AI driven Digital Twin for Water Management for Limpopo River Basin and Inclusive Integration with Citizen Science

IWMI

Gaborone, Botswana
9–11 June 2025

Online Agenda

bit.ly/4jVtXgR

REPUBLIC OF BOTSWANA

LIMCOM
LIMPOPO WATERCOURSE COMMISSION

DIWASA

Supported by

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aws   Digital Earth AFRICA   Global Water Partnership Southern Africa   Microsoft

Day 1

LIMPOPO DIGITAL TWIN

Digital Twin Hands on

Listening Session for Data Challenges
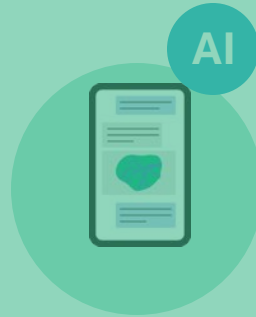
Digital Twin Concept

Hands on:

Water Availability

Irrigation Water Use

Droughts Index

Day 2

AI

AI for Water Management

AI and Data Governance

101 generative AI

Prompt engineering

Hands On:

Limpopo

Water Copilot

Day 3

AI

Citizen Science Co-designs

Creating trust on citizen science data

AI

DIWASA Training

Use cases from DEA

Listening Session

Stakeholder consultation scaling opportunities

Tentative_schedule.docx

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Water Manager Persona - Challenges

As a water manager, my job **is incredibly complex – ensuring reliable water supply, managing resources across borders, dealing with unpredictable weather, and serving our communities**.

Lately, there's a lot of talk about using AI to optimize everything, predict droughts, manage infrastructure.

But frankly, I have some major headaches when it comes to the data needed for this.

Sharing data with neighboring countries is difficult

– there are issues of trust, data formats, and even concerns about who owns the data and if it will be misused.

And when we do get data, ensuring its quality is a constant struggle. How can we even begin to think about AI if we don't have our data house in order? I feel like I'm drowning in data problems before I even get to AI!

Data Governance Principles in the Limpopo River Basin

Why Data Governance and Data Sharing Matters

- AI is only as reliable as the data it receives.

- Inconsistent, outdated, unverified or siloed data can lead to poor or biased decisions.

- Trust and data sharing agreement is critical.

- Transparency and transboundary support toward equity in data availability is necessary.

- Quality control is essential — especially in a transboundary context.

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Key Data Governance Steps

Step	Action	Why It Matters
1. Agree on Sharing Standard Operating Procedures - already commenced by LIMCOM	Use common formats, definitions, units etc. across all countries.	Ensures data is interoperable and comparable, and balanced across the basin.
2. Ensure Metadata	Document where data comes from, how it was collected, by whom, etc.	Helps assess reliability, support referencing and validation, improve trust and trace issues.
3. Define Access Rules	Set clear rules on who can view, share, and edit datasets: at user level and at data set level.	Protects sensitive data and secures trust; enable use-tracking of the system and data.
4. Enable Agreements	Support transboundary data sharing with formal SOP in place, including MoUs where applicable.	Improve trust, reduces friction and avoids misuse or misinterpretation.
5. Implement Equity Checks	Regularly assess how data and AI outputs affect decision making and users as well as in the end, communities.	Prevents reinforcing inequities between regions or groups.

Outcomes

Transparent, trusted data systems that support local decision-making.

AI tools that reflect real conditions and priorities, not just algorithms.

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AI Governance Persona - Challenges

AI is being pitched as the next big solution—optimizing systems, predicting shortages, streamlining operations. But honestly, I have serious concerns about how these systems make decisions. If AI starts determining where water goes and how infrastructure runs, how do I trust its choices?

Then there's the explainability issue—the 'black box' problem. If I don't know why an AI is recommending a particular action, how can I justify using it? **What happens if it gets it wrong?** A misstep could mean a shortage, contamination, or poor resource allocation.

And when that happens, who takes responsibility?

 Is it the AI itself? The developers?

The data providers? Or does the blame fall on managers like me?

