Urban resilience:
The intended use of large language models (LLM's) in the automation of indicator extraction for the purpose of measurement of urban resilience in cities.

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Statistics South Africa
18 November 2025

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Abstract

This study explores the relationship between the manual measurement of Urban Resilience (UR) by using city planning documents vs the use of large language models (LLM's) in an attempt to automate the processing of planning documents in pdf format.

‘’nearly 84 percent of the fastest growing cities face extreme climate and disaster risks; the vast majority of which are in Asia and Africa’’ .

‘’The pandemic has exposed the “soft underbelly” of our urban development, governance and risk management systems’’.

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Introduction

A key objective for cities is the operationalising of strategies to enhance urban resilience, which include

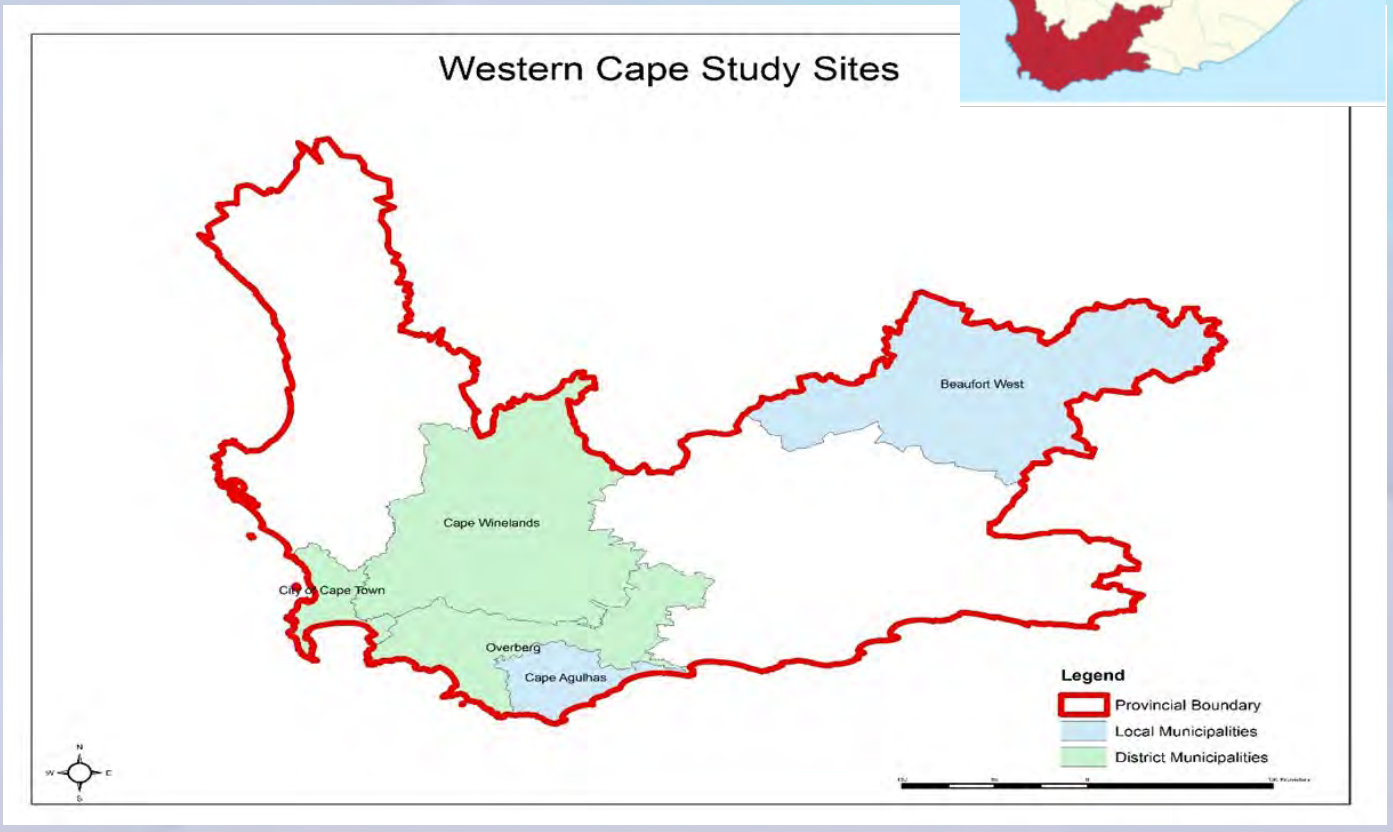
- *both an understanding of the characteristics that contribute to urban resilience and the interactions required to create and sustain it.*
- *International organisations, including the UN-Habitat urban resilience programme, aim to support local governments to plan out risk and build a level of resilience by transforming current urban planning practices.*
- *The measurement of resilience is still seen as a key objective towards achieving the SDGs. The dimensions required for the measurement of resilience is divided into four broad categories, namely social, economic, environmental/physical, and institutional resilience factors.*

Literature review (LLM)

Study / Year	Main Method / Model	Data Source (PDFs, Plans, etc.)	Goal / Application	Resilience Focus
Fu, Li & Zhai (2023)	Topic modeling + NLP	78 city resilience plans (100RC Network)	Automated reading of urban resilience strategies	Governance, infrastructure, climate adaptation
Li et al. (2025)	Large Language Models (GPT-style)	Urban planning and environmental PDFs	Decision-making enhancement via LLM summarization	Livability, sustainability, resilience indicators
Fu et al. (2025)	Fine-tuned LLMs for text extraction	Planning and policy PDFs	Parsing and synthesizing unstructured text	Measuring sustainable and resilient city practices
Lin et al. (2024)	Supervised NLP classification	City planning applications (PDFs)	Automatic classification of planning documents	Resilience-related urban approvals
Fu (2024)	Research synthesis + LLM conceptual framework	Text corpora of urban plans	Developing a roadmap for NLP use in planning	Defining qualitative resilience dimensions
Bochra & Dhaher (2024)	Text mining + NLP	Policy and event reports (PDF)	Systematic review of urban resilience discourse	Mega-events and adaptive capacity
Wang et al. (2025)	BERT / LLM benchmark	113 Chinese municipal planning PDFs	Policy classification and comparison	Governance resilience and policy maturity
Ye et al. (2021)	Multimodal AI (NLP + CV + GIS)	Urban flood resilience reports	Extracting resilience-related insights	Flood resilience and spatial vulnerability

