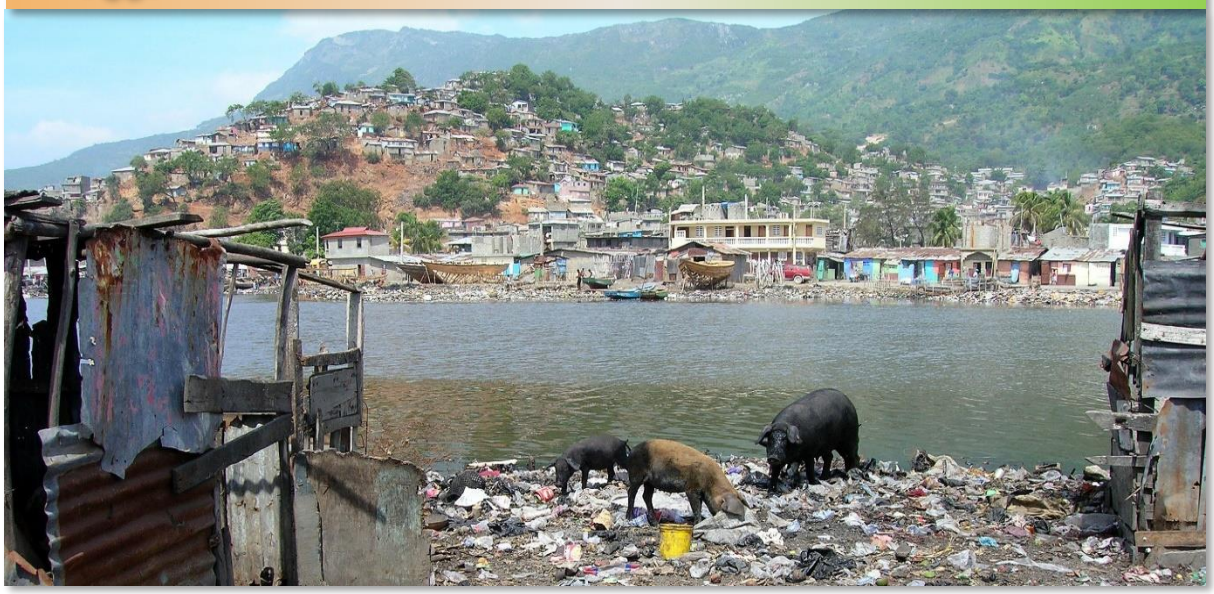


Title

Peri-cene Policy Lab: Baseline Studies

Sub-title

Primary material from the initial review & consultations

Deliverable #

D3-2

Version, Date

V1
April 2021

Lead author

Joe Ravetz

Publication details

Deliverable No.	D3-2
Work Package	WP 3
Main Author(s)	Joe Ravetz
Contributor(s)	Dimas Adrianto, Joe Rees
Date	11-04-21
Version	V1 – raw material for further development
Reviewed by (if applicable)	

This publication has been produced as part of the Peri-urbanisation and climate-environment interactions (Peri-cene) project. Peri-cene was funded by the Natural Environment Research Council (NERC), with the Economic and Social Research Council (ESRC) under the *Towards a Sustainable Earth* programme (2019 – 2021).

NERC is the UK's main agency for funding and managing research, training and knowledge exchange in the environmental sciences. Our work covers the full range of atmospheric, Earth, biological, terrestrial and aquatic science, from the deep oceans to the upper atmosphere and from the poles to the equator. We coordinate some of the world's most exciting research projects, tackling major environmental issues such as climate change, environmental influences on human health, the genetic make-up of life on Earth, and much more. NERC is part of UK Research & Innovation, a non-departmental public body funded by a grant-in-aid from the UK government.

Other funders of the programme included Formas, a Swedish government research council for sustainable development, and the Department of Biotechnology, India.

Peri-cene partners include the University of Manchester (UK), KTH Royal Institute of Technology (Sweden) and the Indian Institute of Technology Madras (India).

Peri-cene Policy Lab: Baseline Studies

Primary material on the 'peri-eco-urban anthropocene'

CONTENTS

1 Introduction

These ‘baselines’ are at the centre of the Peri-cene research and development process. Each city-region has an overview in a structured form for comparison and analysis, and then for development of ‘adaptive pathways’. The material here is drawn from sources including:

- Interview process
- Resources: organizations, policies, reports, academic papers
- Spatial mapping & analysis (separate file)

The ’20-questions’ template here is based on the Peri-cene framework and ‘cause-effect model’, in the 4 main themes in peri-urban / climate interactions:

a) peri-urban development and city-region systems
b) climate change impacts, hazards and risks
c) climate change, vulnerability and sensitivity
d) governance and adaptive capacity

Every city-region is a long story… so we use this template in a flexible way for a simple overview of complex problems. Each city-region has a range of different peri-urban zones, so we focus just on the most critical, with others where time allows.

The templates are work in progress for further discussion, and linked with relevant maps & resources. The whole set of templates is a starting point for the Pathways workshop series.

The summary template here includes space for the new ‘adaptive pathways’ to be filled in from the further rounds of discussion & workshop process.

The results of this are found in the D3-3c, the overall Compendium of peri-urban cases.

Note: the larger case studies of Chennai and Manchester region are not included here, these are in the Deliverables 4a and 4b.

2 Melbourne

Sources

- *Draft & raw material : Joe Ravetz, Dimas Adrianto, Joe Lake Rees (Manchester):*
- *Meeting #1: Andrea Rawluk (Melbourne), Andrew Butt & Lauren Rickard (RMIT) (01-04-21*
- *Meeting #2: Ruth Beilin, Kathryn Davidson (Melbourne) (28-04-21)*

2.1 Peri-urban-climate: summary

This is a short overview of (a) problems / challenges, and later on, (b) responses / pathways. The tables are placed on the workshop whiteboard for discussion.

The focus here is the north west sector centred on the town of Ballarat.

Greater Melbourne contains 31 municipalities, in an affluent multi-cultural metropolis of 4m+, set to double in size in 30 years. Large suburban-peri-urban areas are scattered, car dependent, vulnerable to drought and wildfire, and in certain areas river flooding. Social polarization and middle class vulnerability may be on the increase. Peri-rural areas suffer from out-migration, dependency on agriculture and corporate landholdings, declining services.

Climate hazards include wildfires, drought and all forms of flooding. Coastal areas are at risk from sea level rise and coastal storm hazards on critical infrastructure. These will have increasing knock-on effects on farming, peri-urban communities and ecosystems.

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
PERI-URBAN			
Spatial peri-urban types & patterns:	Urban direct expansion Urban / rural fringe & gradient Counter-urbanization effect Urban agglomeration effect	Large scale suburban development in peri-urban areas is set to continue. The NW direction & town of Ballarat is on a rail route 75 mins from the city	
Spatial peri-urban dynamics (growth / restructuring / transition).	Population growth & housing Technology & infrastructure Economy & employment Real estate & markets	Political economy of housing, suitable for middle & lower-income groups. E.g. Backas March is a 'bedroom community' with minimal services & local jobs, long commutes.	
Peri-urban other drivers (STEEP: social, technical, ecological, policy, culture etc)	Social demographics & lifestyle Environment & resources Policy & governance Culture & ethics	Mixed demographics, transient communities, overlaid on traditional rural towns, & rural elite 'lifestyle' landowners. Underlying issues with traditional owners	
Global-local dynamics & inter-dependencies	Internal structures external interactions power dynamics challenges & conflicts	Much housing is 'buy to rent' & new development is a financial proposition.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
CLIMATE			
Climate change direct effects projections	temperature, precipitation, storm, coastal effects	Temperature projections for 2100 - 1.5 (low) – 5.5 (high). Precipitation reduces ~20% both summer & winter.	
Climate indirect hazards & impacts:	wildfire, heatwave, drought, flood, storm, cyclone landslide, sea incursion etc,	Major wildfire risk is increasing in the hinterland. Drought periods increase with loss of ecosystems & fertile land Sea level rise: large coastal areas to SE & SW are vulnerable to 1m-4m rise.	
Indirect hazards & nexus effects	water resources farming & forestry energy & resources ecosystems & microclimates critical infrastructure	Farming increasingly difficult. Forests are vulnerable to fire & pest Traditional wetlands ecosystems have to adapt rapidly	
Causal loops (impacts of peri-urban on climate change)	CO2 emissions from energy GHG emissions from land-use Land-use & forestry change Carbon storage	Peri-urban development is heavily car based & so contributes to climate emissions, urban air pollution & heat island effects.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
VULNERABILITY			
Physical-ecological vulnerability-sensitivity	• Soil & vegetation • Topography & stability • Settlement form & structure	Much water is trucked in to new communities. High value horticulture is intensive production operation, often located on a declining landscape. Nearby national park & tourist areas also under climate stress	
Functional-economic-infrastructure layers of vulnerability-sensitivity:	• technical & infrastructure • Markets & value effects • Employment & livelihoods	Much of the NW area is economically fragmented with 'deprived' groups, ethnic groups, commuters, traditional rural towns, lifestyle 'horsi-culture' landowners, distant landlords.	
Eco-social-cultural layers of vulnerability-sensitivity:	• Affluence / deprivation • Education / communication • Cultural issues	Inbuilt social structures can increase vulnerability: e.g. in recent grass fires, non-driver women were isolated.	
Adaptive governance capacity-vulnerability-sensitivity-	• Local government • Public services & infrastructure • Emergency services • Civil & community	Estate developers & infrastructure providers have no clear obligations for climate-proof design.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
GOVERNANCE			
Formal government, (governance, regulation)	Spatial planning green belt etc Housing policy Infrastructure development	Local government generally fragmented & under-funded. for fire or flood. Competitive tendering for public services.	
Adaptive / Associative governance: (networks, coalitions, partnerships)	Public sector Private sector Civic sector Citizens etc	Some transfer of responsibility to civic groups. But e.g. the fire emergency service has got more closed & centralized.	
Informality / elite capture / grassroots action:	Informal land-use, settlements, enterprise Corruption & nepotism Social innovation & enterprise for integrated livelihoods	Some new ways of working with traditional owners are emerging, e.g. in fire management.	
System resilience, collective intelligence (combined formal / adaptive / informal)	Social learning & collaboration Social co-creation & mobilization potential System transformation potential	Many forward looking state policies & resources on climate change. But in many communities & in national government, culture of denial & scepticism, overlaid on many other social divides & traumas.	

2.2 Peri-urban-climate: outline

(draft work in progress)

1.	***PERI-URBAN THEMES: ("drivers / stressors / exposure")***	***TYPICAL QUESTIONS***

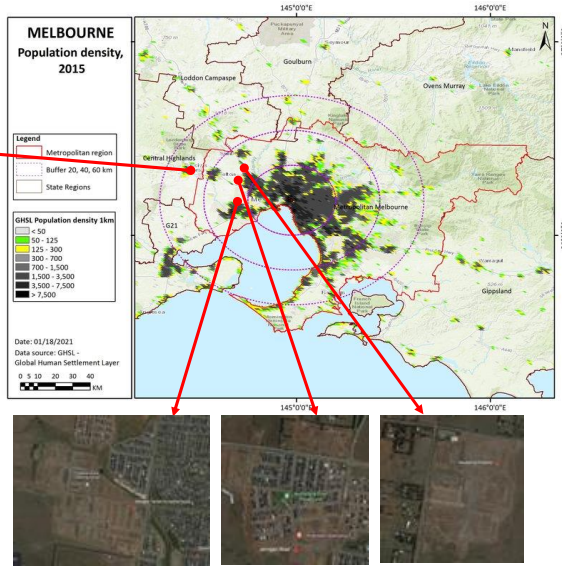
For the case study of Ballarat and its area:

- Rapid new urban development, on train line, but a typical 3 hour commute
- Surrounding area of high landscape value, tourist destination, but under climate pressure
- Much housing is buy to rent, for families coming into new affordable housing
- Social fabric & cohesion is often lacking, also public services
- Water is often trucked in
- The new development takes over previous rural farming towns, including older 'lifestyle' units of 20+ acres with horse stables.
- Large bushfires were seen in the 1980s
- The bushfires also raise the agenda of the indigenous & traditional owners –
- Not only technical approaches, but human centred social / cultural /psychological approaches seem more effective, in management of fire risk, response & recovery

(a)	**Spatial peri-urban types & patterns:**	• ***What is the main geographical type and structure in this city-region / peri-urban zone?***

- The peri-urban areas of Melbourne provide important ecological roles to the urban centre, involving critical water supplies and food production. At the same time, Melbourne's peri-urban areas are facing greater challenges as they are prone to bushfires and coastal flooding particularly in the face of imminent sea level rise.

Residential development in the Town of Bacchus Marsh which was planned to meet the growing demands of housing in the state of Victoria. Bacchus Marsh remains an important town to Melbourne with their significant contribution as a supplier of fresh produces. Currently there is a competition between Bacchus Marsh and Ballarat in the development of residential areas.



Melbourne's 'corridor of housing' – an expansion of Melbourne's urban areas towards the west peri-urban represented by the growth of new residential estates. These residential areas are well connected with motorways both to Melbourne CBD and to other prominent cities (Ballarat and Geelong).

- Melbourne's surrounding towns is urbanising with increase of residential development. Currently there is an increase in the number of people commuting from these towns to Melbourne CBD.
- Melbourne's peri-urban towns are home to important agricultural resources which supply fresh foods for Melbourne. There are growing concerns (e.g. in Bacchus Marsh) over balancing the growth of housing and the importance of protecting these rural values (Cook and Harder, 2012). There is a potentiality of further exploitation of rural landscapes alongside the rising competition with Ballarat in providing housing supplies due

to the growing demand following Melbourne's population growth. An estimate of Victoria's population growth shows an increase of 54% of people resettling in new residential areas in Melbourne's peri-urban areas (Victoria State Government, 2019)

- Besides rising an issue with regards to rural value protection, the urbanising peri-urban towns of Melbourne creates imminent problems of water supply. This problem is exacerbated by climate change where Bacchus Marsh for instance, had already suffered from water insecurity and is prone to droughts which could severely harm the water supply system for both residential areas and farm irrigation (Cook and Harder, 2012).
  -

(b)	**Spatial peri-urban functional dynamics (growth / restructuring / transition).**	• ***How did it evolve / emerge to this situation?***

(c)	**Other drivers (STEEP: social, technical, ecological, policy, culture etc)**	• ***What other causes and drivers of change are in the picture?***

(d)	**Global-local dynamics & inter-dependencies**	• ***Which are the key global / local conflicts & challenges this city-region / peri-urban zone?***

2.	***CLIMATE CHANGE THEMES ("causes / hazards"):***	

(a)	**Climate change direct effects:**	• ***What are the main climate change projections for this area / city-region / peri-urban zone?***

8-20% reduction in water supply to Melbourne by 2050, due to reduced streamflows. Changes in precipitation will cause a contraction of the species in the surrounding Highland forests, resulting in a significant change in the size and location of species range by 2040 [1].

By 2070 (RCP8.5) business as usual average annual temperature is projected to rise 2.6 °C, under a lower emissions future (RCP4.5) average annual temperature is projected to rise by 1.5 °C.

By 2030 average number of hot days (over 35 °C) 12 days. By 2070 average number of hot days under high emissions 17 days, under low emissions 14 days.

By 2030 average number of frost days (under 2 °C) 1 day. By 2070 average number of frost days under high emissions 0 days, under low emissions 1 day.

By 2030, average annual rainfall changes -2%. By 2070 average annual rainfall changes under high emissions -5%, under low emissions -3%.

By 2030 sea level rise is predicted to be between 0.08 - 0.17 m. By 2070 under high emissions 0.20 – 0.45 m, low emissions 0.35 – 0.54 m.

Fire weather is projected to be harsher in future, with an increase in frequency of very high and extreme fire danger days. [2]

(b)	**Climate change direct hazards & impacts:**	• ***What are the expected / projected hazards, impacts and risks?***

increased flooding, increased heatwaves, increased solar radiation, ocean acidification, earlier flowering, increased flood damage, increased maintenance costs, extreme heat impacts, impacts on outdoor sporting events, amplification of existing threats to flora and fauna, changes in habitat, altered disturbance regimes, changing dynamics of invasive species.[2]

(c)	**Indirect hazards & nexus effects**	• ***Which hazards and impacts are most critical for food, energy, water, other infrastructure?***

Victoria State wetlands, rising temperatures and lowering rainfall averages will reduce wetland inundation events, drier wetlands will shift animal and plant communities to those more tolerant of less frequent flooding. [4]

(c)	**Indirect hazards & nexus effects**	• ***Which hazards and impacts are most critical for food, energy, water, other infrastructure?***

periods and planting times, changes in pest and disease distribution, changes in pasture growth, reduced water security, increased disruption to services, increased threats to tourism infrastructure, greater stress on emergency services, greater heat related deaths, mental health effects, changes in disease occurrence. [2]

The most significant costs associated with heatwaves are split between construction and agriculture. Annualised expected impact from heat waves in Victoria is expected to be $AUS 87 million (2018), $AUS 179 million (2030, RCP8.5), $AUS 195 million (2050, RCP4.5), $AUS 264 million (2050 RCP8.5). [5]

High ambient temperature directly affects the efficiency of electricity generation and can lead to breakdowns in: fossil fuels, nuclar, solar PV, and wind. [3]

(d)	**Causal loops (peri-urbanization >> climate change)**	• ***How does the pattern of peri-urbanization cause further climate emissions or urban / rural impacts?***

Heavy urbanisation is increasing the urban heat island effect, development at city fringe or low lying areas means properties are at higher risk of flood impacts. [7]

3.	***VULNERABILITY THEMES sensitivity / capacity***	

(a)	**Physical-ecological vulnerability-sensitivity**	• ***How far are the physical & ecological systems, vulnerable / sensitive or resilient / adaptive?***

Target new and emerging diseases and pests, Increase green urban infrastructure and urban biodiversity, Link habitats to allow species to move, Consider moving selected populations to new areas [2]

(b)	**Vulnerability-sensitivity: functional-economic layers**	• ***How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?***

Consider enterprise diversification, Consider different crop varieties and sowing times, Plan for a secure water supply, Regularly access long and medium range outlooks as well as short-range weather forecasts.
Insure public assets Increase storm water capacity, Adopt water sensitive urban design solutions, Diversify

sources of power and water including decentralised technologies, Consider future climate and sea level rise when locating new infrastructure.

Implement emergency planning for tourist sites, Undertake business continuity planning, Multi-skill staff, Consider enterprise diversification, Prepare for changing seasonal demand. [2]

If there are short falls in energy production, this can be supplemented by supply from alternative generation in the national energy market. Peak demand [3]

(c)	**Vulnerability-sensitivity: social-cultural layers**	• ***How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?***

Use cost-effective pedestal fans in heatwaves, Use existing social networks to support vulnerable community members, Establish contingency plans for patient influxes in hospitals, Increase green spaces and cool zones for heat stress. [2]

(d)	**Vulnerability & adaptive capacity of social institutions**	• ***How far are key institutions (community, civic society, public services etc), vulnerable / sensitive or resilient?***

Water Sensitive Urban Design (WSUD) planning requirements to ensure new urban development's minimise peak storm water flows and pollutants, regenerate urban water landscape to facilitate microclimate cooling, local habitat, and community provisions. [3]

$AUS 30 million invested in climate action. Transitioning city owned buildings from gas to al electric, transitioning fleet where possible to electric. [6]

Improving interdepartmental and cross Victoria links to collectively plan urban renewal and contribute to best city outcomes. Increase City of Melbourne staff climate change understanding, integrate climate adaptation into processes, policies, and governance. [7]

4.	***GOVERNANCE THEMES:*** ***Adaptive action & governance***	

- In 1971, the Melbourne and Metropolitan Boar of Works (MMBW) attempted to synergise the Metropolitan Area planning with Melbourne's peri-urban areas, marking it as one of the early framework of regional integrated plan (Buxton, Carey and Phelan, 2016). This framework aimed at controlling land speculation and to protect significant amount of lands in Melbourne's green belt from urbanisation. This initiative was also followed by the establishment of a regional planning authority to enhance the multisectoral planning aimed at sustaining Melbourne's inner peri-urban planning which had important environmental role for region. One of the key policies and strategies were to prevent land subdivision, which was successful in altering land speculations.
- In a more recent time (2002), through *Melbourne 2030*, authority introduced policy to protect rural areas by means of strict zoning was introduced which was followed by the legislation of urban growth boundaries to protect Melbourne's peri-urban areas from potential exploitation by urban uses (Buxton, Carey and Phelan, 2016). However, the strict policy was eased in 2013 by the state government allowing the influx of non-farming activities into the peri-urban areas. Following this, through *Plan Melbourne* in 2014, authorities attempted for an investigation to identify and protect the most significant agricultural lands. Unfortunately, this was difficult in practice due to the already changing planning system (2013) which was rather permissive for rural land takes.

(a)	**Formal government,** **(governance, regulation)**	• ***How does local / regional government work here & which kind of policies, regulations or plans apply?***

(b)	**Adaptive governance & institutions: (networks, coalitions, partnerships)**	• ***Are there networks, coalitions, partnerships etc, or any emerging signs of these?***

(c)	**Informal governance,** **(corruption, community, livelihood,)**	• ***How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?***

(d)	**System effects, resilience, collective intelligence**	• ***What could be the overall resilience of the system, or collective capacity for learning & thinking?***

2.3 Annex

Basic data

SPATIAL DEVELOPMENT	
Population city-region (2018)	- 4.9m
Land area city-region	- 9993 km2
Density city-region	- 508 pp/km2
Population city-region change	-
CLIMATE HAZARD	
(World Bank data on https://thinkhazard.org - profile for Victoria)	
Extreme heat	- medium
Wildfire	- HIGH
Water scarcity	- low
River flood	- HIGH
Urban flood	- HIGH
Coastal flood	- HIGH
Cyclone	- low
Tsunami	- HIGH
Landslide	- medium
Earthquake	- medium
Volcano	- medium
VULNERABILITY	
Economic type	- OECD
GDP /pp city-region	- $44000 USD
HDI (national 2017)	- 0.939

Sources

Peri-urban governance

Buxton, M., Carey, R. and Phelan, K. (2016) 'The Role of Peri-Urban Land Use Planning in Resilient Urban Agriculture: A Case Study of Melbourne, Australia', in, pp. 153–170. doi: 10.1007/978-3-319-28112-4_10.

Cook, N. and Harder, S. (2012) 'By Accident or Design? Peri-Urban Planning and the Protection of Productive Land on the Urban Fringe'. Boston, MA: Springer US, pp. 413–424. doi: 10.1007/978-1-4614-4484-8_28.

Victoria State Government (2019) 'Victoria in Future 2019 - Population Projections 2016 to 2056'. https://www.planning.vic.gov.au/__data/assets/pdf_file/0032/332996/Victoria_in_Future_2019.pdf (Accessed June 2021)

Climate & vulnerability

[1] Assessing the Vulnerability of Victoria's Central Highlands Forests to Climate Change. C. R. Nitschke & G. M. Hickey.

[2] Climate-Ready Victoria Greater Melbourne. Victoria State Government.

[3] Melbourne Planning Scheme STORMWATER MANAGEMENT (WATER SENSITIVE URBAN DESIGN)

[4] Indicative Assessment of Climate Change Vulnerability for Wetlands in Victoria. Department of Sustainability and Environment Victoria.

[5] Heatwaves in Victoria: A Vulnerability Assessment

[6] Annual Plan and Budget 2020-2021. City of Melbourne.

[7] Climate Change Adaptation Strategy Refresh 2017. City of Melbourne.

General sources

Organisations, Programmes, and Projects

Victorian Centre for Climate Change Adaptation Research
Description: state government research center until 2014
http://www.vcccar.org.au/

Melbourne, C40 Cities
Description: city profile and case studies
https://www.c40.org/cities/melbourne

Department of Environment, Land, Water and Planning, Victoria State Government
Description: programs for environmental issues such as climate change, water, forests, and coasts
https://www.delwp.vic.gov.au/

Sustainability Program, City of Melbourne
Description: programs for water and heat impacts
https://www.melbourne.vic.gov.au/about-melbourne/sustainability/Pages/sustainability-for-melbourne.aspx

Living Melbourne, City of Melbourne
Description: plan for an urban forest to build resilience and adapt to climate change
https://resilientmelbourne.com.au/living-melbourne/

Melbourne Sustainable Society Institute, University of Melbourne
Description: projects on environment and resilience
https://sustainable.unimelb.edu.au/

Reports and Policies

Climate Change Adaptation Strategy Refresh 2017, City of Melbourne
Description: update of the climate context and goals from the 2009 plan
https://www.melbourne.vic.gov.au/sitecollectiondocuments/climate-change-adaptation-strategy-refresh-2017.pdf

Victoria's Climate Change Adaptation Plan 2017-2020, Victoria State Government
Description: integrates adaptation into core sectors in the region
https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0024/60729/Victorias-Climate-Change-Adaptation-Plan-2017-2020.pdf

Resilient Melbourne, City of Melbourne
Description: outlines resilience objectives and projects

https://resilientmelbourne.com.au/wp-content/uploads/2016/05/COM_SERVICE_PROD-9860726-v1-Final_Resilient_Melbourne_strategy_for_web_180516.pdf

Annual Report 2018-2019, City of Melbourne
Description: update on the implementation on the Resilience Strategy
https://resilientmelbourne.com.au/wp-content/uploads/2019/10/Resilient-Melbourne-Annual-Report-2018-19-Full-Double-Spread-Version-Web.pdf

Academic Articles

Fastenrath, Sebastian, Bush, Judy, & Coenen, Lars. (2020). Scaling-up nature-based solutions. Lessons from the Living Melbourne strategy. *Geoforum*, 116, 63-72.
Description: case study of the implementation of the urban forest project
https://doi.org/10.1016/j.geoforum.2020.07.011

Fastenrath, Sebastian, Coenen, Lars, & Davidson, Kathryn. (2019). Urban Resilience in Action: The Resilient Melbourne Strategy as Transformative Urban Innovation Policy? *Sustainability* 11(3), 693.
Description: case study of the implementation of the resilience strategy
https://www.mdpi.com/2071-1050/11/3/693

Moloney, Susie, & Fünfgeld, Hartmut. (2015). Emergent processes of adaptive capacity building: Local government climate change alliances and networks in Melbourne. *Urban Climate*, 14, 30-40.
Description: case study of multi-level governance of climate adaptation
https://doi.org/10.1016/j.uclim.2015.06.009

Rogers, B. C, Bertram, N, Gersonius, B, Gunn, A, Löwe, R, Murphy, C, . . . Arnbjerg-Nielsen, K. (2020). An interdisciplinary and catchment approach to enhancing urban flood resilience: A Melbourne case. *Philosophical Transactions of the Royal Society of London. Series A: Mathematical, Physical, and Engineering Sciences*, 378(2168), 20190201.
Description: participatory approach to flood management in a Melbourne suburb
https://doi.org/10.1098/rsta.2019.0201

3 Surabaya

Sources

- Draft & raw material : from meeting 9th Feb 2021
- Joe Ravetz / Dimas Adrianto / Joe Lake Rees (Manchester):
- Dr. Ismu Rini Dwi Aria: Dr. Wahid Hasyim: Dr. Agus Dwi Wicaksono: Dr. Surjono : Dr.Tech. Christia Meidiana (Surabaya / Brawijaya)

3.1 Peri-urban-climate: summary

This is a short overview of (a) problems / challenges, and (b) responses / pathways (to be developed in the workshop and beyond).

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
PERI-URBAN			
Spatial peri-urban types & patterns:	Urban direct expansion Urban / rural fringe & gradient Counter-urbanization effect Urban agglomeration effect	Sprawl of large-scale residential enclaves surrounded by small housing clusters. Infilling urban development beyond the inner-city area. Peri-urban expansion along river basin to SW, overlaid on paddy field patterns. Major industrial areas to NW & SE	
Spatial peri-urban dynamics (growth / restructuring / transition).	Population growth & housing Technology & infrastructure Economy & employment Real estate & markets	Surabaya Metropolitan Area is the 2nd largest urban agglomeration & most rapidly growing urban region of Indonesia. Formation of contiguous urban areas between neighbouring regencies	
Peri-urban other drivers (STEEP: social, technical, ecological, policy, culture etc)	Social demographics & lifestyle Environment & resources Policy & governance Culture & ethics	Growing middle class & rapid transition from rural society to industrial & urban. Over-pricing of city, preference for peri-urban, property investment motives (some residential areas have low occupancy rate).	
Global-local dynamics & inter-dependencies	Internal structures external interactions power dynamics challenges & conflicts	Surabaya as capital city in main province, means large commuting & in-migration. CBD is shifting to orbital route locations, W&E are becoming industrial, stable growth in north and south. Suramadu bridge connects Surabaya & Madura Island.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
CLIMATE			
Climate change direct effects projections	temperature, precipitation, storm, coastal effects	Precipitation projections: summer large rise, winter rapid fall. Temperature projection of 2-6 degrees by 2100 Sea level rise N&E: rapid development of urban enclaves overlapping areas below sea level	
Climate indirect hazards & impacts:	wildfire, heatwave, drought, flood, storm, cyclone landslide, sea incursion etc,	Growing flood vulnerability & UHI effect. UHI is lower in E&W areas, due to palm & mangrove. North and east development is overlapping with sea level rise areas. River pollution and acid rain.	
Indirect hazards & nexus effects	water resources farming & forestry energy & resources ecosystems & microclimates critical infrastructure	Acidic rain from industrial gas emission flows into water bodies - soil & water contamination - effect on agriculture, public health, quality of drinking water	
Causal loops (impacts of peri-urban on climate change)	CO2 emissions from energy GHG emissions from land-use Land-use & forestry change Carbon storage	High mobilization, dynamic area development, fast population growth requires massive flows of energy, food, water and other goods	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
VULNERABILITY			
Physical-ecological vulnerability-sensitivity	• Soil & vegetation • Topography & stability • Settlement form & structure	family land ownership is small ~1/4 Ha: government policy for each family to have 2 Ha. In Surabaya the pastures could be held by one company or person, local small-scale workers don't own land. Farming in Surabaya is mainly hand managed (non-industrialised), with good maintenance of soils.	
Functional-economic-infrastructure layers of vulnerability-sensitivity:	• technical & infrastructure • Markets & value effects • Employment & livelihoods	peri-urban expansion to S& W overtakes the infrastructure, with long commutes to industrial jobs. Peri-urban communities are polarized - with affluent professional / former rural now industrial workers.	
Eco-social-cultural layers of vulnerability-sensitivity:	• Affluence / deprivation • Education / communication • Cultural issues	Vulnerability decrease & sensitivity increases - higher resiliency: New suburbs & ex-urbs may lack social cohesion & capital. Community participation towards adaptive actions with environmental movement (e.g. mangrove plantation)	
Adaptive governance capacity-vulnerability-sensitivity-	• Local government • Public services & infrastructure • Emergency services • Civil & community	Government initiatives to foster community – private (associations & industries) – academics (e.g. CSR for public parks, river normalization, biophilia, bio pore)	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
GOVERNANCE			

Formal government, (governance, regulation)	Spatial planning green belt etc Housing policy Infrastructure development	2007 spatial planning act recognises the role of local government: practice of planning has improved & more actors are (formally) involved (e.g. developers, local people): but questions on 'real engagement'. Some governments have advanced digital systems.	
Adaptive / Associative governance: (networks, coalitions, partnerships)	Public sector Private sector Civic sector Citizens etc	For water policy government took a top down management view: more recently locals are involved in communications & outreach on waste management & pollution.	
Informality / elite capture / grassroots action:	Informal land-use, settlements, enterprise Corruption & nepotism Social innovation & enterprise for integrated livelihoods	Indonesian Corruption Watch (National – Local Level); WALHI – environmental issues; Indonesian Green Peace: Informal process of land acquisition and planning permission. High level local authority and private sector coalition (the elites) and political interests and goals	
System resilience, collective intelligence (combined formal / adaptive / informal)	Social learning & collaboration Social co-creation & mobilization potential System transformation potential	Social resiliency seems stable + high adaptive capacity; economic resiliency fluctuated – macro level is quite vulnerable, micro level (community level) is quite stable, impact of COVID-19 is significant for informal sectors (UMKM – micro/small enterprises).	

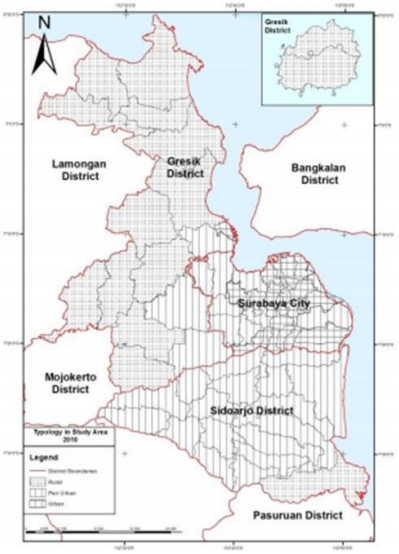
3.2 Peri-urban-climate: outline

Overview

- Surabaya Metropolitan Area is the second largest urban agglomeration after Greater Jakarta and the most rapidly growing urban region in Indonesia (by urban population size).
- In general, sprawl of large-scale residential enclaves surrounded by small housing clusters.
- Infilling urban development (housing, big and local retails) beyond the inner-city area
- Formation of contiguous urban areas between neighbouring regencies (Gresik at the north-west and Sidoarjo at the south).

The position of Surabaya as the capital city, main province, results in large commuting and population attraction to the city. CBD is declining, west and east are becoming industrial, stable growth in north and south. Two main airports. Suramadu bridge connects Surabaya and Madura Island. Peri-urban dominated by sprawling development. Central Surabaya is a green place, attracts visitors.

Climate & environment: increased flood vulnerability, & Urban Heat Island effect is increasing. UHI tends to decrease as more public paths are being developed, UHI in central Surabaya is lowering. In east and west UHI is low, due to area dominated by palm and mangrove. North and east development is overlapping with sea level rise areas. River pollution and acid rain.



1.	***PERI-URBAN THEMES:*** ***("drivers / stressors / exposure")***	***TYPICAL QUESTIONS***

Types of peri-urban. SW development, is clustered housing along roads, large areas of agriculture between road developments. The city is not developing based on the agricultural sector, it has mostly been relying on retail and industry, because the farmland is not governmentally protected there is rapid urban expansion into the agricultural zone.