African Nations: 2025 AI Policy Updates

- **Egypt**
  - Launched the **second edition of its National AI Strategy (2025-2030)** in Jan/Feb 2025, focusing on 6 pillars and 21 strategic initiatives.
  - **Source:** [Factbox: All you need to know about 2nd edition of Egypt national AI strategy - Tech](#), [Egypt launches updated AI strategy for growth in Middle East - Tech in Asia](#), [Egypt National Artificial Intelligence Strategy](#)

- **Ethiopia**
  - Approved a **National AI Policy in June 2024**. In Feb 2025, joined the **Statement on Inclusive and Sustainable AI for People and the Planet**. African Union declared AI a strategic priority in May 2025, with Ethiopia actively involved.
  - **Source:** [DPA Digital Digest: Ethiopia [2025 Edition] - Digital Policy Alert](#), [Africa Declares AI a Strategic Priority as High-Level Dialogue Calls for Investment, Inclusion, and Innovation | African Union](#)

- **Ghana**
  - Launched its **National AI Strategy in September 2024**. Adopted the **Statement on Inclusive and Sustainable AI** in Feb 2025.
  - **Source:** [DPA Digital Digest: Ghana [2025 Edition] - Digital Policy Alert](#)

- **Kenya**
  - Released its **first National Artificial Intelligence Strategy (2025–2030) in April 2025**, focusing on ethical, inclusive, and innovation-driven AI adoption.
  - **Source:** [Kenya's AI Strategy 2025–2030: Signals for Global Companies Operating in Africa](#), [The Kenya National AI Strategy 2025-2030: Regional and Global Positioning](#)

- **Mauritius**
  - Unveiled "**The Blueprint for Mauritius – Digital Transformation 2025-2029**" in May 2025, including development of a **National AI Strategy** and an AI Unit.
  - **Source:** [A Blueprint For Mauritius: A Bridge To The Future - DLA Piper Africa](#), [a blueprint for mauritius a bridge to the future - Ministry of Information Technology, Communication and Innovation](#)

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African Nations: 2025 AI Policy Updates

- **Nigeria**
  - National AI Strategy launched in 2024. In 2025, positioning AI at the center of economic growth with new funding and policy initiatives. Deliberating on AI regulation.
  - **Source:** Nigeria embraces AI for economic growth - Punch Newspapers, DPA Digital Digest: Nigeria [2025 Edition] - Digital Policy Alert

- **Rwanda**
  - National AI Policy released in April 2023. Signed the **Statement on Inclusive and Sustainable AI for People and the Planet** in Feb2025.
  - **Source:** DPA Digital Digest: Rwanda [2025 Edition] - Digital Policy Alert

- **South Africa**
  - G20 Presidency (2025) focusing on digital public infrastructure (DPI) and AI. **National Artificial Intelligence Policy Framework released in Aug 2024** (a framework, not a fully passed law).
  - **Source:** DPI and AI are steering South Africa's G20 Presidency agenda - The World Economic Forum, Practical AI Governance Strategies for SouthAfrican Boards in 2025 & Beyond - BoardCloud

- **Uganda**
  - Expecting a **decision by end of 2025** on adopting a formal AI policy or a flexible framework. Discussions lean towards a strategy/framework.
  - **Source:** Uganda's AI Governance Dilemma: Policy or Framework to Drive Innovation? Decision Expected by 2025 - Nile Post, AI in Uganda Policy andRegulatory Environment - Knowledge Consulting Ltd

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The need for AI Governance

- Ensures AI systems are developed and deployed in a safe, human-centric, trustworthy, and responsible manner.

- **Alignment with Responsible AI Principles:** Incorporating fairness, accuracy, accountability and transparency in AI policy and practice.
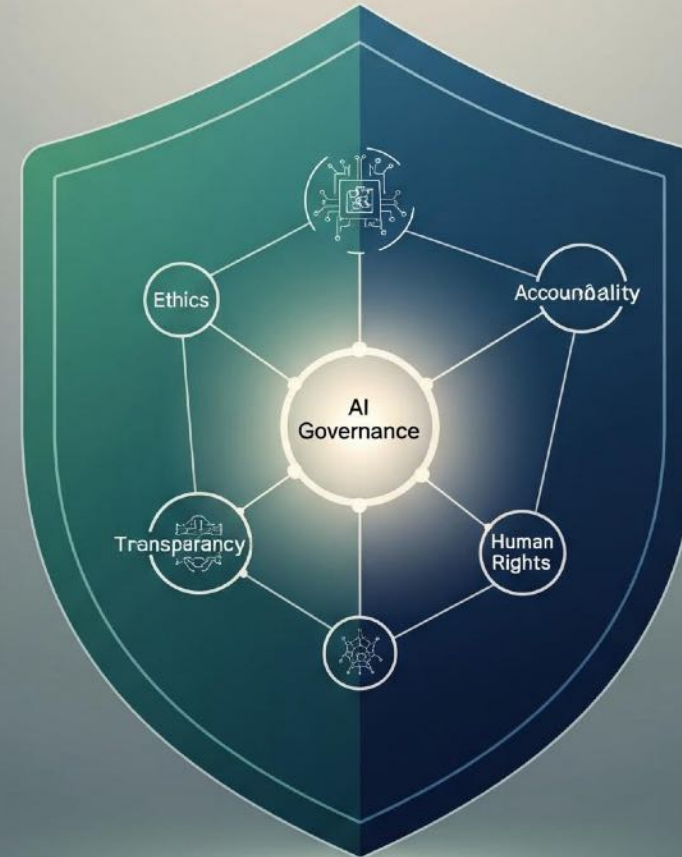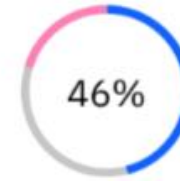
AI Governance Challenges