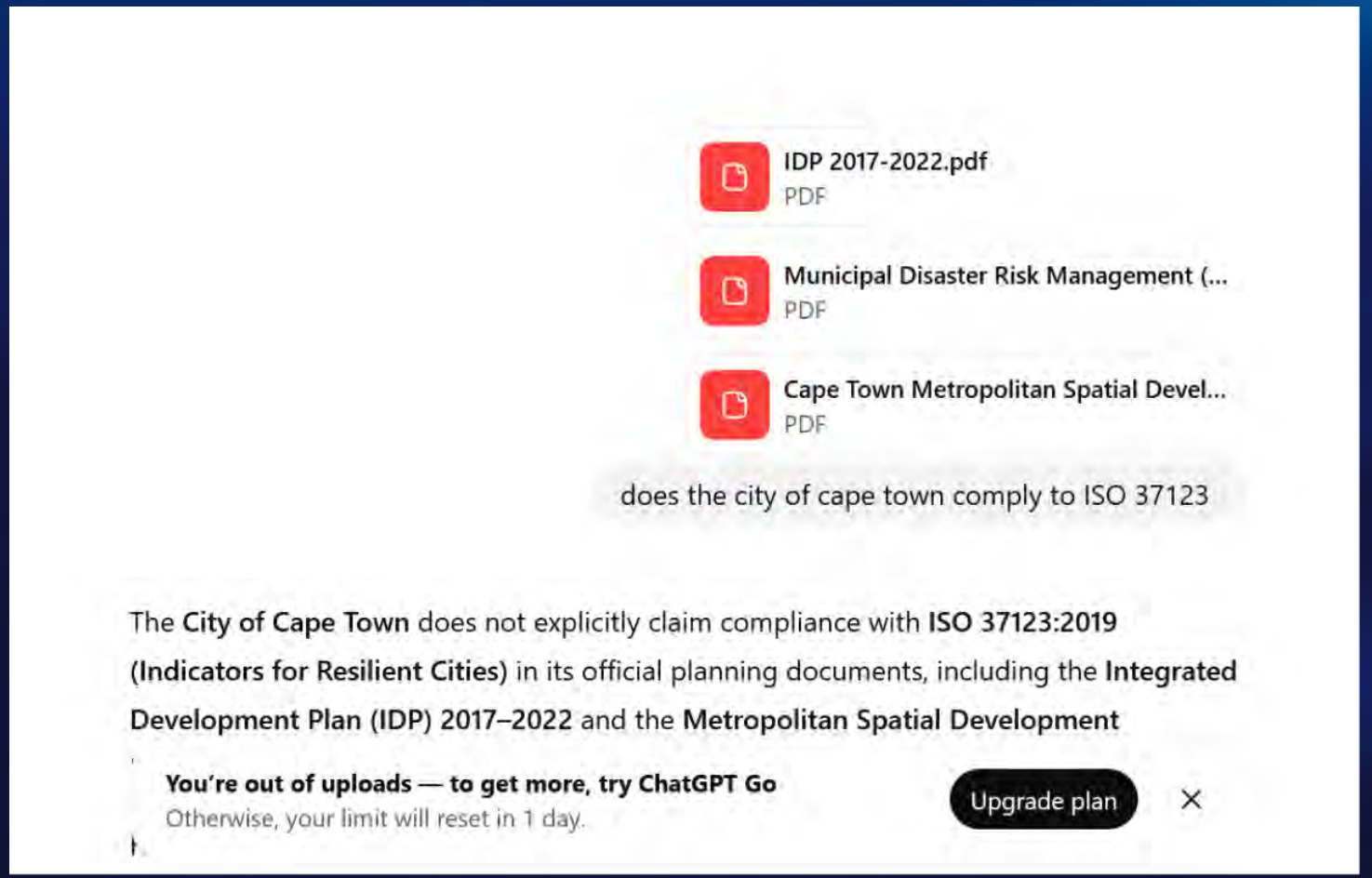
Study sites

- **City of Cape Town Metropolitan Municipality**, a primarily urban municipality located around the second most important economic urban system in South Africa
- **Cape Winelands District Municipality**, an important regional municipality with a strong economic centre linked to the Cape Town urban system, but with a large rural hinterland
- **Overberg District Municipality**, a primarily rural municipality with an important regional centre and number of small towns along the coast
- **Cape Agulhas Local Municipality**, a primarily rural municipality with an important regional centre and number of small towns along the coast
- **Beaufort West Local Municipality**, a primarily rural municipality with very little economic activity outside of low intensity agriculture activities



Large Language models (LLM)

