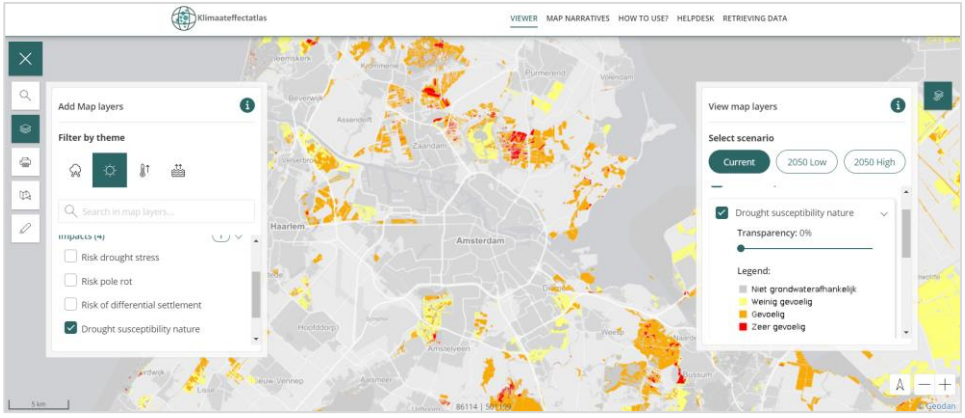


Figure 7: Groundwater level in Amsterdam

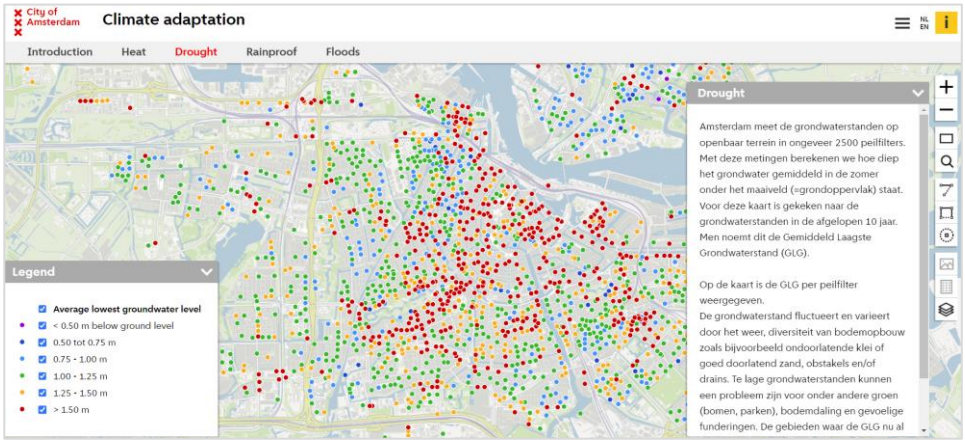


Figure 8: Heat map of Amsterdam

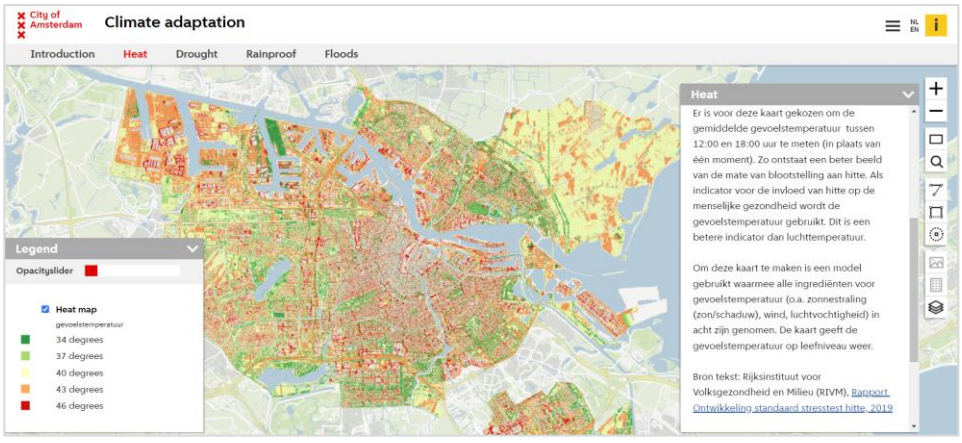


Figure 9: Precipitation projection for 2050 for Amsterdam

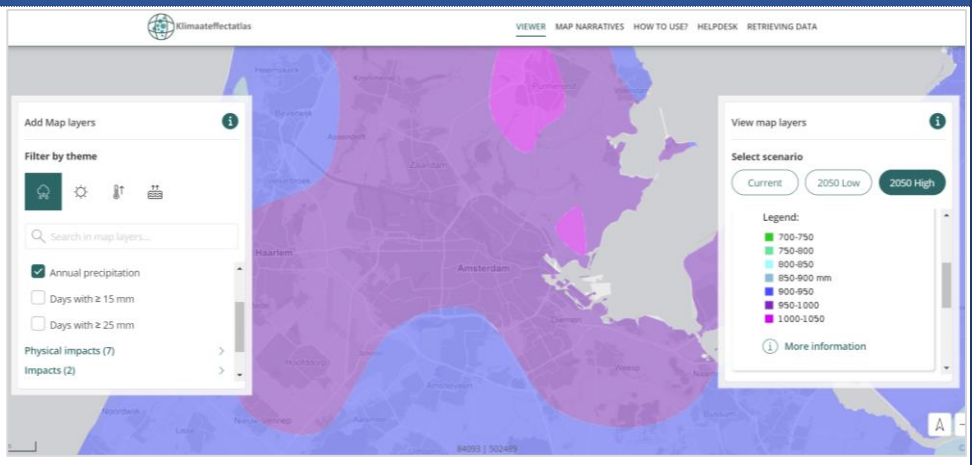
Criteria	Review findings
AMSTERDAM (Netherlands)	
	
3. Advisory or expert group	The City of Amsterdam and the Waternet water company set up Amsterdam Rainproof, a network of 90 different parties throughout the city aiming to make Amsterdam more resistant to the increasingly frequent heavy downpours: https://www.rainproof.nl/. The network includes businesspeople, housing corporations, local green initiatives, knowledge institutions, landscapers, and many other groups, involved in the areas of policy, everyday practice, and knowledge. The city is also engaging with representatives of the Association of Netherlands Municipalities, and with the authorities in other large and medium-sized cities.