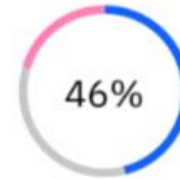80% of business leaders see at least one of these ethical issues as a major concern[3]

48%
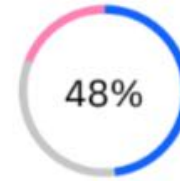
Explainability
Believe decisions made by generative AI are not sufficiently explainable.
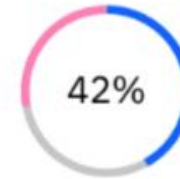
46%

Ethics
Concerned about the safety and ethical aspects of generative AI.

46%

Bias
Believe that generative AI will propogate established biases.

42%

Trust
Believe generative AI cannot be trusted.

GenAI Ethical Risks

Generative AI presents risks which need to be considered & mitigated to scale adoption and users' trust

Ethical Considerations in Generative AI

- Bias & Discrimination

- Privacy & Confidentiality

- Transparency & Accountability

- Fair Use

- Erosion of Trust - Hallucinations

- Environmental Impact - Model Size & Resources
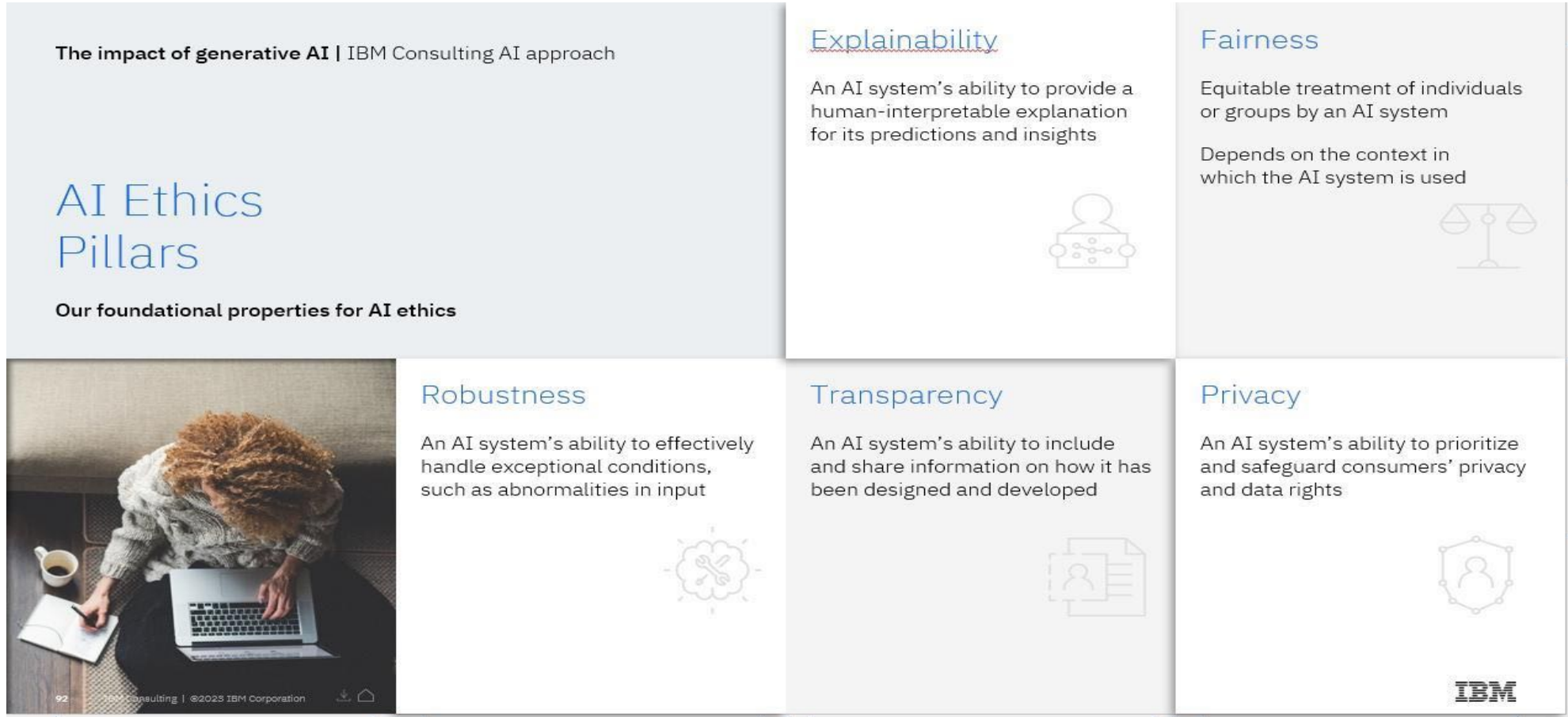
Responsible Generative AI Models