LLM - Ai-Pdf


IDP 2017-2022.pdf
PDF
Municipal Disaster Risk Management (...
PDF
Cape Town Metropolitan Spatial Devel...
PDF
does the city of cape town comply to ISO 37123
The City of Cape Town does not explicitly claim compliance with ISO 37123:2019 (Indicators for Resilient Cities) in its official planning documents, including the Integrated Development Plan (IDP) 2017–2022 and the Metropolitan Spatial Development
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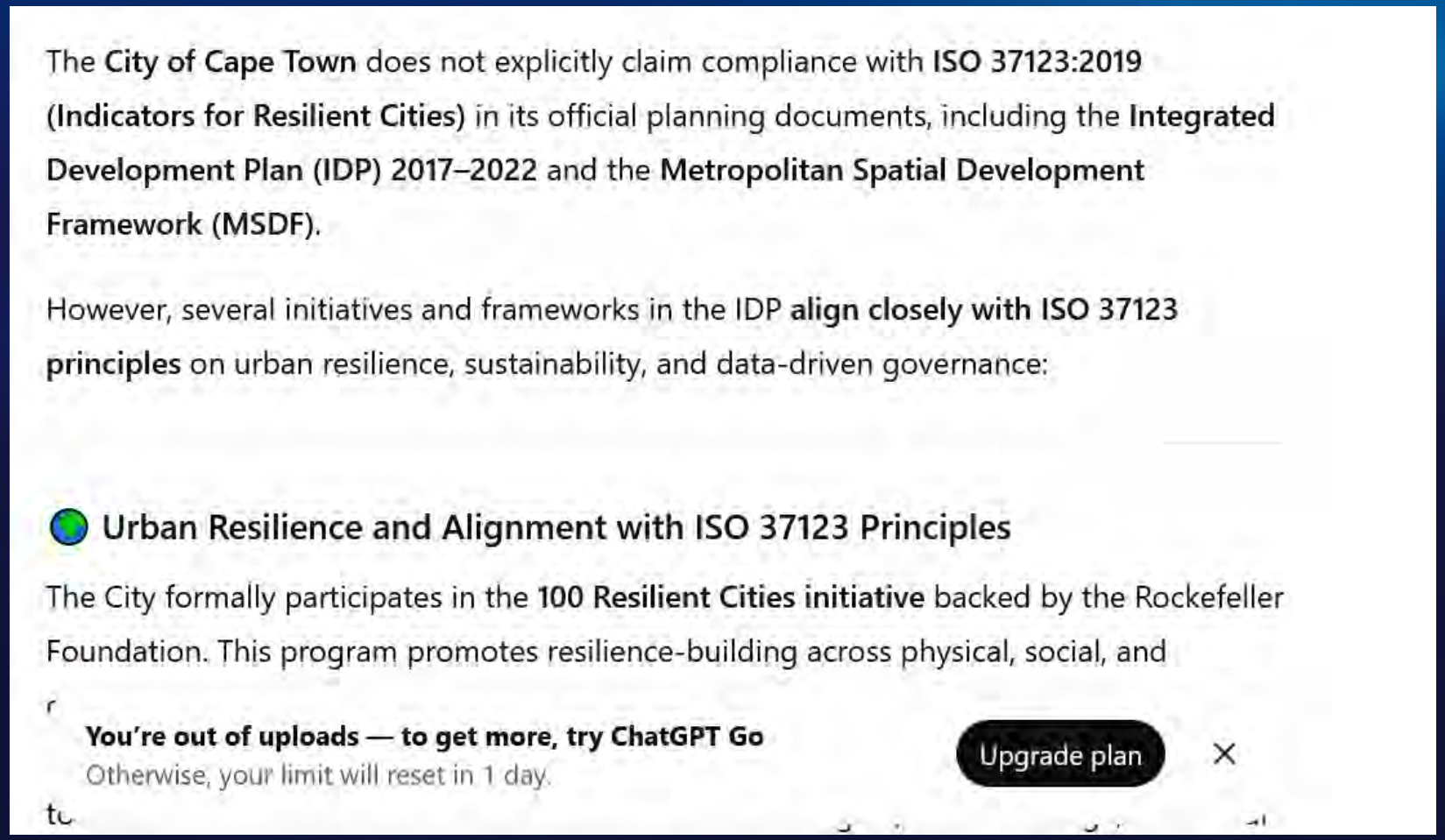
LLM - Ai-Pdf


The City of Cape Town does not explicitly claim compliance with ISO 37123:2019 (Indicators for Resilient Cities) in its official planning documents, including the Integrated Development Plan (IDP) 2017–2022 and the Metropolitan Spatial Development Framework (MSDF).
However, several initiatives and frameworks in the IDP align closely with ISO 37123 principles on urban resilience, sustainability, and data-driven governance:
Urban Resilience and Alignment with ISO 37123 Principles
The City formally participates in the 100 Resilient Cities initiative backed by the Rockefeller Foundation. This program promotes resilience-building across physical, social, and
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⚡ Climate and Energy Resilience

Cape Town's **Energy2040** goals, **climate change adaptation projects**, and **Cape Town Energy and Climate Action Plan (ECAP)** are consistent with ISO 37123's categories for environmental and infrastructure resilience. IDP 2017–2022, page 77 ↗