Table 3: 'Best practice' case studies for London (United Kingdom)

Criteria	Review findings
LONDON (United Kingdom)	
Key hazards	▪ Flood, extreme rainfall, water stress, heatwaves, drought, sea level rise.
1. Commitment to climate change adaptation	▪ Climate emergency declared. ▪ Adaptation plan available since 2011: *Managing Risks and Increasing Resilience. The Mayor's Climate Change Adaptation Strategy*.[7] – Updated in 2020 into a *Climate Action Strategy for 2020-2027*.[8]
2. Development and operation of web-based municipal climate information system	▪ Not one integrated CIS, but various tools and platforms available to access information on climate risks and adaptation. ▪ The 'London Datastore', created by the Greater London Authority, contains a section on environment and a series of datasets and publications on climate change, e.g. annual climate change mitigation and energy reports, state of the environment reports, city environmental strategy: https://data.london.gov.uk/ ▪ Climate information products in the form of maps are available through an ArcGIS platform managed by the city (Figure 10): https://gisportal.london.gov.uk/portal/apps/webappviewer/index.html ▪ In 2022, an extensive climate risk map was produced by Bloomberg Associates in collaboration with the city authorities (Figure 12): https://tinyurl.com/2e5x9cbh ▪ Vulnerability information is also available through the 'Climate Just' information tool, developed with support from the UK Government Environment Agency: www.climatejust.org.uk. The website contains a lot of explanatory information on

[7] Available at: https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/Adaptation-oct11.pdf
[8] Available at: https://www.cityoflondon.gov.uk/assets/Services-Environment/climate-action-strategy-2020-2027-20-10-20.pdf

Criteria	Review findings
LONDON (United Kingdom)	

the meaning of climate hazards, climate change and vulnerability parameters (Figure 11, Figure 13 and

-
- Figure **14**).
- No information on good practice adaptation measures.

Figure 10: Heat map of London

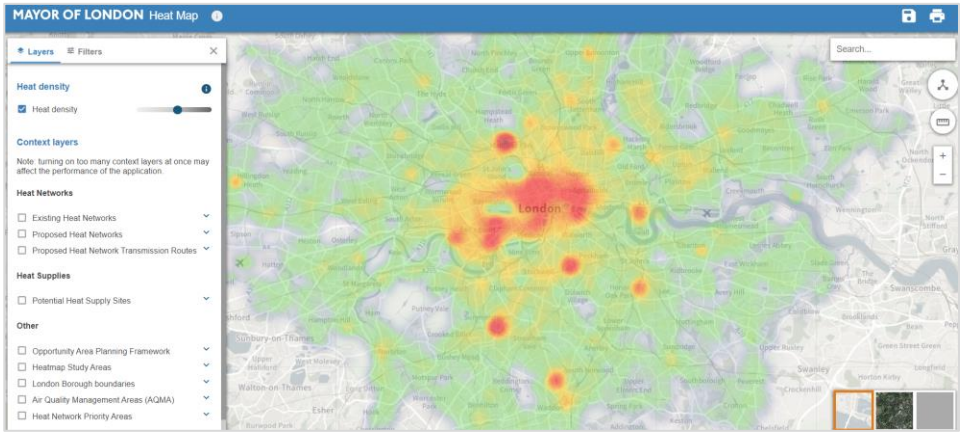


Figure 11: Historical flood extent in London

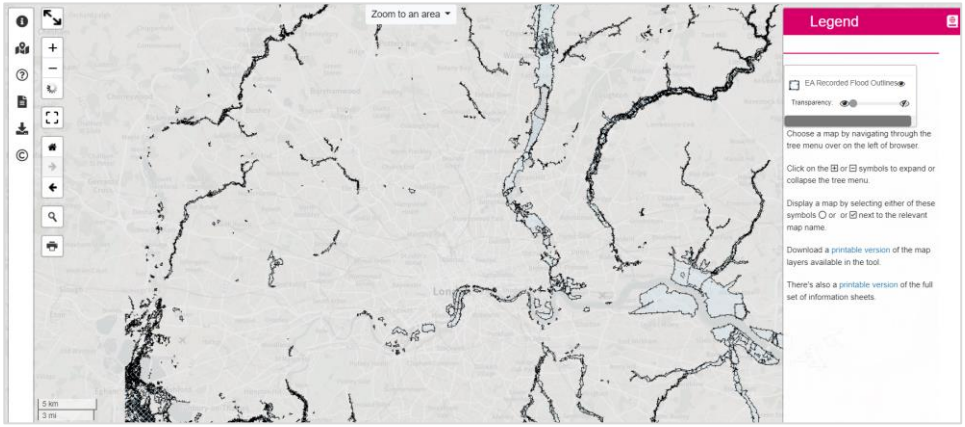
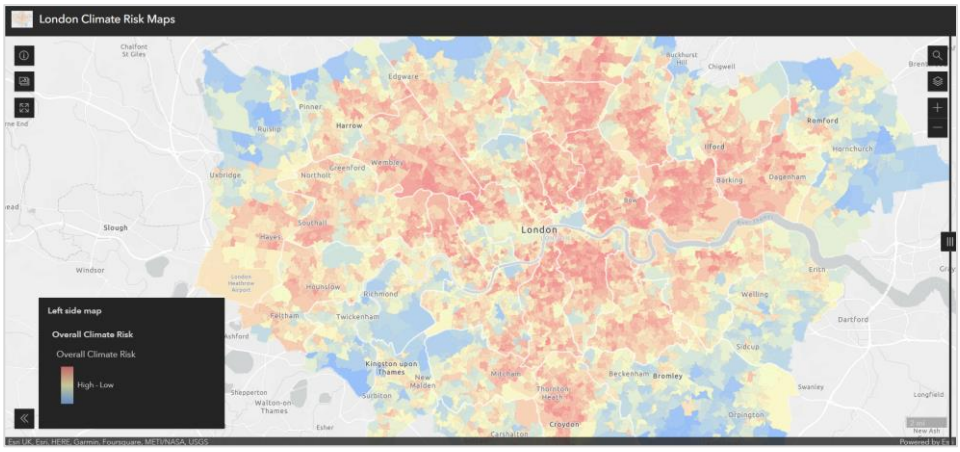