(a)	**Spatial peri-urban types & patterns:**	• ***What is the main geographical type and structure in this city-region / peri-urban zone?***

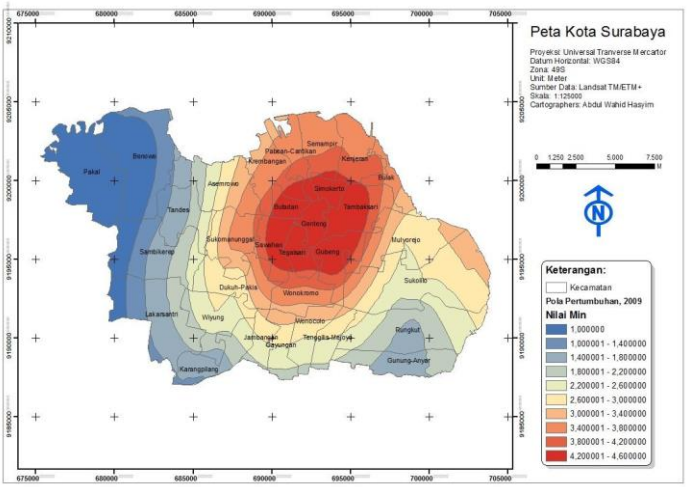
- Surabaya Metropolitan Area is the second largest urban agglomeration after Greater Jakarta and the most rapidly growing urban region in Indonesia (by urban population size).
- In general, sprawl of large-scale residential enclaves surrounded by small housing clusters.
- Infilling urban development (housing, big and local retails) beyond the inner-city area
- Formation of contiguous urban areas between neighbouring regencies (Gresik at the north-west and Sidoarjo at the south).
- Peri-urban of Surabaya city is an area bordering other cities that are included in the Gerbangkertasusila cluster (cities of Gresik, Bangkalan, Mojokerto, Sidoarjo, and Lamongan)

(b)	**Spatial peri-urban functional dynamics (growth / restructuring / transition).**	• ***How did it evolve / emerge to this situation?***

- Declining CBD, emerging growth towards the west and east, stable growth in the south and a re-growing north
- North – South transport hub (North = Tanjung Perak Port – the 2nd biggest port of the nation and South = Juanda international airport – 2nd biggest airport in Indonesia)
- National hubs attracted the growth of Industries and retails
- East – West growth dominated by private developers (Ciputra and Pakuwon).
- More dynamic growth is currently happening in the west
- Imminent rapid growth towards the east with climate and environmental challenges
- The Suramadu Bridge Factor – Increasing connectivity between Surabaya and Bangkalan (Madura Island) attracting more industrial investments on both sides.
- Sprawl development is more dominant than compact development in the peri-urban of Surabaya

(c)	**Other drivers (STEEP: social, technical, ecological, policy, culture etc)**	• ***What other causes and drivers of change are in the picture?***

- Sociocultural – Preferences towards living in the peri-urban, property investment motives (some residential areas have low occupancy rate)
- Economic consideration in residential preference
- Policy gap – urban centre Vs peri-urban.
- Ecological - decreasing area of green open space have turned into built-up areas (Figure 4)
- Culture - High attraction of Surabaya City for job seekers, makes the need for land in the city center very high, land prices soar, and maximum land use efficiency (Figure. 5)



(d)	**Global-local dynamics & inter-dependencies**	• ***Which are the key global / local conflicts & challenges this city-region / peri-urban zone?***

- Global transport hub and industrial development
- heavy burden on cities that need to provide urban facilities to peri-urban zone
- balancing technology, bussines, and environment – the challenge: human capital development for global outlook in the next 2-3 decades.

2.	***CLIMATE CHANGE THEMES ("causes / hazards"):***	

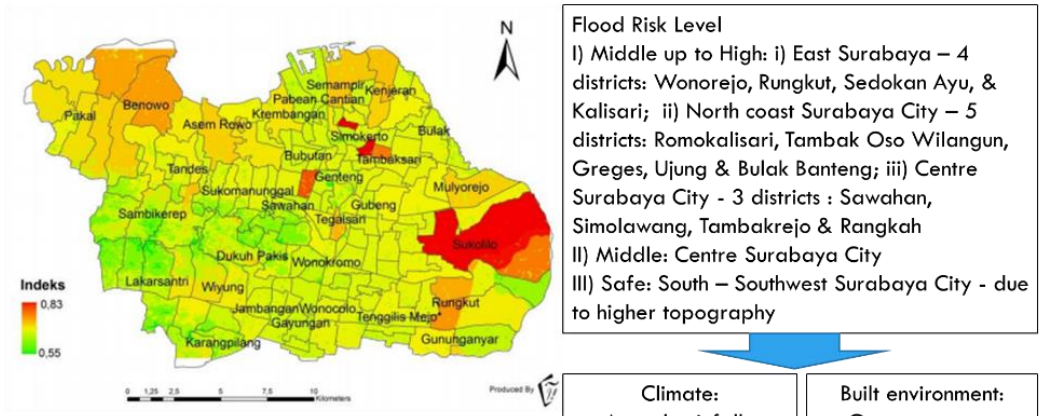
Increased flood vulnerability, Urban Heat Island effect is increasing. UHI tends to decrease as more public paths are being developed, UHI in central Surabaya is lowering. In east and west UHI is low, due to area dominated by palm and mangrove. North and east development is overlapping with sea level rise areas. River pollution and acid rain lead to…

UHI occurs in the central area of Surabaya, UHI is decreasing this is due to public park area increasing. Optimising public park location will continue to reduce UHI. Most UHI occurs in SE Surabaya. Flood risk area is primarily in the N and W. Vegetation cover has reduced in the NE since 1990.

(a)	**Climate change direct effects:**	• ***What are the main climate change projections for this area / city-region / peri-urban zone?***

- Increase in flood vulnerability throughout urban, inner-city and peri-urban, urban heat Islands

Due to high annual rainfall and incompatible drainage system + few green areas, flood occurs every peak of rainy season. Flood risk level: medium – high occurs at East & North Surabaya City (lowland areas); safe at South and Southwest Surabaya City (higher topography)



Flood Risk Level of Surabaya City

Source: https://apifa.or.id/assets/c4ra/journal/buku/surabaya/VI_surabaya.php

- UHI value tends to increase from sub-urban areas to Central Surabaya, caused by urban configuration variables such as building density, sky view factor, and land use.

The value of UHI in Surabaya City (at Central Surabaya) tends to decrease due to increasing number of green areas through public parks development by the government of Surabaya City (2002 – 2014 – 2019 Fig 1 & 2).

UHI at East Surabaya has tendency to increase from east and south sides to central side, indicated by higher temperature in the central due to ratio between open space and built-up areas, whereby in the downtown of East Surabaya is occupied by industrial area (Rungkut Industrial Zone) and Educational facilities, east part is dominated by green areas – ponds and mangroves (2001 – 2006 – 2011 – 2016 – 2019 Fig. 3 & Table 1).

UHI MAP OF SURABAYA CITY

(Source: Arik Yumna Pratiwi – final defence for bachelor degree at Departemen Geomatika ITS entitle "Analisis Perubahan Distribusi Urban Heat Island (UHI) Di Kota Surabaya Menggunakan Citra Satelit Landsat Multitemporal" July 23, 2020)

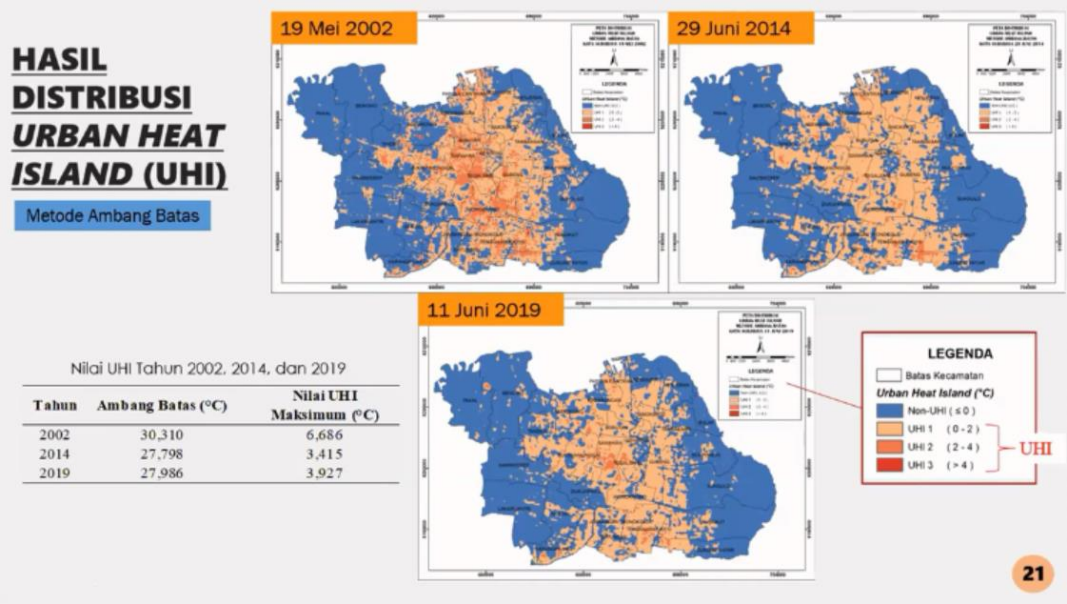


Figure 1. UHI with Threshold Method – Surabaya City

UHI occurs in the centre city of Surabaya

(b)	**Climate change direct hazards & impacts:**	• ***What are the expected / projected hazards, impacts and risks?***

- Sea level rise – North and east, with ongoing development of expanding urban enclaves overlapping the below sea level areas
- Tidal flood/landslides/drought

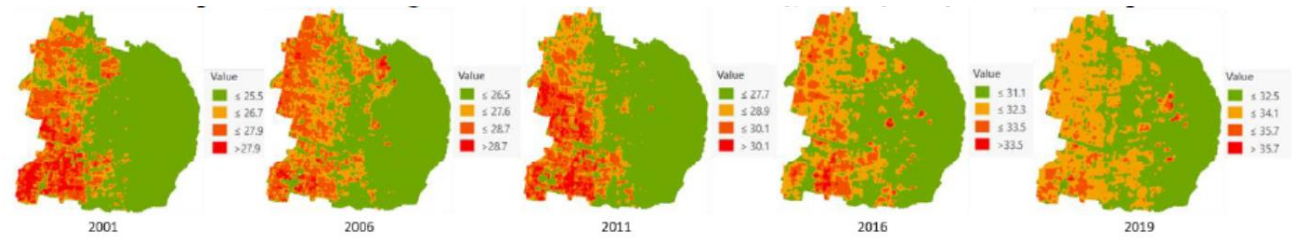


Figure 3. UHI Distribution at East Surabaya

Source: Rivan A W D Syafitri, A Pamungkas, and E B Santoso, Urban Form Factors that Play Important Roles on UHI Spatial-Temporal Pattern: A Case Study of East Surabaya, Indonesia, Open Access Proceedings Journal of Physics: Conference Series

-

(c)	**Indirect hazards & nexus effects**	• ***Which hazards and impacts are most critical for food, energy, water, other infrastructure?***

Acidic rain as an indirect effect of industrial gas emission flows into water bodies → soil & water contamination → effect on agricultural sector, public health, quality of drinking water (main source of drinking water for Surabaya city from river)

Indirect effects on built environment (housing prices, public facilities, critical fasilities), social vulnerability and economic vulnerability.

(d)	**Causal loops (peri-urbanization >> climate change)**	• ***How does the pattern of peri-urbanization cause further climate emissions or urban / rural impacts?***

- Commuters between Surabaya – Gresik Sidoarjo + Mojokerto Pasuruan Greater Malang + Madura island – majority by private cars/motors
- High mobilization, dynamic area development, fast population growth in these areas requires massive flows of energy, food, water and other goods generating desired output (goods & services) and by products (waste/emission) →emitting pollutant, GHGs → global warming → climate change
- Public transportation facilities, convenient and cheap are not evenly distributed, the number of motorized vehicles increases by 12% / year (Suara Surabaya, 2009). Increase CO^2 and temperature.
- Dependency on private modes-like of transportation, the growths of online taxis and taxibikes overrides the growth of public transportation

3.	***VULNERABILITY THEMES sensitivity / capacity***	

(a)	**Physical-ecological vulnerability-sensitivity**	• ***How far are the physical & ecological systems, vulnerable / sensitive or resilient / adaptive?***

Resilience of the city: moderate (RAN-API 2014)

National food security programme is not relevant to Surabaya city, the region must maintain farmland to ensure food security. Agriculture in Java island, family land ownership is small ~1/4 Ha, the government states that each family in Indonesia should have 2 Ha. In Surabaya satellite images the pastures could be held by one company or person, the local small-scale workers don't own land.

Farming in Surabaya is hand managed (non-industrialised), there is good maintenance of soils.

The ecological condition is part of Surabaya, the low lands are mostly covered by water, a residential area development in the east is much more difficult due to water management. This is less of an issue in the west there is much more water.

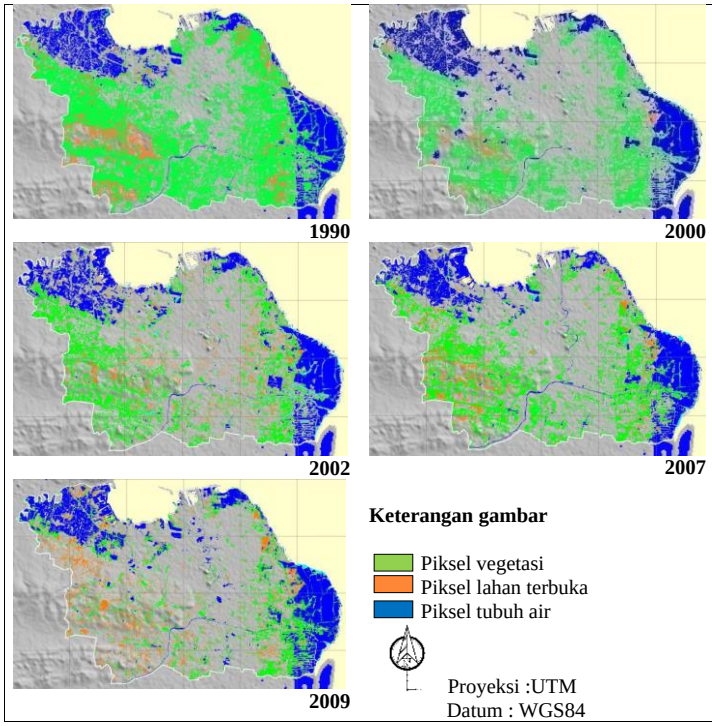


Figure 4. Decreasing area of green open space (big trees) have turned into built-up areas (Source: Abdul Wahid Hasyim, 2012)

(b)	**Vulnerability-sensitivity: functional-economic layers**	• ***How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?***

(temporarily understanding) No significant changes towards functional – economic layers (e.g. 3R – solid waste for sale in the scale of hamlet; plastic waste for bus ticketing)

(c)	**Vulnerability-sensitivity: social-cultural layers**	• ***How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?***

Vulnerability decrease, Sensitivity gradually increases –> higher resiliency: Community participation initiation towards adaptive actions – environmentally friendly movement (e.g. mangrove plantation)

(d)	**Vulnerability & adaptive capacity of social institutions**	• ***How far are key institutions (community, civic society, public services etc), vulnerable / sensitive or resilient?***

Vulnerability decrease, Sensitivity gradually increases –> higher resiliency: Government initiatives to foster community – private (associations & industries) – academics (e.g. CSR for public parks, river normalization, biophilia, bio pore)

4.	***GOVERNANCE THEMES:*** ***Adaptive action & governance***	

Former major of Surabaya was attentive to those living on riverbanks, trying to migrate them to high-rise apartments. This became a socio-political issue, the dividing river of Surabaya has a high risk of flood and poorer settlements along the riverbanks. In response to increasing flood risk.

The local government tried to introduce community waste management, citizens bring waste to informal facility, the govt pay community to collect waste. Waste separation is still difficult, no cultural knowledge, the separated waste is improving waste reduction in Surabaya.

Surabaya river condition, traditionally the government took a top down management view, locals have been involved in recent communications and outreach to reduce the amount of waste thrown in the river. The river is now getting cleaner, the citizens and major get to gether to plan environmental activity. Local activities have improved around mangrove conservation. Wells were built in the river, to reduce the river flow capacity. Road was doubled in size by the river, under the road is also river flow.

(a)	**Formal government, (governance, regulation)**	• ***How does local / regional government work here & which kind of policies, regulations or plans apply?***

- Spatial and sectoral development – the 2007 spatial planning act recognises local government authority's role to conduct spatial planning.
- The practice of planning has been improving and more actors are being (formally) involved (e.g. developers, local people) → However there are issues about 'real engagement'.
- Intensive coordination is necessary to be strengthened → between spatial - sectoral planning horizontally vertically diagonally

Environmental issues are now concerning, growth is directed to the west, because the east has more protected environmental components. The spatial planning of Surabaya stated a large catchment area needs protecting and conserved (1990 discussion). Private developers were asking for empirical evidence, at the time there was insufficient evidence. Developers argued that there is no need to put in place a policy agenda.

(b)	**Adaptive governance & institutions: (networks, coalitions, partnerships)**	• ***Are there networks, coalitions, partnerships etc, or any emerging signs of these?***

Dewan Nasional Perubahan Iklim (National Council for Climate Change) & REDD+ (2015 was diminished) – Direktorat Jendral Pengendalian Perubahan Iklim Environment Forestry Ministry → Badan Restorasi Gambut & Mangrove (Mangrove & Peatland Restoration Agency) → UNFCC Earth Summit; UN-Habitat; KOTAKU-UN: JICA-Ministry of Environment

(c)	**Informal governance, (corruption, community, livelihood,)**	• ***How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?***

- Indonesian Corruption Watch (National – Local Level); WALHI – environmental issues; Indonesian Green Peace

- Informal process of land acquisition and planning permission
- Informal process in the general process and procedures of planning
- High level local authority and private sector coalition (the elites) and the political interests and goals

(d)	**System effects, resilience, collective intelligence**	• ***What could be the overall resilience of the system, or collective capacity for learning & thinking?***

Social resiliency remains stable + high adaptive capacity; economic resiliency fluctuated – macro level is quite vulnerable, micro level (community level) is quite stable, however impact of COVID-19 is significant for informal sectors (UMKM – micro/small enterprises).

3.3 Annex

Basic data

SPATIAL DEVELOPMENT

Population city-region (metropolitan) - 13,100,000
Land area city-region - 5925 km2
Density city-region - 2200 pp/km2
Population city-region change
• Urban population dynamics (1990-2010):
• CBD declining 26%
• Peri-urban growth 350%

CLIMATE-ENVIRONMENT HAZARDS

(World Bank data - https://thinkhazard.org -)

Extreme heat - medium
Wildfire - HIGH
Water scarcity - medium
River flood - medium
Urban flood - medium
Coastal flood - HIGH
Cyclone - *(no data)*
Tsunami - medium
Landslide - low
Earthquake - medium
Volcano - HIGH

VULNERABILITY

Economic type - emerging lower-middle income

GDP /pp city-region	- $13655 / $47200 PPP
HDI (regional 2017)	- 0.81

Sources

Organisations, Programmes, and Projects

Research Centers, Sepuluh Nopember Institute of Technology
Description: research on climate adaptation, sustainability, infrastructure and disasters
https://www.its.ac.id/drpm/beranda/pusat/pusat-penelitian/

Surabaya City Development Planning Agency
Description: access to policy documents
https://bappeko.surabaya.go.id/informasi-publik

Reports and Policies

When non-climate urban policies contribute to building urban resilience to climate change: lessons learned from Indonesian cities, Asian Cities Climate Resilience
Description: report with several case studies in Surabaya
https://pubs.iied.org/pdfs/10630IIED.pdf

Policy Review: Opportunities for Enhancing Coastal Community Resilience and Climate Change Adaptation in Indonesia, USAID
Description: report contains case study of Surabaya's coastal vulnerability
https://www.crc.uri.edu/download/IMC_CCPolPaperFinal_11_12.pdf

Academic Articles

Pamungkas, A., Ciptaningrum, M. U., Jaelani, L. M., and Iranata, D. 2019. Surabaya Resilience Index for Potential Earthquakes: An Institutional Perspective. *Australasian Journal of Disaster and Trauma Studies*, 23(1)
Description: application of CDRI to earthquake preparedness
http://trauma.massey.ac.nz/issues/2019-1/AJDTS_23_1_Pamungkas.pdf

Sayidah Sulma, Eko Kusratmoko, & Ratna Saraswati. (2013). Coastal Physical Vulnerability of Surabaya and Its Surrounding Area to Sea Level Rise. *Makara Journal of Technology*, 16(2), 163-170.
Description: a vulnerability index and multi-criteria analysis of the Surabaya region
http://journal.ui.ac.id/technology/index.php/journal/article/view/1516

Some, Wawan, Hafidz, Wardah, & Sauter, Gabriela. (2009). Renovation not relocation: The work of Paguyuban Warga Strenkali (PWS) in Indonesia. *Environment & Urbanization*, 21(2), 463-475.
Description: relationship between a social movement and government regarding riverside settlements and climate relocation
https://journals.sagepub.com/doi/pdf/10.1177/0956247809343766

Kurniati, Ayu Candra, & Nitivattananon, Vilas. (2016). Factors influencing urban heat island in Surabaya, Indonesia. *Sustainable Cities and Society*, 27, 99-105.
Description: mixed method approach to urban heat islands and recommendations
https://doi.org/10.1016/j.scs.2016.07.006

Hawken, Scott, & Sunindijo, Riza Yosia. (2018). City of Kampung: Risk and resilience in the urban communities of Surabaya, Indonesia. *International Journal of Building Pathology and Adaptation*, 36(5), 543-568.
Description: risks and resilience of informal settlements
https://doi.org/10.1108/IJBPA-02-2018-0025

4 Changsha

Sources

- *Draft & raw material : Joe Ravetz, Dimas Adrianto, Joe Lake Rees (Manchester):*
- *Interviews on 17-05-21 and 19-02-21 with Prof. Kai Zhou: Dr Jin Ran.*

4.1 Peri-urban-climate: summary

This is a short overview of (a) problems / challenges, and (b) responses / pathways (to be developed in the workshop and beyond).

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
PERI-URBAN			
Spatial peri-urban types & patterns:	Urban direct expansion Urban / rural fringe & gradient Counter-urbanization effect Urban agglomeration effect	Peri-urban development is mainly in standard high rise blocks, which replace traditional agricultural lands. Rapid expansion of housing & industrial areas into former rural areas. Grid patterns are overlaid on a rich & complex landscape pattern.	
Spatial peri-urban dynamics (growth / restructuring / transition).	Population growth & housing Technology & infrastructure Economy & employment Real estate & markets	As capital of Hunan province, economic growth & restructuring has doubled its population in 30 years. Rapid development of road network has promoted peri-urban locations. New AirBnB type rental sector.	
Peri-urban other drivers (STEEP: social, technical, ecological, policy, culture etc)	Social demographics & lifestyle Environment & resources Policy & governance Culture & ethics	Rapid change & urbanization of rural areas & communities: Lower income areas are spread around. Government compensation for land acquisition promotes new urban lifestyles.	
Global-local dynamics & inter-dependencies	Internal structures external interactions power dynamics challenges & conflicts	Changsha is on new high speed rail network, with a flow of higher income groups & enterprises.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
CLIMATE			
Climate change direct effects:	temperature, precipitation, storm, coastal effects	Large increase precipitation in winter is projected, smaller in summer. Temperature increase between 2-6 degrees by 2100	
Climate indirect hazards & impacts:	wildfire, heatwave, drought, flood, storm, cyclone landslide, sea incursion etc,	Riverine flooding is already annual, will increase, mainly in the river valleys due to topography. Lakes to the north are seasonal with large fluctuations. Temp rise may change ecosystems with new diseases & pests.	
Indirect hazards & nexus effects	water resources farming & forestry energy & resources ecosystems & microclimates critical infrastructure	Hinterland of small hills shaped by rivers, prone to flooding, with unique wetlands: near urban areas are developed with high flood risk. Landuse is shifting to intensive farming in some areas of level ground.	
Causal loops (impacts of peri-urban on climate change)	CO2 emissions from energy GHG emissions from land-use Land-use & forestry change Carbon storage	Around Changsha many low hills with forest cover, with some tree loss in the hinterland. UHI is increasing along with air pollution.	

THEMES	*SCOPE & TOPICS*	*TYPICAL PROBLEMS*	*RESPONSES: FUNCTIONAL*
VULNERABILITY			
Physical-ecological vulnerability-sensitivity	• Soil & vegetation • Topography & stability • Settlement form & structure	Many settlements are on the edge of water bodies, with risk of future flooding. Landscape to W has unique combination of housing / forest with low paddy fields with frequent flooding.	
Functional-economic-infrastructure layers of vulnerability-sensitivity:	• technical & infrastructure • Markets & value effects • Employment & livelihoods	Rural livelihoods are rapidly urbanized (with land compensation some buy a large car, gamble & start a business). Few have house insurance, but house construction is durable & govt provides basic compensation.	
Eco-social-cultural layers of vulnerability-sensitivity:	• Affluence / deprivation • Education / communication • Cultural issues	could be social conflicts between new urban & old rural: social cohesion / capital is lacking in new urban areas.	
Adaptive governance capacity-vulnerability-sensitivity-	• Local government • Public services & infrastructure • Emergency services • Civil & community	Generally strong centralized forms of government & public services, but with underlying elite patronage.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
GOVERNANCE			
Formal government, (governance, regulation)	Spatial planning green belt etc Housing policy Infrastructure development	Some tension between central, province & city government: & between sustainability & economic growth objectives. Multi-level integrated water & ecological planning is new, also local LID policies & codes.	
Adaptive / Associative governance & institutions: (networks, coalitions, partnerships)	Public sector Private sector Civic sector Citizens etc	National Yangtze protection zone : some regional sustainable development zones. Some civic NGOs are involved, basic citizen participation	
Informality / elite capture / grassroots action:	Informal land-use, settlements, enterprise Corruption & nepotism Social innovation & enterprise for integrated livelihoods	To discuss…	
System resilience, collective intelligence (combined formal / adaptive / informal)	Social learning & collaboration Social co-creation & mobilization potential System transformation potential	To discuss…	

4.2 Peri-urban-climate: outline

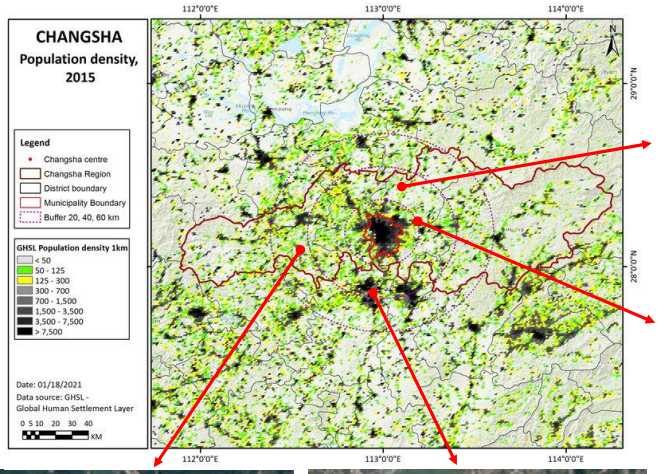
PERI-CENE PROFILE

Changsha is a historic centre (home to Mao Tse-Tung in the 1920s). It is now a rapidly expanding provincial capital, located on a large river system, with a fertile and mountainous hinterland.

Peri-urban development is mainly in standard high rise blocks, which replace traditional agricultural lands. Climate risks include storm, heat, wildfire and regular urban flooding. These are generally under control, but as climate change increases, the effects may be very challenging.

1.	***PERI-URBAN THEMES:*** ***("drivers / stressors / exposure")***	***TYPICAL QUESTIONS***
(a)	Spatial peri-urban types & patterns:	• *What is the main geographical type and structure in this city-region / peri-urban zone?*

Changsha is the Capital of Hunan Province, one of the top 10 most populated regions in China. The growth of urban population has been remarkable from 1.1 million in 1991 to 4.7 million in 2021. Changsha is surrounded by hills, which serve as a constraint to urban expansion.



Water reservoirs at the north peri-urban serving as a vital flood regulator

Growth of Industrial estates beyond the east urban-rural boundary surrounded by low density development of peri-urban settlements

Agricultural areas at the west peri-urban surrounded by low density rural settlements / community

Peri-urban centres – Medium density development of high class residential areas

- Changsha is design as a compact city, with encouragement of high-rise development. Within the inner-city zone (particularly at the west side of the Xiangjiang River), there are development of industrial estates. This area in particular is strictly regulated where only of those green and high-tech industries will be approved for development.
- Urban areas are expanding in a slow rate as the central government applies strict measures in granting development in the peri-urban spaces. The expansion of urban areas is mainly towards the west with enclaves of industrial estates surrounded by low density peri-urban settlements and towards the south forming new suburban centres of high-class medium density residential development.
- In the north peri-urban areas, there are sites managed as water reservoirs which is vital to regulate floods. Meanwhile, the west peri-urban areas comprise of agricultural lands and enterprises surrounded by low-density rural settlements.
- For every agricultural land being converted to urban areas, the landowners are given great amount of financial compensation from the central government. To some extent, this is problematic as there are tendencies for landowners, who profited from the compensatory scheme, to purchase properties in the inner-city zone. Their migration into the urban areas contributed to the abandonment of agriculture. With uncertainties of jobs in the urban centres and their lack of financial investment literacy, they have been put into severe social and economic vulnerability. In overall, this compensatory scheme potentially accelerates urban expansion, while at the same time can cause the proses of rural-urban transformation to become socially and economically problematic. However, it is strictly prohibited for individuals and local authorities to put peri-urban lands on market. The utilisation of peri-urban lands fall under the discretion of the central government.

(b)	Spatial peri-urban functional dynamics (growth / restructuring / transition).	• *How did it evolve / emerge to this situation?*

(c)	Other drivers (STEEP: social, technical, ecological, policy, culture etc)	• *What other causes and drivers of change are in the picture?*

(d)	Global-local dynamics & inter-dependencies	• *Which are the key global / local conflicts & challenges this city-region / peri-urban zone?*

2.	***CLIMATE CHANGE THEMES ("causes / hazards"):***	
(a)	Climate change direct effects:	• *What are the main climate change projections for this area / city-region / peri-urban zone?*

Under emission scenario B2 (mid-low emission scenario) temperature will increase across China at by 1.2 °C, 2.2 °C, and 3.2 °C, by 2020s, 2050s, and 2080s respectively. [2]

(b)	Climate change direct hazards & impacts:	• *What are the expected / projected hazards, impacts and risks?*

Changsha is prone to flooding from the overflowing Xiangjiang River. One of the most recent flood disasters happened in September 2020 (Xinhuanet, 2020 - https://bit.ly/2Oq5UOp) with the collapse of over 21,000 of homes and 628,000 hectares of agricultural lands damaged.

(c)	Indirect hazards & nexus effects	• *Which hazards and impacts are most critical for food, energy, water, other infrastructure?*

(d)	Causal loops (peri-urbanization >> climate change)	• *How does the pattern of peri-urbanization cause further climate emissions or urban / rural impacts?*

Urbanisation is driving the urban heat island effect, which is the main cause of air temperature increase in the city of Changsha. [4]

Water reservoirs is one of the most important environmental components of the peri-urban multi ecosystem services. It is a regulator of flood during heavy rainfall. Other times they are fields for growing agricultural produce.

3.	***VULNERABILITY THEMES sensitivity / capacity***	
(a)	Physical-ecological vulnerability-sensitivity	• *How far are the physical & ecological systems, vulnerable / sensitive or resilient / adaptive?*

(b)	Vulnerability-sensitivity: functional-economic layers	• *How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?*

Breeding stress-resistant crops, developing new agri-tech / biotech, promoting large scale superior crop plantation, new farming technique adoption.

(c)	Vulnerability-sensitivity: social-cultural layers	• *How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?*

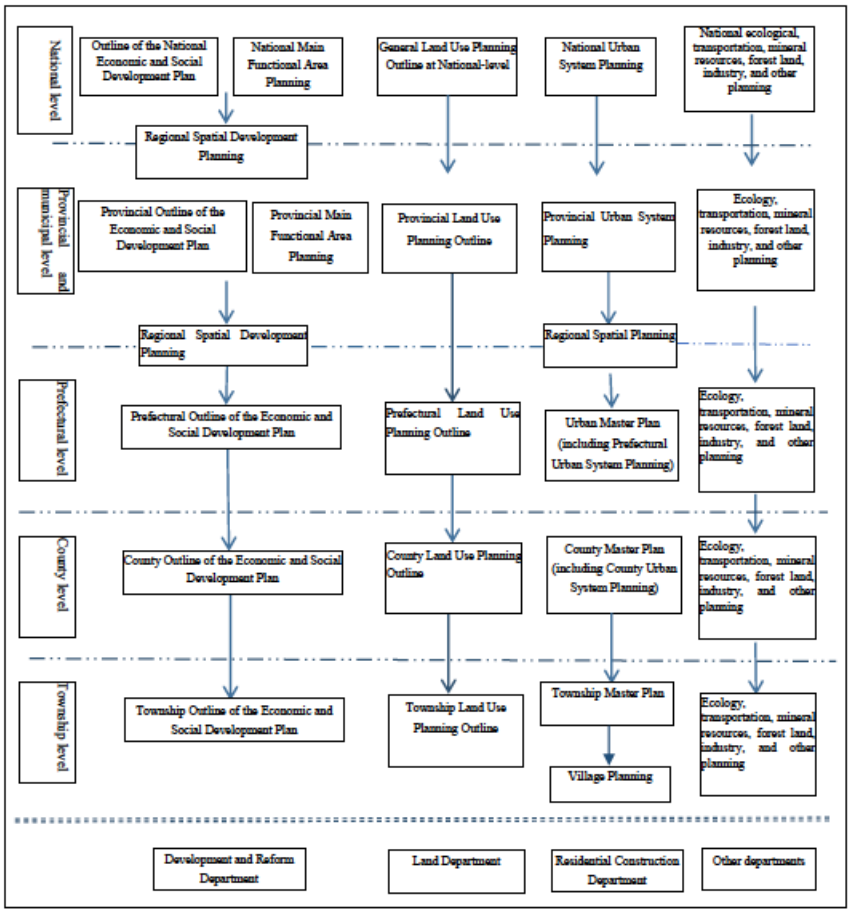
South-to-North Water Transfer Project may cause potential risk area for schistosomiasis in 2040, potential transmission area in 2050. [1]

(d)	Vulnerability & adaptive capacity of social institutions	• *How far are key institutions (community, civic society, public services etc), vulnerable / sensitive or resilient?*

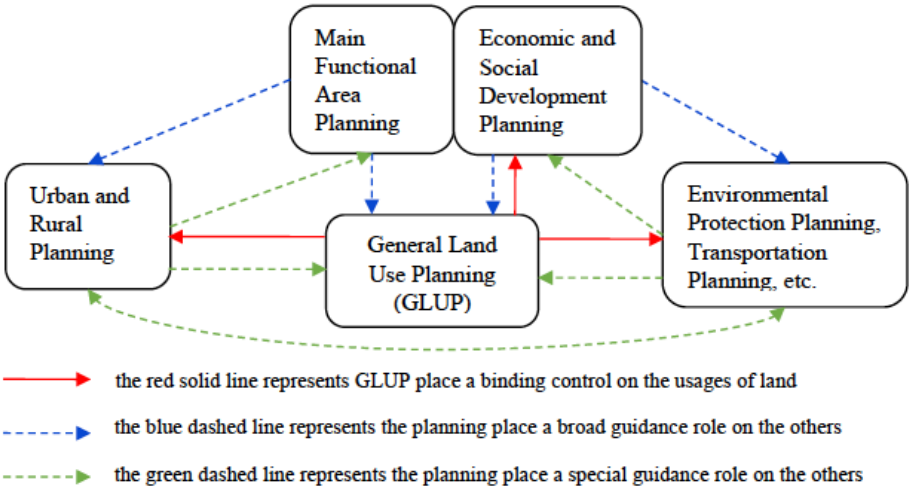
Urban greening modelled showed potential to reduce average air temperature by 0.1 - 0.6 °C, addresses urban heat island. [6]

4.	***GOVERNANCE THEMES:*** ***Adaptive action & governance***	
(a)	Formal government, (governance, regulation)	• *How does local / regional government work here & which kind of policies, regulations or plans apply?*

- In general, China applies a strong Central-local hierarchical spatial planning system. There are 5 themes of planning - (1) Social and economic development plan, conducted by the Development and Reform Department; (2) Land use plan, administered by the Land and Resource Department; (3) Urban and rural planning, conducted by the Urban and Rural Construction Department; (4) Environmental Protection Planning under the Environmental Protection Department and (5) Water conservation planning, which involve other various departments. In practical and constitutional terms, the construction and implementation of spatial planning in China is supervised by the 5 different spatial governance scale levels – Central (national), provincial, municipality (prefectural), county and town.