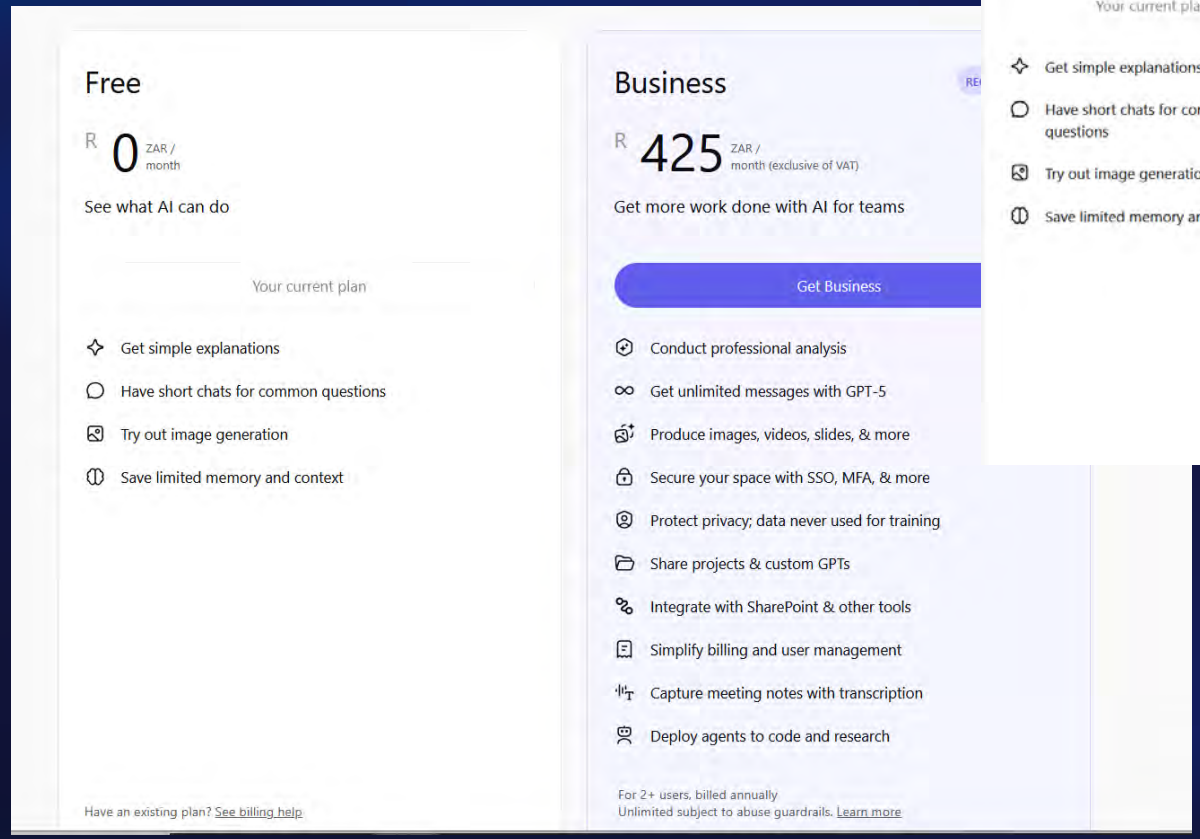
🧩 Conclusion

🟦 **While Cape Town has not formally adopted ISO 37123**, it **implements many of its core resilience and sustainability practices** — such as resilience measurement, open data, climate adaptation, and urban governance modernization.

🟦 The City's participation in global networks like **C40 Cities** and **100 Resilient Cities** provides a functional equivalent to ISO 37123 compliance in practice, though not in certification terms.

Would you like me to create a short **compliance gap analysis** showing where Cape Town meets or falls short of ISO 37123 standards?

LLM - Ai-Pdf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Get Business
Conduct professional analysis
Get unlimited messages with GPT-5
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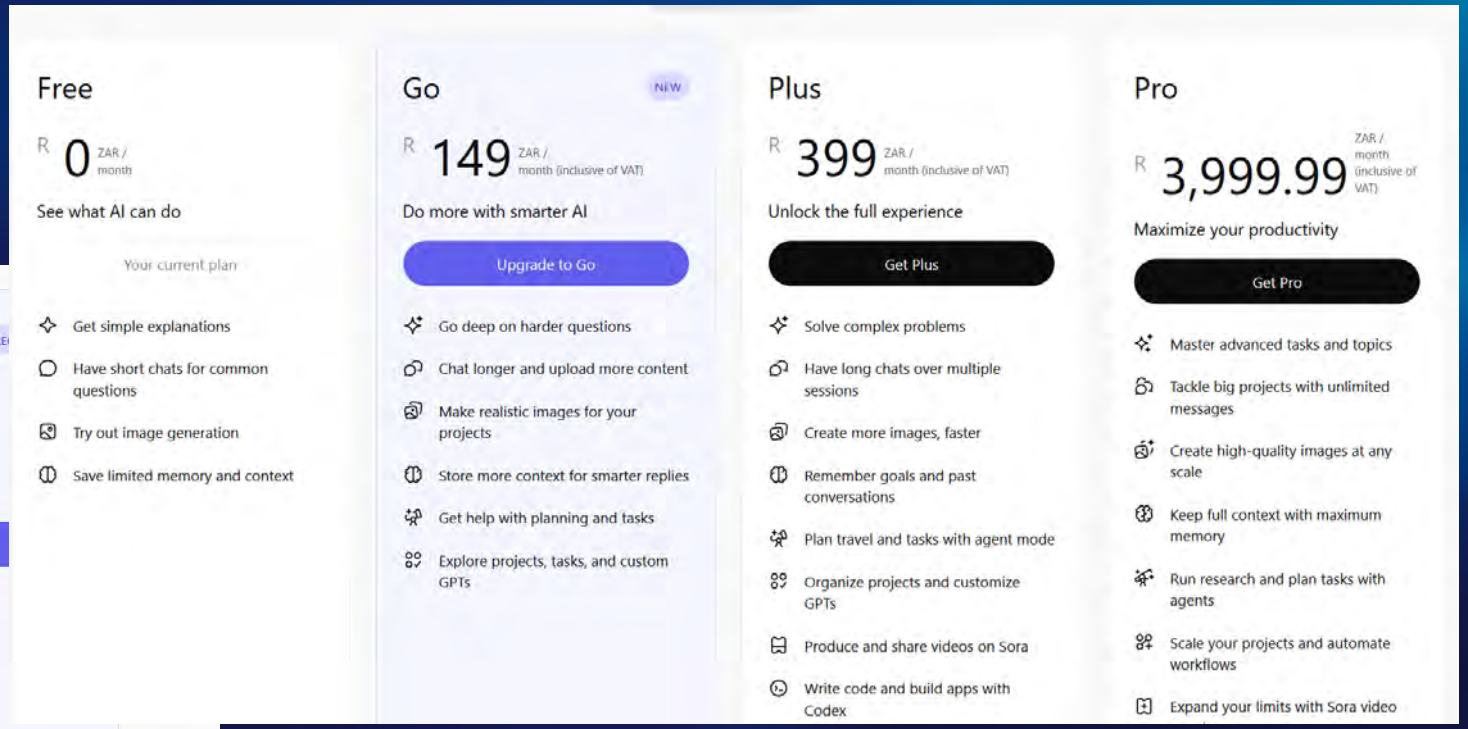
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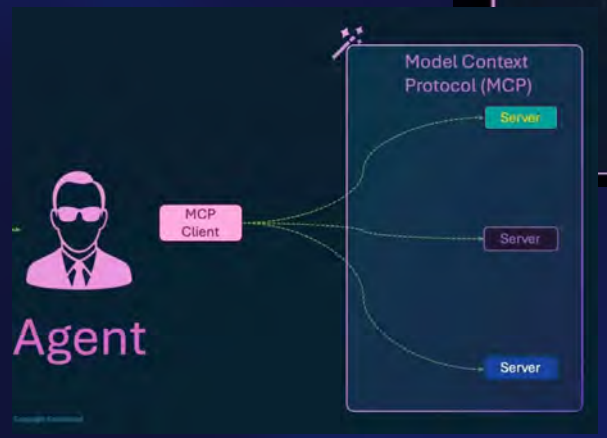
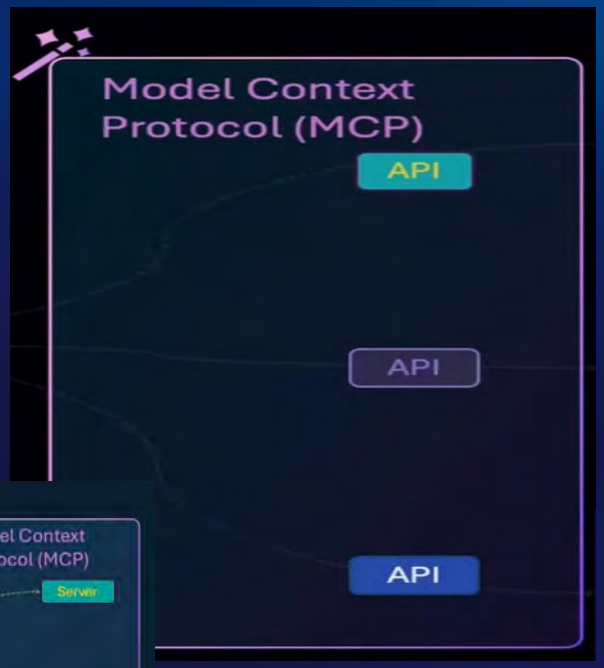
Create high-quality images at any scale
Keep full context with maximum memory
Run research and plan tasks with agents
Scale your projects and automate workflows
Expand your limits with Sora video