Figure 12: London climate risk



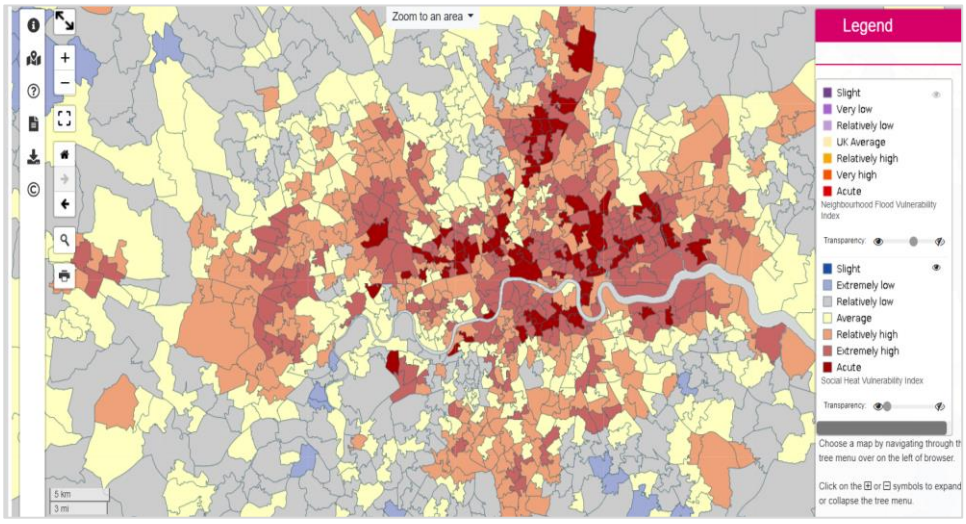
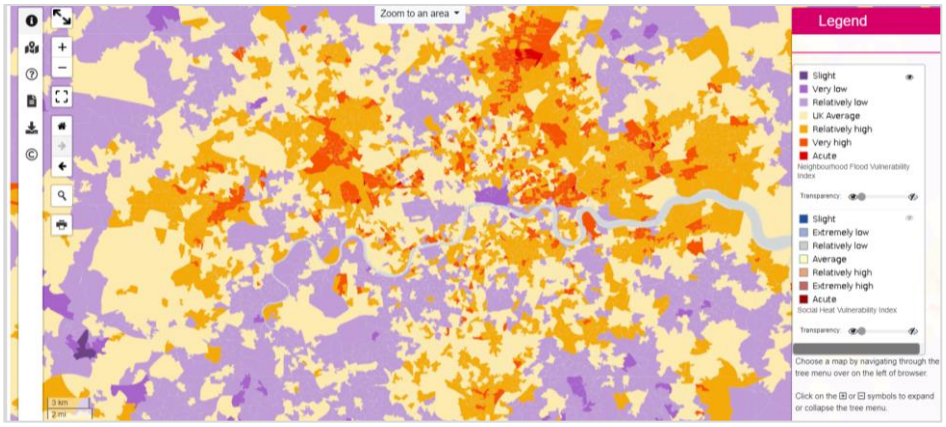
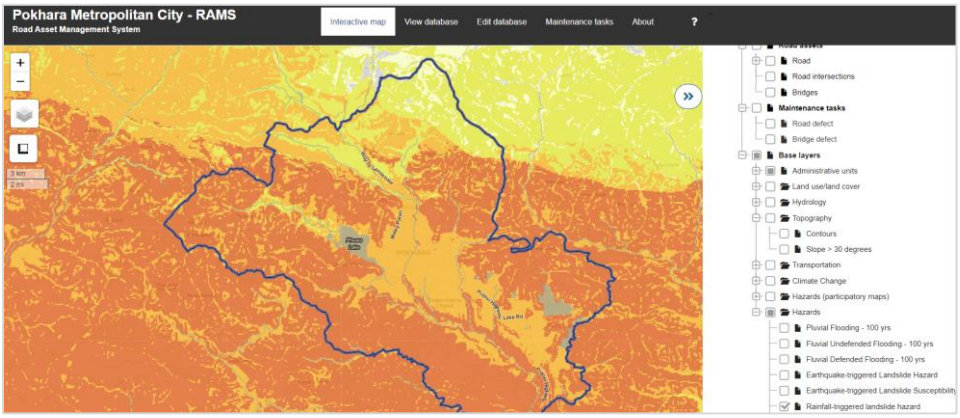
Criteria	Review findings
LONDON (United Kingdom)	
	Figure 13: London heat vulnerability  **Figure 14: London flood vulnerability** 
3. Advisory or expert group	The Mayor of London is part of the 'London Climate Change Partnership', a network of experts from the public, private and community sectors in London established in 2001 and the centre for expertise on climate change adaptation and resilience to extreme weather in London: https://climatelondon.org/. The group has the following mandate: i) driving forward adaptation in London through member organisations leading by example and acting as champions in their sectors; ii) facilitating peer learning and knowledge exchange across sectors; and iii) working with particular sectors to provide relevant guidance and advice about how to adapt.