Spatial Planning Framework in China (Zhou et al. 2017)



Relationship between land use plan and other forms of planning in China (Zhou et al. 2017)

- Beyond the economic reformation, there were increasing competitions among localities to attract investments particularly in the industrial sectors (Wang and Shen, 2014). This brought to challenging times in managing the growth of investments at the provincial and municipal scales. As a response, the central government introduced a new regional planning mechanism as an innovative policy approach to enhance the 5 yearly development plans (which had been disregarded due to the rise of market-oriented planning). This instrument focuses in managing development at a regional level and to ensure the placement of central government control towards development.
- An example of the strong influence of central government in Changsha is how the pro-environmental ideology of the President, which, upon his visit to Hunan Province addressed the importance of XIangjiang River and other ecosystem services within the peri-urban areas as imperative natural capital, was believed to be a strong factor to the urban containment policy of Changsha.

(b)	Adaptive governance & institutions: (networks, coalitions, partnerships)	• *Are there networks, coalitions, partnerships etc, or any emerging signs of these?*

(c)	Informal governance, (corruption, community, livelihood,)	• *How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?*

(d)	System effects, resilience, collective intelligence	• *What could be the overall resilience of the system, or collective capacity for learning & thinking?*

4.3 Annex

Basic data

SPATIAL DEVELOPMENT

Population city-region (i.e. prefecture)	- 8.15m
Land area city-region	- 11819 km2
Density city-region	- 690 pp/km2
Population city-region change	

CLIMATE-ENVIRONMENT HAZARD

(World Bank data on https://thinkhazard.org – for Changsha City)

Extreme heat	- HIGH
Wildfire	- HIGH
Water scarcity	- low
River flood	- medium
Urban flood	- HIGH
Coastal flood	- *(no data)*
Cyclone	- HIGH
Tsunami	- *(no data)*
Landslide	- low
Earthquake	- low
Volcano	- *(no data)*

VULNERABILITY

Economic type	- upper middle, rapid growth
GDP /pp city-region	- $21000 ($40900 ppp)
HDI (national 2017)	- 0.752

Sources:

[1] Climate Change Impacts on Central China and Adaptation Measures. Ren Yong-Jian, Cui Jiang-Xue, Wan Su-Qin, Liu Min, Chen Zheng-Hong, Liao Yu-Fang & Wang Ji-Jun

[2] China's National Assessment Report on Climate Change (II): Climate change impacts and adaptation. Lin Erda, Xu Yinlong, Wu Shaohong, Ju Hui & Ma Shiming

[3] Simulating Climate Change Impacts and Adaptive Measures for Rice Cultivation in Hunan Province, China. Yamei Li, Wenxiang Wu, Quansheng Ge, Yang Zhou & Chenchen Xu.

[4] Exploring harmonious development between urbanization and eco-environment based on climate analysis—A study in Changsha, China. LIU Shao-bo, WEI Chun-yu, GUO Ya-qi, ZENG Xiao-xia, LIU Su, YIN Yi-chen & LIU Yun-guo.

[5] Temperature-based fire frequency analysis using machine learning: A case of Changsha, China. Zhisheng Xu, Dingli Liu & Long Yan.

[6] Numerical Simulation of Local Climate Zone Cooling Achieved through Modification of Trees, Albedo and Green Roofs—A Case Study of Changsha, China. Yaping Chen, Bohong Zheng & Yinze Hu.

[7] An Integrated Approach to Evaluate Urban Adaptive Capacity to Climate Change. Qiangsheng Hu & Xiaorong He

[8] The Lag Effects and Vulnerabilities of Temperature Effects on Cardiovascular Disease Mortality in a Subtropical Climate Zone in China. Jixia Huang, Jinfeng Wang & Weiwei Yu

[9] The integrated eco-environment assessment of the red soil hilly region based on GIS—A case study in Changsha City, China. Li, Zhong-Wu, Zeng, Guang-Ming, Zhang, Hua, Yang, Bin, Jiao &Sheng

General sources

Organisations, Programmes, and Projects

Key Laboratory of Hunan Universities of Resources Use and Environment Change in Dongting Lake Basin, Hunan Normal University

Description: research group on flooding and urban development

https://english.hunnu.edu.cn/info/1135/1276.htm

Green Hunan

Description: environmental NGO focusing on environmental problems in the river basin, based in Changsha

http://www.greenhunan.org.cn/

湖南省人民政府

Description: Provincial Government Departments and Laws

http://www.hunan.gov.cn/hnszf/fzlm/wzdh/szdw/szdh.html

Academic Articles

Liu, S., Wei, C., Guo, Y. et al. (2011). Exploring harmonious development between urbanization and eco-environment based on climate analysis—A study in Changsha, China. *J. Cent. South Univ. Technol.* 18, 101–107

Description: quantitative analysis of relationship between urbanization and temperature change

https://doi.org/10.1007/s11771-011-0666-x

Hu, Q.; He, X. 2018. An Integrated Approach to Evaluate Urban Adaptive Capacity to Climate Change. *Sustainability*, 10, 1272.

Description: entropy, relational and index analysis of urban adaptive capacity

https://doi.org/10.3390/su10041272

Wang, Y., Li, Z., Tang, Z. et al. A GIS-Based Spatial Multi-Criteria Approach for Flood Risk Assessment in the Dongting Lake Region, Hunan, Central China. *Water Resour Manage* 25, 3465–3484 (2011).

Description: quantitative analysis with a database of vulnerability indicators

https://doi.org/10.1007/s11269-011-9866-2

Chen, Y.; Zheng, B.; Hu, Y. 2020. Numerical Simulation of Local Climate Zone Cooling Achieved through Modification of Trees, Albedo and Green Roofs—A Case Study of Changsha, China. *Sustainability*, 12, 2752.

Description: scenario modeling for different temperature cooling options

https://doi.org/10.3390/su12072752

5 Bangkok

Sources

- *Drawn from interview 04-03-21*
- *With advice from Prof. Asan Suwannarit, Prof. Danai Thaitakoo, Dr. Kim Neil Irvine*

5.1 Peri-urban-climate - summary

This is a short overview of (a) problems / challenges, and including space for (b) responses / pathways (to be developed in the workshop and beyond).

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
PERI-URBAN			
Spatial peri-urban types & patterns:	Urban direct expansion Urban / rural fringe & gradient Counter-urbanization effect Urban agglomeration effect	Rapid urbanization of formerly rural areas with industrial & residential development. A complex interaction of new urban development overlaid on existing field patterns, canal & paddy farming systems. Urban expansion to the W more intense with agricultural land takes by urban development. To the N & E peri-urban is mainly in agriculture (prime irrigated parcels) but with growing urban pressure.	
Spatial peri-urban dynamics (growth / restructuring / transition).	Population growth & housing Technology & infrastructure Economy & employment Real estate & markets	Historic primate city, major port and economic powerhouse of Thailand. Bangkok's rapid growth coupled with little urban planning has resulted in a haphazard cityscape and inadequate infrastructure.	
Peri-urban other drivers (STEEP: social, technical, ecological, policy, culture etc)	Social demographics & lifestyle Environment & resources Policy & governance Culture & ethics	Peri-urban development is led by corporate real estate with many forms of suburban and ex-urban development, displacing water-intensive cultivation. The water system & rural field pattern is the main shaper of the urban form. Even with rapid expansion, growing housing shortage & land price inflation.	
Global-local dynamics & inter-dependencies	Internal structures external interactions power dynamics challenges & conflicts	Many developers buy up farming land, some with international finance. The coup made further complications in government & financial systems.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
CLIMATE			
Climate change direct effects projections	temperature, precipitation, storm, coastal effects	Precipitation: summer slow increase is projected: winter major reduction. Temperature rise projection of 1.8 – 5.5 degrees by 2100 Sea level rise – much of coast area is below 2m: most of region 2-4m above sea level. Climate-environment prospects on a tropical savannah coastal location: high risk of extreme heat & wildfire, coastal flooding & cyclone.	
Climate indirect hazards & impacts:	wildfire, heatwave, drought, flood, storm, cyclone landslide, sea incursion etc,	Droughts, coastal and riverine floods (Chao Phraya River). Bangkok is on average 1m above sea level, and currently sinking due to over consumption of groundwater: , combined with sea level rise the risk of coastal flooding increases faster than other coastal areas of Thailand	
Indirect hazards & nexus effects	water resources farming & forestry energy & resources ecosystems & microclimates critical infrastructure	Sea level rise causing salination of farmland: lack of tree cover & biodiversity in the city-region.	
Causal loops (impacts of peri-urban on climate change)	CO2 emissions from energy GHG emissions from land-use Land-use & forestry change Carbon storage	chronic traffic congestion and severe air pollution. Urban heat island - temp increase of 13 °C. International airport was located on agricultural land reducing water drainage services: illegal construction obstructs drainage efficiency, increasing flood severity.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
VULNERABILITY			
Physical-ecological vulnerability-sensitivity	• Soil & vegetation • Topography & stability • Settlement form & structure	With the decline of green open spaces, and destruction of irrigation canal (which also functions as flood regulator) some areas in the peri-urban are prone to flooding. The recent major flood disaster in the north peri-urban triggered temporary out-migration, but now people have returned to inhabit the peri-urban.	
Functional-economic-infrastructure layers of vulnerability-sensitivity:	• technical & infrastructure • Markets & value effects • Employment & livelihoods	As the worlds largest rice exporter, 40% of Thai population rely on agriculture for employment. Tropical storms, and droughts are likely to affect future rice yields. Livestock farming may be at risk due to heat stress, and disease outbreaks. Freshwater fish populations affected during drought periods.	
Eco-social-cultural layers of vulnerability-sensitivity:	• Affluence / deprivation • Education / communication • Cultural issues	Heat stress & water borne diseases e.g. dengue fever. Weather related air pollution will increase with temperature & humidity. Summer heatwaves will affect health labour productivity & increase urban energy consumption: large numbers of migrants are predicted.	
Adaptive governance capacity-vulnerability-sensitivity-	• Local government • Public services & infrastructure • Emergency services • Civil & community	Water management has no central regulation framework; eight agencies, each uncoordinated regulate water use around Thailand. Village level water management is active & in some cases participatory governance.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
GOVERNANCE			
Formal government, (governance, regulation)	Spatial planning green belt etc Housing policy Infrastructure development	Land use planning is ineffective, vested interests shape plans. Recent attempt to transfer authority for spatial planning national to local level. Private sector have already acquired many of the peri-urban lands before land use policy was constructed. Local governments favour 'hard' water management & flood defence.	
Adaptive / Associative governance: (networks, coalitions, partnerships)	Public sector Private sector Civic sector Citizens etc	Environmental grassroot movements of farmers, reconstructing natural water system to mitigate flooding while maintaining supply for crops. But when private sectors approach to purchase their lands at higher prices, they release them & move to another job in the industrial sectors.	
Informality / elite capture / grassroots action:	Informal land-use, settlements, enterprise Corruption & nepotism Social innovation & enterprise for integrated livelihoods	lack of environmental law enforcement, and lack of climate change response framework. Corruption in political systems, and low institutional capacity to consult, and manage real commitments. In the past budgets have been diverted to crony projects, infrastructure investment has suffered.	
System resilience, collective intelligence (combined formal / adaptive / informal)	Social learning & collaboration Social co-creation & mobilization potential System transformation potential	Governance is contested between a centralizing state, under-resourced local authorities, some civic groups & some farmers groups.	

5.2 Peri-urban-climate: outline

Historic primate city, major port and economic powerhouse of Thailand. Bangkok's rapid growth coupled with little urban planning has resulted in a haphazard cityscape and inadequate infrastructure. An inadequate road network with substantial private car usage, have led to chronic and crippling traffic congestion and severe air pollution.

Peri-urban development is led by corporate real estate with many forms of suburban and ex-urban development, displacing water-intensive cultivation.

Climate-environment prospects on a tropical savannah coastal location: high risk of extreme heat and wildfire, coastal flooding and cyclone with other forms of flooding also likely.

1.	***PERI-URBAN THEMES: ("drivers / stressors / exposure")***	***TYPICAL QUESTIONS***

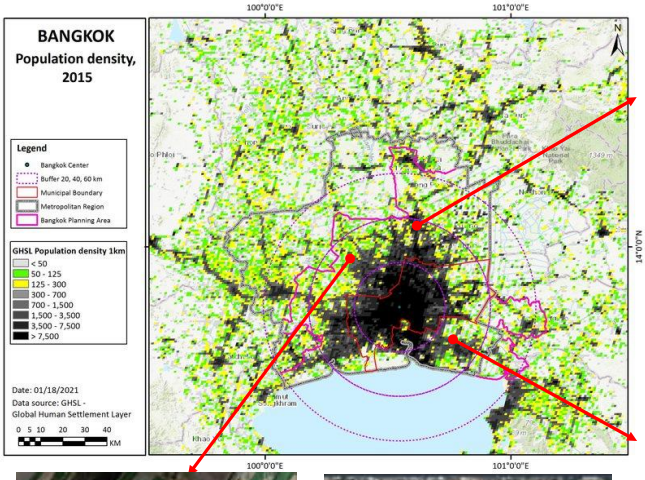
Bangkok is at the heart of urbanising Thailand. With a rapidly increasing urban population, Bangkok's urban areas have expanded in different directions as more investment in the economic and residential sectors are bringing change to the peri-urban areas. Urban expansion towards the west are more intense with increasing rate of agricultural land takes by urban development. Meanwhile, the north and east peri-urban, although at the current time remains predominantly agriculture (prime irrigated parcels) but the pressure of urban development is beginning to deliver rural-urban transformation.

(a)	**Spatial peri-urban types & patterns:**	• ***What is the main geographical type and structure in this city-region / peri-urban zone?***

(b)	**Spatial peri-urban functional dynamics (growth / restructuring / transition).**	• ***How did it evolve / emerge to this situation?***

(c)	**Other drivers (STEEP: social, technical, ecological, policy, culture etc)**	• ***What other causes and drivers of change are in the picture?***

(d)	**Global-local dynamics & inter-dependencies**	• ***Which are the key global / local conflicts & challenges this city-region / peri-urban zone?***



An emerging peri-urban centre in the north of Bangkok towards Ayutthaya. Prime agricultural lands being converted to middle-high class housing, universities and industrial estates.

Suvarnabhumi Airport has been a factor attracting growth in the east peri-urban. Land prices have risen for more than 200% since their operational

Peri-urban agriculture - Irrigated farm lands co-existing with the local community. More agricultural lands are being converted to housing and industries as urban-rural transformation is becoming more intense in the west peri-urban

Medium to high density development and mixture of rural-urban economy in the south peri-urban. These areas are prone to flooding and is highly vulnerable to sea level rise

- Agriculture remains a significant sector for local economy and a contributor to the national GDP. As one of the biggest agricultural nations, Thailand had big agenda to develop their agricultural sector. Since 1700s and proceeding in the past 100 years, Thailand has been extending the irrigation network to maintain productivity of the farming parcels. As a result, many of the agricultural lands within the peri-urban areas are prime and highly productive until recently.
- Rural-urban transformation take place by first by the abandonment of agricultural lands by cutting them of form the irrigation canal. Usually industrial development follows this phase before residential areas are constructed in the following stages. In social-economic terms, there are transformation of jobs from farming to manufacturing industries. Following the agricultural land takes, the construction of manufactures or real estate is usually followed by further damage of the irrigation system. This cause a growing number of abandoned agricultural lands and hence attracted further land takes.
- Land morphology is a factor determining land conversion. Land that are too narrow are usually less attractive particularly to the residential sector. This is apparent in lands obtained from individual farmers, hence are converted slower than elsewhere.
- Part of the peri-urban settlements are informal with poor infrastructure and public services. These settlements usually occur alongside the river/irrigation canal. In these particular areas, the canal also accommodates transport (water taxis) for local mobilisation. Being located alongside the canal means that these informal housing is inhabited on public lands. Another reason for the use of canal transportation is the conflict between new Vs pre-existing residential areas. Most of the pre-existed informal settlements are bypassed of access due to constriction of real estates.
- There is also significant growth of high-rise apartments within the peri-urban, mainly designated for industrial workers. Some of these apartments did not come with sufficient infrastructure and public services.
- With the decline of green open spaces, and destruction of irrigation canal (which also functions as flood regulator) some areas in the peri-urban are prone to flooding. The recent major flood disaster in the north peri-urban triggered temporary out-migration, but now people have returned to inhabit the peri-urban.

2.	***CLIMATE CHANGE THEMES***	

	("causes / hazards"):	

(a)	**Climate change direct effects:**	• ***What are the main climate change projections for this area / city-region / peri-urban zone?***

Droughts, coastal and riverine floods (Chao Phraya River). Bangkok is on average 1m above sea level, and currently sinking due to over consumption of groundwater, combined with sea level rise the risk of coastal flooding increases faster than other coastal areas of Thailand [2].

(b)	**Climate change direct hazards & impacts:**	• ***What are the expected / projected hazards, impacts and risks?***

Flooding, particularly Minburi district. Flooding in and around Bangkok can last over a month [1]. Heat stress and water borne diseases are likely to increase such as dengue fever. Weather related air pollution will continue to increase as temperature and humidity increase. Summer heatwaves will affect health labour productivity and increase urban energy consumption. Increased global migration by 2050, Bangkok predicted to receive large numbers of migrants. Bleaching corals may reduce tourism to the area, having negative economic consequences. [2]

•

(c)	**Indirect hazards & nexus effects**	• ***Which hazards and impacts are most critical for food, energy, water, other infrastructure?***

Strained healthcare infrastructure in response to flood borne diseases. Farming industry affected by flooding [1]. Thailand is the worlds largest rice exporter, 40% of the population rely on agriculture for employment. Tropical storms, and droughts are likely to affect future rice yields. Livestock farming may be at risk due to heat stress, and disease outbreaks. Freshwater fish populations have been and my continue to be affected during drought periods. [2]

(d)	**Causal loops (peri-urbanization >> climate change)**	• ***How does the pattern of peri-urbanization cause further climate emissions or urban / rural impacts?***

Urban heat island in Bangkok looks to have an increase effect of 13 °C. International airport was located on agricultural land reducing water drainage services, this may increase future flood intensity [3]. Illegal construction obstructs drainage efficiency, increasing flood severity [4].

3.	***VULNERABILITY THEMES sensitivity / capacity***	

(a)	**Physical-ecological vulnerability-sensitivity**	• ***How far are the physical & ecological systems, vulnerable / sensitive or resilient / adaptive?***

Climate change will erode coasts; destroy mangroves, and coral reefs. These are protective barriers to the coast. [2]

(b)	**Vulnerability-sensitivity: functional-economic layers**	• ***How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?***

Water management has no central regulation framework; eight agencies, each uncoordinated regulate water use around Thailand. [2] Bangkok economy focuses around manufacturing, and retail it is unclear how these will be affected by climate change. [3]

(c)	**Vulnerability-sensitivity: social-cultural layers**	• ***How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?***

Infrastructure protecting inner Bangkok can exacerbate flooding in the surrounding areas [1]. Community and NGO climate action has prevented potentially damaging infrastructure from going ahead. NGO Thai working Group for Climate Justice (TCJ), submitted a civic position at COP 15. Thai NGO knowledge and participation is likely to grown in the future [2]

(d)	**Vulnerability & adaptive capacity of social institutions**	• ***How far are key institutions (community, civic society, public services etc), vulnerable / sensitive or resilient?***

Flood preparedness is generally undertaken at a private household level not community level [1]. Office of Natural Resources and Environmental Policy and Planning have little authority, and not enough resources. There is a lack of coordination between government ministries. Frequent governmental changes impede clear and consistent climate policy implementation. Local governments are not financially or intellectually resourced enough to implement local climate action. There is a lack of environmental law enforcement, and lack of climate change response framework. Corruption in political systems, and low institutional capacity to consult, and create/monitor concrete commitments. In the past budgets have been diverted to specific crony like projects, public infrastructure investment has suffered [2]. Land use planning is ineffective, vested interests shape plans. [4]

4.	***GOVERNANCE THEMES:*** ***Adaptive action & governance***	

(a)	**Formal government,** **(governance, regulation)**	• ***How does local / regional government work here & which kind of policies, regulations or plans apply?***

- There was an attempt to transfer power/authority for spatial planning policy from the national level to local level but was not smoothly done due to institutional conflicts. Due to dynamics of politics and governance, policy and decision making is now back in the hands of the central government. However, there is an advantage for this as there are problems with institutional capacity among local authorities, which potentially create disintegration if planning were conducted fully at local level. Managing peri-urbanisation and the mitigation of flood and other environmental agenda are strategic policy sector that needs to be managed and decided by a macro / higher level authority.
- Problems with peri-urban planning – Private sector have already acquired many of the peri-urban lands before land use policy was constructed.

(b)	**Adaptive governance & institutions: (networks, coalitions, partnerships)**	• ***Are there networks, coalitions, partnerships etc, or any emerging signs of these?***

(c)	**Informal governance,** **(corruption, community, livelihood,)**	• ***How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?***

- There are grassroot movement of farmers who are concerned with the environment by reconstructing natural water system to mitigate flooding while maintaining the supply of water for crops. The problem is there are only a few and when private sectors approach to purchase their lands at higher prices, they release them and started to move to another job in the industrial sectors.

(d)	**System effects, resilience, collective intelligence**	• ***What could be the overall resilience of the system, or collective capacity for learning & thinking?***

5.3 Basic data

SPATIAL DEVELOPMENT
Population (metropolitan area) - 14.6m
Land area (metropolitan area) - 7761 km2

Density (metropolitan area)	- 1900 pp/km2
Population city-region change	-
CLIMATE HAZARD	
(World Bank data - https://thinkhazard.org -)	
Extreme heat	- HIGH
Wildfire	- HIGH
Water scarcity	- medium
River flood	- medium
Urban flood	- medium
Coastal flood	- HIGH
Cyclone	- HIGH
Tsunami	- *(no data)*
Landslide	- low
Earthquake	- low
Volcano	- *(no data)*
VULNERABILITY	
Economic type	- emerging upper-middle income
GDP /pp city-region	- $14360 USD
HDI (national 2017)	- 0.755

5.4 Sources

Citations

[1] Enhancing Adaptation to Climate Change by Impact Assessment of the Flood in Bangkok. W. A. Marome.
[2] Climate Change and Thailand: Impact and Response. D. Marks.
[3] Urbanising Thailand: implications for climate vulnerability assessment. R. M. Friend, K. Hutanuwatr, Y. Inmuong & B. Lambregts.
[4] Urban Flooding and Climate Change: A Case Study of Bangkok, Thailand. N. Thanvisitthpon, S. Shrestha & I. Pal.
A Preliminary Review on Frameworks for Thai Climate Risk and Approaches in Social/Economic Vulnerability Assessment in Bangkok. K. Hutanuwatr.

General sources

Organisations, Programmes, and Projects
Bangkok, C40 Cities
Description: city profile and case studies
https://www.c40.org/cities/bangkok

Reports and Policies
Bangkok Climate Change Plan, Bangkok Metropolitan Administration
Description: mitigation and adaptation measure and implementation plan
http://www.bangkok.go.th/upload/user/00000231/web_link/air/MP%20Full%20Report%20_Kiso%20clean%20-11.pdf

Bangkok resilience strategy, Bangkok Metropolitan Administration

Description: plan for climate adaptation, economic development, and livability
https://resilientcitiesnetwork.org/downloadable_resources/Network/Bangkok-Resilience-Strategy-English.pdf

Bangkok Assessment Report on Climate Change 2009, Bangkok Metropolitan Administration, Green Leaf Foundation and United Nations Environment Programme
Description: climate mitigation and adaptation assessment
https://wedocs.unep.org/bitstream/handle/20.500.11822/7905/BKK_assessment_report2009.pdf?sequence=3&isAllowed=y

Academic Articles

Limthongsakul, Sani, Nitivattananon, Vilas, & Arifwidodo, Sigit Dwiananto. (2017). Localized flooding and autonomous adaptation in peri-urban Bangkok. *Environment and Urbanization*, 29(1), 51-68.
Description: drivers of flooding and impacts on community storm water infrastructure
https://doi.org/10.1177/0956247816683854

Wongsa S., Vichiensan V., Piamsa-nga N., Nakamura S. (2019) Urban Flooding and Adaptation to Climate Change in Sukhumvit Area, Bangkok, Thailand. In: Mannina G. (eds) *New Trends in Urban Drainage Modelling*. Green Energy and Technology. Springer, Cham.
Description: pilot case study using GIS
https://doi.org/10.1007/978-3-319-99867-1_111

Saito, N. (2014). Challenges for adapting Bangkok's flood management systems to climate change. *Urban Climate*, 9, 89-100.
Description: governance and policy study of BMA's approach to flooding
https://doi.org/10.1016/j.uclim.2014.07.006

Laeni, Naim, Van den Brink, Margo, & Arts, Jos. (2019). Is Bangkok becoming more resilient to flooding? A framing analysis of Bangkok's flood resilience policy combining insights from both insiders and outsiders. *Cities*, 90, 157-167.
Description: analyzes the approach to flooding in the Resilience Strategy
https://doi.org/10.1016/j.cities.2019.02.002

Boossabong P. (2017) Floods and Food in the City: Lessons from Collaborative Governance Within the Policy Network on Urban Agriculture in Bangkok, Thailand. In: Allen A., Griffin L., Johnson C. (eds) *Environmental Justice and Urban Resilience in the Global South*. Palgrave Macmillan, New York.
Description: analysis of resilience and justice potentials of an urban agriculture policy network
https://doi.org/10.1057/978-1-137-47354-7_12

6 Dhaka

Sources

- Interview 18-02-21 with Prof. Ishrat Islam, Dr Uttama Barua, Dr Manoj Kumar Roy
- Draft & raw material : Joe Ravetz, Dimas Adrianto, Joe Lake Rees (Manchester):

6.1 Peri-urban-climate: summary

This is a short overview of (a) problems / challenges, and (b) responses / pathways (to be developed in the workshop and beyond).

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
PERI-URBAN			
Spatial peri-urban types & patterns:	Urban direct expansion Urban / rural fringe & gradient Counter-urbanization effect Urban agglomeration effect	Dhaka is a rapidly growing primate city, over 21 million in Greater Dhaka Area. Peri-urban areas of over 100p/km2, rapidly advance where urban encroaches & merges into high density rural.	
Spatial peri-urban dynamics (growth / restructuring / transition).	Population growth & housing Technology & infrastructure Economy & employment Real estate & markets	Peri-urban is a fluid space, blending urban / rural in physical landscape and socio-cultural conditions. This spreads beyond the metro area to over 100km. Rapid rural-urban migration for jobs & services	
Peri-urban other drivers (STEEP: social, technical, ecological, policy, culture etc)	Social demographics & lifestyle Environment & resources Policy & governance Culture & ethics	Many informal slums are insecure, & seen by elites as a rural problem. Land prices very high in some parts, so development pushed outwards.	
Global-local dynamics & inter-dependencies	Internal structures external interactions power dynamics challenges & conflicts	Multi-national firms finance local industries via local elites, very difficult to set social-environmental standards	

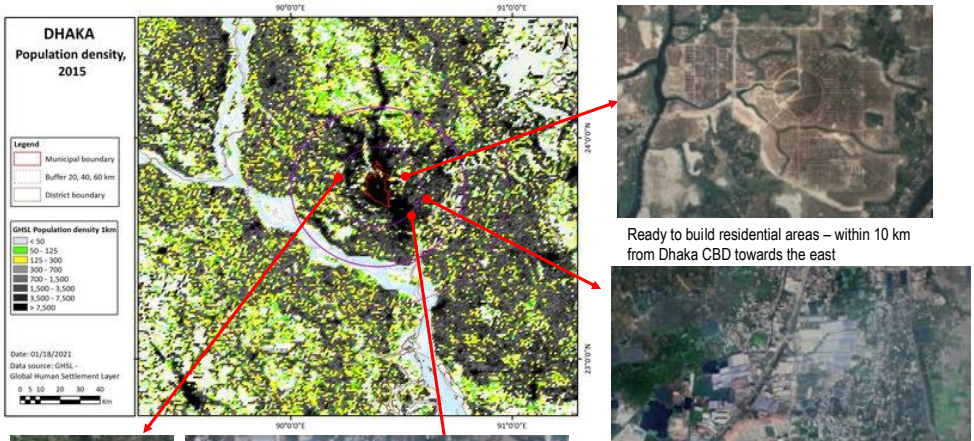
THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
CLIMATE			
Climate change direct effects projections	temperature, precipitation, storm, coastal effects	Temperature projection 1.5-5 degrees by 2100: Precipitation: winter fall of 40%, summer rise of 40% in watershed Sea level rise – indirect effects on river flows	
Climate indirect hazards & impacts:	wildfire, heatwave, drought, flood, storm, cyclone landslide, sea incursion etc,	Increase in event rainfall intensity for short duration events [1]. Cyclones and storm surges are set to increase. Urban Heat Island causes 2 °C uplift: extreme wet heat days may double.	
Indirect hazards & nexus effects	water resources farming & forestry energy & resources ecosystems & microclimates critical infrastructure	Temp increase: Increased energy demand, degraded air quality, water scarcity. Rainfall increase: increased flooding, increased water logging, increased inward migration due to river bank erosion.	
Causal loops (impacts of peri-urban on climate change)	CO2 emissions from energy GHG emissions from land-use Land-use & forestry change Carbon storage	Urban expansion lacks adequate drainage, destroys wetlands with adaptive capacity, leads to traffic & industrial air pollution, depletes groundwater, contributes to UHI, increases energy demand.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
VULNERABILITY			
Physical-ecological vulnerability-sensitivity	• Soil & vegetation • Topography & stability • Settlement form & structure	confluence of 3 major river systems. Much urban green infrastructure is polluted & degraded. Farming in hinterland is declining as land is sold for development. Loss of forest cover in hills to E.	
Functional-economic-infrastructure layers of vulnerability-sensitivity:	• technical & infrastructure • Markets & value effects • Employment & livelihoods	Informal & insecure settlements lack flood investment from govt and/or residents: poor construction (e.g. tin roofs) adds to heat stress.	
Eco-social-cultural layers of vulnerability-sensitivity:	• Affluence / deprivation • Education / communication • Cultural issues	Widening gaps of rich / poor, with elite / gang control of policy & resources. Many transient & migrant communities with lack of social cohesion.	
Adaptive governance capacity-vulnerability-sensitivity-	• Local government • Public services & infrastructure • Emergency services • Civil & community	Much informal adaptation to frequent & short flood events (Barsha)	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
GOVERNANCE			
Formal government, (governance, regulation)	Spatial planning green belt etc Housing policy Infrastructure development	Clientelist state with a dual 'party-archy'. Spatial planning is disconnected between local, metropolitan and national level. Climate policy is recognized but not yet mainstream.	
Adaptive / Associative governance: (networks, coalitions, partnerships)	Public sector Private sector Civic sector Citizens etc	Many civil society organizations in a complex mix of patronage. NGOS are active in slum dwelling advocacy, for security & services.	
Informality / elite capture / grassroots action:	Informal land-use, settlements, enterprise Corruption & nepotism Social innovation & enterprise for integrated livelihoods	Corruption & elite capture is standard. Informal settlements often without basic services are in the grip of local elite & enforcers.	
System resilience, collective intelligence (combined formal / adaptive / informal)	Social learning & collaboration Social co-creation & mobilization potential System transformation potential	However Bangladesh is a known development 'success story', due to high levels of education and gender empowerment.	

6.2 Peri-urban-climate: outline

1.	***PERI-URBAN THEMES: ("drivers / stressors / exposure")***	***TYPICAL QUESTIONS***



Ready to build residential areas – within 10 km from Dhaka CBD towards the east

Textile Industries just outside of the 20 km buffer, surrounded by low-middle class medium density housing. Textile has been the biggest contributor to the national GDP

Edge City – Medium density residential areas Vs Agricultural lands and communities

Dhaka's urban expansion – Urban gradients → Industrial estate, medium density housing and agricultural lands

- Dhaka Metro Area is a fast-growing urban area with an average density of 1500 people/Km2.
- Dhaka's urban areas expanded mainly towards the south-east with growth of residential areas and industries. These areas contain large amount of agricultural lands but has now been taken by private sectors.
- The peri-urban was pictured as a fluid space where at current times there are strong blending between urban and rural in terms of physical landscape and socio-cultural conditions. These typical areas existed beyond the border of the metro area (around the 20 km buffer and beyond)
- The problem with Dhaka's urban growth is that it exacerbates the vulnerability of flooding as water flows from the north towards the south east. Dhaka's urban centre has an elevation above the surrounding regions with large areas of urban slums blocking the flow of water. This made Dhaka's south and east peri-urban areas prone to flooding
- Many of the lowland areas within the peri-urban are now exploited as new residential areas are being developed under the excuse that those areas which are predominantly agriculture are no longer a productive.
- The main issue in the peri-urban areas is the loss of livelihoods due to urban-rural economic transformation

(a)	**Spatial peri-urban types & patterns:**	• ***What is the main geographical type and structure in this city-region / peri-urban zone?***

(b)	**Spatial peri-urban functional dynamics (growth / restructuring / transition).**	• ***How did it evolve / emerge to this situation?***

(c)	**Other drivers (STEEP: social, technical, ecological, policy, culture etc)**	• ***What other causes and drivers of change are in the picture?***

(d)	**Global-local dynamics & inter-dependencies**	• ***Which are the key global / local conflicts & challenges this city-region / peri-urban zone?***

2.	***CLIMATE CHANGE THEMES ("causes / hazards"):***	

(a)	**Climate change direct effects:**	• ***What are the main climate change projections for this area / city-region / peri-urban zone?***

Increase in event rainfall intensity for short duration events [1]. Cyclones and storm surges are set to increase. There is a trend of decreasing seasonal rainfall in monsoon and winter. Higher temperatures and increased instances of extreme rainfall [5]. Dhaka temperature is expected to increase 1.5 – 2 °C by 2060. Urban Heat Island causes 2 °C warmer temperatures in urban area compared to peri-urban area [7]

(b)	**Climate change direct hazards & impacts:**	• ***What are the expected / projected hazards, impacts and risks?***

Temp increase: Increased energy demand, degraded air quality, water scaricity.

Rainfall increase: increased flooding, increased water logging, increased inward migration due to river bank erosion.

Flooding: damage to house holds, road and infrastructure damage, damge to utilities, spread of water borne disease.

Drought: sever ground water scarcity.

Heat / cold waves: Short term energy demand changes, heat stresses. [7]

•

(c)	**Indirect hazards & nexus effects**	• ***Which hazards and impacts are most critical for food, energy, water, other infrastructure?***

Reduction in seasonal rainfall smooth provision of water and energy may become obstructed. Higher temperatures and increased rainfall extremes will increase incidences of disease e.g. E. coli incidence [5]. Peak daily energy consumption correlates with temperature, as global and local temperature rises it is very likely that urban energy consumption will increase between 5 – 16% by 2100.

(d)	**Causal loops (peri-urbanization >> climate change)**	• ***How does the pattern of peri-urbanization cause further climate emissions or urban / rural impacts?***

Building in eastern and north-eastern areas of Dhaka is not accompanied by sufficient drainage, increasing the potential hazards of flooding in these areas [3]. Groundwater use makes up 70% of the water supply, as more area is urbanised the availability of surface water will reduce, resulting in a greater use of groundwater from increased population and decreased availability of surface water [4]. Wetland degradation, decreasing stored carbon, increases carbon emissions. Illegal urban encroachment is reducing natural drainage.[7]

3.	*VULNERABILITY THEMES sensitivity / capacity*	

(a)	Physical-ecological vulnerability-sensitivity	• *How far are the physical & ecological systems, vulnerable / sensitive or resilient / adaptive?*

Introduction of vegetation to dense urban settings reduces urban heat island effect. Cost and maintenance of green and blue infrastructure are barriers to city implementation [2].