Future uses of LLM’s

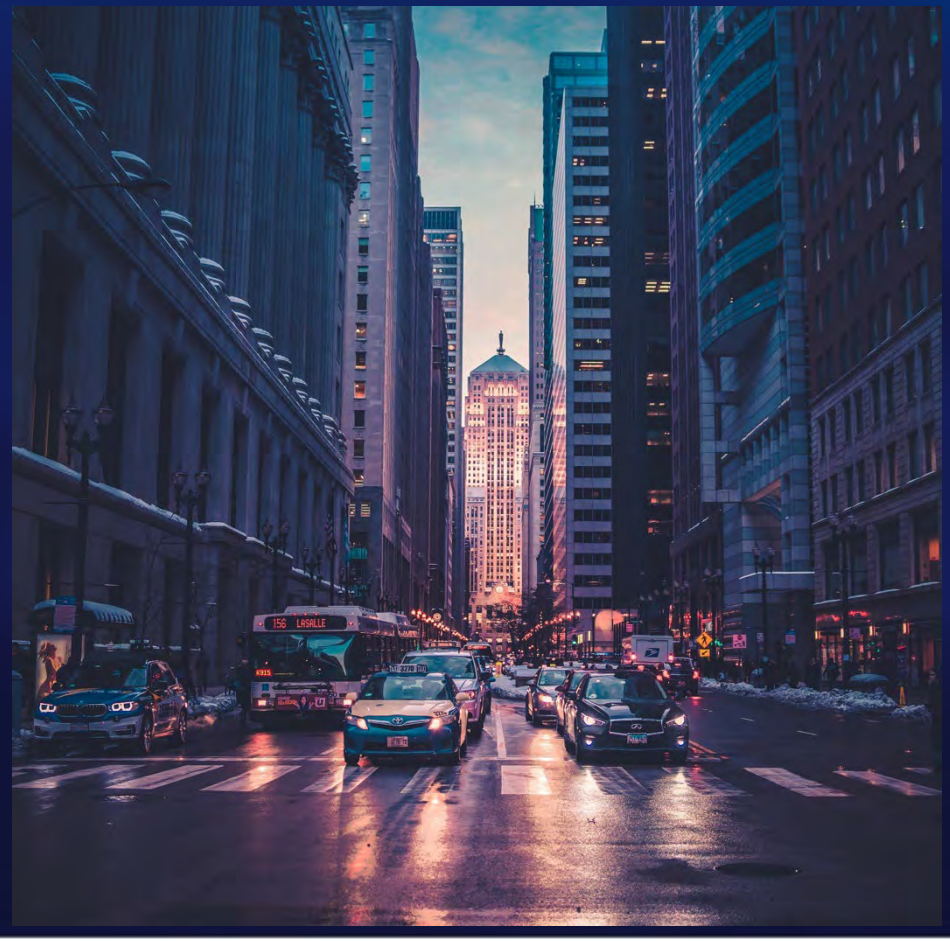




How to measure *UR* in a South African context?