Table 4: 'Best practice' case studies for Pokhara (Nepal)

Criteria	Review findings
POKHARA (Nepal)	
Key hazards	▪ Flood, sinkholes, landslides and glacial lake outburst floods.

Criteria	Review findings
POKHARA (Nepal)	
1. Commitment to climate change adaptation	▪ There is no climate change adaptation or disaster risk reduction strategy or plan available at Pokhara city level. ▪ In 2022, the city developed a land use plan that considers hazard and climate change threats (though not yet formally adopted): *Risk and Inclusion-Sensitive Land-Use Plan (RISLUP)*.[9]
2. Development and operation of web-based municipal climate information system	▪ One integrated CIS platform focused on CIS for climate resilient road and drainage asset planning and management: https://dev.icem.com.au/nepalams/. Contains a database of road assets, including information on level of maintenance and needs for repair. ▪ Mainly climate information products in the form of interactive maps – with overlays possible between hazard and climate data and infrastructure data (▪ ▪ ▪ Figure 15, Figure 16 and Figure 17). ▪ No information included on adaptation options, nor reference to the city's water management plans, land use plans, or other policy documents. **Figure 15: Rainfall-induced landslides in Pokhara**  **Figure 16: Sinkholes identified for Pokhara**

[9] Available at: https://docs.google.com/document/d/1kW1_oIzqpDajW-5iscThr-Pf9Zzo7Wh4/edit

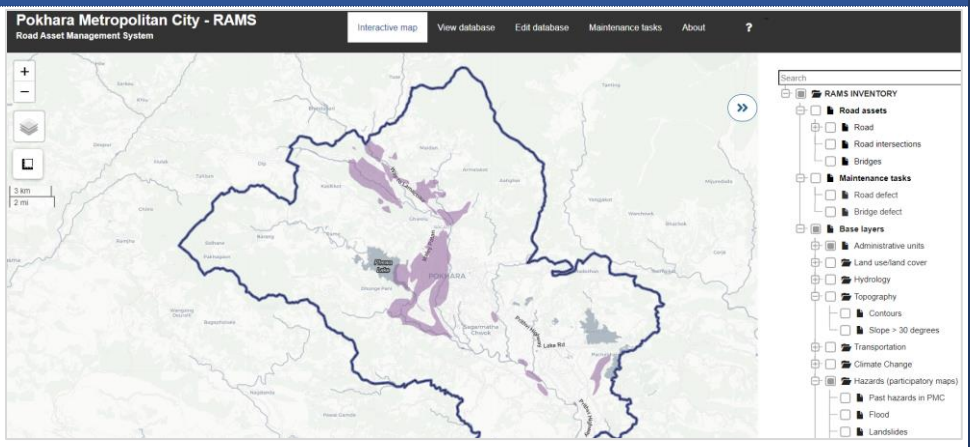
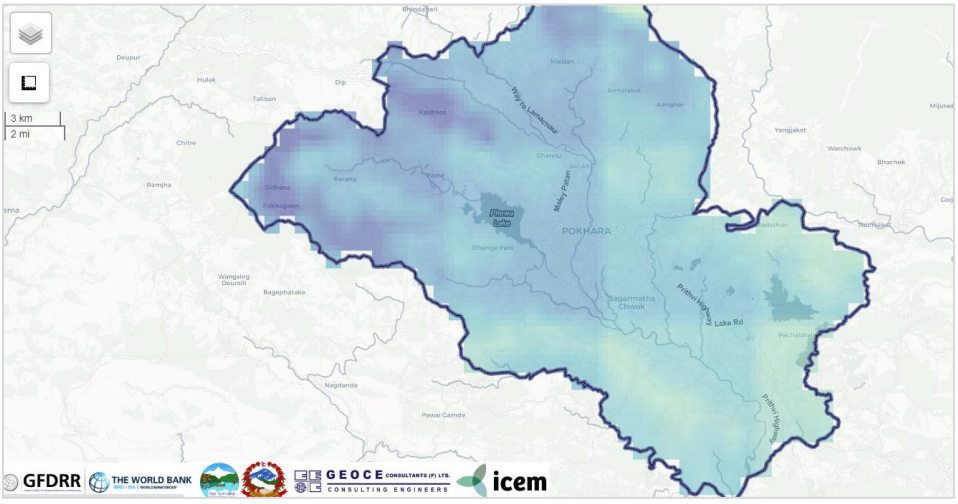
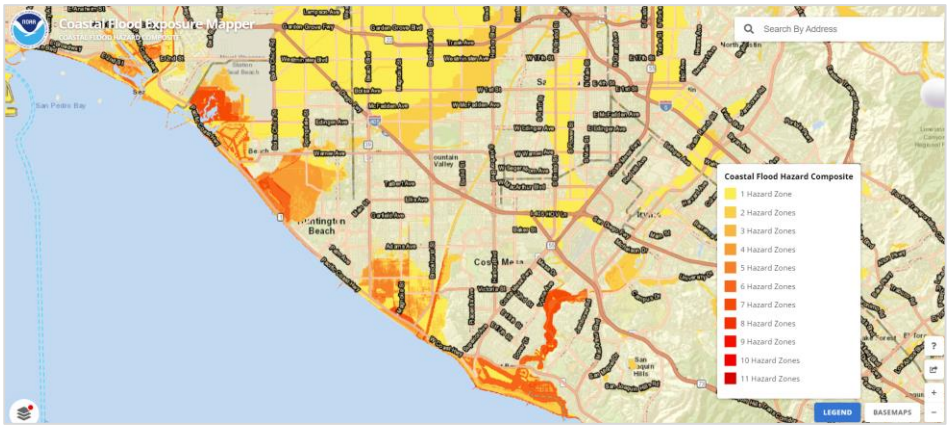
Criteria	Review findings
POKHARA (Nepal)	
	 **Figure 17: Precipitation projection for 2050, for Pokhara** 
3. Advisory or expert group	There is no expert group on climate change adaptation or inter-departmental body at the city level available. The District Administration Offices are in charge of disaster risk management, there is a local disaster management committee chaired by the Mayor, and an Environment and Disaster Management Division headed by the Municipal Police, but these agencies lack budgets and other resources to be effective on adaptation or serve as expert groups.