(b)	Vulnerability-sensitivity: functional-economic layers	• *How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?*

Informal housing faces issues of water-logging and poor drainage, high winds, and urban fire are also threats to these neighbourhoods [3]. The Dhaka Water Supply and Sewerage Authority (DWASA) are planning to switch from groundwater to surface water supply in response to rapid urbanization [4]

(c)	Vulnerability-sensitivity: social-cultural layers	• *How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?*

Dhaka faces high income inequality reducing poorer areas ability to adapt to climate change without support. Poorer housing areas where residents own their property hesitate to improve their dwellings due to threat of demolition. Many of the informal housings don't have access to basic infrastructure such as clean water or drainage [3]. Informal settlements do respond to flood disasters by using flood barriers across doors, increasing furniture height, and arranging higher storage facilities. [4]

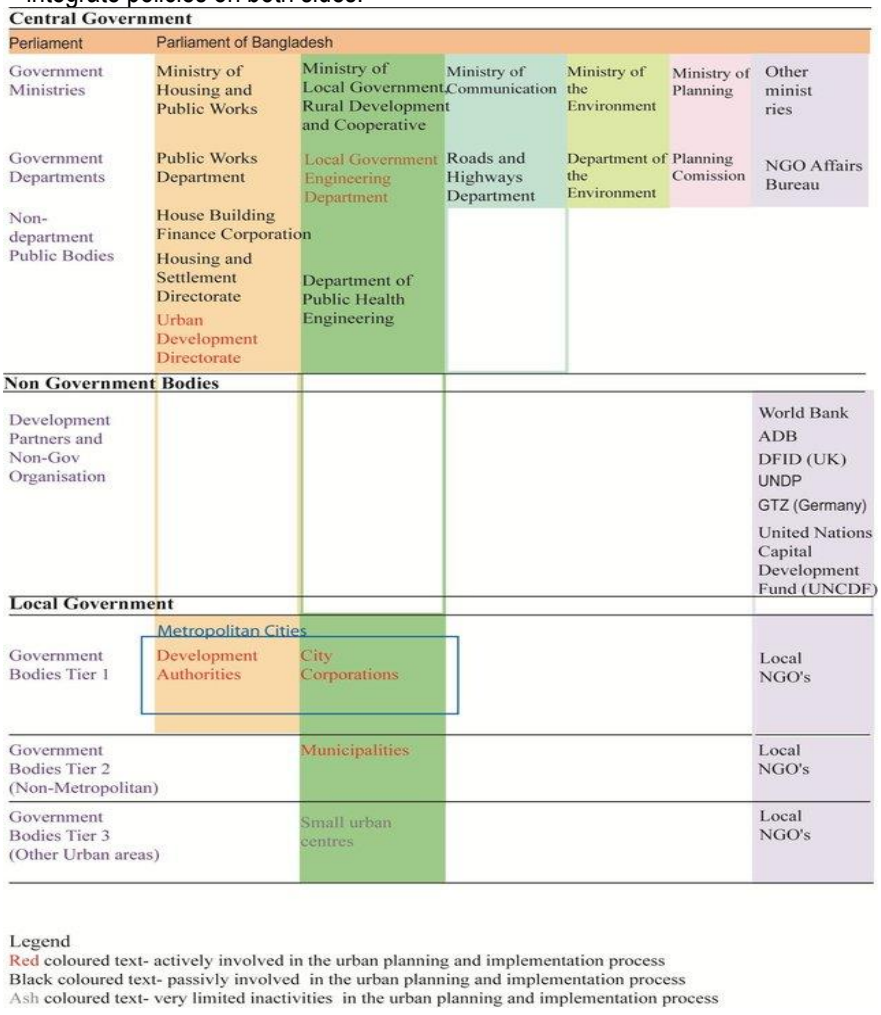
(d)	Vulnerability & adaptive capacity of social institutions	• *How far are key institutions (community, civic society, public services etc), vulnerable / sensitive or resilient?*

There is a community level unwillingness to pay for urban greening to mitigate climate change effects, e.g. UHI, flooding [2]. 30% of the population live in insecure tenancies, faced with evictions, many are homes are controlled by gangs. Informal settlements are poorly managed, formal intervention is restricted due to corruption in politics and policing. [3] Corruption is high in Dhaka, worlds 29th most corrupt National Government, and 70% of people reported paying a bribe to a government official in 2010, 46% believe that corruption nationally is increasing. National level planning policies have directly integrated climate change. Dhaka level policies focus on climate change impacts, [4]

4.	***GOVERNANCE THEMES:*** ***Adaptive action & governance***	

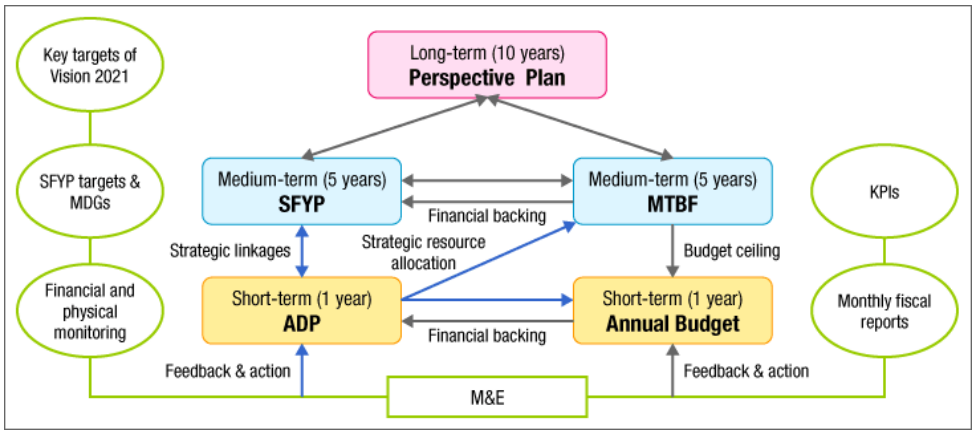
(a)	**Formal government, (governance, regulation)**	• ***How does local / regional government work here & which kind of policies, regulations or plans apply?***

- Spatial planning is conducted involving the national and 3 different Tiers of local level authorities.
- The fundamental problem of spatial planning is the dysconnectivity between planning at local, metropolitan and national level (with regards to scale and time/period) which made an overall problem of policy disintegration.
- Another problem is that there are 2 local authorities governing the Dhaka metro region and is difficult to integrate policies on both sides.



Legend
Red coloured text- actively involved in the urban planning and implementation process
Black coloured text- passivly involved in the urban planning and implementation process
Ash coloured text- very limited inactivities in the urban planning and implementation process

Bangladesh spatial planning framework (Sowgat, 2012)



Territorial planning management systemin Bangladesh (Document of General Economics Division (GED), Planning Commission, Bangladesh government in MLIT, Japan)

(b)	**Adaptive governance & institutions: (networks, coalitions, partnerships)**	• ***Are there networks, coalitions, partnerships etc, or any emerging signs of these?***

- The role of NGO in development planning has been notable since 2007, when they advocate urban slum dwellers to not be excluded from public and infrastructure service delivery. This is an example of the potential ways forward to solve some of the problems in planning the peri-urban – involving wider actors

(c)	**Informal governance, (corruption, community, livelihood,)**	• ***How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?***

(d)	**System effects, resilience, collective intelligence**	• ***What could be the overall resilience of the system, or collective capacity for learning & thinking?***

6.3 Basic data

Climate Hazard	
(World Bank data profile for Dhaka)	
Extreme heat	- High
Wildfire	- High
Water scarcity	- Medium
River flood	- High
Urban flood	- High
Coastal flood	- High
Cyclone	- High
Tsunami	- No data
Landslide	- Low
Earthquake	- Medium
Volcano	- No data

6.4 Sources

Climate impacts & vulnerability theme

[1] Development of IDF Curve for Dhaka City Based on Scaling Theory under Future Precipitation Variability Due to Climate Change. S. Afrin, M. M. Islam, & M. M. Rahman.

[2] Ecosystem services management: An evaluation of green adaptations for urban development in Dhaka, Bangladesh. N. J. Ziniaa, & P. McShane.

[3] Factors in building resilience in urban slums of Dhaka, Bangladesh. I. Ahmed.

[4] Climate change adaptation planning for Global South megacities: the case of Dhaka. M. Araos, J. Ford, L. Berrang-Ford, R. Biesbroek & S. Moser

[5] Climate Change Implications for Dhaka City: A Need for Immediate Measures to Reduce Vulnerability. G. Rabbani, A. A. Rahman, & N. Islam.

[6] Potential Impact of Climate Change on Residential Energy Consumption in Dhaka City. M. S. A. Shourav, S. Shahid, B. Singh, M. Mohsenipour, E. Chung & X. Wang.

[7] Dhaka structure plan 2016-2035. Rajdhani Unnayan Kartripakkha, Government of the People's Republic of Bangladesh

Urban planning & governance theme

Ministry of Land, Infrastructure, Transport and Tourism, Japan (2020) 'An Overview of Spatial Policy in Asian and European Countries'. (https://www.mlit.go.jp/kokudokeikaku/international/spw/general/bangladesh/index_e.html) Accessed April 2021

Mortoja, M. G. and Yigitcanlar, T. (2020) 'How does peri-urbanization trigger climate change vulnerabilities? An investigation of the dhaka megacity in Bangladesh', Remote sensing (Basel, Switzerland). MDPI AG, 12(23), pp. 1–41. doi: 10.3390/rs12233938.

Sowgat, T., Wang, Y. P. and McWilliams, C. (2017) 'Pro-poorness of planning policies in Bangladesh: the case of Khulna city', International planning studies. Routledge, 22(2), pp. 145–160. doi: 10.1080/13563475.2016.1220287

General sources

Roy, M.K, Hanlon, J, Hulme, D, (2016) *Bangladesh Confronts Climate Change: Keeping Our Heads Above Water:* London, Anthem

Organisations, Programmes, and Projects

International Centre for Climate Change and Development
Description: research group based in Dhaka
http://www.icccad.net/

Reports and Policies

Dhaka and Western Zone Transmission Grid Expansion Project, Asia Development Bank
Description: climate risk and vulnerability assessment
https://www.adb.org/sites/default/files/linked-documents/51137-003-sd-01.pdf

Flood Risk Management in Dhaka: A Case for Eco-Engineering Approaches and Institutional Reform, Global Facility for Disaster Reduction and Recovery
Description: integrating flood management into urban planning
https://www.gfdrr.org/en/publication/flood-risk-management-dhaka

Academic Articles

Haque, Anika Nasra, Grafakos, Stelios, & Huijsman, Marijk. (2012). Participatory integrated assessment of flood protection measures for climate adaptation in Dhaka. *Environment and Urbanization*, 24(1), 197-213.
Description: multi-criteria analysis of flood measures on the eastern fringe
https://doi.org/10.1177/0956247811433538

Araos, Malcolm, Ford, James, Berrang-Ford, Lea, Biesbroek, Robbert, & Moser, Sarah. (2016). Climate change adaptation planning for Global South megacities: The case of Dhaka. *Journal of Environmental Policy & Planning*, 19(6), 682-696.
Description: qualitative case study of climate change preparedness
https://doi.org/10.1080/1523908X.2016.1264873

Ahmed, Farhana, Moors, Eddy, Khan, M. Shah Alam, Warner, Jeroen, & Terwisscha van Scheltinga, Catharien. (2018). Tipping points in adaptation to urban flooding under climate change and urban growth: The case of the Dhaka megacity. *Land Use Policy*, 79, 496-506.
Description: case study of flood exposure under different urbanization and climate change scenarios
https://doi.org/10.1016/j.landusepol.2018.05.051

Zinia, Naeema Jihan, & McShane, Paul. (2018). Ecosystem services management: An evaluation of green adaptations for urban development in Dhaka, Bangladesh. *Landscape and Urban Planning*, 173, 23-32.
Description: surveys to understand perceptions of green roofs
https://doi.org/10.1016/j.landurbplan.2018.01.008

Dasgupta, Susmita, Zaman, Asif, Roy, Subhendu, Huq, Mainul, Jahan, Sarwar, & Nishat, Ainun. (2015). *Urban Flooding of Greater Dhaka in a Changing Climate: Building Local Resilience to Disaster Risk* (Directions in Development--Environment and Sustainable Development). Washington, DC: World Bank.
Description: book aiming to improve flood resilience policies
http://hdl.handle.net/10986/22768

Alam, M. J. (2014). "The organized encroachment of land developers"—Effects on urban flood management in Greater Dhaka, Bangladesh. *Sustainable Cities and Society*, 10, 49-58.
Description: case study of violations of land-use regulations by developers
https://doi.org/10.1016/j.scs.2013.05.006

7 Cairo

Sources

- *Based on interview 17-02-21 and slides from: Prof. Dr. Ghada Farouk Hassan: Prof. Marwa Khalifa: Dr Shimaa Ali; Eman Abouziyan: Dr Ado Ampofo: Dr Samy Afifi: Dr Lenz Sulzer: Esraa El-Marakby*
- *Draft & raw material : Joe Ravetz, Dimas Adrianto, Joe Lake Rees (Manchester):*

7.1 Peri-urban-climate: summary

This is a short overview of (a) problems / challenges, and including space for: (b) responses / pathways (to be developed in the workshop and beyond).

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
PERI-URBAN			
Spatial peri-urban types & patterns:	Urban direct expansion Urban / rural fringe & gradient Counter-urbanization effect Urban agglomeration effect	Peri-urban areas around GCR include: (a) expansion around the ring road / encroachment on agriculture land: (b) urban incursions into desert, mainly new satellite cities: (c) older towns on the river, or in the Delta: this whole area is in peri-urban landuse patterns & densities, so is included here.	
Spatial peri-urban dynamics (growth / restructuring / transition).	Population growth & housing Technology & infrastructure Economy & employment Real estate & markets	Population growth & housing space per person: many are 'informal' constructions with parallel sets of standards. Real estate markets promote rapid expansion	
Peri-urban other drivers (STEEP: social, technical, ecological, policy, culture etc)	Social demographics & lifestyle Environment & resources Policy & governance Culture & ethics	Growing middle class demands higher space standards, however many new satellites lack services & networks, so not popular.	
Global-local dynamics & inter-dependencies	Internal structures external interactions power dynamics challenges & conflicts	Special links between government military & business promote both encroachment around urban edge, & new satellite towns & cities in the desert.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
CLIMATE			
Climate change direct effects projections	temperature, precipitation, storm, coastal effects	Temperature projection: 2-7 degrees rise by 2100. Summer increase high, winter is modest. Precipitation reduces by up to 40% in winter & summer, but upstream could be increases of 30-40%. Extreme wet heat days of 35+ may double. Sea level rise (SLR) & salt intrusion into the Delta.	
Climate indirect hazards & impacts:	wildfire, heatwave, drought, flood, storm, cyclone landslide, sea incursion etc,	Urban heat island effect compounds with air pollution & landuse change on periphery. Recent increase in rainfalls & flooding in winter caused houses collapse, power outages & chaotic traffic.	
Indirect hazards & nexus effects	water resources farming & forestry energy & resources ecosystems & microclimates critical infrastructure	peri-urban areas on agricultural lands causes depletion & land cover change, leading to soil loss & food insecurity.	
Causal loops (impacts of peri-urban on climate change)	CO2 emissions from energy GHG emissions from land-use Land-use & forestry change Carbon storage	Rapid growth in road traffic on the peri-urban & satellite cities & towns: these rely on intensive energy & water supply in the desert landscape.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
VULNERABILITY			
Physical-ecological vulnerability-sensitivity	• Soil & vegetation • Topography & stability • Settlement form & structure	Delta area is very fertile & managed long term, but rising temperatures & flooding will cause problems. GCR peri-urban is vulnerable to desertification & reduces capacity of urban area.	
Functional-economic-infrastructure layers of vulnerability-sensitivity:	• technical & infrastructure • Markets & value effects • Employment & livelihoods	Many buildings are sub-standard in space, ventilation, green areas. Infrastructure provision of electricity, water, sewage etc, the peri-urban areas, mainly depends on illegal connections to the public networks or depending on off-grid sources.	
Eco-social-cultural layers of vulnerability-sensitivity:	• Affluence / deprivation • Education / communication • Cultural issues	Conflicts can arise with urban expansion on agricultural lands & the livelihoods of villages. Many communities are divided between high value enclaves & middle-lower value informal settlements.	
Adaptive governance capacity-vulnerability-sensitivity-	• Local government • Public services & infrastructure • Emergency services • Civil & community	Political changes has caused disruption to the coordination of different services, emergency, health, education, housing etc.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
GOVERNANCE			

Formal government, (governance, regulation)	Spatial planning green belt etc Housing policy Infrastructure development	Metropolitan-regional & peri-urban development plans, also the upgrading of informal areas, are often linked to international grants & NGOs. Climate policy is not yet in the mainstream. The land owned and controlled by the government forms around 90%of the country's surface area: with lack of updated property titling, registration, and transfer systems	
Adaptive / Associative governance: (networks, coalitions, partnerships)	Public sector Private sector Civic sector Citizens etc	*"Public lands, especially those on the fringes of towns and other areas where lands are potentially valuable, are often under dispute between governorates, public authorities, specialized companies, squatters (both formal and informal), the military, and the security forces'*	
Informality / elite capture / grassroots action:	Informal land-use, settlements, enterprise Corruption & nepotism Social innovation & enterprise for integrated livelihoods	Special links between government military & business promote both encroachment around urban edge, & new satellite towns & cities in the desert.	
System resilience, collective intelligence (combined formal / adaptive / informal)	Social learning & collaboration Social co-creation & mobilization potential System transformation potential	A well established civil service seems to keep the country running through times of political changes.	

7.2 Peri-urban-climate: outline

A historic and modern city with a very dense older core housing nearly 10 million, surrounded by a Greater Cairo Region with an equivalent population. The Greater Cairo Region (GCR) is defined as the Governorate of Cairo, in addition to Giza governorate and Qalyubia Governorate, plus the new urban communities that are located around Cairo. High levels of traffic congestion and pollution led to the construction of one of the world's busiest metro systems.

Peri-urban development is concentrated in the expanding cluster of satellite cities and towns. However the entire Delta region is in a similar peri-urban development pattern and density type, so is included here in the wider hinterland of GCR.

Climate-environment hazards are centred on water in an arid climate, with many forms of flooding and water scarcity combined.

7.3 ASU presentation:

Climate change

A dominant type of the peri-urban areas (not planned new urban communities) in GCR mainly is located around the ring road as an illegal expansion of the core city or as an encroachment on agricultural lands.

- These structures are highly exposed to a high level of pollution because of the roads' approximate and the high capacity of motorized vehicles
- In addition, the compact urban form with low permeability may suffer from UHI effect
- The expansion of the peri-urban areas on the agricultural lands causes agricultural lands removal and land cover changing, which can lead to food insecurity among other challenges.

climate change – urban flooding

- In addition to water shortages, the city, especially its per-urban areas and new urban communities are challenged by urban flooding, whose dangers are intensified by increased urbanization around the city that limits where floodwaters can flow.
- These extreme weather conditions, that are expected to grow due to climate change and water systems in cities in the global south are often unable to cope with these challenges, bringing cities to halt and damages and losses in millions (WEF, 2011).
- In the past years, Egypt has been witnessing increase in rainfalls and flooding in the winter seasons that caused houses collapse, power outages and chaotic traffic conditions (Egyptian Streets, 2020).

Vulnerability themes

- Some of the Peri-urban areas suffer from the inappropriate urban structure (physical vulnerability). Buildings suffer from inadequate spaces for living or inappropriate orientation for ventilation. On the other hand, there are buildings with well-constructed concrete structure.
- Infrastructure provision of the peri-urban areas in terms of electricity, water, sewage....etc. mainly depends on illegal connections to the public networks or depending on off-grid sources.

Governance

- Some development plans of the peri-urban areas depends on international grants such as GIZ grant for developing the informal areas in Egypt and initiatives of the NGOs.
- The governmental act in these areas is represented in granting legal ownership rights to residents of these areas and legalizing their status and their benefit from the infrastructure.
- On the physical layer, those areas can suffer from some sort of conflict in term of building requirements that can mainly happen in expanded urban areas on the agricultural lands when the area is following a village and attached to cities.

Governance - Public land management

- The land owned and controlled by the government forms around 90%of the country's surface area. Managing this resource in ways that benefit the country's economy and the mass of its people is crucial.

- **Challenges related to public land management:**

- There is almost no publically available **public land information system or inventory**, resulting in confusion for both investors and citizens alike on which institutions control what land, where it is available, and under what conditions.

"Public lands, especially those on the fringes of towns and other areas where lands are potentially valuable, are often under dispute between governorates, public authorities, specialized companies, squatters (both formal and informal), the military, and the security forces. Existing documentation or maps of land assignments may be put forward by an agency to secure its claim to a piece of land, only to find that other authorities produce other documentation that contradicts this".

- The **lack of updated property titling, registration, and transfer systems**. This is an issue that affects all land— whether public or private, cultivated or desert— but it affects public land in particular since without legal registration, it is hard to protect these lands, whether allocated or unallocated.

- There is **limited monitoring of development projects 'feedback loops**', once lands have been allocated to find out what has worked and what hasn't and why. The various authorities that allocate public land, such as NUCA, GARPAD, and TDA, rarely carry out evaluations or lessons-learned exercises.

- The **need for a coherent national policy that defines the purposes of the public land asset** and how to deal with it is yet to be met, individual self-serving decisions about public land are common. there are general pronouncements about generating employment and creating affordable housing for the poor. But the actual figures show how little public land has managed to directly benefit the masses.

- Sims, David. Egypt's Desert Dreams : Development or Disaster?, The American University in Cairo Press, 2015.

Issues to be discussed

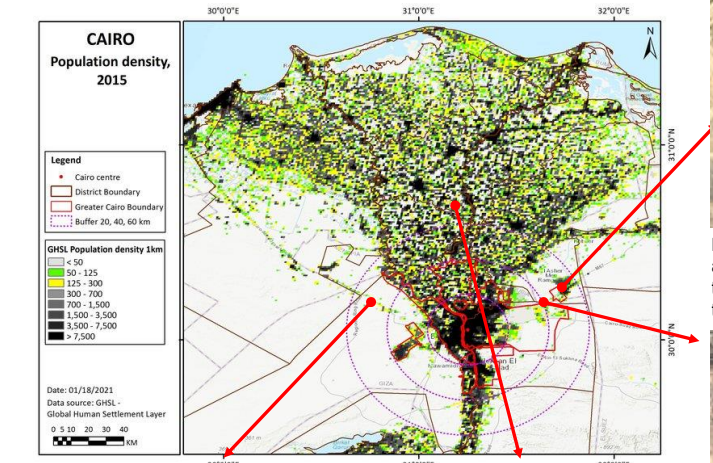
- Is there a delineation (physical demarcation) of peri urban areas round GCR?

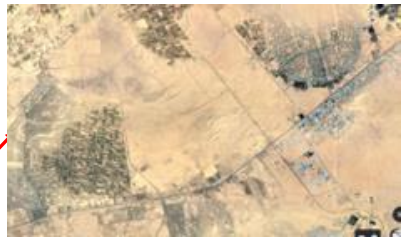
- How to identify and classify peri urban areas within the context of GCR? Through common urban fabric or administrative division?

7.4 Peri-cene template

1.	***PERI-URBAN THEMES: ("drivers / stressors / exposure")***	***TYPICAL QUESTIONS***

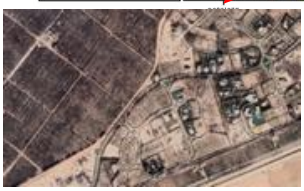
- Urban areas of Cairo had been expanding extensively to the north towards the coastal areas where farmlands are the predominant social and economic activities. In these areas there are several satellite cities of medium to high density which forms a pattern of polycentric urban region.





Regional corridor – Highway connecting Cairo with the port and the development of the Suez Canal Economic Zone triggered growth of residential and economic activities along the corridor

High class peri-urban residential areas and gated communities constructed alongside the regional corridor



Urban expansion large plots of high class housing converting agricultural lands towards the west peri-urban areas

Polycentric urban expansion towards the north with medium to high density of satellite towns

- In recent times Cairo's urban areas are expanding towards the east and west in a form of scattered and sporadic urban development. In these areas there are construction of several high-class residential areas, mainly within the 20-40 km buffer zone.
- Some of the scattered urban expansion were unplanned. Agricultural lands are being converted by buildings that are known to be illegal (without planning permission?). These are also emerging alongside the ring road towards the north.
- Multinational companies settle around the Suez Canal economic zone, which trigger growth alongside the highway connecting the Cairo urban centres to the canal. This regional corridor bypasses the existing settlements as density seems to be increasing with more newly built high-class residential areas. The development of this regional corridor coincides with the emerging growth of economic activities in Ramadan City, which is situated between Cairo and the Suez Canal

(a)	**Spatial peri-urban types & patterns:**	• ***What is the main geographical type and structure in this city-region / peri-urban zone?***

(b)	**Spatial peri-urban functional dynamics (growth / restructuring / transition).**	• ***How did it evolve / emerge to this situation?***

(c)	**Other drivers (STEEP: social, technical, ecological, policy, culture etc)**	• ***What other causes and drivers of change are in the picture?***

(d)	**Global-local dynamics & inter-dependencies**	• ***Which are the key global / local conflicts & challenges this city-region / peri-urban zone?***

2.	***CLIMATE CHANGE THEMES ("causes / hazards"):***	

(a)	**Climate change direct effects:**	• ***What are the main climate change projections for this area / city-region / peri-urban zone?***

Sea level rise (SLR), salt intrusion into the Nile delta [1]. Annual Egyptian temperatures under business as usual conditions (RCP8.5) to increase by 0.1 – 1.0 °C by 2030, 1.5 – 2.5 °C by 2050, 4.0 – 6.0 °C by 2100 [5]. Annual precipitation is set to decrease by 5% by 2030, 13% by 2050, and 22% by 2100. [2]

(b)	**Climate change direct hazards & impacts:**	• ***What are the expected / projected hazards, impacts and risks?***

Salination of agricultural land by SLR [1]. Human health affected due to increased particulate matter and heat stress [2]. With an increase of 4 °C the river Nile flow would reduce by 68% [4]

(c)	**Indirect hazards & nexus effects**	• ***Which hazards and impacts are most critical for food, energy, water, other infrastructure?***

Loss of agricultural land. Nile delta contributes to 50% of Egypt's agricultural land [1].

(d)	**Causal loops (peri-urbanization >> climate change)**	• ***How does the pattern of peri-urbanization cause further climate emissions or urban / rural impacts?***

As the urban sprawl grows there will be less agricultural land available for food growth [1]. Unregisted groundwater extraction makes it more difficult to manage salination of groundwater through leakage. [6]

3.	*VULNERABILITY THEMES sensitivity / capacity*	

a)	**Physical-ecological vulnerability-sensitivity**	• ***How far are the physical & ecological systems, vulnerable / sensitive or resilient / adaptive?***

Salinity increasing in Nile delta will result in larger groundwater extraction. salt infiltration into groundwater will result in less viable sources of groundwater. The increase in salinity may have impact on the local biodiversity.

Soil sealing is a problem within the Nile delta, this is primarily due to urbanization. [7]

(b)	**Vulnerability-sensitivity: functional-economic layers**	• ***How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?***

Egypt produces 60% of its food, 40% of its grain, as fertile land reduces this food debt will increase [1]. Economic (GDP) losses from climate change are between 1.6 – 2.4 % by 2030, 2.1 – 6.0 % by 2060, most of these losses are associated with declining agriculture [3].

(c)	**Vulnerability-sensitivity: social-cultural layers**	• ***How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?***

95% of the population have access to clean water, 98% have access to sanitation. [2]

(d)	**Vulnerability & adaptive capacity of social institutions**	• ***How far are key institutions (community, civic society, public services etc), vulnerable / sensitive or resilient?***

Perceptions of climate change are high in rural and urban communities of Egypt. There is some knowledge of adaptation strategies, but these are not always directly linked by actors to climate change e.g. changing cropping seasons. There is a lack of regionally adjusted community-based climate change adaptation policies; there is a lack of strong institutional structures to develop and enforce these type of policies. There is no national Egyptian board for climate adaptation actions. [8]

4.	***GOVERNANCE THEMES:*** ***Adaptive action & governance***	

- One of the challenges in governing peri-urban areas are the uncertainties of policy as there are different standards, for instance to regulate buildings for urban areas and rural areas. There is a need for policies specific to regulate, control and monitor peri-urban development.
- Currently, there are different authorities in public sectors regulating land use – e.g. land alongside the Nile River is regulated by the Ministry of Environment. The Ministry of AUF have many land properties for the use of certain purposes, but not fully controlled. Also, there are lands where the use is under the control of local municipalities.

(a)	**Formal government, (governance, regulation)**	• ***How does local / regional government work here & which kind of policies, regulations or plans apply?***

(b)	**Adaptive governance & institutions: (networks, coalitions, partnerships)**	• ***Are there networks, coalitions, partnerships etc, or any emerging signs of these?***

(c)	**Informal governance, (corruption, community, livelihood,)**	• ***How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?***

(d)	**System effects, resilience, collective intelligence**	• ***What could be the overall resilience of the system, or collective capacity for learning & thinking?***

7.5 Adaptive pathways

(to be developed in the workshop & follow up)

5.	***SYNERGISTIC PATHWAY MAPPING:*** *(these are to be addressed in the Pathways workshop)*		
(a)	*Systems / baselines (present)*	• *Which are the key 'baseline' cross-cutting issues & challenges in this process so far?*	***What are the top 3 challenges for the peri-urban and climate change?*** (Prof Ghada Farouk Hassan) • Reducing and directing land-use change and land-use intensity • Lack of standardized environmentally friendly technical solutions

			• Lack of integrated risk management, monitoring and administrative transformation systems (Dr Ampofo) • Shrinking of agriculture land then expected impacts on food security • Increasing phenomenon of urban Heat island as the urban areas are expended • Slum-ification or the increasing rate of slums and outstandards living condition
(b)	*Scenarios (future possibilities)*	• *Which are the most critical trends, uncertainties, alternative futures?*	•
(c)	*Synergies (future opportunities)*	• *What are the most visionary ideas, synergies, connections, collective intelligence opportunities?*	***What are the top 3 opportunities?*** (Prof Ghada Farouk Hassan) • Urban farming • Increase share green area per person in cities • Increasing national investement at rural area to refrein the increase (Dr Ado Ampofo) • Strategic regional planning, GIS supported multicriterial DSS • Strengthening technology diffusion through collaborative industrial development and regulative backing • Balancing social and technical feedback components for multiple stakeholder integration
(d)	*Strategies (present pathways for action*	• *Which are the most practical & future proof pathways, strategies & actions?*	•

7.6 Basic data

SPATIAL DEVELOPMENT

Population (metropolitan area) - 20.44m
Land area (metropolitan area) - 17267 km2
Density (metropolitan area) - 1185 pp/km2
Population change -

CLIMATE HAZARD

(World Bank data - https://thinkhazard.org -)

Extreme heat - medium
Wildfire - HIGH
Water scarcity - HIGH
River flood - HIGH
Urban flood - HIGH
Coastal flood - *(no data)*

Cyclone	- *(no data)*
Tsunami	- *(no data)*
Landslide	- medium
Earthquake	- low
Volcano	- *(no data)*
VULNERABILITY	
Economic type	- lower middle income
GDP /pp city-region	- $14000 USD PPP
HDI (regional 2017)	- 0.70

7.7 Sources

Climate theme

[1] Climate Change Impacts, Vulnerabilities and Adaption Measures for Egypt's Nile Delta. K. A. A. Abutaleb, A. H. E. Mohammed, & M. H. M. Ahmed.

[2] DEVELOPMENT AND CLIMATE CHANGE IN EGYPT: FOCUS ON COASTAL RESOURCES AND THE NILE. S. Agrawala, A. Moehner, M. El Raey, D. Conway, M. van Aalst, M. Hagenstad, & J. Smith.

[3] Egypt's economic vulnerability to climate change. J. B. Smith, B. A. McCarl, P. Kirshen, R. Jones, L. Deck, M. A. Abdrabo, M. Borhan, A. El-Ganzori, M. El-Shamy, M. Hassan, I. El-Shinnawy, M. Abrabou, M. K. Hassanein, M. El-Agizy, M. Bayoumi, & R. Hynninen.

[4] Climate Change Impacts, Vulnerabilities and Adaption Measures for Egypt's Nile Delta. K. A. A. Abutaleb, A. H. E. Mohammed, & M. H. M. Ahmed.

[5] Working Group 2, AR5, Chapter 22 – Africa. I. Niang, O. C. Ruppel.

[6] Groundwater Management for Sustainable Development Plans for the Western Nile Delta. M. G. A. Eltarabily, & A. M. Negm.

[7] The Prediction and Assessment of the Impacts of Soil Sealing on Agricultural Land in the North Nile Delta (Egypt) Using Satellite Data and GIS Modeling. E. Hendawy, A. A. Belal, E. S. Mohamed, A. Elfadaly, B. Murgante, A. A. Aldosari, & R Lasaponara.

[8] Local community perception of climate change adaptation in Egypt. P. Froehlich, & M Al-Saidi.

Urban governance theme

Osman, T., Arima, T. and Divigalpitiya, P. (2016) 'Measuring Urban Sprawl Patterns in Greater Cairo Metropolitan Region', Journal of the Indian Society of Remote Sensing. New Delhi: Springer India, 44(2), pp. 287–295. doi: 10.1007/s12524-015-0489-6.

General sources

Sims, D, with Mitchell, T, (2015): *Egypt's Desert Dreams: Development or Disaster?* Cairo, The American University in Cairo

Organisations, Programmes, and Projects
Climate Change Adaptation and Urban Resilience, Participatory Development Programme
Description: project focused on adaptation measures in Greater Cairo
http://www.egypt-urban.net/climate-change-adaptation-and-urban-resilience/

Reports and Policies
Protecting Health from Heat Stress in Informal Settlements of the Greater Cairo Region, Deutsche Gesellschaft für, Internationale Zusammenarbeit
Description: heat impacts and recommendations for a vulnerable group
https://health.bmz.de/what_we_do/climate_health/Vulnerability_assessments/50_va_cairo/Qualitative_vulnerability_and_adaptation_assessment_Cairo_2016.pdf

Greater Cairo Urban Development Strategy, Ministry of Housing, Utilities and Urban Communities
Description: integrated regional plan with economic, social and environmental themes
https://unhabitat.org/sites/default/files/download-manager-files/Egypt%20-%20Greater%20Cairo%20Urban%20Development%20Strategy%20Vol.%201%20-%202012%20-%20EN.pdf

Academic Articles
Aboulnaga M., Alwan A., R. Elsharouny M. (2019) Climate Change Adaptation: Assessment and Simulation for Hot-Arid Urban Settlements – The Case Study of the Asmarat Housing Project in Cairo, Egypt. In: Sayigh A. (eds) *Sustainable Building for a Cleaner Environment. Innovative Renewable Energy*. Springer, Cham.
Description: long-term climate change scenario assessment of a building project
https://doi.org/10.1007/978-3-319-94595-8_37

El-Hattab, M, S.M, Amany, & G.E, Lamia. (2018). Monitoring and assessment of urban heat islands over the Southern region of Cairo Governorate, Egypt. *The Egyptian Journal of Remote Sensing and Space Sciences*, 21(3), 311-323.
Description: quantitative study of urban heat islands and land cover
https://doi.org/10.1016/j.ejrs.2017.08.008

8 Kumasi

Sources

- *Interview 08-02-21 with Patrick Brandful Cobbinah (Uni Melbourne): Frank Mintah (KNUST)*
- *Draft & raw material : Joe Ravetz, Dimas Adrianto, Joe Lake Rees (Manchester):*

8.1 Peri-urban-climate: summary

This is a short overview of (a) problems / challenges, and (b) responses / pathways (to be developed in the workshop and beyond).