International

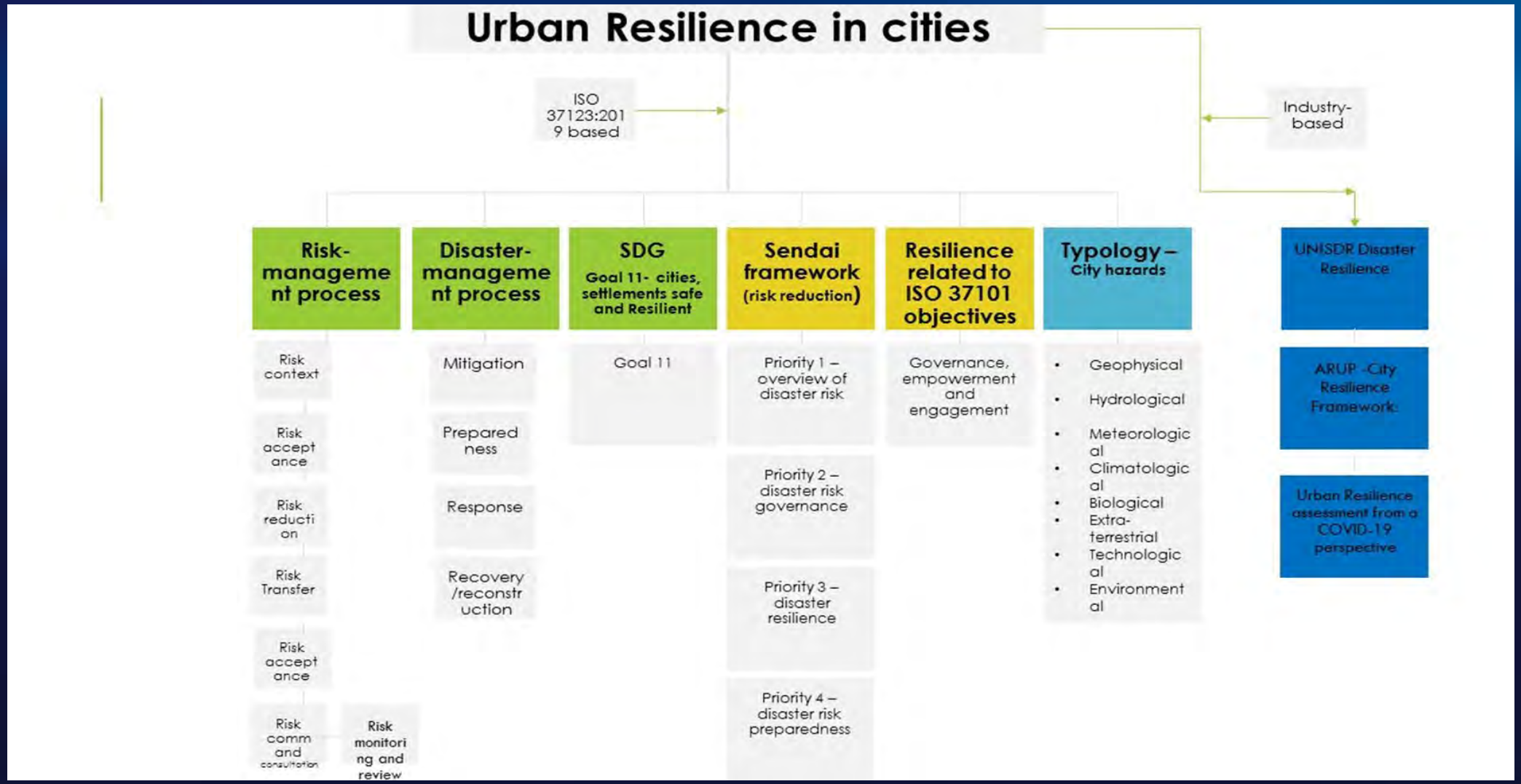
- Evaluate the current international resilience instruments available for planning in the various study areas.



Local

- To assess whether the IUDF framework has made an impact towards the development of the IDP's of cities in order to prepare for Urban Resilience implementation.
- Identify suitable alternative resilience measurement frameworks and instruments for implementation within local municipalities in South Africa other than the IDP and IUDF.
- Explore the implementation of multi-criteria decision analysis in the selection and assessment of suitable resilience indicators

UR frameworks



Methodology

Aim

- To provide a comparative analysis of existing components of mainstream urban resilience frameworks versus what is commonly found in cities.

Data sources

- Planning instruments. Through secondary content analysis the study analyses the planning for urban resilience in local policy documents and plans.

Methods

- The TOPSIS method is basically used to assist with structuring the decision-making process by setting up an indicator hierarchy that models the decision problem and its context.

Analysis

- The TOPSIS MCDA method firstly selects the best urban resilience framework representative of the ideal city planning instruments based on the selective criteria from the IUDF levers.

Resilience Indicator duplication table

Indicator number	Framework / Indicator	1. ISO 37123 indicators: risk-management process	2. ISO 37123 indicators: disaster-management process	3. ISO 37123 indicators: SDG's	4.ISO 37123 indicators: Sendai framework	5.ISO 37123 indicators: ISO 37101 issues	6.UNISDR Disaster Resilience Scorecard: 70 indicators	7.ARUP -City Resilience Framework: 52 indicators	8.Urban Resilience assessment: COVID-19 perspective
1	5.1 Historical disaster losses as a percentage of city product	-	-	√	√√	√	√	-	√
2	5.2 Average annual disaster loss as a percentage of city product	-	-	√	√√	√	√	-	√
3	5.3 Percentage of properties with insurance coverage for high-risk hazards	√	√	-	√√√	√	√	√	-
4	5.4 Percentage of total insured value to total value at risk within the city	√	√	-	√√	√	√	√	-
5	5.5 Employment concentration	-	-	-	--	√	√	√	√
6	5.6 Percentage of the workforce in informal employment	-	-	√	-	√	√	√	-
7	5.7 Average Household income (disposable)	-	-	-	-	-	√	√	-

IUDF levers to assess compliance to UR framework

Lever	Title	Description
Lever 1	Integrated spatial Planning	Promotes spatially organisation, guided investments to encourage integrated social and economic development for sustainable quality of life
Lever 2	Integrated transport and mobility	Promotes walking, cycling and use of mix transportation modes for access to economic opportunities, education, healthcare and recreation
Lever 3	Integrated sustainable human settlements	Promotes multi-functional settlements that provides connected social services and work opportunities
Lever 4	Integrated urban infrastructure	Promotes resource efficient infrastructure systems to boost more inclusive economic growth rather than traditional infrastructure
Lever 5	Efficient land governance and management	Promote growth through land and property investment, ensuring more income for municipalities to promote multi-functional urban spaces
Lever 6	Inclusive economic development	Promote efficient urban economies, stimulate entrepreneurialism and innovation, sustainable livelihoods, and increase the tax base and expansion of public services and amenities.
Lever 7	Empowered active communities	Promote socially and culturally active and diverse citizens, who want to make a difference in South Africa work
Lever 8	Effective urban governance	Promote institutionalism, good fiscal reform and planning capabilities to build urban resilient urban spaces.
Lever 9	Sustainable finances	Promote a good fiscal framework that acknowledges the potential of urban spaces, and stimulate inclusive urban growth.