Table 5: 'Best practice' case studies for Los Angeles (United States)

Criteria	Review findings
LOS ANGELES (United States)	
Key hazards	▪ Wildfire, heat, drought, coastal erosion, storms, stormwater flooding, sea level rise

Criteria	Review findings
LOS ANGELES (United States)	
1. Commitment to climate change adaptation	▪ Los Angeles has established a climate change strategy in 2015: *Los Angeles Region Framework for Climate Change Adaptation and Mitigation,*[10] and more recently, approved the *Green New Deal Sustainability Plan 2019*.[11] ▪ California developed a state level adaptation strategy in 2021: *California Climate Adaptation Strategy*[12] – informed by climate change assessments, including for Los Angeles.[13]
2. Development and operation of web-based municipal climate information system	▪ Not one integrated CIS, but various platforms available to access information on hazard and climate risks at state and municipal level. ▪ Interactive GIS platform on fire hazards in Los Angeles available (but password protected): https://tinyurl.com/4t6aa4yw ▪ City-level flood hazard maps available through national-level 'Coastal Flood Exposure Mapper' portal (Figure 18): https://coast.noaa.gov/digitalcoast/tools/flood-exposure.html ▪ Los Angeles County Vulnerability Assessment results available online, including maps on risk and (social, structural and natural resources) vulnerability (Figure 19): https://storymaps.arcgis.com/stories/3f0409b676ec47b999f4ed9be8664d45 ▪ Climate change baseline and projections for a range of hazard and climate parameters available for the entire state of California through the 'Cal-Adapt' CIS: https://cal-adapt.org/ (Figure 20) - Includes a map viewer and database. ▪ A repository of resources for climate adaptation planning and decision-making called 'Adaptation Clearinghouse' is also available at: https://resilientca.org/ **Figure 18: Flood hazard in Los Angeles**  **Figure 19: Wildfire risk and vulnerability in Los Angeles**

[10] Available at: https://www.waterboards.ca.gov/losangeles/water_issues/programs/climate_change/docs/2015/Climatechange-frameworkforclimatechangeadaptation-final7-20-2015.pdf
[11] Available at: https://plan.lamayor.org/
[12] Available at: https://climateresilience.ca.gov/
[13] Available at: https://www.energy.ca.gov/sites/default/files/2019-11/Reg%20Report-%20SUM-CCCA4-2018-007%20LosAngeles_ADA.pdf