(this is based on comments by PBC)

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
PERI-URBAN			
Spatial peri-urban types & patterns:	Urban direct expansion Urban / rural fringe & gradient Counter-urbanization effect Urban agglomeration effect	Built & developed as a concentric 'Garden city', radiated by 5 main corridors, connecting Kumasi to Ghana. Peri-urban devolvement occurs along the major corridors: led by individuality, local and traditional land management combined with planning agencies. Peri-urban change map shows rapid conversion of rural to peri-urban in SE areas.	
Spatial peri-urban dynamics (growth / restructuring / transition).	Population growth & housing Technology & infrastructure Economy & employment Real estate & markets	small communities that live around the cities, farming communities (subsistence). The subsistence farmers cannot afford to buy their land, the tribal leaders can sell it off. Even if land is 'bought' by those living on the land, it is leased for 99 years. With rapid urbanisation the traditional leaders just take the land back.	
Peri-urban other drivers (STEEP: social, technical, ecological, policy, culture etc)	Social demographics & lifestyle Environment & resources Policy & governance Culture & ethics	Middle income families are pushing subsistence farmers out of their land. Some farmers are changing livelihoods to construction. Peri-urban areas are growing mainly by middle class encroachment, under a dual 'customary' legal system, displacing the land and livelihoods of many indigenes.	
Global-local dynamics & inter-dependencies	Internal structures external interactions power dynamics	Kumasi is the commercial hub of Ghana & transport links enable	

	challenges & conflicts	transactions. Farming and former national parks are being encroached. Most of the wetlands and rivers are drying out, this is changing the ability for farmers to farm and so they must diversify their livelihood or relocate.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
CLIMATE			
Climate change direct effects projections	temperature, precipitation, storm, coastal effects	Temperature projections to 2100 – 2-7+ degrees rise: Precipitation: DJF 30% uplift, with growing storm conditions. Extreme wet heat days of 35+ degrees could double or more	
Climate indirect hazards & impacts:	wildfire, heatwave, drought, flood, storm, cyclone landslide, sea incursion etc,	All existing river systems are set to flood in rainy season.	
Indirect hazards & nexus effects	water resources farming & forestry energy & resources ecosystems & microclimates critical infrastructure	Forestry loss in most of hinterland, many forest wildfires in NE sector. Farming under pressure from new economic models, urbanizing cultures / lifestyles.	
Causal loops (impacts of peri-urban on climate change)	CO2 emissions from energy GHG emissions from land-use Land-use & forestry change Carbon storage	Landuse change is impacting on ecosystems & carbon balance: water balance is fragile for subsistence farmers.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
VULNERABILITY			
Physical-ecological vulnerability-sensitivity	• Soil & vegetation • Topography & stability • Settlement form & structure	Unreliable rainfall patterns with heavy reliance. Inadequate irrigable lands. Harvest failures from improper adaptive strategies. Reduced biological productivity. Progressive loss of non-timber forest products. Increased land degradation, loss of arable land.	
Functional-economic-infrastructure layers of vulnerability-sensitivity:	• technical & infrastructure • Markets & value effects • Employment & livelihoods	Reduction in livestock size and nutrition. Industry disruption possibly due to energy sector crisis. Raw material supply chain disruption. Higher risk property insurance. Population displacement.	
Eco-social-cultural layers of vulnerability-sensitivity:	• Affluence / deprivation • Education / communication • Cultural issues	Informal settlements are moved but without a clear location, so residents move back towards the centre, which then is unattractive to the middle classes, who then seek new peri-urban locations. Westernisation of the middle class is changing the housing preferences from compound housing to nuclear family living, greater peri-urbanisation.	
Adaptive governance capacity-vulnerability-sensitivity-	• Local government • Public services & infrastructure • Emergency services • Civil & community	Huge diversity of faith groups and informal community networks. African cities are largely informal, 80% of economic activities is informal, of 80% of land ownership is informal as owned by tribal leaders.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
GOVERNANCE			

Formal government, (governance, regulation)	Spatial planning green belt etc Housing policy Infrastructure development	Kumasi is seen as the 'seat of the king': conflict between traditional 'customary' authority & modern administration. In reality traditional leaders are determining land use due to a weak planning system. Currently tribal leaders own 80% of the land.	
Adaptive / Associative governance: (networks, coalitions, partnerships)	Public sector Private sector Civic sector Citizens etc	Informal housing development occurs across Kumasi, in locations lacking infrastructure (water, electricity, roads). First housing is built, then access to infrastructure is considered.	
Informality / elite capture / grassroots action:	Informal land-use, settlements, enterprise Corruption & nepotism Social innovation & enterprise for integrated livelihoods	People buy land and develop it before they have sought permission from planning authority. Land is bought from traditional owner. Traditional or tribal leaders need to work with new planning systems: the power struggle results in the informal development of Kumasi.	
System resilience, collective intelligence (combined formal / adaptive / informal)	Social learning & collaboration Social co-creation & mobilization potential System transformation potential	To be discussed…	

8.2 Peri-urban-climate: outline

The second city of Ghana is located in the Ashanti region with strong tribal identities and social structures. Peri-urban areas are growing mainly by middle class encroachment, under a dual 'customary' legal system, displacing the land and livelihoods of many indigenes.

In this tropical rainforest location, climate-environment risks include flooding, water scarcity, extreme heat and wildfire.

Context (PBC)

Build and developed as a concentric city, the city is radiated by 5 main corridors, the corridors connect Kumasi to wider Ghana. The peri-urban devolvement occurs along the major corridors. Peri-urbanisation is led by individuality, local and traditional land management combined with planning agencies. The reality is traditional leaders are determining land use, due to a weak planning system. Land along major corridors is highly sought. The production of infrastructure also drives peri-urban change. Land speculation around the University. Expansion of Kumasi airport, production of a major industrial hub (vehicles and meat) these are driving localised peri-urbanisation. The concentricity of the city drives the peri-urbanisation location.

The city is regarded as the city of culture. Kumasi is the seat of the king. Conflict between traditional authority and

People buy land and develop it before they have sought permission from planning authority. Land bought from traditional owners. Traditional or tribal leaders need to work with new planning systems. There is a power struggle. This struggle results in the informal development of Kumasi

Culturally, you are highly respected if you have your own house. Informal housing development occurs across Kumasi. Houses are put in locations lacking infrastructure (water, electricity, roads). First housing is built, then access to infrastructure is considered. The fundamental issue is the conflict between trial.

Westernisation of the middle class is changing the housing preferences from compound housing to nuclear family living, greater peri-urbanisation.

African cities are largely informal, 80% of economic activities is informal, of 80% of land ownership is informal as owned by tribal leaders. Informality is an opportunity.

Citizens living in the peri-urban are typically middle class and up. Within the city centre to live in the peri-urban do so because the rent is high, opportunity for larger living space.

In the city suburbs they migrate out and lower income communities can move in. Some living in slums are rich and saving to redevelop their home town.

Many of those living in slums are migrants to the city.

In Kumasi there are small communities that live around the cities, farming communities (subsistence). The subsistence farmers cannot afford to buy their land, the tribal leaders can sell it off. Even if land is 'bought' by those living on the land, it is leased for 99 years. With rapid urbanisation the traditional leaders just take the land back. Middle income families are pushing subsistence farmers out of their land. Some farmers are changing lively hoods to construction.

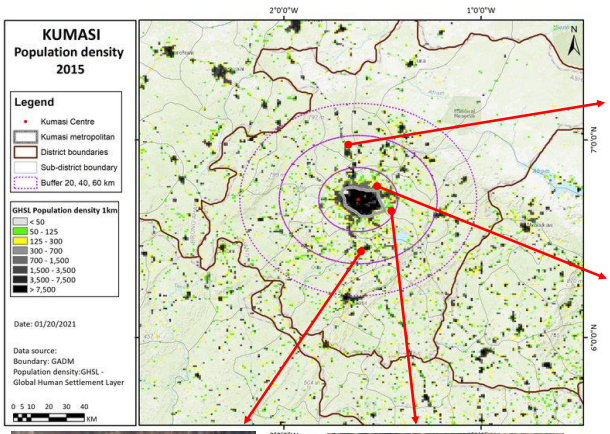
Strong cultural links to the land they farm on are broken due to middle class bloat to the peri-urban region.

Growth in middle income flats, many migrants to the city are middle income citizens, following attending Kumasi university the students tend to settle in the city.

1.	***PERI-URBAN THEMES: ("drivers / stressors / exposure")***	***TYPICAL QUESTIONS***

(a)	**Spatial peri-urban types & patterns:**	• ***What is the main geographical type and structure in this city-region / peri-urban zone?***

- The city of Kumasi forms a concentric growth typology with 5 regional corridors connecting the urban centre with its urban hinterlands. The 5 main corridors also connect Kumasi with other cities, which facilitates commuting from several other cities towards Kumasi.
- The nature of concentric growth pattern means that most of the economic activities are centralised within the Kumasi CBD. However, the recent urban growth exhibits a pattern of linear urban expansion alongside the 5 main regional corridors. This linear growth is dominated by single family housing with emerging growth of retails and industries.
- These 5 corridors connecting Kumasi with the urban hinterlands are in sufficient quality to functionally accommodate long distance – car dependant commuting. Expansion of low-density settlements can also be seen alongside the main corridors with insufficient local road network. Most of these local roads are in poor condition (gravel/earthen surfaces).
- Many of the settlements and economic activities in the peri-urban are informal with insufficient services of transport and energy infrastructure



Linear growth alongside one of the main regional corridors

Kumasi Airport, which is now an international airport is a factor in the inner city growth

Low density housing with poor road infrastructures

Single family housing within the 20 km zone

(b)	**Spatial peri-urban functional dynamics (growth / restructuring / transition).**	• ***How did it evolve / emerge to this situation?***

- Currently there is a reoccurring problem urban slums, which, despite of prolonged efforts to regenerate the CBD, the they still continue to exist. The problem is that the eviction plans are not always followed by a plan to define where these urban slums shall be relocated. As a result, due to most of the slum inhabitants are still relying to their source of income/livelihoods in the urban centre, they kept on returning or refusing to be relocated elsewhere.
- The failures to bring in CBD regeneration have resulted in the overall declining liveability of the urban centre, which became one of the forces for the middle class to migrate to the peri-urban areas.
- The emergence of major economic activities (industrial/commercial) and infrastructures in the peri-urban triggers land speculation – particularly alongside the main regional corridors. This includes the upgrading of Kumasi Airport from domestic to international airport, which contributed to the rapid urban expansion towards the eastern part
- The land speculation is exacerbated by the motives to accumulate capital investments – e.g. land purchase by families of tribal leaders to be sold to private developers at a later time. Currently, approximately 80% of the land falls into the ownership of these tribal leaders

(c)	**Other drivers (STEEP: social, technical, ecological, policy, culture etc)**	• ***What other causes and drivers of change are in the picture?***

- There is a changing lifestyle among the middle-class urban population which is to live in a larger housing size in a lower density area at the peri-urban. Owning a house is also seen as 'climbing a social ladder' where they gain more respect from the community. This has triggered the increase of housing demands in the peri-urban, especially from the middle-class population who cannot afford to live in the urban centres. Therefore, the majority of the peri-urban dwellers are for this particular social class, which continue to serve as a potential market for peri-urban residential development.

Agriculture is the main economic sector for the peri-urban. The growing demand for housing and other urban economies (retails, industries) accelerates the land take. The value of agriculture has been declining and more farming parcels have been taken by tribal leaders before releasing them to private developers.

(d)	**Global-local dynamics & inter-dependencies**	• ***Which are the key global / local conflicts & challenges this city-region / peri-urban zone?***

2.	***CLIMATE CHANGE THEMES ("causes / hazards"):***	

(a)	**Climate change direct effects:**	• ***What are the main climate change projections for this area / city-region / peri-urban zone?***

(b)	**Climate change direct hazards & impacts:**	• ***What are the expected / projected hazards, impacts and risks?***

•

(c)	**Indirect hazards & nexus effects**	• ***Which hazards and impacts are most critical for food, energy, water, other infrastructure?***

(d)	**Causal loops (peri-urbanization >> climate change)**	• ***How does the pattern of peri-urbanization cause further climate emissions or urban / rural impacts?***

3.	***VULNERABILITY THEMES sensitivity / capacity***	

Economic sectors of vulnerability (GH)

Agriculture

Cassava, Yam, Cocoyam, Cocoa.

Vulnerability cause

Unreliable/unpredictable rainfall, deforestation, degraded soils, drought, low income source, production rate drop due to temperature increase. aging population of farmers, spatial decline of available growth areas

Adaptation measures

Introduce varieties with different maturity periods, introduce drought resistant varieties, integrate nutrient management into cropping, afforest degraded forest land, generate alternative income sources, change irrigation to under root.

Adaptation programmes

RTIMP, WAPP, CARE International.

Vulnerability-sensitivity: social-cultural layers

How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?

Climate change and health

Malaria, Diarrhoea, Guinea worm, cerebral spinal meningitis, measles.

Vulnerability cause

Measles cases will increase by 2080 due to increased air temp, and reduced rainfall (although currently decreasing). Gradual rise of incidence of meningitis cases over range of months where cases are typically high. Diarrhoea increase risk due to reduced rainfall and increased mean air temp.

Adaptation measures

Breaking transmission cycle, destroying mosquito and cyclops breeding sites. Management of cases. Reduce cyclops host contact through provision of safe water, filtration of water, searching for active cases to avoid water contact. Ensuring infected persons avoid contact with ponds. Chemical destruction of crustaceans, vaccination of high risk groups, increased vaccine campaigns. Improving housing and ventilation. Improving case management and education.

Adaptation programmes

UNDP climate change and health project, Climate change and health in coastal community in Accra Project (RIPS).

Poverty Linkages

Nationwide

Vulnerability cause

Unreliable rainfall patterns. Heavy reliance on rainfall. Inadequate irrigable lands Harvest failures from improper adaptive strategies. Reduced biological productivity. Progressive loss of non-timber forest products. Increased land degradation, loss of arable land. Reduction in livestock size and nutrition. Industry disruption possibly due to energy sector crisis. Raw material supply chain disruption. Higher risk property insurance. Population displacement.

Adaptation measures

(a)	**Physical-ecological vulnerability-sensitivity**	• ***How far are the physical & ecological systems, vulnerable / sensitive or resilient / adaptive?***

(b)	**Vulnerability-sensitivity: functional-economic layers**	• ***How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?***

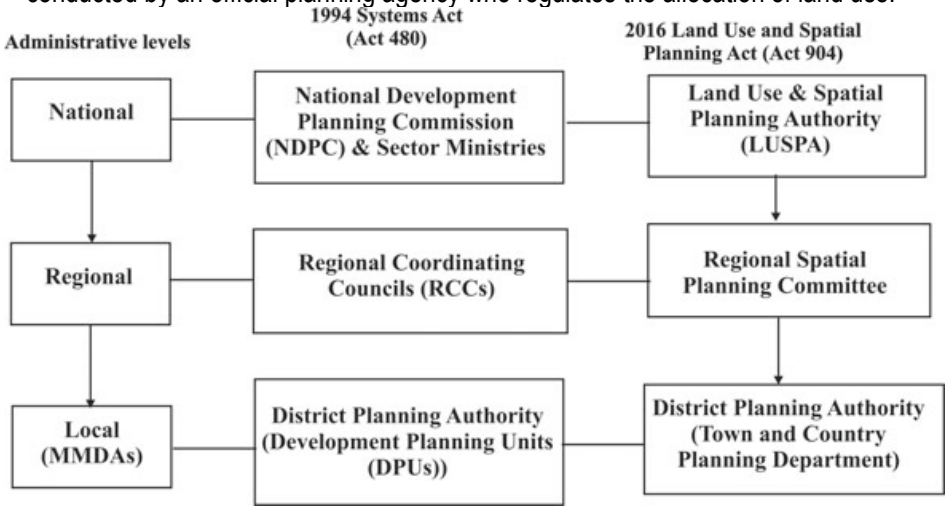
(c)	**Vulnerability-sensitivity: social-cultural layers**	• ***How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?***

(d)	**Vulnerability & adaptive capacity of social institutions**	• ***How far are key institutions (community, civic society, public services etc), vulnerable / sensitive or resilient?***

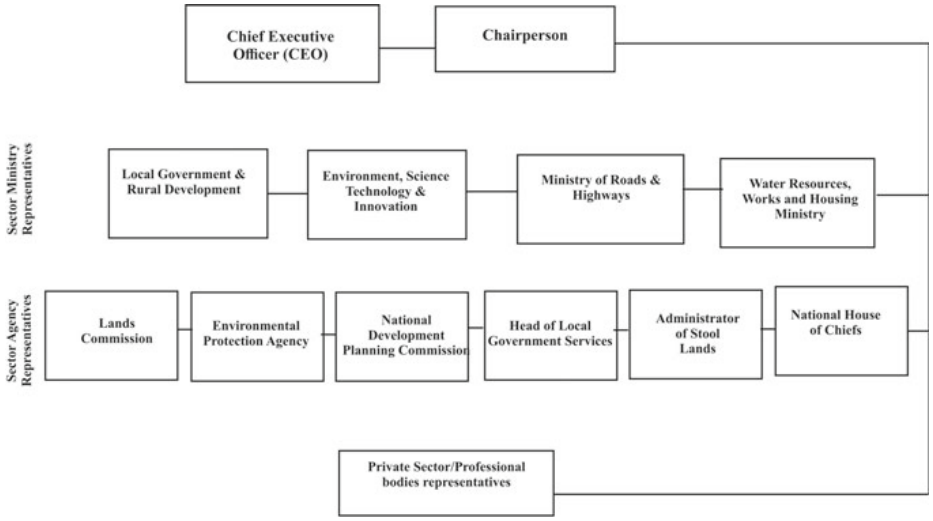
4.	***GOVERNANCE THEMES:*** ***Adaptive action & governance***	

(a)	**Formal government, (governance, regulation)**	• ***How does local / regional government work here & which kind of policies, regulations or plans apply?***

- Kumasi applies a statutory and customary land ownership / management system, which recognises the existence of the state (statutory) and customary (indigenous community / tribal leaders) as landowners. Currently the tribal leaders own 80% of the land in Kumasi. Spatial planning / land use management is conducted by an official planning agency who regulates the allocation of land use.



Institutional arrangements of Spatial Planning in Ghana (Acheampong, 2018)



Governing body of land use and spatial planning in Ghana (Acheampong, 2018)

(b)	**Adaptive governance & institutions: (networks, coalitions, partnerships)**	• ***Are there networks, coalitions, partnerships etc, or any emerging signs of these?***

(c)	**Informal governance, (corruption, community, livelihood,)**	• ***How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?***

- The process of purchasing land is often informal. Tribal leaders acquired lands from individual owners then sell them to private developers. The transfer of ownership and the use of land beyond is often not regulated or were utilised without obtaining planning permission.
- An issue was also found with regards to development in wetlands. Despite regulations on important nature reserves, wetlands are continuously converted to residential zones

(d)	**System effects, resilience, collective intelligence**	• ***What could be the overall resilience of the system, or collective capacity for learning & thinking?***

- For better management of peri-urban areas, tribal leaders need to collaborate with professional authorities to ensure better outcomes of urban development

8.3 Basic data

SPATIAL DEVELOPMENT

Population city-region	- 3.2m
Land area city-region	- 254 km2
Density city-region	- 12600 pp/km2
Population city-region change	

CLIMATE HAZARD

(World Bank data - https://thinkhazard.org – data for Ashanti province)

Extreme heat	- medium
Wildfire	- HIGH
Water scarcity	- medium
River flood	- HIGH
Urban flood	- HIGH
Coastal flood	- *(no data)*
Cyclone	- *(no data)*
Tsunami	- *(no data)*
Landslide	- low
Earthquake	- medium
Volcano	- *(no data)*

VULNERABILITY

Economic type	- lower middle-income
GDP /pp city-region	- $2266 USD / $7360 PPP
HDI (national 2017)	- 0.592

8.4 Sources

Urban governance themes

Acheampong, R. A. (2018) Spatial Planning in Ghana: Origins, Contemporary Reforms and Practices, and New Perspectives. Cham: Springer International Publishing AG (The Urban Book Series).

Campion, B. and Owusu-Boateng, G. (2013) 'The Political Ecology of Wetlands in Kumasi, Ghana', International Journal of Environment and Bioenergy, 7, pp. 108–128

Climate & vulnerability themes

[1] https://unfccc.int/resource/docs/natc/ghanc3.pdf

[2] Climate Change and Variability in Ghana: Stocktaking Felix A. Asante 1,† and Franklin Amuakwa-Mensah 2,†,*

[3] Urban planning and climate change in Ghana Patrick Brandful Cobbinah, Michael Osei Asibey, Marcia Opoku-Gyamfi, Charles Peprah

[4] Peri-Urban Development in Kumasi, Samuel Afrane.

[5] Green to Grey: An Urban Heat Assessment of Kumasi, Ghana

General sources

Reports and Policies

The Study on the Comprehensive Urban Development Plan for Greater Kumasi in the Republic of Ghana, Ministry of Environment, Science, Technology And Innovation, Town and Country Planning Department
Description: comprehensive report including environmental issues
http://www.luspa.gov.gh/files/EIJR13206-Greater-Kumasi-01.pdf

Academic Articles

Cobbinah, Patrick Brandful, Asibey, Michael Osei, Opoku-Gyamfi, Marcia, & Peprah, Charles. (2019). Urban planning and climate change in Ghana. *Journal of Urban Management*, 8(2), 261-271.
Description: qualitative case study of Kumasi's climate policies
https://doi.org/10.1016/j.jum.2019.02.002

Campion, Benjamin Betey, & Venzke, Jörg-Friedhelm. (2012). Rainfall variability, floods and adaptations of the urban poor to flooding in Kumasi, Ghana. *Natural Hazards* , 65(3), 1895-1911.
Description: flood adaptation measures in informal settlements
https://link.springer.com/article/10.1007%2Fs11069-012-0452-6

Darkwah, Rhoda Mensah, Cobbinah, Patrick Brandful, & Anokye, Prince Aboagye. (2018). Contextualising urban resilience in Ghana: Local perspectives and experiences. *Geoforum*, 94, 12-23.
Description: qualitative case study of resilience for climate adaptation in Kumasi
https://doi.org/10.1016/j.geoforum.2018.05.023

Owusu-Ansah, J. K. (2015). The influences of land use and sanitation infrastructure on flooding in Kumasi, Ghana. *GeoJournal*, 81(4), 555-570.
Description: qualitative case study with recommendations for flood management
https://link.springer.com/article/10.1007/s10708-015-9636-4

Korah, Prosper Issahaku, & Cobbinah, Patrick Brandful. (2017). Juggling through Ghanaian urbanisation: Flood hazard mapping of Kumasi. *GeoJournal*, 82(6), 1195-1212.
Description: multi-criteria and spatial analysis of flood hazard zones
https://link.springer.com/article/10.1007/s10708-016-9746-7

Amoateng, P., Finlayson, C. M., Howard, J., & Wilson, B. (2018). A multi-faceted analysis of annual flood incidences in Kumasi, Ghana. *International Journal of Disaster Risk Reduction*, 27, 105– 117.
Description: qualitative case study of flooding with future recommendations
https://doi.org/10.1016/j.ijdrr.2017.09.044

Cobbinah, Patrick Brandful, Gaisie, Eric, Oppong-Yeboah, Nana Yaw, & Anim, Desmond Ofosu. (2020). Kumasi: Towards a sustainable and resilient cityscape. *Cities*, 97, 102567.
Description: development, resilience and sustainability
https://doi.org/10.1016/j.cities.2019.102567

9 Helsinki

Sources

- *Based on interview, 11-02-21*
- *Mika Ristimaki, Ville Helminen, Kari Oinonen, Juha Nurmi*
- *Draft & raw material : Joe Ravetz, Dimas Adrianto, Joe Lake Rees (Manchester):*

9.1 Peri-urban-climate: summary

This is a short overview of (a) problems / challenges, and (b) responses / pathways (to be developed in the workshop and beyond).

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
PERI-URBAN			
Spatial peri-urban types & patterns:	Urban direct expansion Urban / rural fringe & gradient Counter-urbanization effect Urban agglomeration effect	Rapid expansion of suburban family housing, followed by some reverse movement back to cities, in search of jobs, culture etc. Large expansion of per-urban densities are seen on the maps.	
Spatial peri-urban dynamics (growth / restructuring / transition).	Population growth & housing Technology & infrastructure Economy & employment Real estate & markets	Public services & public transport not easy to provide in scattered low density developments. Decentralization push via multi-locality, digital services & jobs – in tension with the pull of community & networks.	
Peri-urban other drivers (STEEP: social, technical, ecological, policy, culture etc)	Social demographics & lifestyle Environment & resources Policy & governance Culture & ethics	Social & cultural drivers: mythology of the forest lifestyle: demographic shift & out-migration of rural young. Also out-migration of urban families to smaller towns	
Global-local dynamics & inter-dependencies	Internal structures external interactions power dynamics challenges & conflicts	Helsinki metro region rapid expansion, while many rural regions are shrinking with large social costs. Large 'beltway' sprawl area around orbital road witih global businesses.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
CLIMATE			
Climate change direct effects projections	temperature, precipitation, storm, coastal effects	Temperature rise projection 2080-2100: 1.5 to 6.5 degrees max Precipitation winter: 30%+ average Precipitation summer: 20%+ average	
Climate indirect hazards & impacts:	wildfire, heatwave, drought, flood, storm, cyclone landslide, sea incursion etc,	Large areas of pluvial flood risk in forest hinterland. Fluvial flood risk increased by rainfall intensity and melting snow. Increased winter flooding. Sea level rise due to climate change increases flood risk	
Indirect hazards & nexus effects	water resources farming & forestry energy & resources ecosystems & microclimates critical infrastructure	Floods / heavy rains: farming damage, water services effected. Drought: Increased irrigation for farming, weakened flora growth, increased forest fire risk, decreased summer hydropower production, diminishing groundwater sources, water traffic difficulties	
Causal loops (impacts of peri-urban on climate change)	CO2 emissions from energy GHG emissions from land-use Land-use & forestry change Carbon storage	Increasing city density and climate change may increase the flood risk due to increased impermeable surface and intensified rainfall	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
VULNERABILITY			
Physical-ecological vulnerability-sensitivity	• Soil & vegetation • Topography & stability • Settlement form & structure	Wildfires in some forest areas. Tick-borne diseases may increase as growing season increases. Biodiversity threatened buy increased city development and reduction of green areas. Flora will be affected by rapid change in winter conditions, loss of species may affect habitats and eco-system functions. Plant diseases and pests may increase.	
Functional-economic-infrastructure layers of vulnerability-sensitivity:	• technical & infrastructure • Markets & value effects • Employment & livelihoods	Climate change may possibly combine with other demographic changes, influx of migration, urban rural divisions etc: Flood defence is advanced, however not possible to cover the large areas of hinterland	
Eco-social-cultural layers of vulnerability-sensitivity:	• Affluence / deprivation • Education / communication • Cultural issues	Generally a strong society with high cohesion. Reduced sunlight in winter months may exacerbate winter depression. Aging populations will experienced increase health risks due to increased heat stress.	
Adaptive governance capacity-vulnerability-sensitivity-	• Local government • Public services & infrastructure • Emergency services • Civil & community	Local government is generally well organized but there may be some in-flexibility.	

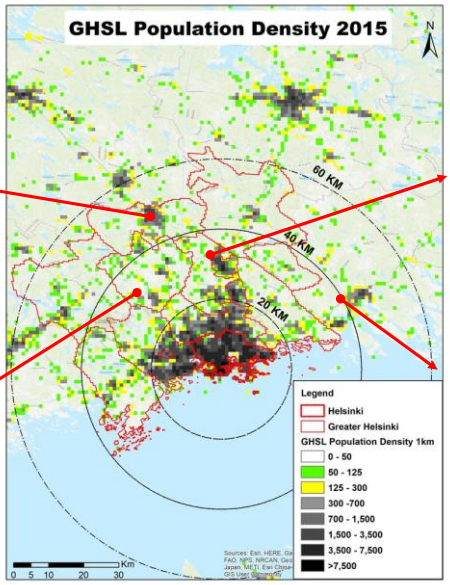
THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
GOVERNANCE			
Formal government, (governance, regulation)	Spatial planning green belt etc Housing policy Infrastructure development	Regional planning for the metro region is now taking shape, in a sophisticate multi-level system. The Ministry provides a toolkit for climate policy assessment.	
Adaptive / Associative governance: (networks, coalitions, partnerships)	Public sector Private sector Civic sector Citizens etc	Many civil society groups are strong, e.g. labour unions, academics, heritage etc.	
Informality / elite capture / grassroots action:	Informal land-use, settlements, enterprise Corruption & nepotism Social innovation & enterprise for integrated livelihoods	From the Anti-Corruption.fi Finland is one of the least corrupt countries in the world	
System resilience, collective intelligence (combined formal / adaptive / informal)	Social learning & collaboration Social co-creation & mobilization potential System transformation potential		

9.2 Peri-urban-climate: outline

1.	***PERI-URBAN THEMES: ("drivers / stressors / exposure")***	***TYPICAL QUESTIONS***

- Helsinki has evolved from a monocentric city to a polycentric region as a result of urban expansion. The new peri-urban sub-centres are medium-size towns which are continuously expanding with new low-density residential areas and road infrastructures retrofitted in the adjacent enclaves. These towns are connected with railway services, which was a factor accelerating the growth of peri-urban areas.
- Helsinki's surrounding region is also home for many attractive landscapes. Apparently, this had attracted a considerable growth of, for instance, holiday cottages/resorts in the peri-urban, mostly nearby the lakes

Formation of polycentric peri-urban areas towards the north



Low density peri-urban areas with regional railway connection

Recently developed residential areas + road infrastructures on an extended existing peri-urban enclave

Growth of cottages at attractive peri-urban landscapes

- It was found that there was significant growth of single-family housing in the north-east during 2000-2007. But this trend had changed significantly beyond 2007, where peri-urban dwellers migrated to the city centre as urban centres provide more of the services and livelihoods. The majority of these formerly peri-urban dwellers preferred to inhabit the urban centres. Following the peri-urban to urban migration, there has been substantial migration from other countries (e.g. Estonia and Russia) to Helsinki's peri-urban areas. This dynamic population figure contributed to the overall population increase in the Helsinki City-region.
- An important issue worth looking at is population ageing, both in the urban and the peri-urban areas. Most of the age 70> group are living in single family houses. Within the next 10-20 years, these houses will be released to the market
- The problem with peri-urbanisation is centralised in the issue of public service delivery. Due to the nature of the scattered structure of peri-urban development, there are difficulties in ensuring equal provision of public services (e.g. health and transport) particularly across the recently growing towns.
- "I think one key game changer for the future of peri urban is the aim of getting down the emissions - low carbon society. This leads to questions like: what are the practical and political possibilities of enlarging the area of good public transport outside the main metropolitan area? Is it possible in post-corona era, when there are big changes the ways to do shopping, ways to communicate and work?"

"I think we should take into account the consequences of digitalization to peri-urban. The logic of merchandise and services is changing rapidly and will reflect e.g. to need to travel, workplaces, manufacturing and logistics"

(a)	**Spatial peri-urban types & patterns:**	• ***What is the main geographical type and structure in this city-region / peri-urban zone?***

(b)	**Spatial peri-urban functional dynamics (growth / restructuring / transition).**	• ***How did it evolve / emerge to this situation?***

(c)	**Other drivers (STEEP: social, technical, ecological, policy, culture etc)**	• ***What other causes and drivers of change are in the picture?***

(d)	**Global-local dynamics & inter-dependencies**	• ***Which are the key global / local conflicts & challenges this city-region / peri-urban zone?***

2.	***CLIMATE CHANGE THEMES ("causes / hazards"):***	

- In our institute there is a lot of research that supports the monitoring to calculate the floods, which is happening more in the western part and……
- As Helsinki city-region grows, there are lots of construction of housing, infrastructure, digging tunnels, bridges, railways and so on and lot of rocks and sands is needed- these material comes from the peri-urban.
- There is a big bridge coming from the southeast to the delta area of the sand and is crushing the peri-urban areas of the city region. There are lots of digging and raw materials, this is one that I this kind of per-urbanisation process should take into account. It's a big planning problem, how to circulate the materials in urban systems and so on.

(a)	**Climate change direct effects:**	• ***What are the main climate change projections for this area / city-region / peri-urban zone?***

Increased rainfall intensity, shorter winter season, reduced sunlight hours in winter months. Increased heat stress in summer season, 32 °C in 2050's as common as 30 °C in 1990's. Water temperature will increase, frozen period in gulf of Finland shorter by 1 - 3 months by 2100.Sea salinity may decrease, sea water will acidify by increased dissolved carbon dioxide. Increased rainfall and freezing may increase accidents whilst walking around city. [1]

(b)	**Climate change direct hazards & impacts:**	• ***What are the expected / projected hazards, impacts and risks?***

Pluvial flood risk due to increased rainfall intensity. Fluvial flood risk increased by rainfall intensity and melting snow. Increased winter flooding. Sea level rise due to climate change increases flood risk. [1]

•

(c)	Indirect hazards & nexus effects	• *Which hazards and impacts are most critical for food, energy, water, other infrastructure?*

Increased rainfall may lead to increased hydropower production (5% increase in 40 years). Increased windiness will increase potential for wind power. Solid fuel availability and quality are at risk due to increased rainfall. Decrease need to use winter heating due to warming.[4]

Floods / heavy rains: farming damage, water services effected.
Drought: Increased irrigation for farming, weakened flora growth, increased forest fire risk, decreased summer hydropower production, diminishing groundwater sources, water traffic difficulties.

Storms and winds: Damages to infrastructure, forest damage, difficulties for sea traffic, increased insurance premiums.
Frost damages: risk to crop cultivation, weakened berry yields.

(d)	Causal loops (peri-urbanization >> climate change)	• *How does the pattern of peri-urbanization cause further climate emissions or urban / rural impacts?*

Increasing city density and climate change may increase the flood risk due to increased impermeable surface and intensified rainfall. [1]

3.	*VULNERABILITY THEMES sensitivity / capacity*	

(a)	**Physical-ecological vulnerability-sensitivity**	• ***How far are the physical & ecological systems, vulnerable / sensitive or resilient / adaptive?***

Tick-borne diseases may increase as growing season increases. Biodiversity threatened buy increased city development and reduction of green areas. Flora will be affected by rapid change in winter conditions, loss of species may affect habitats and eco-system functions. Plant diseases and pests may increase.

Resilience – increasing tree and plant species diversity, planting those suited to the changing climate conditions.