- Controllable Output Generation
    - Trusted Data Acquisition
    - Domain Adaptation
    - Prompt Engineering
    - Bias Mitigation
    - Adversarial Training
    - Human-in-the-loop
    - Post-Generation Validation

- Transparency & Explainability for Generative AI*

- Generative AI Model Impact Assessment*

* Research efforts in the industry

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AI Ethics Pillars

The impact of generative AI | IBM Consulting AI approach

AI Ethics Pillars

Our foundational properties for AI ethics

Explainability

An AI system's ability to provide a human-interpretable explanation for its predictions and insights

Fairness

Equitable treatment of individuals or groups by an AI system

Depends on the context in which the AI system is used

Robustness

An AI system's ability to effectively handle exceptional conditions, such as abnormalities in input

Transparency

An AI system's ability to include and share information on how it has been designed and developed

Privacy

An AI system's ability to prioritize and safeguard consumers' privacy and data rights

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AI Governance Considerations

Consider these components:

Regulatory compliance

Manage AI to meet upcoming safety and transparency regulations and policies worldwide—a "nutrition label" for AI.

- Translate external AI regulations into policies for automated enforcement
- Enhance adherence to regulations for audit and compliance
- Use dynamic dashboards for compliance across policies and regulations

Automatic metadata
Data transformation and lineage capture through Python notebooks.

Risk management

Proactively detect and mitigate risks monitoring fairness, bias, drift, and new LLM metrics.

- Automate facts and workflow for compliance to business standards
- Identify, manage, monitor and report on risk and compliance at scale
- Use dynamic dashboards for clear, concise, customizable results
- Enhance collaboration across multiple regions and geographies

Open
Support governance of models build and deployed in third party tools.

Lifecycle governance

Manage, monitor, and govern AI models from IBM, open source communities, and other model providers.

- Monitor, catalog and govern AI models from where they reside
- Automate the capture of model metadata
- Increase prediction accuracy, identifying how AI is used and where it lags

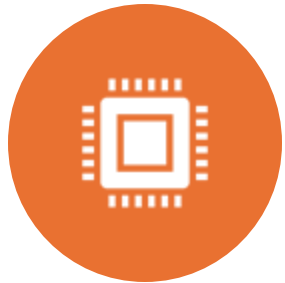**Comprehensive**
Govern the end-to-end AI lifecycle.

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GenAI for Water Managers

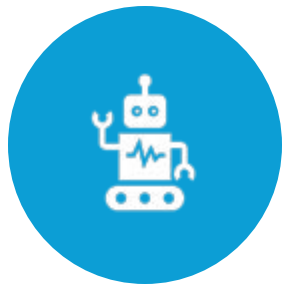### Hands-on Prompt Engineering

D.Darlington

Introduction to Generative AI

Generative AI is a powerful subset of artificial intelligence that can create or "generate" new, original content and data that closely resembles real-world data.