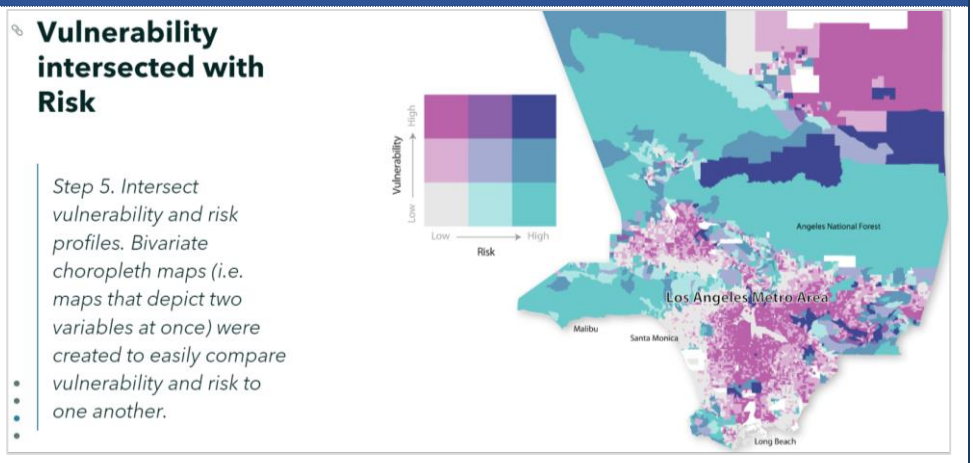
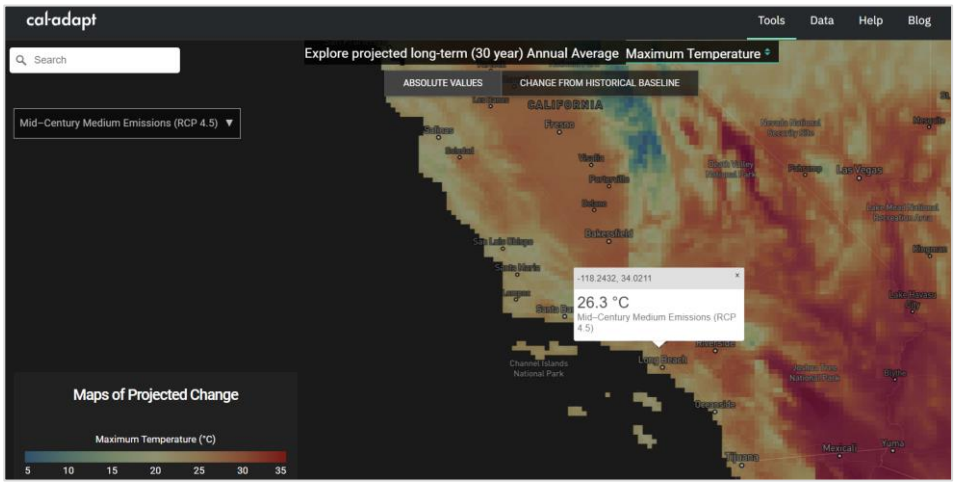
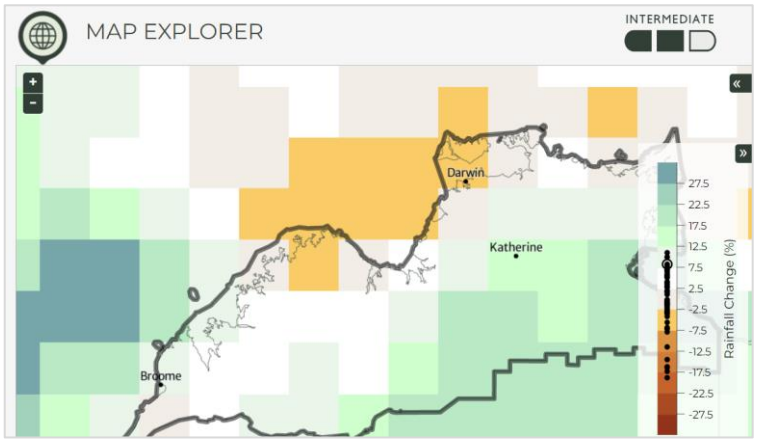
Criteria	Review findings
LOS ANGELES (United States)	
	 **Figure 20: Projected annual average maximum temperature for California** 
3. Advisory or expert group	Established in 2007, the Los Angeles Regional Collaborative for Climate Action and Sustainability is a network of local and regional decision-makers ensuring a sustainable Los Angeles County prepared for the impacts of climate change: https://www.laregionalcollaborative.com/. It is one of eight regional collaboratives in California supporting climate change science, policy and planning efforts across sectors. The network includes climate practitioners from city and county government, regional agencies, non-profits, businesses, and academia.

Table 6: 'Best practice' case studies for Darwin (Australia)

Criteria	Review findings
DARWIN (Australia)	
Key hazards	▪ Heatwaves, higher temperatures, drought, extreme weather events, extreme rainfall, floods and sea level rise.
1. Commitment to climate change adaptation	▪ Climate emergency declared by the mayor in 2019.

Criteria	Review findings
DARWIN (Australia)	
	▪ Darwin City has issued a climate resilience strategy and action plan, covering both mitigation and adaptation: *City of Darwin 2030 Climate Emergency Strategy*.[14] In addition, the city also has a *Greening Darwin Strategy*, *Waste and Resource Recovery Strategy*, and *Coastal Erosion Management Plan*.[15]
2. Development and operation of web-based municipal climate information system	▪ No integrated CIS platform, but several platforms and resources available, mostly at national level. ▪ No portal on adaptation measures, but information integrated in documents such as strategies and plans. ▪ Extensive climate information, projections, models, data and publications available from a national-level climate change portal: https://www.climatechangeinaustralia.gov.au/en/ - Information for Darwin City available as part of the Monsoonal North West region (Figure 21 and Figure 22). ▪ Interactive map tool on coastal inundation available, with projections until 2100: https://coastalrisk.com.au/home (Figure 23). **Figure 21: Projected rainfall change in 2050 for the north west region, including Darwin** 

[14] Available at: https://www.darwin.nt.gov.au/sites/default/files/publications/attachments/1092105_CoD_ClimateEmergencyStrategy_WEB.pdf

[15] Available at: https://www.darwin.nt.gov.au/council/governance-strategy/strategic-and-municipal-planning/a-cool-clean-and-green-city-strategies