Invasive species in the Baltic Sea, water temperature will increase, salinity may decrease. Salinity decrease may threaten key species. Sea acidification. [1]

(b)	**Vulnerability-sensitivity: functional-economic layers**	• ***How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?***

Transboundary impacts – increased raw material costs. Increased energy costs. [1]
Flood adaptation: Elevated building heights, floating houses, elevated street level infrastructure, regular public rescue services. [3]

(c)	**Vulnerability-sensitivity: social-cultural layers**	• ***How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?***

Reduced sunlight in winter months may exacerbate winter depression. Aging populations will experienced increase health risks due to increased heat stress.[1]

(d)	**Vulnerability & adaptive capacity of social institutions**	• ***How far are key institutions (community, civic society, public services etc), vulnerable / sensitive or resilient?***

Consideration of climate change must be taken at all decision-making levels in Helsinki. Carefully modelling flooding will help development planning to reduce associated risk. Urban heat island (UHI) was raised as a concern that it had not been mapped. [1] UHI has recently been mapped, there are areas of high risk. [2]

4.	***GOVERNANCE THEMES:*** ***Adaptive action & governance***	

(Kari Oinonen): one key game changer for the future of periurban is the aim of getting down the emissions - low carbon society. This leads to questions like: what are the practical and political possibilities of enlarging the area of good public transport outside the main metropolitan area, how to do this? Is it possible in post-corona era, when there are big changes the ways to do shopping, ways to communicate and work

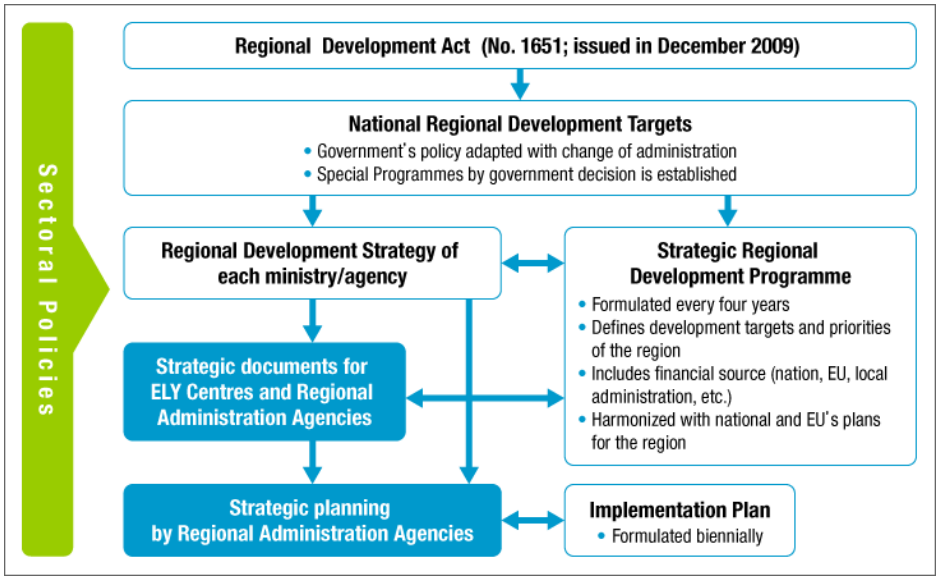
Helsinki metropolitan area was among the first (at least in Europe) to make climate change adaptation strategy and has implemented that for something like 10-15 years. Floods and stormwaters are taken into account well in land use planning

we should take into account the consequencs of digitalization to periurban. The logic of merchandise and services is changing rapidly and will reflect eg. to need to travel, workplaces, manufcturing and logistics

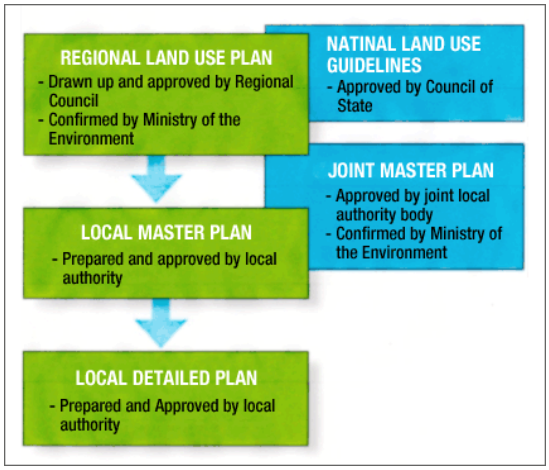
(a)	**Formal government, (governance, regulation)**	• ***How does local / regional government work here & which kind of policies, regulations or plans apply?***

Name and Field of Plan/Policy	Organization	Web site
Regional Policy (overall) Rural Policy Committee, Islands Policy	Ministry of Economic Affairs and Employment	https://tem.fi/en
Land Use Plan, Environmental Plan	Ministry of the Environment	http://www.ym.fi/en-us
Rural Policy	Ministry of Agriculture and Forestry	http://www.mmm.fi/en/index/ministry.html
Transport and Communication Policy	Ministry of Transport and Communications	https://www.lvm.fi/en/home
Regional-level economic, transport and environmental development	Centres for Economic Development , Transport and the Environment (ELY) : 15 on the main land	

Authorities in Finland's Spatial Planning (Source: MLIT Japan - https://www.mlit.go.jp/kokudokeikaku/international/spw/general/finland/index_e.html Accessed 6 March 2021)



(Source: MLIT Japan - https://www.mlit.go.jp/kokudokeikaku/international/spw/general/finland/index_e.html Accessed 6 March 2021)



Land use planning system in Finland (Source: MLIT Japan - https://www.mlit.go.jp/kokudokeikaku/international/spw/general/finland/index_e.html Accessed 6 March 2021)

(b)	**Adaptive governance & institutions: (networks, coalitions, partnerships)**	• ***Are there networks, coalitions, partnerships etc, or any emerging signs of these?***

(c)	**Informal governance, (corruption, community, livelihood,)**	• ***How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?***

According to a corruption watch source (Anti-Corruption.fi) Finland is one of the least corrupt countries in the world

(d)	**System effects, resilience, collective intelligence**	• ***What could be the overall resilience of the system, or collective capacity for learning & thinking?***

9.3 Basic data

Climate hazard

(World Bank data profile for Uusimaa)

Extreme heat	- Low
Wildfire	- Medium
Water scarcity	- Low
River flood	- Very low
Urban flood	- Very low
Coastal flood	- Medium
Cyclone	- No data
Tsunami	- No data

Landslide	- No data
Earthquake	- Very low
Volcano	- No data

9.4 Sources

Sources

[1] https://www.hel.fi/static/liitteet/kaupunkiymparisto/julkaisut/julkaisut/julkaisu-32-19-en.pdf

[2] Zoning and weighting in urban heat island vulnerability and risk mapping in Helsinki, Finland. Aleksi Räsänen, Kimmo Heikkinen, Noora Piila & Sirkku Juhola.

[3] Legitimate adaptive flood risk governance beyond the dikes: the cases of Hamburg, Helsinki and Rotterdam. Heleen Mees, P.P.J. Driessen & Hens Runhaar.

[4] Finland's Integrated Energy and Climate Plan, Ministry of Economic Affairs and Employment.

[5] Finland's National Adaptation Strategy, Ministry of Agriculture and Forestry

General sources

(from Ville Helminen):

- https://hiilineutraalisuomi.fi/en-US
- https://www.uudenmaanliitto.fi/en/development_and_planning/regional_programming/climate_neutral_helsinki-uusimaa_2035
- https://helsinkismart.fi/cases/?_cases_theme=climate-neutrality#acf-cases-listing
- https://hslfi.azureedge.net/contentassets/7352e50fa96b4f4c9d017860c4363eaf/mal_summary_report_210x260_en_rgb.pdf
-

Organisations, Programmes, and Projects
Climate Protection, City of Helsinki
Description: strategies for climate action and conservation
https://www.hel.fi/helsinki/en/housing/environmental/programmes/climate-action/

Urban Environment Division, City of Helsinki
Description: environmental reports and climate policies
https://www.hel.fi/kaupunkiymparisto/en

Helsinki Institute of Sustainability Science; the Urban Environmental Policy Research Group; and the Research Centre for Ecological Change, University of Helsinki
Description: research on climate adaptation and sustainability
https://www.helsinki.fi/en/researchgroups/urban-environmental-policy

Climate Street Project
Description: local pilot projects for mitigation and adaptation
https://ilmastokatu.fi/en/

Reports and Policies

Helsinki Metropolitan Area Climate Change Adaptation Strategy, Helsinki Region Environmental Services Authority
Description: policies for various sectors such as land-use, buildings, and water
https://ilmastotyokalut.fi/files/2014/10/11_2012_Helsinki_Metropolitan_Area_Climate_Change_Adaptation_Strategy.pdf

Climate Smart Helsinki, City of Helsinki
Description: integrated mitigation and adaptation plan
https://www.hel.fi/hel2/ksv/julkaisut/esitteet/esite-2017-4-en.pdf

Storm water management program, City of Helsinki
Description: objectives, priorities, monitoring, and city organization
https://www.hel.fi/static/liitteet/kaupunkiymparisto/julkaisut/julkaisut/julkaisu-03-18-en.pdf

Weather and Climate Change Risk Assessment, City of Helsinki and the Finnish Meteorological Institute
Description: report that outlines the climate risks and vulnerabilities
https://resilientcities2018.iclei.org/wp-content/uploads/B1_Additional_Helsinki-weather-and-climate-risks-summary.pdf

Academic Articles

Klein, Johannes, Klein, Johannes, Mäntysalo, Raine, Mäntysalo, Raine, Juhola, Sirkku, & Juhola, Sirkku. (2016). Legitimacy of urban climate change adaptation: A case in Helsinki. *Regional Environmental Change*, 16(3), 815-826.
Description: qualitative analysis of adaptation planning
https://link.springer.com/article/10.1007/s10113-015-0797-y

Juhola, S. (2013). Adaptation to Climate Change in the Private and the Third Sector: Case Study of Governance of the Helsinki Metropolitan Region. *Environment and Planning C: Government and Policy*, 31(5), 911-925.
Description: private and third sector participation in adaptation governance
https://doi.org/10.1068/c11326

Ruuhela, Reija, Jylhä, Kirsti, Lanki, Timo, Tiittanen, Pekka, & Matzarakis, Andreas. (2017). Biometeorological Assessment of Mortality Related to Extreme Temperatures in Helsinki Region, Finland, 1972-2014. *International Journal of Environmental Research and Public Health*, 14(8), 944.
Description: time series analysis of the relationship between temperature change and mortality in the region
https://www.mdpi.com/1660-4601/14/8/944

Räsänen, Aleksi, Heikkinen, Kimmo, Piila, Noora, & Juhola, Sirkku. (2019). Zoning and weighting in urban heat island vulnerability and risk mapping in Helsinki, Finland. *Regional Environmental Change*, 19(5), 1481-1493.
Description: assessment of zoning and spatial mapping of UHI vulnerabilities and risks
https://link.springer.com/article/10.1007/s10113-019-01491-x

10 Naples

(abbreviated version)

10.1 Peri-urban themes

No.	THEMES	QUESTIONS	NOTES
1.	**PERI-URBAN THEMES (drivers / stressors / exposure)**		
a.	Spatial peri-urban types & patterns	What is the main geographical type and structure in this city-region / peri-urban zone?	• Naples Metropolitan Area is home to more than 4 million people, which is considered as one of the largest urban agglomeration in the South of Italy. • Naples Metropolitan Areas developed from a monocentric spatial structure, with Naples being the growth centre surrounded by rural landscapes. In the last 50 years however, Naples has been growing rapidly with expansion of urban areas proliferating to the outskirts. Based on an observation conducted by Papa and Mazzeo (2014), Naples urban expansion was very intense in early 2000s, where the urban built up areas doubled within the inner peri-urban zone. Most of the urban investment proliferated to the north peri-urban, which brought massive land use conversion. Until recently, more than 50% of Naples' north peri-urban landscapes have been urbanised. • According to an observation on the pattern of peri-urbanisation, it was found that Naples' peri-urban fabric has a low spatial fragmentation (OECD, 2018). However, this might not confirm the absence of socio-spatial fragmentation, or the observation was limited only at the inner peri-urban zones • Lower density development was found in the further peri-urban zones where spatial fragments are prevalent, characterised by heterogeneity of economic activities. Indications of illegal peri-urban development were found apparently due to time gaps between periods where landscapes were urbanising and the delayed spatial regulation addressing strict zoning controls. Transport infrastructure was also built to respond to problems (e.g. congestion) instead of a result of deliberate peri-urban planning (Papa and Mazzeo, 2014)
b.	Spatial peri-urban functional dynamics (growth / restructuring / transition)	How did it evolve / emerge to this situation?	
c.	Other drivers (STEEP: social, technical, ecological, policy, culture etc.)	What other causes and drivers of change are in the picture?	
d.	Global-local dynamics & inter-dependencies	Which are the key global / local conflicts & challenges this city-region / peri-urban zone?	

10.2 Climate themes

No.	THEMES	QUESTIONS	NOTES
2.	CLIMATE CHANGE THEMES (drivers / stressors / exposure)		
a.	Climate change direct effects	What are the main climate change projections for this	Temperature shows an overall warming of 1.0 ± 0.1 °C. over the last century. Temperature is set to

No.	THEMES	QUESTIONS	NOTES
		area / city-region / peri-urban zone?	increase between 2.0 °C and 5.1 °C by 2099 (SRES A1B / RCP6.0 scenario, balanced energy source scenario 700 ppm by 2100). [1]
b.	Climate change direct hazards and impacts	What are the expected / projected hazards, impacts, and risks?	Observed increase in daily precipitation events, even in areas with a decrease in mean precipitation. Predicted decrease in average precipitation of 4% to 26% by 2099. Predicted decrease of cold days, increase of heatwaves duration, days with temperature 5 °C above normal value. Sea level rise of 3mm/year over the 1990's. Ecosystems expected to migrate north, [1]
c.	Indirect hazards and nexus effects	Which hazards and impacts are most critical for food, energy, water, other infrastructure?	Predicted reduction in electricity generation from hydropower, generation already reduced by 23% between 2001 and 2005. Reduced availability of potable water, reduced water for thermoelectric power plants. Growing period increase of 10-15 days per °C increase in yearly average temp. 5% of floods caused by climate change will be occurring on the coast near Rome and Naples. Increases in summer heat related mortality. Decreases in winter cold related mortality. Changes in disease burden. Increases in risk of accidents from extreme weather. Impacts on mortality due to extreme events. Increase in water borne disease outbreaks could increase due to extreme rainfall (rainfall or drought). [1] A 1 °C, increase in summer temperature reduces agricultural land values by 62%, a 1 °C increase in spring increases land values by 37%. [2] In 2004 groundwater accounted for 99.7% of drinking water requirements in Campania (wider Naples region), groundwater recharge is decreasing due to decreased precipitation, and increased evapotranspiration due to warmer temperatures. Infiltration reduced by up to 30% from 1980s to 2000s, if the trend continues it is expected that in 50 years ground water resources will decrease by about 70%. If this trend continues by 2050 6 million people in Campania will face a water crisis. [3] Impact on Italian farmland value is estimated to be between +1.5% to -15.8% by 2100. [2]
d.	Causal loops	How does the pattern of peri-urbanisation cause further climate emissions or urban / rural impacts?	Uptake of air conditioners was expected to be 14 million units by 2011, if this electricity continues to be generate by fossil fuels, the summer temperatures will continue to rise. [1]

10.3 Vulnerability themes

No.	THEMES	QUESTIONS	NOTES
2.	VULNERABILITY THEMES (drivers / stressors / exposure)		
a.	Physical-ecological vulnerability-sensitivity	How far are the physical and ecological systems, vulnerable / sensitive or resilient / adaptive?	Forest fires are frequent in Campania, but as a result of better citizen education the number of fires is decreasing. [1]
b.	Vulnerability-sensitivity: functional-economic layers	How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?	White Certificates systems aim to promote energy efficiency and reducing emissions. [1]
c.	Vulnerability-sensitivity: social-cultural layers	How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?	
d.	Vulnerability and adaptive capacity of social institutions	How far are key institutions (community, civic society, public services), vulnerable / sensitive or resilient?	Campania region have run a 'save energy public campaign' [1]

10.4 Governance themes

4.	**GOVERNANCE THEMES (Adaptive action & governance)**		
a.	Formal government (governance, regulation)	How does local / regional government work here & which kind of policies, regulations or plans apply?	• At least until 2014, Italy does not have a national urban policy, but the role of the state has been quite strategic by promoting the restructuring of provincial government which enables cities to take responsibilities for managing and authorizing development at local levels. To ensure a nation-wide control over local urban development agenda, an inter-ministerial panel for urban policy was established in 2012 aiming to address issues of (1) institutional cross-boundary matters and make necessary interventions for enhanced policy-making, (2) urban sprawl with close observation on the need to support the provision of regional infrastructure, and (3) to maintain strategic management with regards to the provision of housing (OECD, 2017) • One of the biggest challenges for Italy's spatial governance is the longstanding organized crime and corruption. Another point to be raised is the

			prevalence of declining areas in the peri-urban (particularly in the former industrial sites in the east and west peri-urban). In respond to this, Italy has established a new town planning scheme in 2004 which aims to restore and regenerate the neighborhoods (Urbact, n.d).

10.5 Sources

Papa, R. and Mazzeo, G. (2014) *Characteristics of Sprawl in the Naples Metropolitan Area. Indications for Controlling and Monitoring Urban Transformations*. doi: 10.1007/978-3-319-09129-7_38.

OECD (2017) 'The State of National Urban Policy in Italy'. https://www.oecd.org/regional/regional-policy/national-urban-policy-Italy.pdf (Accessed June 2021)

OECD (2018) 'Rethinking Urban Sprawl: Moving Towards Sustainable Cities'. https://www.oecd.org/environment/tools-evaluation/Policy-Highlights-Rethinking-Urban-Sprawl.pdf (Accessed June 2021)

Urbact (n.d) 'NAPLES'. https://urbact.eu/naples-0 (Accessed June 2021)

[1] Ministry for the Environment, Land and Sea. Fourth National Communication under the UN Framework Convention on Climate Change, Italy November 2007

[2] A Ricardian Analysis of the Impact of Climate Change on Italian Agriculture. M. Bozzola, E. Massetti, R. Mendelsohn & F. Capitanio

[3]Effects of climate change on groundwater resources in Campania (southern Italy). D. Ducci & G. Tranfaglia

General sources

Organisations, Programmes, and Projects

Ambiente, Paesaggio, Mare e Tutela animali (Environment, Landscape, Sea and Animal Protection), Comune di Napoli

Description: thematic area of the municipality

https://www.comune.napoli.it/ambiente-mare-tutela-animali

Academic Articles

Losasso M. (2021) Environmental Crisis and Climate Adaptation of the Urban Voids of Naples Historic Centre UNESCO Site. In: Bevilacqua C., Calabrò F., Della Spina L. (eds) *New Metropolitan Perspectives*. Smart Innovation, Systems and Technologies, vol 178. Springer, Cham.

Description: environmental design for 'climate-proofing'

https://doi.org/10.1007/978-3-030-48279-4_186

Pasquale De Toro, & Silvia Iodice. (2018). Ecosystem Health Assessment in urban contexts: A proposal for the Metropolitan Area of Naples (Italy). *Ce.S.E.T. Aestimum*, (72), 39.

Description: quantitative analysis and indicator development to assess ecosystem health

https://doi.org/10.13128/Aestimum-23968

Padulano, Roberta, Reder, Alfredo, & Rianna, Guido. (2019). An ensemble approach for the analysis of extreme rainfall under climate change in Naples (Italy). *Hydrological Processes*, 33(14), 2020-2036.

Description: quantitative analysis of climate changes in Naples

https://doi.org/10.1002/hyp.13449

Apreda, Carmela, D'Ambrosio, Valeria, & Di Martino, Ferdinando. (2019). A climate vulnerability and impact assessment model for complex urban systems. *Environmental Science & Policy*, 93, 11-26.

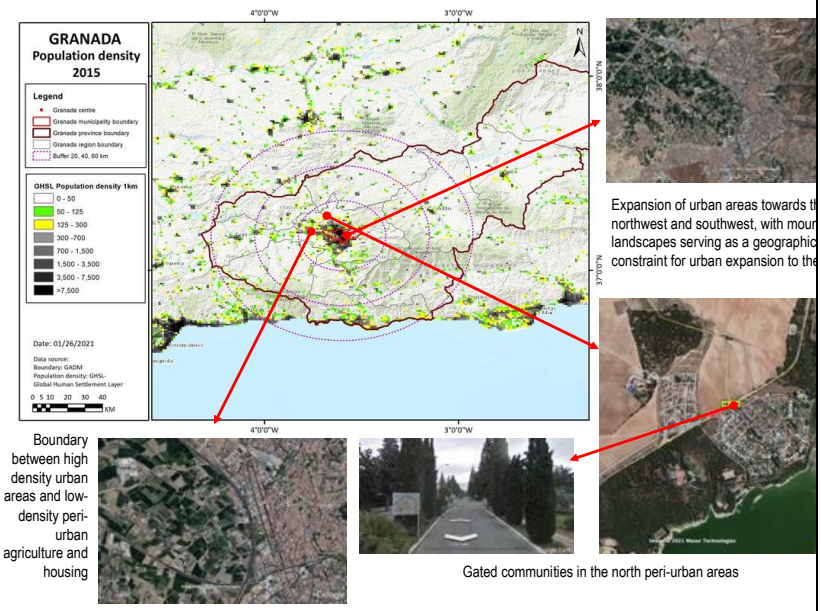
Description: a hierarchical model to assess heat waves and flooding

https://doi.org/10.1016/j.envsci.2018.12.016

11 Granada

(abbreviated version)

11.1 Peri-urban themes

<table>
<tr><th>No.</th><th>THEMES</th><th>QUESTIONS</th><th>NOTES</th></tr>
<tr><td colspan="4">1. PERI-URBAN THEMES (drivers / stressors / exposure)</td></tr>
<tr><td>a.</td><td>Spatial peri-urban types & patterns</td><td>What is the main geographical type and structure in this city-region / peri-urban zone?</td><td>• Granada is one of the top three rapidly sprawling regions in Spain along with Madrid and Victoria (Morollon et al., 2014). One of the compelling factors of urban expansion is the growing networks of Motorways connecting Granada urban centre with its surrounding regions.
• Granada's urban areas are expanding towards the northwest and southwest peri-urban, dominated by development of residential areas and road infrastructures. Meanwhile the mountainous landscapes serve as a constraint for urban expansion to the east.</td></tr>
<tr><td>b.</td><td>Spatial peri-urban functional dynamics (growth / restructuring / transition)</td><td>How did it evolve / emerge to this situation?</td><td> 

Expansion of urban areas towards th northwest and southwest, with moun landscapes serving as a geographic constraint for urban expansion to the
Boundary between high density urban areas and low-density peri-urban agriculture and housing
Gated communities in the north peri-urban areas
• The economic sectors of the peri-urban are dominated by agriculture and tourism. Most of the peri-urban agriculture are located in the southwest peri-urban, while the south relies on coastal tourism. Meanwhile, some of the peri-urban villages are experiencing economic depression with insufficient water supplies.
• One of the problems to look at in the future is the agricultural sectors. With its role as a main economic sector for the southwest peri-urban and a provider of local foods, these faring parcels are threatened by imminent rural-urban transformation as the peri-urban population continues to grow alongside the declining population density in the urban centres.</td></tr>
</table>

11.2 Climate themes

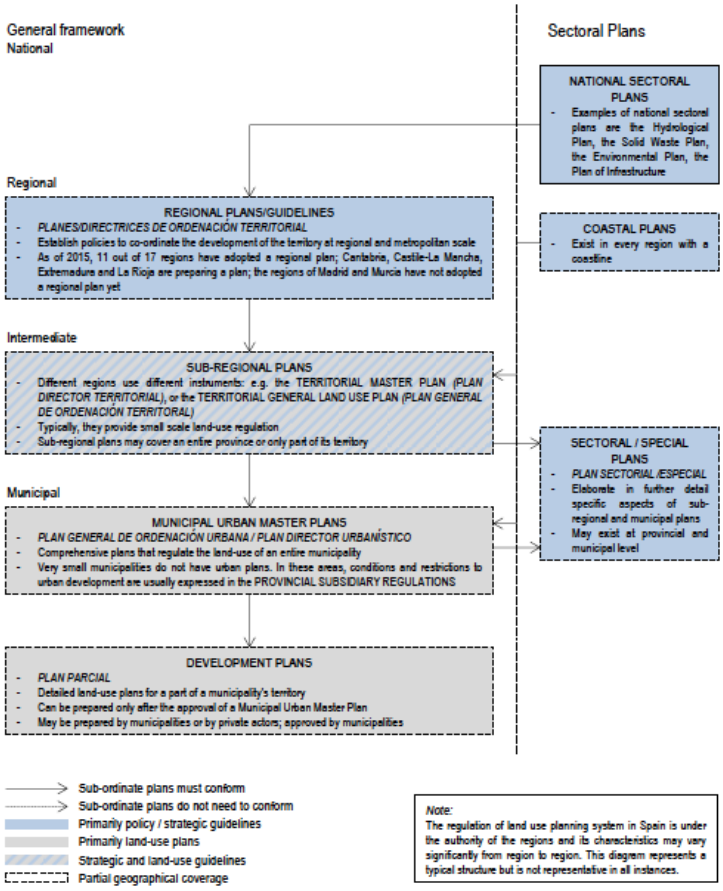
No.	THEMES	QUESTIONS	NOTES
2.	CLIMATE CHANGE THEMES (drivers / stressors / exposure)		
a.	Climate change direct effects	What are the main climate change projections for this area / city-region / peri-urban zone?	0.4 °C / decade winter temp increase, 0.7 °C / decade summer temp increase (A2 scenario). Increased frequency of days with extreme maximum temperatures. Reduction in rainfall in Andalucía region over latter half of C. 20th. [2]
b.	Climate change direct hazards and impacts	What are the expected / projected hazards, impacts, and risks?	Longer flowering season [1]. Spread of parasite species to new territories, greater incidence frequency of pine caterpillars in Scots pine in Andalusian forests. Recession of cork oak. Recession of shrub lands. Bird, mammal, and reptile biodiversity loss. Decrease in soil organic carbon. Water erosion across almost half of soils.
c.	Indirect hazards and nexus effects	Which hazards and impacts are most critical for food, energy, water, other infrastructure?	Fishing industry? Heavy winter rains have historically caused hundreds of embankment failures on key roads in the Andalucía region. Historic Andalucía landslips have been caused by rainfall greater than historic 100 year maxima at 30% of monitoring sites.[2] Reduction in maize yield, increase in rain-fed spring wheat yield. [4]
d.	Causal loops	How does the pattern of peri-urbanisation cause further climate emissions or urban / rural impacts?	Logging, alterations of slope drainage increase hill side infrastructure failure due to slope / embankment failures. [2]

11.3 Vulnerability themes

No.	THEMES	QUESTIONS	NOTES
2.	VULNERABILITY THEMES (drivers / stressors / exposure)		
a.	Physical-ecological vulnerability-sensitivity	How far are the physical and ecological systems, vulnerable / sensitive or resilient / adaptive?	Alhambra forest diversification increases forest resilience to climate change. [3] Bird populations around Granada are relatively diverse and resilient in a review of nine European cities. [5]
b.	Vulnerability-sensitivity: functional-economic layers	How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?	Recession of cork oak, affects local economy and agriculture. Andalusian Tourism is a large industry concentrated in July, August, and September.[2]
c.	Vulnerability-sensitivity: social-cultural layers	How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?	Increased pollen count, many trees experiencing longer flowering periods, this has already caused increased incidence of allergies, this trend will potentially increase in future. [3]

No.	THEMES	QUESTIONS	NOTES
d.	Vulnerability and adaptive capacity of social institutions	How far are key institutions (community, civic society, public services), vulnerable / sensitive or resilient?	*[limited information available]*

11.4 Governance themes

4.	GOVERNANCE THEMES (Adaptive action & governance		
a.	Formal government (governance, regulation)	How does local / regional government work here & which kind of policies, regulations or plans apply?	• Spanish Land Use Planning Organisation (OECD, 2017)  Some notes on the problems of peri-urban governance: • Lack of communication among neighbouring authorities where planning is often in silos. This particular issue has made difficult in planning the peri-urban, especially in the management of green belt. This needs a more robust reginal framework to ensure the connectivity of green belt areas. On the other hand, the concept of Bioregion is not fully engaged in the process of planning, which involve also controlling and managing the process of rural-urban transformation. With this problem, the future of Spain's green belt in particular, or the peri-urban areas in general are heading towards jeopardy.
b.	Adaptive governance & institutions:	Are there networks, coalitions, partnerships	•

	(networks, coalitions, partnerships)	etc., or any emerging signs of these?	
c.	Informal governance, (corruption, community, livelihood)	How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?	•
d.	System effects, resilience, collective intelligence	What could be the overall resilience of the system, or collective capacity for learning & thinking?	• The big matter in governance is that the lack of climate change experts in government

11.5 Sources

[1] Climate Change in Spain: Phenological Trends in Southern Areas. García-Mozo, H., Mestre, A. and Galán, C.

[2] A Preliminary General Assessment of the Impacts in Spain Due to the Effects of Climate Change. Ministerio de Medio Ambiente

[3] Charting trends in the evolution of the La Alhambra forest (Granada, Spain) through analysis of pollen-emission dynamics over time Paloma Cariñanos, Manuel Casares-Porcel, Ana Valle Díaz de la Guardia, Rafael De la Cruz-Márquez & Consuelo Díaz de la Guardia

[4] Climate change and crop adaptation in Spain: consistency of regional climate models. A. Garrido, D. Rey, M. Ruiz-Ramos & M. I. Mínguez.

[5] Insurance for the future? Potential avian community resilience in cities across Europe. Federico Morelli, Yanina Benedetti, Juan Diego Ibáñez-Álamo, Piotr Tryjanowski, Jukka Jokimäki, Marja-Liisa Kaisanlahti-Jokimäki, Tomás Pérez-Contreras, Philipp Sprau, Jukka Suhonen, Reuven Yosef, Mario Díaz & Anders Pape Møller

Organisations, Programmes, and Projects

Adapta Granada

Description: climate change adaptation program

http://www.adaptagranada.es/

Portal Andaluz del Cambio Climático (Climate change portal for Andalucia), Junta de Andalucía

Description: platform for climate change information and policies

http://www.juntadeandalucia.es/medioambiente/site/pacc/menuitem.cd82a679aca907be77f751105510e1ca/?vgnextoid=0a5c1e9604273210VgnVCM10000055011eacRCRD&vgnextchannel=0a5c1e9604273210VgnVCM10000055011eacRCRD

Instituto Desarrollo Regional, Univeridad de Granada

Description: research institute with themes on urban growth and the environment

http://idr.ugr.es/idr/es/

Granada, Andalucia Resiliente

Description: civil society group for sustainability in the region

http://andaluciaresiliente.net/portfolio-items/granada

Sostenicity

Description: urban environmental organization with pilot projects in Andalucia

https://sostenicity.com/

Reports and Policies

Plan de adaptación al cambio climático (Provincial Plan for Adaptation to Climate Change), Diputación de Granada

Description: objectives, evaluations and plans for adaptation in the region

https://www.dipgra.es/uploaddoc/areas/894/Resumen%20ejecutivo%20ppaccgr%20adapta-granada.pdf

De Medidas Frente Al Cambio Climático Y Para La Transición Hacia Un Nuevo Modelo Energético En Andalucía (Measures for Climate Change and for a transition to a new energy model in Andalucia), Parlamento de Andalucía

Description: energy transition, climate mitigation and adaptation plan

http://www.parlamentodeandalucia.es/webdinamica/portal-web-parlamento/pdf.do?tipodoc=coleccion&id=134514&cley=8

Academic Articles

Matarán Ruiz A., Yacamán Ochoa C. (2020) Participative Agri-Food Projects in the Urban Bioregion of the Vega of Granada (Spain). In: Fanfani D., Matarán Ruiz A. (eds) *Bioregional Planning and Design: Volume II*. Springer, Cham.

Description: participation in an alternative food system in peri-urban Granada

https://doi.org/10.1007/978-3-030-46083-9_6

Calatrava, J. (2014). La agricultura interurbana como componente del urbanismo verde: el caso de la aglomeración de Granada. *Revista Española de Estudios Agrosociales y Pesqueros*, 239, 13–55.

Description: analyzes the relationship between urban agriculture and green urbanism

https://dialnet.unirioja.es/servlet/articulo?codigo=4934484

12 Santiago

Sources

- *Based on interview 12-04-21*
- *Contributions from Jorge Insulza Contrardo & Marie Geraldi Hermann*
- *Draft & raw material : Joe Ravetz, Dimas Adrianto, Joe Lake Rees (Manchester):*

12.1 Peri-urban-climate: summary

This is a short overview of (a) problems / challenges, and (b) responses / pathways (to be developed in the workshop and beyond).

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
PERI-URBAN			
Spatial peri-urban types & patterns:	Urban direct expansion Urban / rural fringe & gradient Counter-urbanization effect Urban agglomeration effect	Santiago expanded rapidly during the dictatorship & since, organized on a grid plan. Low income housing was sited on transit corridors. Much recent near-peri-urban is disconnected gated enclaves with own services. In hinterland, peri-urban expansion of older towns & modernization of rural economy.	
Spatial peri-urban dynamics (growth / restructuring / transition).	Population growth & housing Technology & infrastructure Economy & employment Real estate & markets	urban real estate markets push out-migration to peri-urban, mainly car-based: more pressure due to geography. Enclaves get larger	
Peri-urban other drivers (STEEP: social, technical, ecological, policy, culture etc)	Social demographics & lifestyle Environment & resources Policy & governance Culture & ethics	Middle class culture favours the peri-urban gated community. Rural areas want to be 'urban' & many urban areas want 'rural'.	
Global-local dynamics & inter-dependencies	Internal structures external interactions power dynamics challenges & conflicts	Santiago is primate city with large N-S gravity pull. Recent political changes shift towards indigenous economic activity, but most real estate controlled by elite wealth.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
CLIMATE			
Climate change direct effects projections	temperature, precipitation, storm, coastal effects	Temperature rise projection to 2100: 1.5 – 5.5 degrees average Precipitation projection: summer 30-50% reduction, winter 20-30% reduction. Major seismic problems with San Ramon fault: link with climate change?	
Climate indirect hazards & impacts:	wildfire, heatwave, drought, flood, storm, cyclone landslide, sea incursion etc,	urban flash flooding & drought events set to increase. Reduced water availability affecting hydroelectricity, mining, agribusiness, human consumption.	
Indirect hazards & nexus effects	water resources farming & forestry energy & resources ecosystems & microclimates critical infrastructure	Forest depletion to W, fire zone to NW. Generally arid landscape will increase in drought & heat. Major losses to agriculture in a high emissions scenario.	
Causal loops (impacts of peri-urban on climate change)	CO2 emissions from energy GHG emissions from land-use Land-use & forestry change Carbon storage	Urban impacts on land-use & land cover combine with climate change, causing soil & ecosystems loss.	

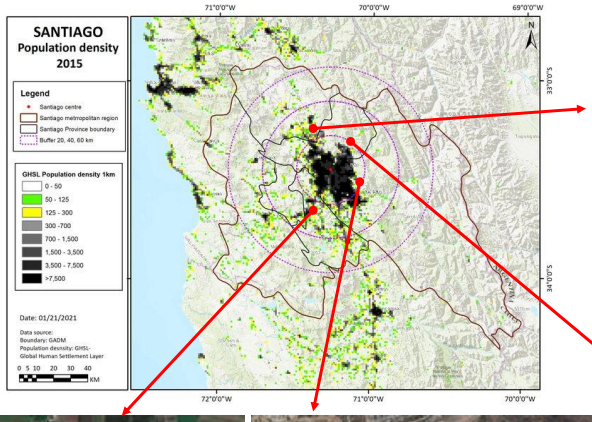
THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
VULNERABILITY			
Physical-ecological vulnerability-sensitivity	• Soil & vegetation • Topography & stability • Settlement form & structure	Santiago Metro region extends to near the coast, with fertile valleys & forested hills, against the Cordillera of the Andes. A generally dry climate is set to get much drier.	
Functional-economic-infrastructure layers of vulnerability-sensitivity:	• technical & infrastructure • Markets & value effects • Employment & livelihoods	Fragmented planning fails to connect with ecological patterns – or to provide infrastructure services & jobs in the right locations. Water / energy sectors lack integration of structure or policy.	
Eco-social-cultural layers of vulnerability-sensitivity:	• Affluence / deprivation • Education / communication • Cultural issues	Social divisions on the S side, between high-class residential areas next to existing social housing & local long-term community. Displacement of farming creates socio-economic problems with 'rural gentrification'. Urban poverty is rising & causes political pressures.	
Adaptive governance capacity-vulnerability-sensitivity-	• Local government • Public services & infrastructure • Emergency services • Civil & community	Resilience through participatory processes has been explored, however this needs rolling out at a larger and continuous scale. [4] There is potential to increase the resilience to climate change by engaging with structural inequalities. Peri-urban is developing randomly around the system of rural residential plots: liberalisation policies bring transformations that policy makers cannot control.	