They are built on transformer architectures and Large Language Models (LLMs)

The rise of LLMs brings exciting possibilities for human-computer interaction
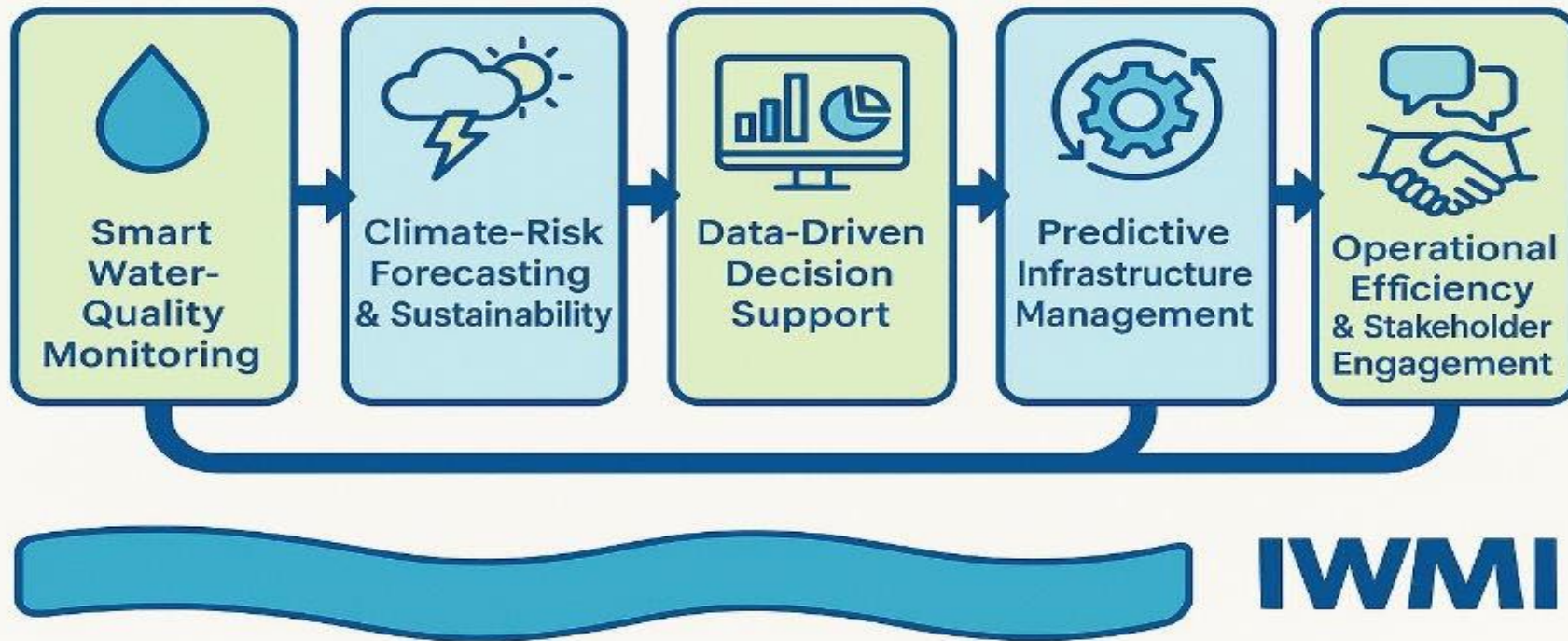
GenAI can produce various outputs, including text, images, video, audio, and even code

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Have you used any GenAI tool?

What are the tasks you use AI for?

Applications of GenAI for Water Managers

What is Prompting?

The Art and Science of Guiding AI.

- A **prompt is the input you provide** to the AI model to elicit a specific response