Table 5: The compliance scores of indicators to IUDF levers

Urban resilience frameworks	Number of Indicators	IUDF Lever Alignment
1. ISO 37123 indicators: risk-management process.	53	Lever 1, 3, 4, 6, 8
1. ISO 37123 indicators: disaster-management process	36	Lever 1, 2, 3, 6, 8
1. ISO 37123 indicators: Goal 11 of the SDG	115	Lever 2, 3, 4, 5, 6, 7, 8, 9
1. ISO 37123 indicators: Sendai framework	97	Lever 1, 2, 3, 4, 5, 6, 7, 8, 9
1. ISO 37123 indicators: ISO 37101 issues	148	Lever 1, 2, 3, 4, 5, 6, 7, 8, 9
1. UNISDR Disaster Resilience Scorecard	69	Lever 1, 2, 3, 4, 5, 6, 7, 8, 9
1. ARUP-City Resilience Framework	52	Lever 1, 2, 3, 4, 5, 6, 7, 8, 9
1. Urban Resilience assessment from a COVID-19 perspective	6	Lever 1, 2, 3, 4, 5, 6, 7, 8, 9

Table 6: Preliminary assessment for ideal framework selection based on IUDF levers

Weight																		
Urban resilience Frameworks/Resilience Criteria	Number of indicators	Lever 1	Policy 1	Lever 2	Policy 2	Lever 3	Policy 3	Lever 4	Policy 4	Lever 5	Policy 5	Lever 6	Policy 6	Lever 7	Policy 7	Lever 8	Policy 8	Lever 9	Policy 9
1. ISO 37123 indicators: risk-management process:	53	$X_{1,1}$		$X_{1,2}$		$X_{1,3}$		$X_{1,4}$		$X_{1,5}$		$X_{1,6}$		$X_{1,7}$		$X_{1,8}$		$X_{1,9}$	
2. ISO 37123 indicators: disaster-management process	36	$X_{2,1}$		$X_{2,2}$		$X_{2,3}$		$X_{2,4}$		$X_{2,5}$		$X_{2,6}$		$X_{2,7}$		$X_{2,8}$		$X_{2,9}$	
3. ISO 37123 indicators: Goal 11 of the SDG	115	$X_{3,1}$		$X_{3,2}$		$X_{3,3}$		$X_{3,4}$		$X_{3,5}$		$X_{3,6}$		$X_{3,7}$		$X_{3,8}$		$X_{3,9}$	
4. ISO 37123 indicators: Sendai framework	97	$X_{4,1}$		$X_{4,2}$		$X_{4,3}$		$X_{4,4}$		$X_{4,5}$		$X_{4,6}$		$X_{4,7}$		$X_{4,8}$		$X_{4,9}$	
5. ISO 37123 indicators: ISO 37101 issues	148	$X_{5,1}$		$X_{5,2}$		$X_{5,3}$		$X_{5,4}$		$X_{5,5}$		$X_{5,6}$		$X_{5,7}$		$X_{5,8}$		$X_{5,9}$	
6. UNISDR Disaster Resilience Scorecard	69	$X_{6,1}$		$X_{6,2}$		$X_{6,3}$		$X_{6,4}$		$X_{6,5}$		$X_{6,6}$		$X_{6,7}$		$X_{6,8}$		$X_{6,9}$	
7. ARUP -City Resilience Framework	52	$X_{7,1}$		$X_{7,2}$		$X_{7,3}$		$X_{7,4}$		$X_{7,5}$		$X_{7,6}$		$X_{7,7}$		$X_{7,8}$		$X_{7,9}$	
8. Urban Resilience assessment from a COVID-19 perspective	6	$X_{8,1}$		$X_{8,2}$		$X_{8,3}$		$X_{8,4}$		$X_{8,5}$		$X_{8,6}$		$X_{8,7}$		$X_{8,8}$		$X_{8,9}$	

MCDA method

- Multi-criteria decision analysis (MCDA) - the purpose and content of Urban Resilience indicators used to assess whether the city's current planning mechanisms are sufficient to create, document and monitor resilience.

- The MCDA method ensures that the selection of indicator criteria and alternatives are done in a transparent manner which will be used to quantitatively assess content towards the selected Urban Resilience frameworks and the iterative selection of indicator criteria and alternatives for testing its compliance with various city planning instruments.

$$\overline{X}_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{n} X_{ij}^2}}$$