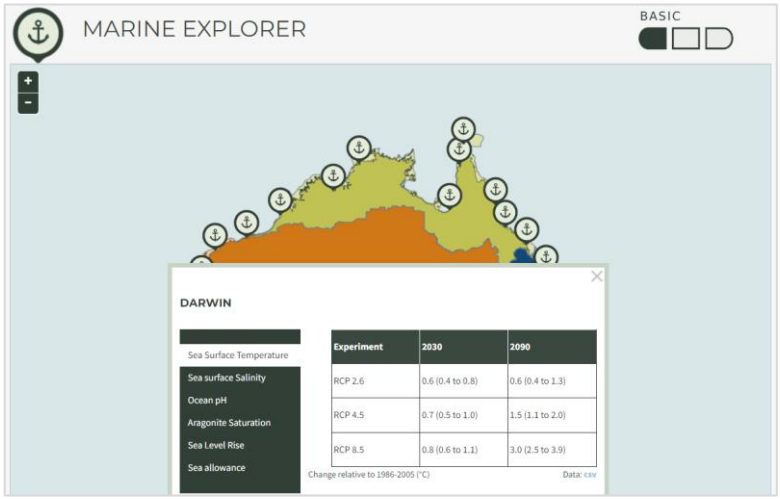
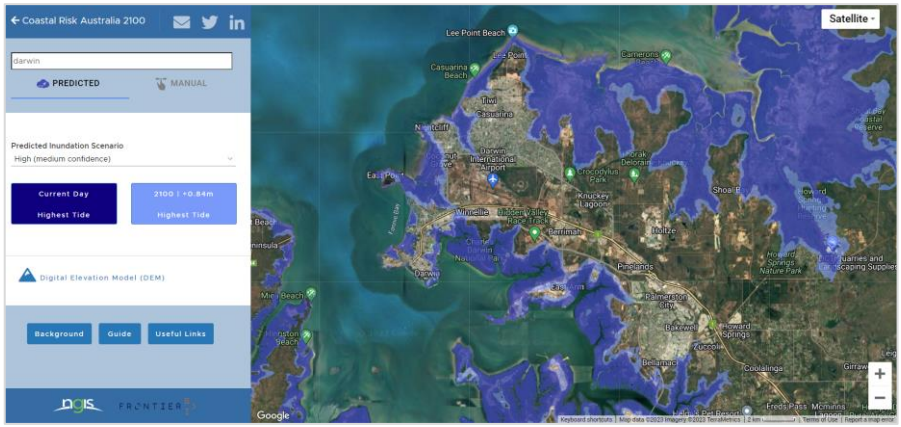
Criteria	Review findings
DARWIN (Australia)	
	Figure 22: Projected changes in coastal and marine indicators for Darwin  **Figure 23: Coastal inundation projections for Darwin, current day and for 2100** 
3. Advisory or expert group	There is no information available online on potential groups or partnerships on climate change adaptation in Darwin.

Table 7: 'Best practice' case studies for Toronto (Canada)

Criteria	Review findings
TORONTO (Canada)	
Key hazards	▪ Heatwaves, flash flood, drought, ice storms, lightning, tornadoes
1. Commitment to climate change adaptation	▪ Toronto has a very clear commitment to addressing climate change, and a special focus on recognizing indigenous knowledge and the role of indigenous communities in adaptation and community and ecosystem resilience ▪ The city developed its first climate change adaptation strategy in 2019, based on a resilience assessment conducted in 2017: *Toronto's First Resilience Strategy.*[16] The city also has a mitigation strategy, since 2021: *TransformTO Net Zero Strategy*.[17]

[16] Available at: https://www.toronto.ca/ext/digital_comm/pdfs/resilience-office/toronto-resilience-strategy.pdf
[17] Available at: https://www.toronto.ca/legdocs/mmis/2021/ie/bgrd/backgroundfile-173758.pdf

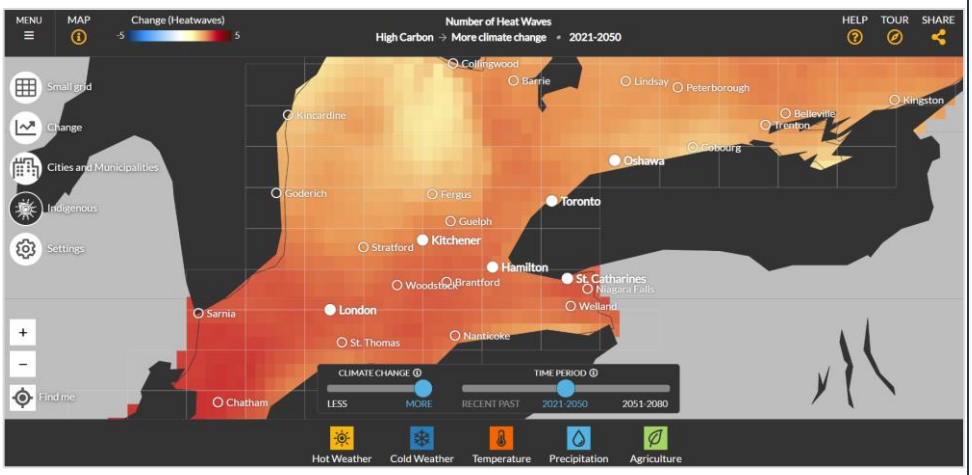
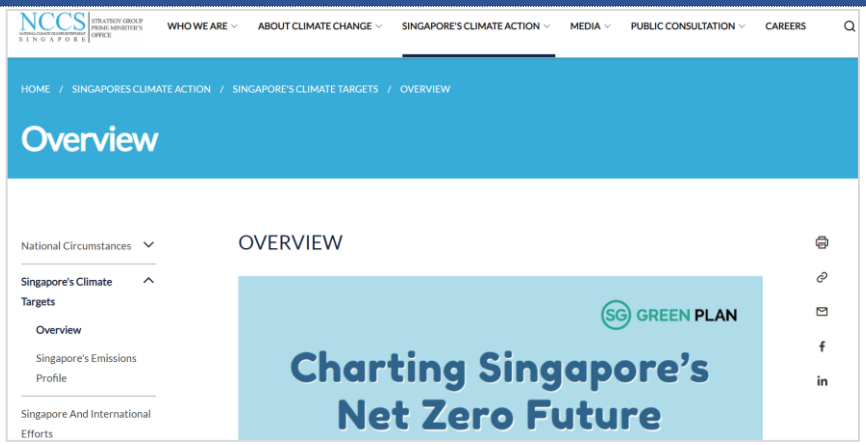
Criteria	Review findings
TORONTO (Canada)	
2. Development and operation of web-based municipal climate information system	▪ There is no municipal CIS platform. ▪ An extensive national level bilingual atlas exists containing downscaled climate projections, impact information for multiple sectors, maps, indigenous knowledge and good practice measures on adaptation, publications and videos: https://climateatlas.ca/ - Contains city-level factsheets, including for Toronto[18] ▪ Some datasets relevant for climate change are also available through the city's open data portal and catalogue: https://open.toronto.ca/catalogue **Figure 24: Projected number of heat waves, for 2050, including for Toronto** 
3. Advisory or expert group	A Climate Resilience Working Group was established to guide and support the development of the city's resilience strategy. The group was made up of members from within the City and from external organizations. The city has also established a Resilience Office and several working groups to provide implementation and oversight for the implementation of the strategy.