THEMES	*SCOPE & TOPICS*	*PROBLEMS & CHALLENGES*	*RESPONSES & PATHWAYS*
GOVERNANCE			
Formal government, (governance, regulation)	Spatial planning green belt etc Housing policy Infrastructure development	Spatial governance is fragmented between 52 boroughs. Metropolitan area was planned on grid pattern, but the speed of peri-urban expansion seems beyond the current capacity of planning. Local governments are generally inwards & short termist.	
Adaptive / Associative governance: (networks, coalitions, partnerships)	Public sector Private sector Civic sector Citizens etc	Active civil society with pressure groups, lobby groups etc, however much is deeply embedded in structures of elite power	
Informality / elite capture / grassroots action:	Informal land-use, settlements, enterprise Corruption & nepotism Social innovation & enterprise for integrated livelihoods	The political elite merges into business / real estate / extractive industries, with widespread clientelism & nepotism.	
System resilience, collective intelligence (combined formal / adaptive / informal)	Social learning & collaboration Social co-creation & mobilization potential System transformation potential	There may be underlying layers of cohesion and resilience, alongside with deep political-cultural divisions	

12.2 Peri-urban-climate: outline

1.	***PERI-URBAN THEMES: ("drivers / stressors / exposure")***	***TYPICAL QUESTIONS***

- In general, there is an uneven distribution of Chile's population where Santiago, the Capital of Chile, currently holds approximately half of the total national population. With this population figure, Santiago has undergone rapid urbanization with increasing density in the urban centre.



High class gated residential estate in the north outskirts of Santiago. More agricultural lands are being converted to facilitate the growth of gated communities

The south peri-urban of Santiago are predominantly rural with attractive landscapes. This area is currently urbanising rapidly with more medium-high class residential areas being built surrounding the rural landscapes

The east peri-urban accommodates the growth of high-class residence and condominium, with mountainous landscape becoming the growth constraint. Infilling urban expansion is prevalent in this area.

High-class residential estates and condominium in the Lo Barnechea Town and low-class social housing separated by regional highway.

- The 1960 Santiago's spatial plan was carried out with good concept of urban structure with its urban centre developing in a grid spatial structure. However, there seemed to be difficulties in controlling urban growth, which resulted in fuzzy development of peri-urban areas. Santiago has undergone urban sprawl involving the growth of several new satellite towns in the surrounding region. These small towns have grown rapidly with their own social, economy and environmental problems that are beginning to be as complex as Santiago's urban centre.
- In general, Santiago's peri-urban areas are dominated by development of new high-class residential areas. Most are in the form of gated communities and high-rise apartments / condominium. Most of these properties were established in the north and east peri-urban. Currently, proliferation of housing is happening in the south peri-urban where the landscapes are predominantly rural. Due to the attractive nature of the south peri-urban landscapes, more development of gated communities and condominium are taking place and converting agricultural lands in a rapid pace.
- Social conflicts were found at the south peri-urban due to the influx of high-class residential areas which were built near the existing social housing and other local and long-term community. Displacement of farming is prevalent which also creates socio-economic problems as consequences of this 'rural gentrification'.
- With more high-class residential areas built in Santiago's peri-urban areas, there had been an increase in commuting. Commuting is even more possible with expansion of regional highways connecting the new suburbs/town with Santiago's urban centre. Unfortunately, mass public transport network has not been the priority of Santiago's authorities in the regional development agenda.
- In statistical terms, only 10 out of 52 boroughs in Santiago Metro Region rely more on rural sectors (agriculture) as a source of income for the local people. Other boroughs are or have already shifted to secondary and tertiary economic sectors.

(a)	**Spatial peri-urban types & patterns:**	• ***What is the main geographical type and structure in this city-region / peri-urban zone?***

(b)	**Spatial peri-urban functional dynamics (growth / restructuring / transition).**	• ***How did it evolve / emerge to this situation?***

(c)	**Other drivers (STEEP: social, technical, ecological, policy, culture etc)**	• ***What other causes and drivers of change are in the picture?***

(d)	**Global-local dynamics & inter-dependencies**	• ***Which are the key global / local conflicts & challenges this city-region / peri-urban zone?***

2.	***CLIMATE CHANGE THEMES ("causes / hazards"):***	

(a)	**Climate change direct effects:**	• ***What are the main climate change projections for this area / city-region / peri-urban zone?***

Temperature increase (RCP8.5, business as usual), by 2035 annual minimum temperatures may increase by 2 °C, by 2065 minimum summer temperatures may increase by 0 – 2 °C, by 2100 winter minimum temperatures may increase by 2 – 8 °C.

Temperature increase (RCP8.5) by 2035 annual maximum temperature up to 2 °C. By 2065 summer maximum temperature is up between 0 – 2 °C. By 2100 maximum winter temperatures may increase by 6 – 8 °C.

Rainfall (RCP8.5), by 2065 summer decrease of 60 – 100%, by 2100 summer and winter decrease of 60 – 100%. [1]

(b)	**Climate change direct hazards & impacts:**	• ***What are the expected / projected hazards, impacts and risks?***

Reduced water availability affecting hydroelectricity, mining, agribusiness, human consumption. Subtropical zone extending into south of the country, cyclone paths displaced south.

Isotherm will move higher, reduction of Andean snow stores, reduced water availability and flow.

Increased CO2 concentrations reduce the pore opening of plants, less transpiration, less water transported to atmosphere. [1]

•

(c)	**Indirect hazards & nexus effects**	• ***Which hazards and impacts are most critical for food, energy, water, other infrastructure?***

Reduced water availability affecting hydroelectricity, human consumption. [1]

In an A2 scenario (high emissions) by 2040 reduction in crop agriculture in the central zone of 4000 t ha^{-1}, reduction in fruit agriculture by 3000 t ha^{-1}. These tonnages per hectare equate to total losses of 128,000 t of crops, and 627,000 t of fruit. [2]

(d)	**Causal loops (peri-urbanization >> climate change)**	• ***How does the pattern of peri-urbanization cause further climate emissions or urban / rural impacts?***

3.	*VULNERABILITY THEMES sensitivity / capacity*	

(a)	Physical-ecological vulnerability-sensitivity	• *How far are the physical & ecological systems, vulnerable / sensitive or resilient / adaptive?*

Ecological resilience planning ecology into urban green areas, planning biodiversity and nature outside urban areas, and finally landscape ecology. Unfortunately the current state is green spaces dispersed through the urban area failing to form a real system with no spatial relation to water movement or urban microclimates. The landscape development planning is still early and under developed. [5]

(b)	Vulnerability-sensitivity: functional-economic layers	• *How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?*

Urban planning instruments do not contain concepts related to landscape ecology. [5] Water and energy sectors do not have integrated institutional structures or instruments. This leaves little room for adaptive capacity. Unless there is a change in governance structures the response to climate change may not move beyond a limited physical infrastructure investment programme. [7]

(c)	Vulnerability-sensitivity: social-cultural layers	• *How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?*

Resilience through participatory processes has been explored, however this needs rolling out at a larger and continuous scale. [4]

There is potential to increase the resilience to climate change by engaging with structural inequalities rather than focusing on managing siloed risks, as is currently the case. [6]

(d)	Vulnerability & adaptive capacity of social institutions	• *How far are key institutions (community, civic society, public services etc), vulnerable / sensitive or resilient?*

Land around Santiago is developing uncontrolledly around the system of rural residential plots. The negatie effect of land liberalisation policies have resulted in land transformations that policy makers cannot control. [3]

4.	***GOVERNANCE THEMES:*** ***Adaptive action & governance***	

(a)	**Formal government, (governance, regulation)**	• ***How does local / regional government work here & which kind of policies, regulations or plans apply?***

- In general, Santiago's rapid urban expansion is a result of an ineffective spatial and urban development management. One of the main problems are disintegration in spatial planning where all the 52 boroughs is not sufficiently connected in a macro regional policy.

(b)	**Adaptive governance & institutions: (networks, coalitions, partnerships)**	• ***Are there networks, coalitions, partnerships etc, or any emerging signs of these?***

- Spotlighting on the different spatial structure between the CBD (with their grid spatial structure) and the peri-urban (sprawling and unorganised spatial structure), it indicates the gap in planning the two areas. It is difficult for planning to catch up with Santiago's rapid peri-urbanisation. This has been exacerbated with involvement of the private sectors who have power to influence the planning outcome, particularly as they bring new economic and residential investment to the peri-urban areas.
- One of the top priorities for Santiago's urban region strategy is to empower the integration of all boroughs and ensure the interconnection of peri-urban centres

(c)	**Informal governance, (corruption, community, livelihood,)**	• ***How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?***

(d)	**System effects, resilience, collective intelligence**	• ***What could be the overall resilience of the system, or collective capacity for learning & thinking?***

12.3 Basic data

Climate hazard: (World Bank data profile for Santiago)

Extreme heat	- Low
Wildfire	- High
Water scarcity	- High
River flood	- Low
Urban flood	- Low
Coastal flood	- No data
Cyclone	- No data
Tsunami	- No data
Landslide	- High
Earthquake	- High
Volcano	- Low

12.4 Sources

Citations

[1] Climate change projections of temperature and precipitation in Chile based on statistical downscaling. D. Araya-Osses, A. Casanueva, C. Román-Figueroa, J. Manuel Uribe & Manuel Paneque.
[2] The economic impacts of climate change on the Chilean agricultural sector. A non-linear agricultural supply model. R. Ponce, M. Blanco & C. Giupponi
[3] Promoted Urbanization of the Countryside: The Case of Santiago's Periphery, Chile (1980–2017). V. J. Barrado, J. L. Suckel, B. T. Olhabé & F. C. Cona
[4] Resilience to climate change: from theory to practice through co-production of knowledge in Chile. R. Borquez, P. Aldunce & Carolina Adler.
[5] Ecological Planning in Santiago, Chile. How Far Are We? Classification of Planning Initiatives Based on a Brief Literature Review. M. C. Picon, F. de la Barrera, S. Reyes, R. Forray & A. Berrizbeitia.
[6] Adaptive Capacity as Local Sustainable Development: Contextualizing and Comparing Risks and Resilience in Two Chilean Regions. J. R. Barton, F, Gutiérrez-Antinopai & M. Escalona Ulloa.
[7] Climate Change Adaptive Capacity in Santiago de Chile: Creating a Governance Regime for Sustainability Planning. J. R. Barton.

General reference

Organisations, Programmes, and Projects

Adapt Chile
Description: network for municipalities with adaptation projects
https://adapt-chile.org/

Santiago, C40 Cities
Description: city profile and case studies
https://www.c40.org/cities/santiago

Gobierno Regional Metropolitano de Santiago
Description: policies and programs for the region
https://www.gobiernosantiago.cl/estrategias-y-politicas-para-la-region-metropolitana/

Fundación Terram
Description: environmental non-profit
https://www.terram.cl/

Reports and Policies

Santiago Humano y Resiliente, RMS
Description: explains the concept, context and challenges of resilience in Santiago with a six pillar strategy
http://santiagoresiliente.cl/

Estrategia de Resiliencia: Cambio Climático en la Región Metropolitana de Santiago (Resilience strategy: climate change in the Santiago region), Centro de Cambio Global UC, Green Lab UC, CEDEUS UC
Description: climate mitigation and adaptation strategy that characterizes vulnerabilities and outlines future scenarios
http://santiagoresiliente.cl/assets/uploads/2017/05/Informe-Etapa-4_Final_CCG-UC_CambioClimatico.pdf

Cortés, G., Schaller, S., Rojas, M., Garcia, L., Descalzi, A., Vargas, L., & McPhee, J. (2012). Assessment of the current climate and expected climate changes in the Metropolitan Region of Santiago de Chile. Leipzig: UFZ-Discussion Paper.
Description: quantitative downscaling analysis to understand the hydrometeorological changes in the region
http://hdl.handle.net/10419/58274

Academic Articles

Inostroza, Luis, Palme, Massimo, & De la Barrera, Francisco. (2016). A Heat Vulnerability Index: Spatial Patterns of Exposure, Sensitivity and Adaptive Capacity for Santiago de Chile. *PloS One*, 11(9), E0162464.
Description: use GIS, remote-sensing and principal component analysis to develop a vulnerability index
https://doi.org/10.1371/journal.pone.0162464

Bonelli, Sebastián, Vicuña, Sebastián, Meza, Francisco J, Gironás, Jorge, & Barton, Jonathan. (2014). Incorporating climate change adaptation strategies in urban water supply planning: The case of central Chile. *Journal of Water and Climate Change*, 5(3), 357-376.
Description: modelling to propose and evaluate adaptation options for water resources
https://doi.org/10.2166/wcc.2014.037

Krellenberg K., Hansjürgens B. (eds) *Climate Adaptation Santiago*. Springer, Berlin, Heidelberg.
Description: book focusing on urbanization and climate adaptation, especially natural hazards, energy and water
https://doi.org/10.1007/978-3-642-39103-3_6

Barton, Jonathan Richard, Krellenberg, Kerstin, & Harris, Jordan Michael. (2014). Collaborative governance and the challenges of participatory climate change adaptation planning in Santiago de Chile. *Climate and Development*, 7(2), 175-184.
Description: case study outlining the collaborative governance approach used to develop Santiago's adaptation plan
https://doi.org/10.1179/0308018814Z.00000000097

Barton, J.R. (2013). Climate change adaptive capacity in Santiago de Chile: Creating a governance regime for sustainability planning. *International Journal of Urban and Regional Research*, 37(6), 1916–1933.
Description: explores the governance challenges of the water and energy sectors
https://onlinelibrary.wiley.com/doi/abs/10.1111/1468-2427.12033

Krellenberg, K., Müller, A., Schwarz, A., Höfer, R., & Welz, J. (2013). Flood and heat hazards in the Metropolitan Region of Santiago de Chile and the socio-economics of exposure. *Applied Geography*, 38, 86–95.
Description: explores connection between land-use change and climate changes such as flooding and heat waves
https://doi.org/10.1016/j.apgeog.2012.11.017

Müller, A., Reiter, J., & Weiland, U. (2011). Assessment of urban vulnerability towards floods using an indicator-based approach – a case study for Santiago de Chile. *Natural Hazards and Earth System Sciences*, 11, 2107–2123.
Description: mixed method and multi-scale approach to develop a vulnerability map
https://nhess.copernicus.org/articles/11/2107/2011/

13 Toronto

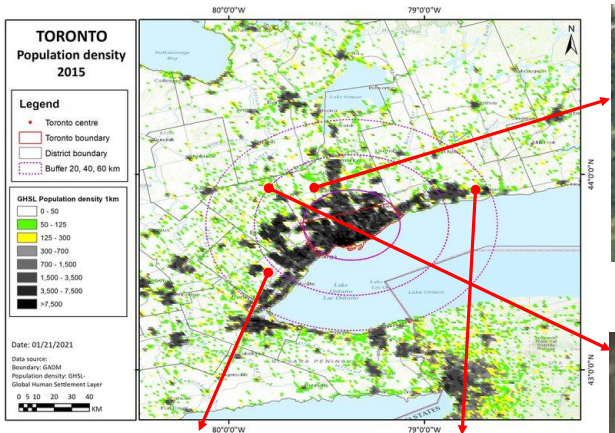
Sources

- *From interview 24-02-21*
- *With contributions from Kathy McPherson, Tom Bowers*
- *Draft & raw material : Joe Ravetz, Dimas Adrianto, Joe Lake Rees (Manchester):*

13.1 Peri-urban-climate: outline

1.	***PERI-URBAN THEMES: ("drivers / stressors / exposure")***	***TYPICAL QUESTIONS***

- Toronto is situated in the 'golden horse shoe' area, a region where approximately 25% of Canada's population live. Toronto's urban areas continues to expand, mainly to the west and north of the region. Urban expansion is also prominent in the city of Hamilton where the request to extend the municipal boundary is now being negotiated over the potentiality of expanding to the green protected areas.



Low-medium density development in the north peri-urban areas, with single family housing built near golf course

Toronto's green belt with farming as a main economic activity – Conversion or development on farmlands is restricted.

Scattered low density residential areas within the "white belt" area of the west peri-urban area. These zones are predicted to be urbanising in the near future

Declining East Ontario – The city of Oshawa (50-60 km buffer) experienced a declining economy due to the reduction of jobs (e.g. General Motors used to employ 23,000 workers since 1980s. This has declined to 3,000 in 2018)

- Toronto's peri-urban areas consist of the green belt (which predominates the northern peri-urban) and the "white belt" zone, which situated in between the built-up areas and the green belt. (see map below)

- The green belt is the 'protected countryside' where urban development, especially on agricultural lands, is highly restricted. The only acceptable urban development is alongside the main roads forming a linear urban spatial structure. Meanwhile, the 'white belts' (zones in between the urban built up and the green belt) are zones already under negotiation to be transformed into urban areas. Most of the lands within these zones are likely to be owned already by private companies or individuals who are not farmers.
- Toronto targeted their urban population to be around 50 million in 2040. This projection considers the growth and further potential increase of international in-migration.
- With the growth of population and potential in-migration, Toronto's housing market prices have tripled in the last 10 years, hence there will be more people preferring to live in the peri-urban rather than the CBD
- Some problems/issues with regards to peri-urbanisation - Inequality in terms of infrastructure services (e.g. more highways are being constructed but none of them are useful for the low-income people), commuting time as more people reside in peri-urban areas, unequal distribution of public services (e.g. insufficient schools in low income neighbourhoods). There is also a trend of peri-urban hollowing in the city of Oshawa due to the declining activities in the car manufacturing industry.
- There are also dynamic changes in the farming sectors – Consolidation of a number of small and medium farm sites. Some of the farm houses are being converted to single family homes.

(a)	**Spatial peri-urban types & patterns:**	• ***What is the main geographical type and structure in this city-region / peri-urban zone?***

(b)	**Spatial peri-urban functional dynamics (growth / restructuring / transition).**	• ***How did it evolve / emerge to this situation?***

(c)	**Other drivers (STEEP: social, technical, ecological, policy, culture etc)**	• ***What other causes and drivers of change are in the picture?***

(d)	**Global-local dynamics & inter-dependencies**	• ***Which are the key global / local conflicts & challenges this city-region / peri-urban zone?***

Climate change

2.	***CLIMATE CHANGE THEMES ("causes / hazards"):***	

(a)	**Climate change direct effects:**	• ***What are the main climate change projections for this area / city-region / peri-urban zone?***

Ontario annual mean surface air temperature increase:

- RCP2.6 (limiting global warming to 2 °C rise by 2100), 1.1 - 2.1 °C increase by 2050, 1.0 – 2.1 °C by 2100.
- RCP8.5 (business as usual), 1.7 – 2.9 °C by 2050, 5.3 – 6.9 °C by 2100.

Annual number of hot days increase:

- RCP2.6, 3.6-7.1 increase by 2050, 2.8 – 6.8 by 2100.
- RCP8.5, 6.8-10.8 increase by 2050, 28.1 – 44.5 by 2100.

Change in length of growing season for warm-season crops:

- RCP2.6, 6.9 -17.5 increase by 2050, 8.0 – 19.1 by 2100.
- RCP8.5, 11.8 – 22.8 increase by 2050, 36.9 – 50.8 by 2100.

Annual mean precipitation changes:

- RCP2.6, 0.4 – 11.1 % increase by 2050, - 0.1 – 10.8 % by 2100.
- RCP8.5, 1.8 – 12.4 % increase by 2050, 8.5 – 26.1 % by 2100.

Annual maximum daily rainfall (10 year return period):

- RCP2.6, 1.4 – 8.4 % increase by 2050, 2.1 – 10.9 % by 2100.
- RCP8.5, 3.6 – 11.4 % increase by 2050, 15.4 – 26.7 % by 2100. [4]

(b)	**Climate change direct hazards & impacts:**	• ***What are the expected / projected hazards, impacts and risks?***

Warmer water temperatures will allow new waterborne pathogens to move northward or existing ones to flourish. [1]

•

(c)	Indirect hazards & nexus effects	• *Which hazards and impacts are most critical for food, energy, water, other infrastructure?*

Heavy downpours may result in combined swer overflows, damaged infrastructure, erosion of stream and rive banks, and flushing of pollutants into waterways. Hydroelectric production will be affected by drop in lake water levels. Nuclear and coal generating stations efficiency will decrease due to reduced efficiency of condensers. Summer energy demand increased, greater electrical energy strain may lead to brownouts or blackouts. Transport may be affected by blackouts due to traffic light outage. Shipping activity at the Port of Toronto will face significant costs if water levels in the Great Lakes Basin drops, ships will have to reduce loads to navigate shallower channels. Flights may be affected more due to increased incidence of extreme weather events. Storm damage to buildings is likely to increase. Milder winters have brought more freeze-thaw cycles leading to greater building material wear, increases in extreme weather events will damage infrastructure. [1]

(d)	Causal loops (peri-urbanization >> climate change)	• *How does the pattern of peri-urbanization cause further climate emissions or urban / rural impacts?*

Increased urban development that does not mitigate for increased rainfall intensity through flood mitigation will increase the flood risk in the city of Toronto due to decreased surface permeability leading to more surface flooding. Though compared to other major Canadian cities climate change will be the dominant effect of flooding as development in Toronto has maintained some green and blue infrastructure to combat flooding [3].

Greater urbanisation will increase the urban heat island effect, putting greater pressure on residents health during times of extreme heat [6].

Vulnerability themes

3.	***VULNERABILITY THEMES sensitivity / capacity***	

(a)	**Physical-ecological vulnerability-sensitivity**	• ***How far are the physical & ecological systems, vulnerable / sensitive or resilient / adaptive?***

Toronto ecosystem will continue to face pressure from urban growth, heat stress, air and water pollution. Urban forest will suffer from increased severity and duration of heat waves. Animal and plant species of wetlands will likely change, invasive species will continue to increase. greater surface water evaporation may lead to significantly lower water levels in river system. [1]

(b)	**Vulnerability-sensitivity: functional-economic layers**	• ***How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?***

Poorer air quality, or threat of infectious diseases may affect tourism to Toronto. Electrical blackouts will disrupt economic output. [1]

Toronto's first resilience strategy (2019) outlines strategy process, Toronto resilience, and actions. [5] Actions include:

- create city-wide action plan through mobility initiatives and priorities
- prioritise service and improvements to make Toronto Transit Commission systems safer, affordable, resilient
- move people more efficiently within rights of ways by expanding demo projects

To protect health during extreme heat:

- explore policy and regulatory options to protect vulnerable populations
- Investigate new and emerging research on health-based evidence for maximum temperature standards
- Improve effectiveness of Toronto's Hot Weather Response Plan through ongoing monitoring and evaluation [2]

(c)	**Vulnerability-sensitivity: social-cultural layers**	• ***How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?***

Toronto's first resilience strategy (2019) outlines strategy process, Toronto resilience, and actions. Actions include:

- Support residents to prepare home for shocks
- Enable wide-scale change in apartments to improve resilience and retrofit
- Enhance capacity to recover from shocks through grassroots action and network building [5]

To protect health during extreme heat:

- explore policy and regulatory options to protect vulnerable populations
- Investigate new and emerging research on health-based evidence for maximum temperature standards
- Improve effectiveness of Toronto's Hot Weather Response Plan through ongoing monitoring and evaluation

[2]

(d)	**Vulnerability & adaptive capacity of social institutions**	• ***How far are key institutions (community, civic society, public services etc), vulnerable / sensitive or resilient?***

Toronto's first resilience strategy (2019) outlines strategy process, Toronto resilience, and actions. Actions include:

- Institutionalize an integrated resilience approach to flooding
- centralise recourse towards city-wide flood planning
- review flood mitigation accounting for resilience
- mitigate effects of extreme heat
- promote a sustainable and resilient food system
- integrate resilience into development and land use planning
- expand corporate civic engagement
- increase transparency to improve trust in government
- integrate equity into city planning process
- build relationships with indigenous communities
- embed resilience as a practice across the city
- integrate climate resilience into TransformTO (Toronto climate action strategy)
- Integrate resilience into emergency management
- Improve risk management and communication to residents
- support local partners in academia, industry, and community
- Position Toronto as a regional, national, and international resilience leader.

[5]

Governance themes

4.	***GOVERNANCE THEMES:*** ***Adaptive action & governance***	

(a)	**Formal government,** **(governance, regulation)**	• ***How does local / regional government work here & which kind of policies, regulations or plans apply?***

- Land use planning is conducted at municipal levels, while areas of strategic development which involve cross-boundary partnership is guided by the provincial development planning.
- While the framework promotes inclusive planning, there is a gap of knowledge particularly in formulating the green belt policy – local people and farmers have insufficient knowledge on policies regulating the green belt.

(b)	**Adaptive governance & institutions: (networks, coalitions, partnerships)**	• ***Are there networks, coalitions, partnerships etc, or any emerging signs of these?***

- There is an emerging framework for environmental planning. For instance, the clean air partnership which focuses on promoting sustainable cities. However, protecting the green belt does not seem to be the main agenda of this framework.

(c)	**Informal governance,** **(corruption, community, livelihood,)**	• ***How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?***

- There is obvious donation from political party, but nothing is known about corruption
- There is a long history of mafia that links to construction industries. Anecdote: they drive to people's houses to make decisions.
- The minister who is responsible for the spatial plan could change the direction of plan if the is an agreement from the majority of people.

(d)	**System effects, resilience, collective intelligence**	• ***What could be the overall resilience of the system, or collective capacity for learning & thinking?***

Further Notes

Tientien Hu, Sharis Design: February 24 2021

To me, the threats to our Greenbelt include the development/urban sprawl and the dumping of contaminated materials.

- Urban Sprawl

  Clear political boundaries separate each jurisdiction within the Greenbelt; however, the ecological impact can't be separated. I have always been thinking how the Planning Act monitors the Greenbelt Plan and how

the development projects between each municipality will be reviewed. Even though there are bylaws to protect the land, some municipalities and developers are still taking the land out of the Greenbelt. The first reason is because of the supply and demand of real estate. The Canadian's immigration policy seems to be one of the best ways to improve the economy quickly. Very recently the immigration doors were even opened wider, see below.

"It is important to stress that the crisis has not impacted Canada's resounding commitment to welcoming immigrants, temporary foreign workers, and international students. In fact, Canada has doubled down on this commitment due to the crisis. **Under its new 2021-2023 Immigration Levels Plan, Canada aims to welcome over 400,000 new immigrants per year, which is the highest levels in its history.**" (https://www.cicnews.com/2021/01/canada-immigration-a-preview-of-2021-0116663.html#gs.utqte5)

The new comers bring money and skills that will stimulate the construction business (building new homes, buying materials etc.). When the housing prices go up, many people start to flip their houses. Then the blue colour labour shortage cause building prices keep going up dramatically. The increasing housing prices affect the urban settings because more home owners to want to sell their houses and to move further into suburban with some money in hand.

As well, many municipalities encourage the housing development. From the Parkland Dedication and Density Bonus by-laws, all sound good for providing more green spaces for the municipality, but also encourage developers to start new construction projects. Under Parkland Dedication, developers can provide cash-in-lieu for parkland in instances where there may be limited opportunity within a development to provide land for parkland, and instead a sum is paid to the City to be used towards park development elsewhere. As well, Density Bonuses offer developments a level of density that surpasses the allowable Floor Area Ratio (FAR) in exchange for amenities or housing needed by the community. However, if there is no clearly established purpose of the program and a maximum overall density, the control is limited.

I became a real estate agent in 2017, while showing some properties located in the Greenbelt plan protected area; I found the protection of Greenbelt area is not highly promoted. Except professionals, most people may have heard it but all limited to real estate subjects, such as they won't be able to easily extend their home in a designated area. Maybe, because of the sufficient natural supplies here, people won't think of the natural resources as much as in other countries that have fewer resources.

- Land contaminated

The more the development, the more the massive amounts of excess soil will have to be removed from those sites. Especially with the lack of land in GTA, some abundant industrial and brownfield sites are under developed and the contaminated soil is being dumped on the Leslie street spit, Greenbelt land and rural site etc. According to Ontario Soil Regulation Task Force, "Not long after the establishment of the three greenbelt plans - the Greenbelt Plan, the Oak Ridges Moraine Conservation Plan, and the Niagara Escarpment Plan - these protected areas saw cavalcades of dump trucks bringing in and dumping soil. This excess soil has come from condo excavations, transit projects, and redeveloped industrial lands".

Taiwan is a country with limited land. All public and private construction projects cannot start until the proposal of soil balance on a site is approved. With legislation, the Taiwan Environmental Protection Administration (TEPA) initiated an online system in 1997 to better manage tracking. After three years of testing, the Industrial Waste Control Center (IWCC) was officially established in 2000. It offers functions like online integration, mobilization, and analysis tools. All construction site have been monitored from 2005. The Construction waste must be transported to the treatment facilities. The reporting system has been improved to not only trace the waste flow, but also to monitor the actual amount of waste generated.

Challenge 1- Sustainable Garden City in 2021

Self-contained communities are surrounded by "greenbelts"

Theory and practice show that second-tier cities can play an important role in linking the urban and the rural. Second-tier cities are the middle ground of the urban system. Toronto and other areas that are surrounded by the Greenbelt, due to the price of land and labour, have less chance of the surrounding agricultural lands being able to support the communities, like the concept of the Garden City.

I had done a paper related to the native flower supply system around Toronto. After interviewing some local growers, two of the reasons that their businesses were failing include the shortage of labour and the increasing price of the land. They all complained about their sons/daughters not being interested in this business. Not to mentioned that the scale of the businesses won't be able to let them reduce the price to compete with imported flowers from South America. I think this situation also applies to agriculture land.

Challenge 2- Living and Working style changes in 2021

With the pandemic, many people find themselves working from home; houses around GTA, four season cottages are in high demand. One benefit is that people are driving much less. These changes are helping to increase the housing prices in Hamilton, London, and Whitby. On the contrary, more downtown Toronto condos and office building become 'challenging' investments.

Challenge 3- The Lacking of infrastructure

I have no real statistics, but I've noticed more flooding of roads in Toronto of late when there is a heavy rain. Compares to Taiwan this rain is not a heavy rain. With the increase of population and more development, will there be even more flooding before an improved infrastructure is in place?

Further Discussion

I am interested in the force (attraction power) between urban and suburban, and the roll of peri urban area. Will that force reach a dynamic balance by proper planning and policies? Like a pendulum? I would need real statistics to prove it:) .

13.2 Basic data

SPATIAL DEVELOPMENT

Population city-region (metropolitan)	- 13,100,000
Land area city-region	- 5925 km2
Density city-region	- 2200 pp/km2
Population city-region change	-

CLIMATE-ENVIRONMENT HAZARDS

(World Bank data - https://thinkhazard.org -)

Extreme heat	- medium
Wildfire	- HIGH
Water scarcity	- medium
River flood	- medium
Urban flood	- medium
Coastal flood	- HIGH
Cyclone	- *(no data)*
Tsunami	- medium
Landslide	- low
Earthquake	- medium
Volcano	- HIGH

VULNERABILITY

Economic type	- emerging lower-middle income
GDP /pp city-region	- $13655 / $47200 PPP
HDI (regional 2017)	- 0.81

13.3 Sources

Citations

[1] A scan of climate change impacts on Toronto. The Clean Air Partnership
[2] A Climate of Concern: Climate Change and Health Strategy for Toronto 2015
[3] The Effect of Climate Change and Urbanization on the Demand for Low Impact Development for Three Canadian Cities. S. Kaykhosravi, U. T. Khan & M. A. Jadidi.
[4] Canada's Changing Climate Report. Government of Canada.
[5] Toronto's First Resilience Strategy (2019). City of Toronto.
[6] Toronto's Urban Heat Island – Exploring the Relationship between Land Use and Surface Temperature. C. Rinner & M. Hussain.

General

Organisations, Programmes, and Projects

2019 Climate Resilience Framework and Recommendations Report, City of Toronto
Description: Integrated mitigation and adaptation framework with recommendations
https://www.toronto.ca/wp-content/uploads/2019/05/8ecc-CRF_Final_v3_AODA.pdf

Climate Change, Toronto and Region Conservation Authority
Description: Adaptation projects including flood protection and watershed management
https://trca.ca/conservation/climate-change/

Toronto, C40 Cities
Description: City profile with case studies
https://www.c40.org/cities/toronto

Climate Risk Institute
Description: non-profit with projects for climate assessments, infrastructure, and resilience in Ontario
https://climateriskinstitute.ca/

Climate Change, Toronto Environmental Alliance
Description: community projects and reports for climate adaptation
https://www.torontoenvironment.org/climate_change

Community Resilience to Extreme Weather
Description: community mapping of climate risks and resiliency index in Toronto
http://www.crewtoronto.ca/our-projects/neighbourhood-resiliency-maps/

Reports and Policies

Ontario's Great Lakes Strategy, Government of Ontario
Description: environmental goals and priorities to protect the Great Lakes
https://www.ontario.ca/page/ontarios-great-lakes-strategy

Ontario Climate Change and Health Toolkit, Ministry of Health and Long-term care
Description: technical report with adaptation assessment guidelines and health modelling study
http://health.gov.on.ca/en/common/ministry/publications/reports/climate_change_toolkit/climate_change_toolkit.pdf

Ahead of the Storm… Preparing Toronto for Climate Change, Toronto Environment Office
Description: Climate change adaptation plan from 2008
http://www.climateneeds.umd.edu/pdf/ahead_of_the_storm.pdf

Toronto Resilience Strategy, City of Toronto
Description: defines resilience and outlines a strategy for the city and region
https://www.toronto.ca/ext/digital_comm/pdfs/resilience-office/toronto-resilience-strategy.pdf

Academic Articles

Perdeaux, S. 2017. Climate Change Adaptation 'Stories' of Ontario: A collection of five adaptation initiatives from across Ontario. Climate Change Impacts and Adaptation Division of Natural Resources Canada.
Description: contains four case studies on water-related initiatives in the Toronto region
http://www.climateontario.ca/doc/RACIII/Climate_Change_Stories_of_Ontario_Final.pdf

Paterson, J.A., Ford, J.D., Ford, L.B. et al. 2012. Adaptation to climate change in the Ontario public health sector. *BMC Public Health* 12, 452.
Description: analysis of interviews conducted with public health officials in Ontario
https://link.springer.com/article/10.1186/1471-2458-12-452

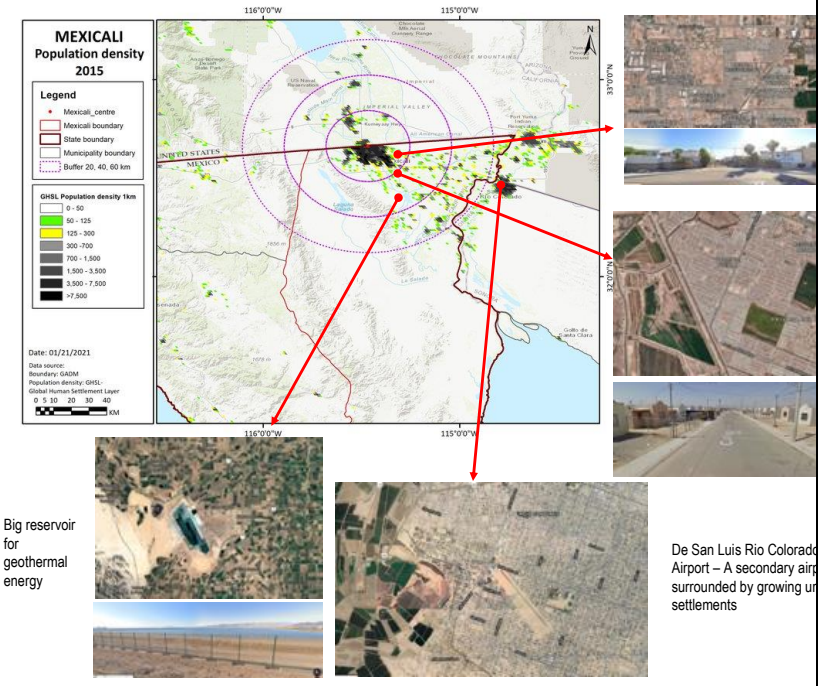
Henstra, D. (2012). Toward the Climate-Resilient City: Extreme Weather and Urban Climate Adaptation Policies in Two Canadian Provinces. *Journal of Comparative Policy Analysis*, 14(2), 175-194.
Description: Compares Toronto and Halifax's climate adaptation policy development
https://doi.org/10.1080/13876988.2012.665215

Zeuli, Kimberly, Nijhuis, Austin, Macfarlane, Ronald, & Ridsdale, Taryn. (2018). The Impact of Climate Change on the Food System in Toronto. *International Journal of Environmental Research and Public Health*, 15(11), 2344.
Description: analysed potential of weather events to influence Toronto's food system
https://doi.org/10.3390/ijerph15112344

14 Mexicali

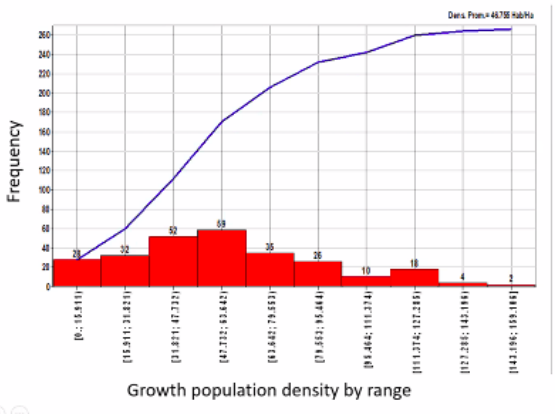
(Abbreviated version)

14.1 Peri-urban themes

No.	THEMES	QUESTIONS	NOTES
1.	**PERI-URBAN THEMES (drivers / stressors / exposure)**		
a.	Spatial peri-urban types & patterns	What is the main geographical type and structure in this city-region / peri-urban zone?	• Mexicali lies on the US-Mexico border with a dynamic growth of urban areas expanding towards the south and east. The outward spread of low-density development has caused the declining population density at the urban centres. Population are distributed to the east (for high-class peri-urban dwellers) and south / south east (middle-class dwellers). Meanwhile, the Laguna Salada, a mountainous area surrounded by agricultural lands, serve as a constraint for urban expansion towards the west / southwest. • Besides housing, industrial development is also an emerging sector of the peri-urban 
b.	Spatial peri-urban functional dynamics (growth / restructuring / transition)	How did it evolve / emerge to this situation?	• The urban to peri-urban migration is caused mainly by the provision of housing that is spatially distributed towards the east and southeast peri-urban. In recent years, this migration has become more significant. • Developers play a key role in developing an expanding structure of urban and regional development. Developers gain profit in the peri-urban property business by purchasing lands at lower prices and selling them at significantly higher prices. These developers have strong connection with authorities which they attempt to influence the direction of land use policies to accommodate the growth of residential development. • A structure of bioregional south – reservoir, river basin and geothermal power plant at the south
c.	Other drivers (STEEP: social,	What other causes and drivers of change	

No.	THEMES	QUESTIONS	NOTES
	technical, ecological, policy, culture etc.)	are in the picture?	• Peri-urban transformation: Abandoned low-class peri-urban residential areas are transforming to middle-upper class. At first, the low-class residential areas were part of the public housing agenda, which is to provide affordable housing for the low-income communities. In later development, the value of the area declined due to vandalism and rising crime. This have attracted developers to acquire these areas and rebuilt them to apartments, condominium and other middle-upper housing supplies. • The remaining low-class residential areas are gradually declining. Most of these settlements do not have sufficient infrastructure services and are in high risk of crime which is exacerbated by the lack of facilities like police stations. • For agriculture, most of the lands were owned by the states (before 1990). After 1990, the state granted private ownership status of these farming parcels. But as the value declines, labour farmers refused to return to faming. This subsequently caused further decline of agriculture. From this stage, landowners sell or rent their lands to private developers, which later being converted to residential, industrial and commercial activities
d.	Global-local dynamics & inter-dependencies	Which are the key global / local conflicts & challenges this city-region / peri-urban zone?	• This goes with the US-Mexican border and the interrelation of water resources influencing both sides. The agricultural lands in Mexicali's peri-urban areas rely on water supply that flows from the US. In general, Mexicali has vulnerability in terms of water supply. This is exacerbated by the government who is continuously encouraging FDI to invest more without appropriate measures of how to supply these industrial activities, let alone the construction process.