Calculate Normalised Matrix

$$V_{ij} = \bar{X}_{ij} \times W_j$$

Calculate weighted Normalised Matrix

$$S_i^+ = \left[\sum_{j=1}^{m} \left(V_{ij} - V_j^+ \right)^2 \right]^{0.5}$$

Calculate the Euclidean distance from the ideal best

$$S_i^- = \left[\sum_{j=1}^{m} \left(V_{ij} - V_j^- \right)^2 \right]^{0.5}$$

Calculate the Euclidean distance from the ideal worst

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-}$$

Calculate Performance Score

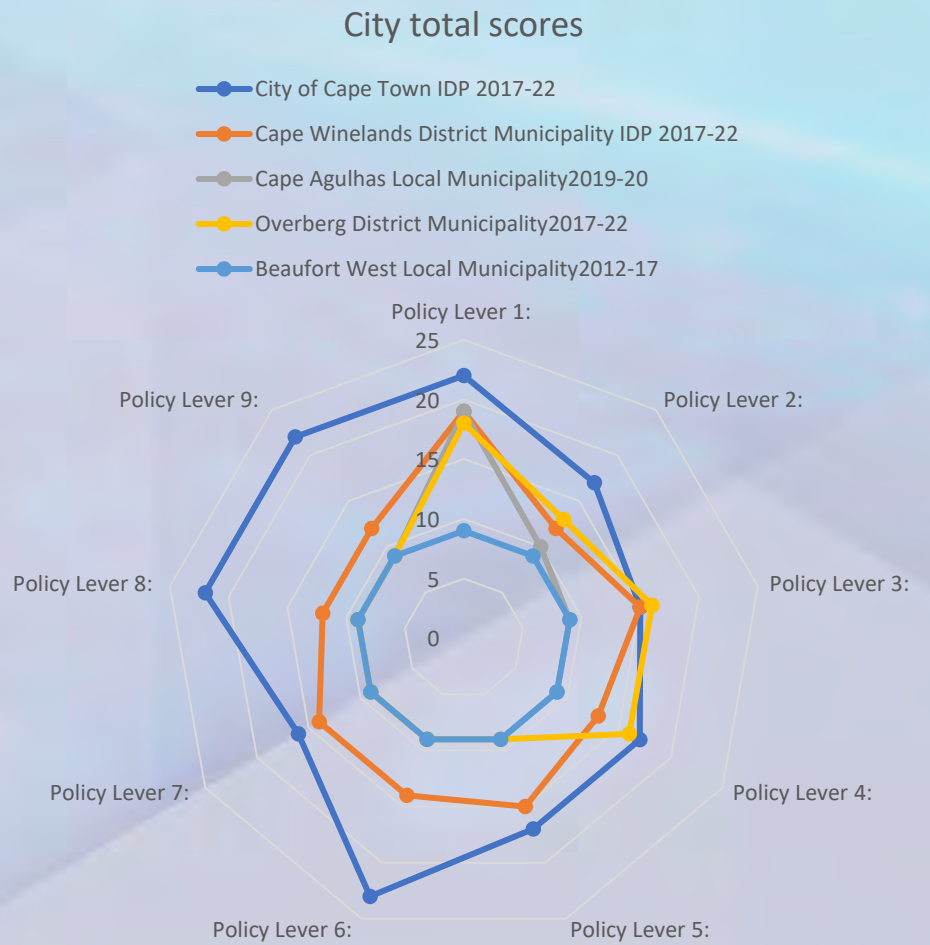
Conclusion

The results of the MCDA-TOPSIS method of alternatives (levers) testing using set criteria can be interpreted by the Pi values. Those values closer to 1 should indicate the stronger or ideal solution and those values closer to zero indicate a non-ideal solution.

The rank values were added manually to the values closer to 1, which represents the ideal urban resilience framework for the selected alternatives (levers).

The urban resilience framework that ranked number 01 in the MCDA method is the *ISO 37123 indicators*: *risk-management process*.

This framework is closely linked to the risk management process which represents key components of the disaster management plan of the city.



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Conclusion

- The TOPSIS MCDA method firstly selected the best Urban Resilience framework and indicated the ideal city planning instruments based on the selective criteria from the IUDF levers.
- The ISO 37123 risk based assessment has proven to be the most technical in nature requesting very specific information that require an in depth knowledge of the study sites.
- The urban resilience framework that ranked number 01 in the MCDA method is the *ISO 37123 indicators*: *risk-management process*.

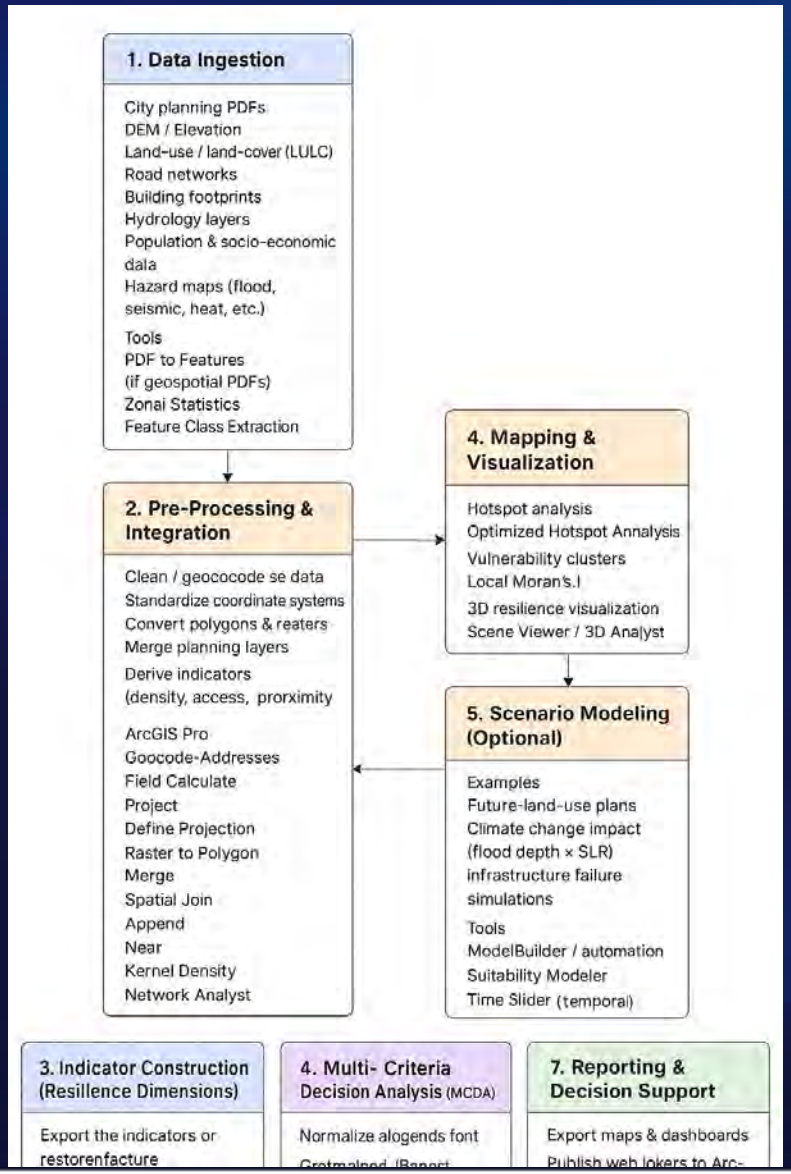
This framework is closely linked to the risk management process which represents key components of the disaster management plan of the city.

- What is clear is that the ultimate goal is for a generic urban resilience plan to be implemented across cities in the Western Cape and ultimately South Africa, and to ensure that best practice urban resilience information sharing occur across the spectrum of municipalities.
- With regards to specific disasters, such as Covid-19, it seems to have caught most cities off-guard, even though there are mentions of these in some disaster management plans, but not given a very high risk rating initially.
- The Covid-19 derived resilience framework does highlight key learnings for the future planning of disease pandemic events, especially around urban form (importance of greening and recreation as mitigating factors), environmental air quality and issues around transportation risks, investment in scientific operations, a need for heterogeneous economic structures, global supply chains affecting investments and the need for budgetary inputs towards urban and rural resilience.

Conclusion

- The greatest advantage in using the MCDA method is that qualitative methods can be used to analyse data from different planning documentation in a transparent and normalised fashion even if the format and values differ significantly.
- The international shift from disaster response to risk reduction is a welcomed response as most risks can easily be addressed via risk mitigation within disaster plans.
- Future research need to include above to inform cities what the status of their urban resilience measurements reflect pre- and post any disaster, to inform specific areas in need of reform and improvement.

Next phase: ArcGIS workflow



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