Table 8: 'Best practice' case studies for Singapore

Criteria	Review findings
SINGAPORE	
Key hazards	▪ Temperature and rainfall increase, monsoon and sea level rise
1. Commitment to climate change adaptation	▪ Singapore has committed to achieving net zero emissions by 2050. ▪ Besides the 2020 *Long-Term Low-Emissions Development Strategy*, Singapore also developed a sustainable development strategy in 2022, covering climate change adaptation and mitigation: *Singapore Green Plan 2030*.[19]
2. Development and operation of web-based municipal climate	▪ There is no municipal or national-level CIS platform or website dedicated to sharing hazard, climate change and risk information. ▪ The National Climate Change Secretariat maintains a comprehensive website, with information on policy, programs and publications: https://www.nccs.gov.sg/ **Figure 25: Singapore Government's climate change platform**

[18] Available at: https://climateatlas.ca/sites/default/files/cityreports/Toronto-EN.pdf
[19] Available at: https://www.greenplan.gov.sg/

Criteria	Review findings
SINGAPORE	
information system	
3. Advisory or expert group	A Resilience Working Group, under the Inter-Ministerial Committee on Climate Change, was established in 2007 to study Singapore's vulnerability to the effects of climate change and develop long-term plans on resilience. In addition, the Centre for Climate Research Singapore was set up to provide climate advisory support to Singapore and the region. It is working with the UK Met Office Hadley Centre to provide projections of future climate change.

It is apparent from this review of the official websites of municipal governments that are committed to climate change adaptation that the sharing of climate information and climate information products are not typically accessible through their websites. While a minority of sites provide links to the national meteorological agency where climate data may be visualised, in the municipal websites reviewed there was limited sharing of climate data. However, all of the sites reviewed do share webpages and/or links to adaptation plans and some provide more detailed documentation on adaptation measures for different sectors, such as for infrastructure and housing. The absence of climate data is probably not unexpected given the highly technical expertise required to interpret climate data and transform climate information into sector-based climate services, and skills not likely to be found in most municipal governments, however the lack of such information does reduce the transparency of the decision-making process that is advocating adaptation in the urban environment. For instance, the provision of web-based functionality to allow users to overlay future projections of climate variables (precipitation, temperature), flooding and extreme climate indices, would help stakeholders to appreciate future climate threats and the areas at highest risk of exposure in their communities.

Climate information is typically shared either through descriptions on simple HTML webpages or in PDF documents. None of the websites appear to offer interactive functionality that would allow stakeholders to examine how future climate and hazards may impact particular sectors, for instance the overlaying of projected floods from sea level rise or overtopping of rivers with critical infrastructure or population centers. Such tools could be used to engage stakeholders in better understanding the impacts of climate change and the range of possible adaptation solutions. The potential to engage stakeholders through official municipal websites has not been realised.

Another possible cause of the lack of climate information provision in municipal websites is the IT expertise required and associated costs to manage spatial data platforms. The technical capacity for managing a web-based spatial (GIS) platform and associated data is much greater than that required for a relatively simple content management system (e.g., WordPress, Drupal). However, both the technical capacity to develop and manage a web-based climate information system can be readily outsourced. It is somewhat surprising that few of the municipalities committed to adaptation offer little in the way of climate information and services that can be accessed by stakeholders and local communities.

3 RECOMMENDATIONS FOR LISA CONCEPT

Based on the review of best practices literature and case studies, the following recommendations have been formulated for the development of the LISA platform:

1. Adopt a whole-of-city approach (i.e., address multiple sectors that may be impacted by climate threats)
    a. Identify key climate threats to the municipality (e.g., heat and flood in Battambang)
    b. Consider threats to public health, energy, transportation, water, natural resources and assets, housing, and the economy
2. Aim to develop an end-to-end LISA where feasible
    a. Integrate data on future climate projections
    b. Integrate maps of climate hazards (e.g., outputs from future flood projections and historical flood events)
    c. Integrate data on socio-economic indicators (e.g., from census surveys)
    d. Identify areas of highest exposure and vulnerability to support prioritization
    e. Integrate data relevant to each sector that can inform adaptation
    f. Include an inventory of existing or potential adaptation measures to make the climate information actionable
3. Develop a scientific expert group on climate to tailor climate services to each sector (this group can make use of the LISA platform).
4. Develop an expert climate change adaptation group to advise on adaptation measures for each key sector (this group to integrate the climate services into adaptation measures). The group should bring together national, subnational experts, including academia, NGOs, community representatives and private sector
5. Capacity building for municipal staff
    a. Training on the use of LISA to identify climate risk hot spots and identification of appropriate adaptation measures for municipal governments to address climate threats
    b. Training on the management of the LISA platform.

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Correspondence:
info@icem.com.au
26 Lane 86 To Ngoc Van Street,
Tay Ho District, Hanoi, Vietnam
(t) +84 24 3823 9127
(f) +84 24 3719 0367
www.icem.com.au