Spatial distribution of population density in the AUC of Mexicali 1990-2005



14.2 Climate themes

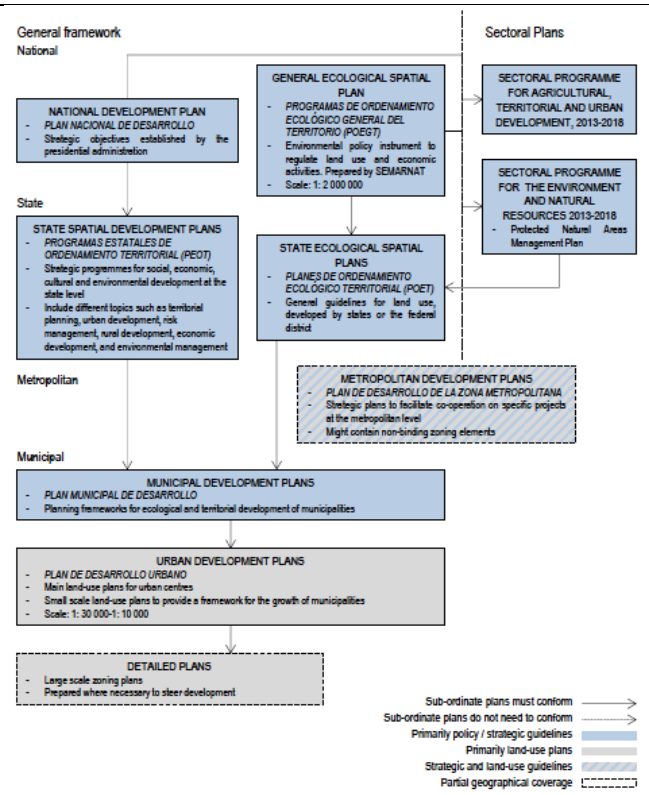
No.	THEMES	QUESTIONS	NOTES
2.	CLIMATE CHANGE THEMES (drivers / stressors / exposure)		
a.	Climate change direct effects	What are the main climate change projections for this area / city-region / peri-urban zone?	Temperature effects – 3 °C average temperature increase (A2 scenario – increased population, heterogeneous development), extreme maximum temperature increase of +9 °C in July by 2050 [1]. Extreme weather – Reported in between 2000 - and 2010 there were 2.3 times as many heatwaves compared to 1970 – 1980 [2].
b.	Climate change direct hazards and impacts	What are the expected / projected hazards, impacts, and risks?	Heat associated deaths – As heatwaves increase, deaths associated with heat, “heatstroke”, will increase. [2] Total Annual Rainfall has increased in the Mexicali region (1922 – 2004) [3] ENSO (El Niño Southern Oscillation) extremes likely to increase, resulting in drier climate during La Niña years, and wetter La Niño years [4].
c.	Indirect hazards and nexus effects	Which hazards and impacts are most critical for food, energy, water, other infrastructure?	Water – 57% comes from the Colorado River, 37% comes from underground sources, 10% comes from coastal aquifers. As there is no current capacity to store rainwater the future La Niña years may be problematic for Mexicali. There will be increased water consumption across the USA-Mexico border from the Colorado river, water scarcity may increase in Mexicali. [6] Water consumption by farming in the Mexicali Valley uses more water than is provided by the Colorado river. [12] If underground sources are not recharged a water crisis in the Mexicali Valley will occur.
d.	Causal loops	How does the pattern of peri-urbanisation cause further climate emissions or urban / rural impacts?	Urban heat island – greater urbanisation and migration to urban areas results in higher exposure to extreme heat. An additional maximum intensity effect of 5.2 °C in the summer time further increases the impact of extreme heat in the region. [7] Urbanisation and transport emissions - By 2025 transportation will account for 44% of the state emissions [9]. 84% of daily trips are private cars, 68% of Mexicali air pollution is from transport, continued urbanisation may result in increased private car use, increasing city emissions, and worsening air quality. This growth and use of private vehicles may be a result of removing taxes and mandatory insurance. [10]

14.3 Vulnerability themes

No.	THEMES	QUESTIONS	NOTES
2.	VULNERABILITY THEMES (drivers / stressors / exposure)		
a.	Physical-ecological vulnerability-sensitivity	How far are the physical and ecological systems, vulnerable / sensitive or resilient / adaptive?	Unregulated use of pesticides and fertilizers in agriculture, alongside water overuse have effects on the local flora and fauna.
b.	Vulnerability-sensitivity: functional-economic layers	How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?	Use of recycled water is at 80% in the Mexicali valley, this improves resilience to water shortages. [6] Cyclones
c.	Vulnerability-sensitivity: social-cultural layers	How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?	Predicted population increases in urban areas of Baja California will be concentrated in border cities; Mexican urban centres are likely to increase from 44.6% of the population (2005) to 58.1% by 2030. [5]
d.	Vulnerability and adaptive capacity of social institutions	How far are key institutions (community, civic society, public services), vulnerable / sensitive or resilient?	Farming vulnerability - water use changes upstream in the Colorado river will directly impact the availability of water in the Baja California area. Diversifying crop portfolios with low water consumption crops increases farmers resilience to water shortages. Investing in drip watering systems may improve irrigation and reduce water loss. Cement lining canals is also a consideration to improve water transportation to farm sites, cement lining however reduces the recharge ability of groundwater sources, potentially delaying but increasing the impact of a future water crisis. [13] [14] State Climate Action Plan – 3 HE institutions, 2 federal authorities, binational environ cooperation: they identified over 100 actions in mitigation and adaptation to climate change.

14.4 Governance themes

4.	GOVERNANCE THEMES (Adaptive action & governance)		
a.	Formal government (governance, regulation)	How does local / regional government work here & which kind of policies, regulations or plans apply?	• Spatial planning is conducted by a state agency which regulates the land use.

			 Spatial Planning Framework of Mexico (OECD, 2017)
b.	Adaptive governance & institutions: (networks, coalitions, partnerships)	Are there networks, coalitions, partnerships etc., or any emerging signs of these?	•
c.	Informal governance, (corruption, community, livelihood)	How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?	• Indicatively, there is a strong coalition between private developers with authorities. Through this political relation, developers were able to influence the land use policy, which became a factor to the rapid growth of peri-urban areas • The government is transforming from an agent for people (e.g. through public housing agenda) to an agent who advantages from the profit of property markets
d.	System effects, resilience, collective intelligence	What could be the overall resilience of the system, or collective capacity for learning & thinking?	•

14.5 Sources

[1] Extreme temperature scenarios in Mexicali, Mexico under climate change conditions. O.R.García Cueto, N.Santillán Soto, M.Quintero Núñez, S.Ojeda Benítez, & N.Velázquez Limó
[2] Heat waves and heat days in an arid city in the northwest of México: current trends and in climate change scenarios. Rafael O. García Cueto, Adalberto Tejeda Martínez & Ernesto Jáuregui Ostos

[3] Trends in rainfall and extreme temperatures in northwestern Mexico, Oscar G. Gutiérrez-Ruacho , Luis Brito-Castillo, Sara C. Díaz-Castro, Christopher J. Watts

[4] https://www.climate.gov/news-features/blogs/enso/changes-enso-impacts-warming-world

[5] Climate Change and U.S.-Mexico Border Communities, Margaret Wilder (University of Arizona)
[6] Water-energy nexus in semiarid regions and coastal cities of California and Baja California. Gabriela Muñoz Meléndez.

[7] Urbanization effects upon the air temperature in Mexicali, B. C., México. Rafael Garcia Cueto, Adalberto Tejeda Martínez, Gonzalo Bojorquez.

[8] Urban expansion and change of land uses: city of Mexicali 1990 – 2005. Osvaldo Leyva Camacho, R Venegas-Cardoso, Rosa Rojas-Caldelas, & Arturo Ranfla Gonzalez
[9] Climate change and the economy in Baja California: Assessment of macroeconomic impacts of the State's Climate Action Plan. Dan Wei, Alejandro Brugués, Adam Rose, Carlos A. de la Parra, Rigoberto García, & Federico Martínez.
[10] Understanding Public Transport Ridership in Developing Countries to Promote Sustainable Urban Mobility: A Case Study of Mexicali, Mexico. Alejandro Sánchez-Atondo, Leonel García , Julio Calderón-Ramírez, José Manuel Gutiérrez-Moreno, & Alejandro Mungaray-Moctezuma

[11] Baja California: Biodiversity Conservation and Sustainable Use in the north of Mexico

[12] Assessing Water Demand for Agriculture in the Mexicali Valley Aquifer Delta of the Colorado River using Remote Sensing and GIS. Rubio-Velazquez, Javier

[13] Farm Resilience to Water Supply Variability: An Econometric Analysis of Risk Management in the Mexicali Valley, Mexico. Schuster, Elizabeth

[14] A Line Drawn in Water: Aquifers Beneath the Mexico-United States Border. Paul Stanton Kibel

Organisations, Programmes, and Projects

Sistema Estatal de Información Ambiental (State system of environmental information), Secretaría de Protección al Ambiente del Gobierno del Estado de Baja California

Description: environmental data and programs in the Baja California state

http://www.spabc.gob.mx/seiabc/#:~:text=El%20Sistema%20Estatal%20de%20Informaci%C3%B3n,medio%20ambiente%20y%20los%20recursos

Dirección de Impacto ambiental (Directorate of environmental impact), Gobierno de Baja California

Description: programs for environmental audits, management, impacts, and planning in the state

http://www.spabc.gob.mx/direccion/impacto-ambiental/

Fundacion Helice

Description: non-profit civil society organization to promote environmental protection in Baja California

http://fundacionheliceac.com/index.htm

Reports and Policies

El agua en el valle de Mexicali, Baja California: origen, uso y destino (Water in the Mexicali valley: origin, use and destination), Instituto Mexicano de Tecnología del Agua

Description: a report to communicate scientific data to citizens about water's lifecycle

https://www.imta.gob.mx/gobmx/2020/EL_AGUA_VALLE_MEXICALI.pdf

Programa Estatal de Protección al Ambiente de Baja California 2015-2019 (State program of environmental protection), Gobierno del estado de Baja California

Description: outlines present and future environmental conditions and strategies for the Baja California state

http://www.copladebc.gob.mx/publicaciones/2018/planesyprogramas/PROGRAMA%20Medio%20ambiente.pdf

Programa Especial de Desarrollo Rural para la Región del Valle de Mexicali 2015-2019 (Program for rural growth of the Mexicali Valley Region), Comité de Planeación para el Desarrollo del Estado
Description: regional rural growth comprehensive plan that includes economic, social, and environmental issues

http://www.copladebc.gob.mx/programas/especiales/Programa%20Especial%20del%20Valle%20de%20Mexicali.pdf

Diagnóstico y restauración de los humedales Ramsar de Baja California (Diagnostic and restoration of the Ramsar wetlands in Baja California), Secretaría de Protección al Ambiente. Gobierno del Estado de Baja California

Description: review and analysis of research on protected Ramsar wetlands

http://www.spabc.gob.mx/wp-content/uploads/2017/11/DIAGNOSTICO-Y-RESTAURACION-DE-LOS-HUMEDALES-RAMSAR-DE-B.C.-2012.pdf

Academic Articles

García Cueto, O. R, Santillán Soto, N, Quintero Núñez, M, Ojeda Benítez, S, & Velázquez Limón, N. (2013). Extreme temperature scenarios in Mexicali, Mexico under climate change conditions. *Atmósfera*, 26(4), 509-520.

Description: quantitative analysis of temperature change with discussion of implications

https://doi.org/10.1016/S0187-6236(13)71092-0

Austria and Bandala. (2016). Maximum Temperatures and Heat Waves in Mexicali, Mexico: Trends and Threshold Analysis. *Air, Soil and Water Research* 9: 21–28.

Description: quantitative analysis of temperatures

https://journals.sagepub.com/doi/pdf/10.4137/ASWR.S32778

Villanueva-Solis, J. (2017) Urban Heat Island Mitigation and Urban Planning: The Case of the Mexicali, B. C. Mexico. *American Journal of Climate Change*, 6, 22-39.

Description: analyzes the relationship between urban heath island, urbanization, and housing

https://m.scirp.org/papers/73976

Argelia Melero Hernández, Margarito Quintero Núñez, & Moisés Galindo Duarte. (2013). Análisis de las estrategias de mitigación y adaptación del sector transporte en la ciudad de Mexicali (Analysis of the mitigation and adaptation strategies of the transport industry in the city of Mexicali). *Estudios Fronterizos*, 14(28), 79-105.

Description: discusses mitigation, adaptation and urban growth factors of the transport industry

http://ref.uabc.mx/ojs/index.php/ref/article/download/63/110?inline=1

R. Rojas-Caldelas, C. Peña-Salmon, E. Corona-Zambrano, A. Arias-Vallejo & O. Leyva-Camacho. (2013). Environmental sustainability agenda: Metropolitan Area of Mexicali, Baja California, Mexico. *Sustainable Development and Planning* 173, 267-277.

Description: research based on fieldwork in Mexicali that seeks to integrate environmental sustainability with urban planning

https://www.witpress.com/Secure/elibrary/papers/SDP13/SDP13022FU1.pdf

Schuster, Elizabeth, & Colby, Bonnie. (2013). Farm and Ecological Resilience to Water Supply Variability. *Journal of Contemporary Water Research & Education*, 151(1), 70-83.

Description: research based on fieldwork in Mexicali to understand agricultural water management

https://doi.org/10.1111/j.1936-704X.2013.03153.x

15 San Diego

(abbreviated version)

15.1 Baseline template

This is a short overview of (a) problems, and (b) responses / pathways, both functional & synergistic.

THEMES	*SCOPE & TOPICS*	*TYPICAL PROBLEMS*	*RESPONSES:*
PERI-URBAN			
Spatial peri-urban types & patterns:	Urban direct expansion Urban / rural fringe & gradient Counter-urbanization effect Urban agglomeration effect	Steady population growth leads to rapid PU expansion, from urban fringe to far hinterland, into the Sierra range. Extensive road networks have outstripped water provision, with high value housing in near desert conditions	
Spatial peri-urban dynamics (growth / restructuring / transition).	Population growth & housing Technology & infrastructure Economy & employment Real estate & markets	local 'rooted' farmlands are replaced by mobile farming, capital intensive & open to real estate dynamics of land appreciation. . Larger family houses are now shifting to multiple occupation, with growing automobile dependency.	
Peri-urban other drivers (STEEP: social, technical, ecological, policy, culture etc)	Social demographics & lifestyle Environment & resources Policy & governance Culture & ethics	Policy aims towards transit-based compact urban form, but cannot contain urbanization & real estate economy. Larger campuses (business, health, education), relocate to the peri-urban, supported by a growing highway network. West coast lifestyle images are about open air & mobility.	
Global-local dynamics & inter-dependencies	Internal structures external interactions power dynamics challenges & conflicts	The US-Mexico border is a special situation, with SD-Tijuana as one functional system, divided & segregated.	

THEMES	*SCOPE & TOPICS*	*TYPICAL PROBLEMS*	*RESPONSES:*
CLIMATE			
Climate change direct effects projections	temperature, precipitation, storm, coastal effects	Temperature rise by 2060 between 2.2 and 5 degrees: >50% increase in heatwave days: drier and hotter summers with wetter and stormier winters.	
Climate indirect hazards & impacts:	wildfire, heatwave, drought, flood, storm, cyclone landslide, sea incursion etc,	SLR of 2m could cost $400m per year. Extreme heat could reach 43 degrees. Already wildfires are rampant in the northern hills, with many side-effects.	
Indirect hazards & nexus effects	water resources farming & forestry energy & resources ecosystems & microclimates critical infrastructure	Most water is from Colorado basin, now in crisis management: drastic effects on farm production & critical infrastructure.	
Causal loops (impacts of peri-urban on climate change)	CO2 emissions from energy GHG emissions from land-use Land-use & forestry change Carbon storage	Development by 2100 on current trends will replace up to: 150 sq miles of agriculture, 75 sq miles of grassland, 200 sq miles of forest: all areas of carbon storage & ecosystems / species migration	

THEMES	*SCOPE & TOPICS*	*TYPICAL PROBLEMS*	*RESPONSES: FUNCTIONAL*
VULNER-ABILITY			
Physical-ecological vulnerability-sensitivity	• Soil & vegetation • Topography & stability • Settlement form & structure	PU development tends to disrupt & deplete landscape quality & resilience: soils, water systems, land stability etc.	
Functional-economic-infrastructure layers of vulnerability-sensitivity:	• technical & infrastructure • Markets & value effects • Employment & livelihoods	The wider urbanization of the region & hinterland, shifts from a rural / small town system (vulnerable in some ways), to a conurbation system of mono-functional land-use, automobile systems, real estate logic of value	
Eco-social-cultural layers of vulnerability-sensitivity:	• Affluence / deprivation • Education / communication • Cultural issues	Growing social & ecological awareness e.g. schools, colleges, unions: but not easy to translate this into systemic change.	
Adaptive governance capacity-vulnerability-sensitivity-	• Local government • Public services & infrastructure • Emergency services • Civil & community	High level of civil / emergency services: but these tend to fall short with vulnerable populations in trailer parks, shacks & cars: migrant, homeless, excluded of many kinds.	

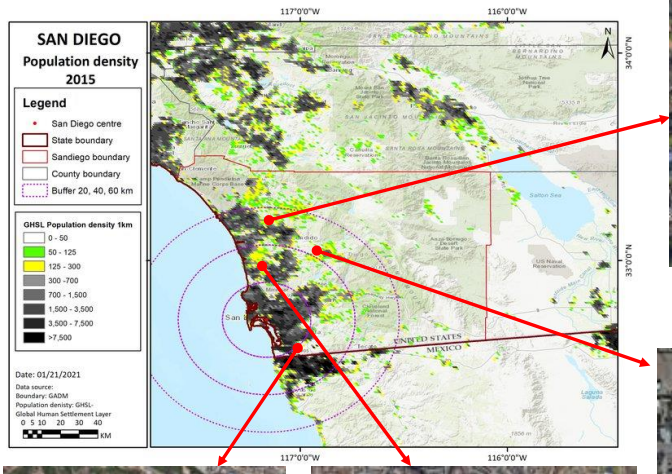
THEMES	*SCOPE & TOPICS*	*TYPICAL PROBLEMS*	*RESPONSES:*
GOVERNANCE			

Formal government, (governance, regulation)	Spatial planning green belt etc Housing policy Infrastructure development	SD has many layers of strategic planning, including low-impact transport, environment & climate adaptation. It is debatable how far these can resist the forces of real-estate induced urbanization & financialization	
Adaptive / Associative governance & institutions: (networks, coalitions, partnerships)	Public sector Private sector Civic sector Citizens etc	Active civic building in many forms: e.g. higher education & new agenda for the 'rooted' university, e.g. Bio-regional Centre.	
Informality / elite capture / grassroots action:	Informal land-use, settlements, enterprise Corruption & nepotism Social innovation & enterprise for integrated livelihoods	Food Alliance & similar grassroots action from local food & ecology projects. Much informal social capital in urban / peri-urban neighbourhoods is almost invisible. Meanwhile grassroots vigilantes are active on the desert border	
System resilience, collective intelligence (combined formal / adaptive / informal)	Social learning & collaboration Social co-creation & mobilization potential System transformation potential	California may have a unique profile of individual awareness & empowerment, combined with a fragmented & displaced civic & public realm…	

15.2 Peri-urban themes

1.	***PERI-URBAN THEMES: ("drivers / stressors / exposure")***	***TYPICAL QUESTIONS***

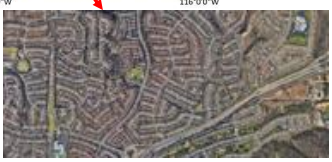
- Although with steady population growth, San Diego's is experiencing rapid urban expansion with dynamic rural-urban transformation in the peri-urban areas



Community farm in Vista, around 53 km to the north of Sand Diego, surrounded by single family peri-urban housing

Community organic farm within a low density growing town of Ramona

The Tijuana River Valley – A rapidly growing peri-urban centre at the State's border with emerging growth of housing.



High-class residential neighbourhood around 30km towards the north of San Diego.

- San Diego's urban areas mainly expand towards the north east with agricultural lands being converted to housing. More urban growth will be targeted at the area in the future with further potential loss of farms and their community. With increase in the development of highways, it is expected that more commuting neighbourhoods will be constructed in the near future. Meanwhile, peri-urban development is also taking place down south towards the US-Mexico border around the Tijuana river causing the loss of several rural lands and heritage.
- Besides the growth of housing, there are projected growth of higher education facilities as universities are purchasing great amount of lands in the peri-urban. On the other hand, extractive industries are also playing a key role in the dynamic growth of peri-urban areas. These imminent rural-urban transformations brings great pressure to the farming sector as currently more farm lands are being cut-off from water services and sold to the market.
- In general, there is a neglect of rural value as peri-urban areas are treated more as a place for extraction
- Issues with the south peri-urban areas, in relation to the US Mexico-border, the waste water and sewerage deriving from the urban slums on the Mexican side is flowing towards San Diego. This concerns with water quality in San Diego

15.3 Climate themes

2.	***CLIMATE CHANGE THEMES ("causes / hazards"):***	

No.	THEMES	QUESTIONS	NOTES
2.	CLIMATE CHANGE THEMES (drivers / stressors / exposure)		

No.	THEMES	QUESTIONS	NOTES
a.	Climate change direct effects	What are the main climate change projections for this area / city-region / peri-urban zone?	Annual temperature rise of 2.2 - 3.3 °C under RCP 4.5 (strong climate mitigation policy), a rise of 3.6 – 5 °C under RCP 8.5 (business as usual). Under a 3.5 °C increase scenario, heatwave days are projected to increase 20-50%. Wetter winters, drier spring and autumn. Sea level rise of 30cm by 2050. Increased wildfire, coastal storms, floods, droughts, increased rainfall volatility. Average wettest day over a 5 year period is project to increase 10-20% under RCP 4.5, or 15-30% under RCP 8.5 [3]
b.	Climate change direct hazards and impacts	What are the expected / projected hazards, impacts, and risks?	Under a sea level rise of 2m there could be a loss of $USD 400 million in commercial and industrial property annually. Increased hospitalisations from hazardous temperature extremes, potential increase in vector-borne diseases. Under RCP 8.5 hottest day per year for San Diego will be from 32 – 43 °C. Night time heatwaves are expected to increase by 51% by 2100 (RCP 8.5). Precipitation changes and increased fire risk will result in increased deadly post-fire debris flows. [3]
c.	Indirect hazards and nexus effects	Which hazards and impacts are most critical for food, energy, water, other infrastructure?	Precipitation is already insufficient to serve the demands of the current San Diego residents, most water for San Diego is sourced from the Colorado River basin. Energy use is projected to rise 6-27% under RCP 8.5 by 2100. 15-45% reduction in avocado crop by 2050, decline in orange production. From 2005-2015 25% of orchard trees were removed from production due to rising costs of water. Higher temperature decreases transmission line efficiency by 0.27% - 2.1% per 1 °C. A 100-year storm event could knock out four electrical substations for two weeks in the San Diego Bay. Increased wildfire will also increase the number of downed power lines. [3]
d.	Causal loops	How does the pattern of peri-urbanisation cause further climate emissions or urban / rural impacts?	Transportation accounts for 41% of California emissions [2]. San Diego County population projected to pass 4 million by 2050, housing these additional residents poses a threat to ~ 200 taxa of plants and animals if development occurs uncontrolled. Human ignition sources are primary drivers of regional fires, increased development and population increases will accelerate number of wildfires experienced. Urbanisation, sea wall defences, and river damning are reducing the sedimentation of the San Diego shoreline, this in turn increases damage from coastal erosion, thus threatening coastal developments, increased flooding, and ecosystem degradation. Urbanisation prevents the migration of wetlands away from sea level rise, wetlands act as a carbon sink, as the sea level rises the wetlands will reduce in size resulting in fewer emissions being absorbed. Beach nourishment (sand deposition to restore beaches) can result in groundwater flooding, damage local ecosystems, impact localised sand movements. Development by 2100 will replace up to: 150 sq miles of agriculture, 75 sq miles of grassland, 200 sq miles of forest, these are areas of potential carbon storage, increased development will result in a net increase in emissions.[3]

15.4 Vulnerability themes

3.	***VULNERABILITY THEMES sensitivity / capacity***	

No.	THEMES	QUESTIONS	NOTES
2.	VULNERABILITY THEMES (drivers / stressors / exposure)		
a.	Physical-ecological vulnerability-sensitivity	How far are the physical and ecological systems, vulnerable / sensitive or resilient / adaptive?	Temperature changes have the potential to impact species distribution, flowering, breeding. Increased drought will cause species favouring and ecosystem shifts. More fires will lead to vegetation type conversion, mostly from shrub dominated to non-native grasses, exacerbated by drought conditions. Marine layer clouds and fog (MLC) reduce drought, and improve growth rates, however uncertain MLC in climate scenarios result in difficult modelling for the effect on drought, fire, or species divergence. Adaptive ecosystem management e.g. by connecting ecosystems will strengthen ecosystem resilience to stressors. San Diego County Water Authority is pursuing water source diversification with the aim to have 46% of their water sourced locally by 2035. Some of San Diego's water resources are likely to decrease by 10% or more by 2050. [3]
b.	Vulnerability-sensitivity: functional-economic layers	How are the infrastructure and economic systems vulnerable / sensitive or resilient / adaptive?	Ocean Protection Sea Level Rise Guidance, recommends adaptive management in planning to adapt to the evolving threat from sea level rise. Increasing beach nourishment to alleviate coastal flood risk, promote tourism. Through increasing public transit and bicycle use, SANDAG estimates San Diego region could reduce GHG emissions 21% by 2035[3]
c.	Vulnerability-sensitivity: social-cultural layers	How far are the underlying social-cultural systems (individuals, households, communities), vulnerable / sensitive or resilient / adaptive?	Oak tree death will affect Californian Indians; the oak tree is culturally significant and forms a basis for food and economy. Agriculture and carbon farming have the potential to absorb 5.9 tonnes of CO_2e per hectare. Increased soil carbon provides nutrients and increased water-holding capacity. Smoke and poor air quality exposure from fire is likely to increase respiratory illnesses. [3]
d.	Vulnerability and adaptive capacity of social institutions	How far are key institutions (community, civic society, public services), vulnerable / sensitive or resilient?	Develop alternative land use and transportation scenarios, to reduce GHG emissions. Develop a regional bicycle plane early action program. Prepare an active transportation implementation strategy, safe routes to school and to transit. Develop a regional transit orientated development strategy/policy. [1] Climate action plan includes strategies to reduce GHG emissions, and prepare for sea level rise, extreme heat, prolonged drought, and more destructive wildfires [2]

[1] 2050 Regional Transportation Plan/Sustainable Communities Strategy Commitments Progress Report January 2014. SANDAG.

[2] San Diego Forward, 2021 Regional plan Climate Action Planning. SANDAG.

[3] San Diego Region Report, California's Fourth Climate Change Assessment. J. Kalansky & D. Cayan.

15.5 Governance themes

4.	***GOVERNANCE THEMES:*** ***Adaptive action & governance***	

- There had been efforts to manage peri-urban growth which themes on connecting neighbourhoods and the land use of the peri-urban. But it remains unclear about the concept of peri-urban neighbourhoods. In those initiatives there are bubbles of elite actors who have strong influence on how peri-urban area are being governed. These elite coalition is situated within the local government system (the state have less authority on determining the land use plan)
- San Diego food system Alliance – an initiative established in 2012 to encourage the involvement of citizens in producing and distributing food resources
- There is also an alliance of 8 US and Mexican Universities for research and cooperation with regards to manage the US-Mexican border.

(a)	**Formal government,** **(governance, regulation)**	• ***How does local / regional government work here & which kind of policies, regulations or plans apply?***
(b)	**Adaptive governance & institutions: (networks, coalitions, partnerships)**	• ***Are there networks, coalitions, partnerships etc, or any emerging signs of these?***
(c)	**Informal governance,** **(corruption, community, livelihood,)**	• ***How much is corruption / elite capture a major issue, & what informal / grassroots opportunities also come up?***
(d)	**System effects, resilience, collective intelligence**	• ***What could be the overall resilience of the system, or collective capacity for learning & thinking?***

15.6 Sources

Organisations, Programmes, and Projects
San Diego Climate Collaboration, University of San Diego
Description: a network for mitigation and adaptation
https://www.sandiego.edu/soles/hub-nonprofit/initiatives/climate-collaborative/

Sustainability Department, City of San Diego
Description: Climate Action Plan, annual reports, and budget analysis
https://www.sandiego.gov/sustainability/climate-action-plan

Resilience Department, City of San Diego
Description: Programs and plans for storm water runoff, urban forests, sea level rise, and drought
https://www.sandiego.gov/sustainability/resilience

Resilient Coastlines Project of Greater San Diego, Climate Science Alliance
Description: Alliance that has projects, working groups and climate summits on landscapes, conservation, resilience, and biodiversity
https://www.climatesciencealliance.org/archive/resilient-coastlines-project

Climate Program, The San Diego Foundation
Description: Regional collaboration for mitigation and adaptation
https://www.sdfoundation.org/programs/programs-and-funds/climate/

Reports and Policies
Regional Adaptation Needs Assessment 2019, San Diego Regional Climate Collaborative; San Diego Association of Governments; Tijuana River National Estuarine Research Reserve; The San Diego Foundation
Description: Identifies adaptation needs and opportunities for the region
https://digital.sandiego.edu/npi-sdclimate/13/

2021 Regional Plan, SANDAG
Description: Merges the Regional Transportation Plan, Sustainable Communities Strategy, and Regional Comprehensive Plan
https://www.sdforward.com/about-san-diego-forward/developing-the-2021-regional-plan

San Diego Region Coastal Sea Level Rise Analysis, Caltrans
Description: Sea level rise projections and guidance for regulations, especially concerning transport infrastructure
https://dot.ca.gov/caltrans-near-me/district-11/programs/district-11-environmental/i-5pwp-toc/appd

San Diego Region Fourth Climate Change Assessment Report 2018, University of California San Diego
Description: Outlines climate impacts to informs policies and programs
https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-009_SanDiego_ADA.pdf

Sea Level Rise Adaptation Strategy for San Diego Bay 2012, ICLEI
Description: Collaboratively produced regional plan
https://icleiusa.org/wp-content/uploads/2015/08/San-Diego-Sea-Level-Rise.pdf

Sea Level Rise Vulnerability Assessment & Coastal Resiliency Report 2019, Port of San Diego
Description: Proposals to address sea level rise in accordance with regulations
https://pantheonstorage.blob.core.windows.net/environment/FINAL-San-Diego-Unified-Port-District-Sea-Level-Rise-Vulnerability-and-Coastal-Resiliency-Report-AB691.pdf

Academic Articles
Messner, S., Miranda, S. C., Young, E., & Hedge, N. (2011). Climate change-related impacts in the San Diego region by 2050. *Climatic change*, *109*(1), 505-531.
Description: Outlines potential impacts and makes recommendations for local and regional level
https://link.springer.com/article/10.1007/s10584-011-0316-1

Guirguis, K., Basu, R., Al-Delaimy, W. K., Benmarhnia, T., Clemesha, R. E., Corcos, I., ... & Vashishtha, D. (2018). Heat, disparities, and health outcomes in San Diego County's diverse climate zones. *GeoHealth*, *2*(7), 212-223.
Description: Analyzes health impacts of temperature change in three climate zones
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2017GH000127

Vahmani, P., Sun, F., Hall, A., & Ban-Weiss, G. (2016). Investigating the climate impacts of urbanization and the potential for cool roofs to counter future climate change in Southern California. *Environmental Research Letters*, *11*(12), 124027.
Description: Models the potential for cool roofs to address air temperature increase linked to urbanization
https://iopscience.iop.org/article/10.1088/1748-9326/11/12/124027/meta