- The purpose is to **provide context, instructions, and examples** to help the AI understand your intent
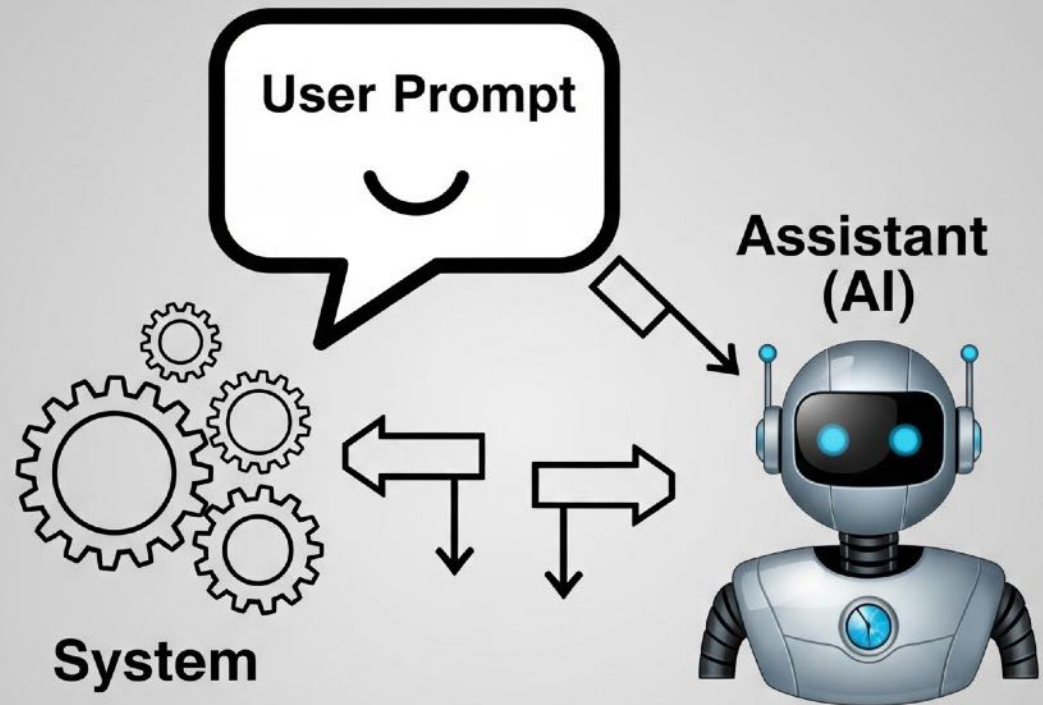
- **Good prompts = Good results**
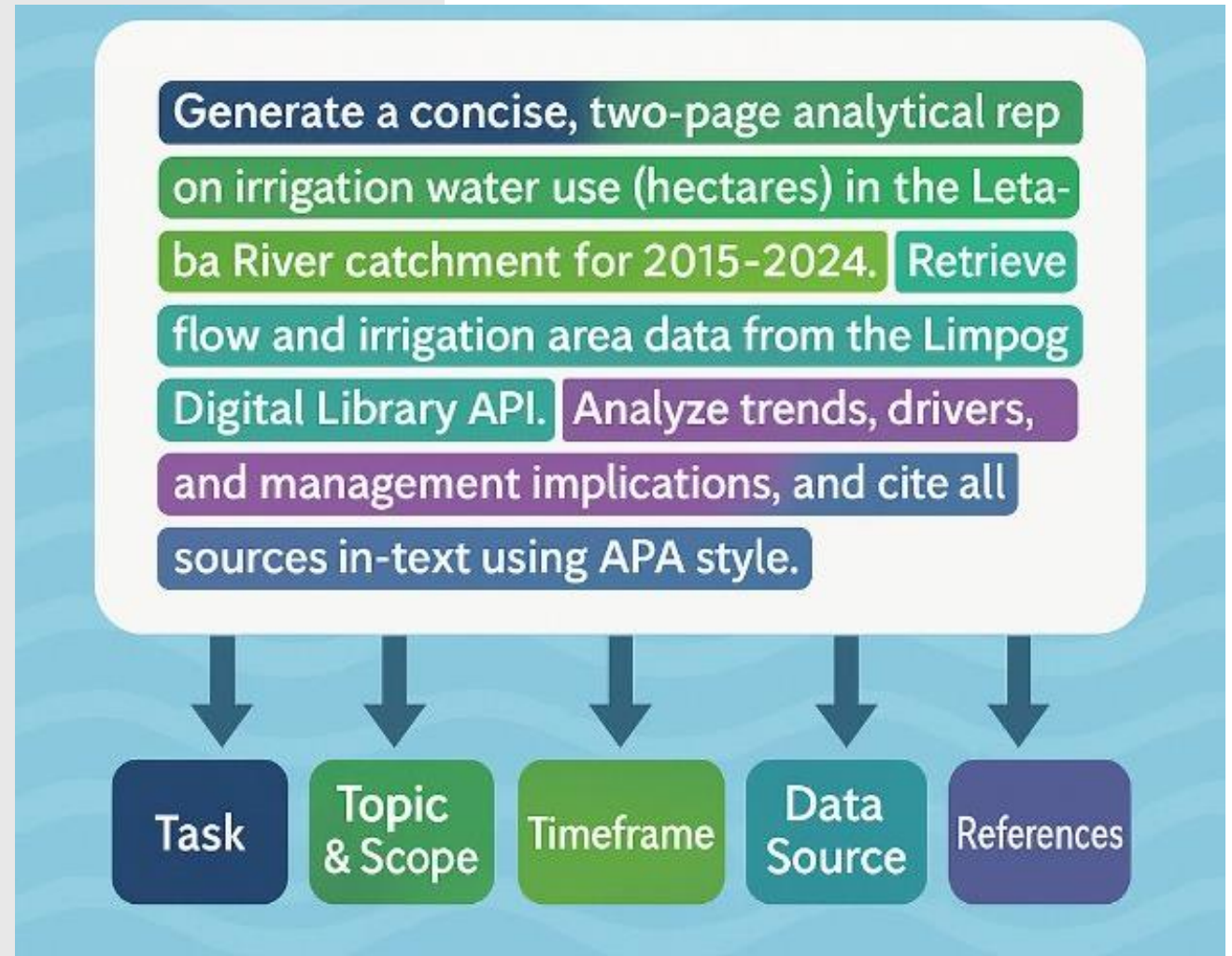
Understanding AI Interactions: Roles Explained

System Prompt: Defines AI's role, identity, persona, and rules. Set by the developers.

User Prompt: Your instruction or query to the including context, format, rules, and examples.
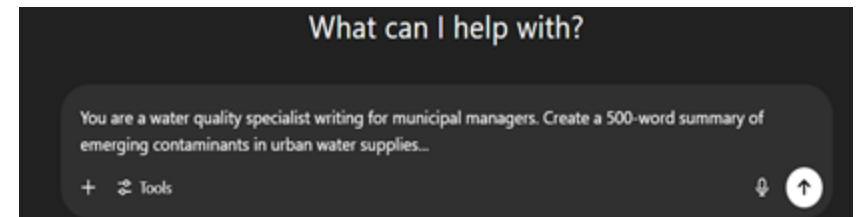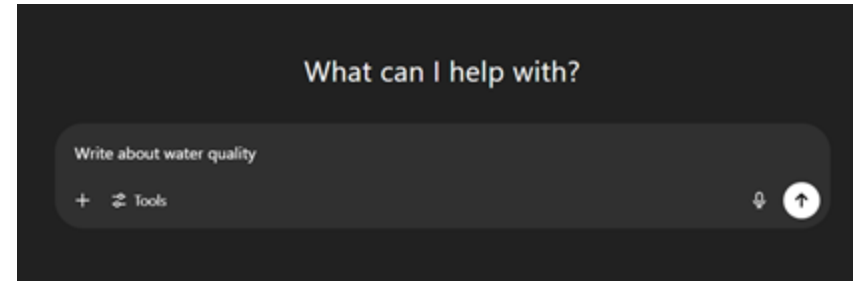
Assistant Prompt: AI's response. Can reinforce desired behavior or serve as a template for future outputs.

Ask me a question like
I was an AI

Prompt Engineering Fundamentals

- Specificity over generality

- Context is crucial for technical accuracy

- Examples guide style and detail level

- Iteration improves outputs systematically

- Avoid Conflicting Instructions: Don't use contradictory terms (e.g., "Detailed summary") as LLMs struggle with nuance. Be singular in your intent.

- Optimise Prompt Length: Shorter, information-dense prompts often perform better than longer ones.

- Understand AI Capabilities & Limitations: Prompt engineering helps you better understand what LLMs can and cannot do. Knowing different models' strengths is crucial.

- Choose the Right Model: Select models based on task complexity; smarter models are often better for mission-critical tasks despite slightly higher cost.

What can I help with?

Write about water quality

+ Tools

What can I help with?

You are a water quality specialist writing for municipal managers. Create a 500-word summary of emerging contaminants in urban water supplies...

+ Tools

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Responsible AI Use and Ethical Considerations

Risks and Challenges:

Hallucinations: When AI provides inconsistent, incorrect, or nonsensical outputs. Often happens with vague instructions or guessing. **Hard to spot, making fact-checking vital**.

Bias: Outputs may contain stereotypes or unfair representations, reflecting biases in training data.

Adversarial Prompting: Prompts designed to manipulate the AI. Includes:

• Prompt Injection: Overriding original instructions or safety guidelines.
• Prompt Leaking: Extracting confidential or sensitive information.
• Jailbreaking: Bypassing safety filters.

How Prompt Engineering Helps Mitigation:

By **carefully controlling the input and guiding the AI's focus**, prompt engineering helps mitigate bias and minimize the risk of generating inappropriate or offensive content.

Using **specific, detailed prompts and iterating** helps avoid biased outputs. Use inclusive language.

Providing clear instructions and context helps improve model performance and leads to more accurate outputs, reducing factuality issues.

Iteration (e.g., Chain of Density) helps check for hallucinations.

Prompt engineering can help improve the safety of LLMs.

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Understanding GenAI Tools

The Landscape of Tools.

- Various tools exist, supporting different modalities (text, images, code, etc.)

- Important to understand the capabilities of different models

- Some tools are better for specific tasks (e.g., ChatGPT for summarization, Bard/Gemini for up-to-date information)

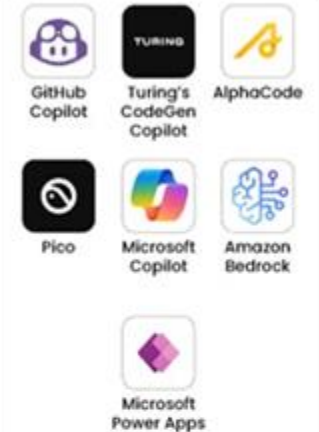- Tools may offer different interfaces (e.g., standard chat vs. API playgrounds)
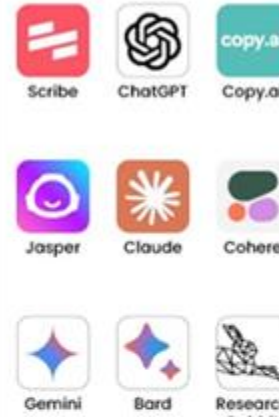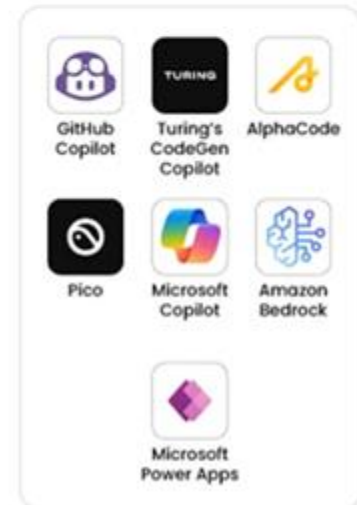
Hands-on Prompt Engineering Exercise
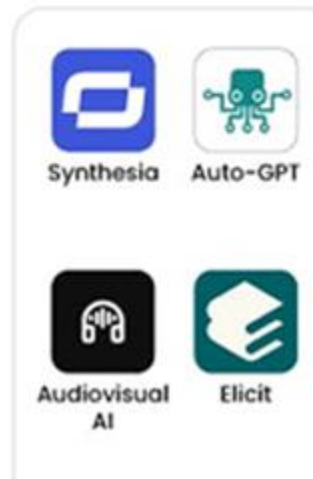
Key Takeaways

Prompt engineering is essential for effectively using GenAI

Mastering prompting skills helps you get better results, understand AI capabilities/limitations, and interact more effectively.

Structure your prompts thoughtfully using the T.C.R.E.I. framework.

Always evaluate and iterate your prompts and the AI's output

Fact-check for bias and accuracy

Avoid sharing sensitive data
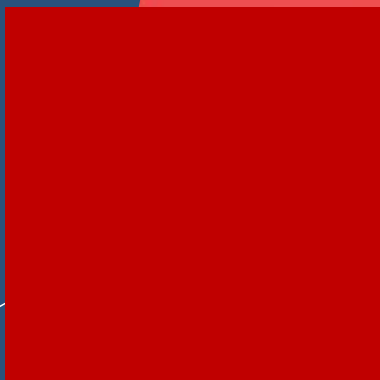
Prompt Examples for Hands-on Exercise

1. What are the best strategies for optimizing water allocation during drought conditions?

2. Which rainfall station is closest to the Balule e-flow site, and what were the monthly rainfall totals (mm) for 2024? Please show the table and an accompanying chart.

3. How should emergency response plans be updated for extreme rainfall events?

4. What are the best digital twin applications for water distribution systems?

5. How can water utilities collaborate with farmers to ensure sustainable groundwater use?

6. For compliance purposes, show me the e-flow alert levels across the entire basin on 2025-02-28 (end-of-month). I'd like the results in a table and a colour-coded map.

7. Could you list every reservoir, lake and dam in the Limpopo basin: name, capacity, coordinates in a clean table ordered by capacity so that I can paste into a report?

8. Show the irrigation changes and rainfall charts in the Letaba catchment over the last 5 years (2019-2025). Highlight any trends, drivers or management implications, and provide in-text references.

9. Summarise all the studies that have been done in the Limpopo River Basin that focus on water availability and eflow/ewr determination please use Harvard style intext referencing.

10. I'm compiling a briefing on the Luvuvhu River. Please give me the environmental-flow, natural-flow, present-flow and water-availability values from 2024-11-01 to 2025-04-30, and include a line chart of the trends. Cite your sources in-text.

THANK YOU!

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Research and Innovation for Water Security
Driving Action • Propelling Change

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