Geo-hazard Potential Mapping Using GIS and Artificial Intelligence

Theoretical Background and Uses Case from Namibia

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AfricaGIS 2017
Geospatial and Statistical information imperatives for the 'Africa We Want'
20-24 NOVEMBER 2017
ADDIS ABABA, ETHIOPIA

Motivation

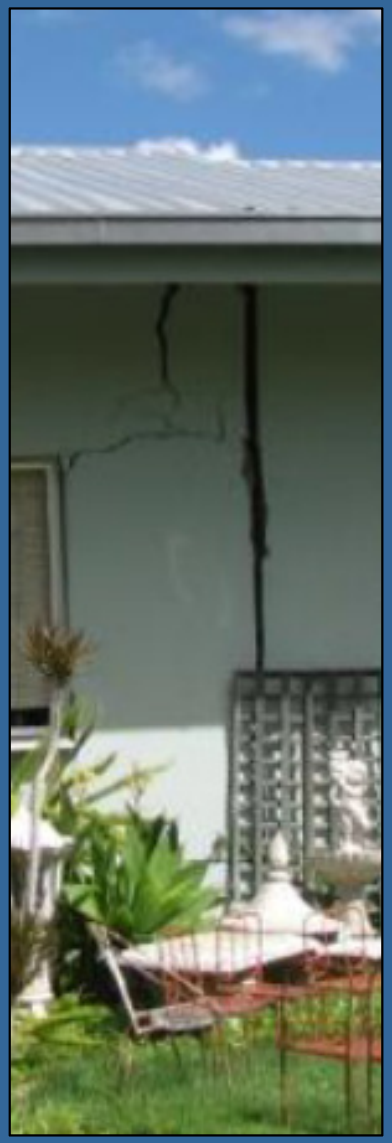
- Geo-hazards are not avoidable, very often
- Geo-hazards create big damages

- We need to manage the risks
- We need to understand geo-hazards
- We need to locate endangered areas
- We need to organise protection & mitigation measures

GEO-HAZARD MAP and RISK MAP

Methodology: Objectives

- **Combination** of field work, damage data inventory & analysis, remote sensing data analysis, and advanced data interpretation
- Production of **geo-hazard, vulnerability and risk maps** as a basis for advice on urban land use planning
- Creation of a standard **mapping-based risk assessment approach** for the GSN
- **Technical capacity building** to enable the GSN staff to execute similar projects in other cities



Methodology: Working Area

City: Windhoek
Country: Namibia

Methodology: Working Area

Area: 645 km^2
Population: 322,500 (2010)
Elevation: 1700 m above sea level

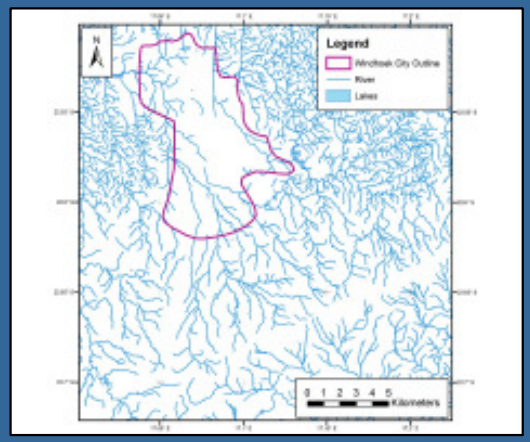
Methodology: Types of Geo-Hazards

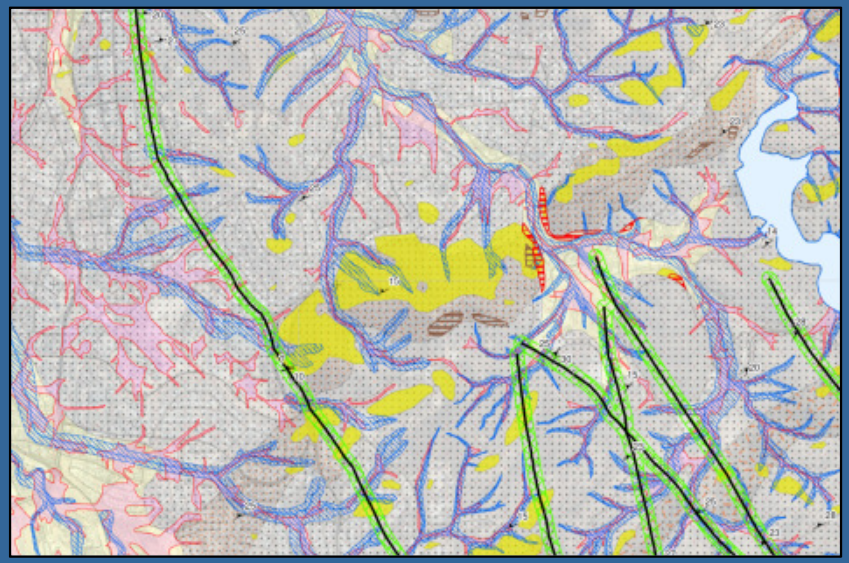
Risks to be analysed:

1) **Fault related instabilities**
2) **Slope instabilities**
3) **Mud flows/ inundations**
4) **Erosion gullies and related issues**
5) **Near surface ground water**

Methodology: Working Steps

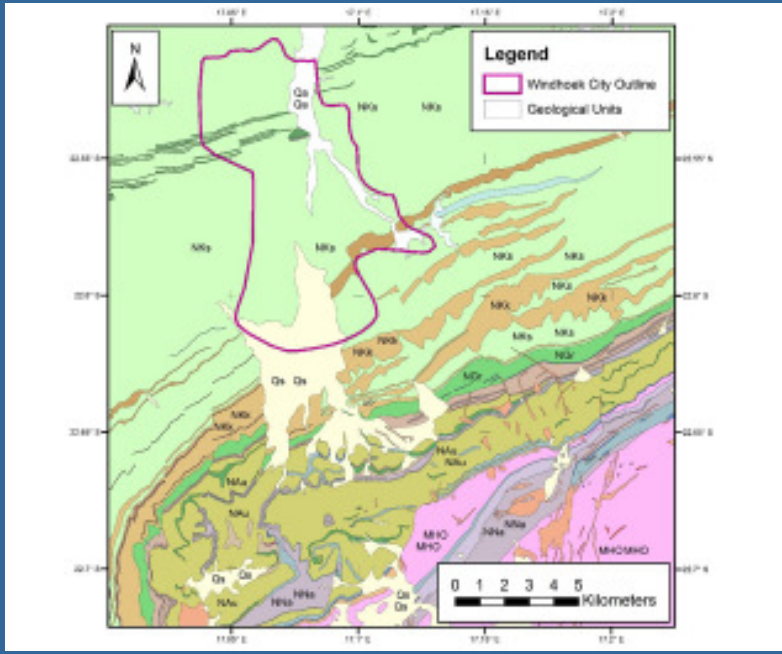
1) Review of existing data
2) Field mapping
3) GIS mapping / processing
4) Predictive mapping
5) Map compilation
6) Reporting

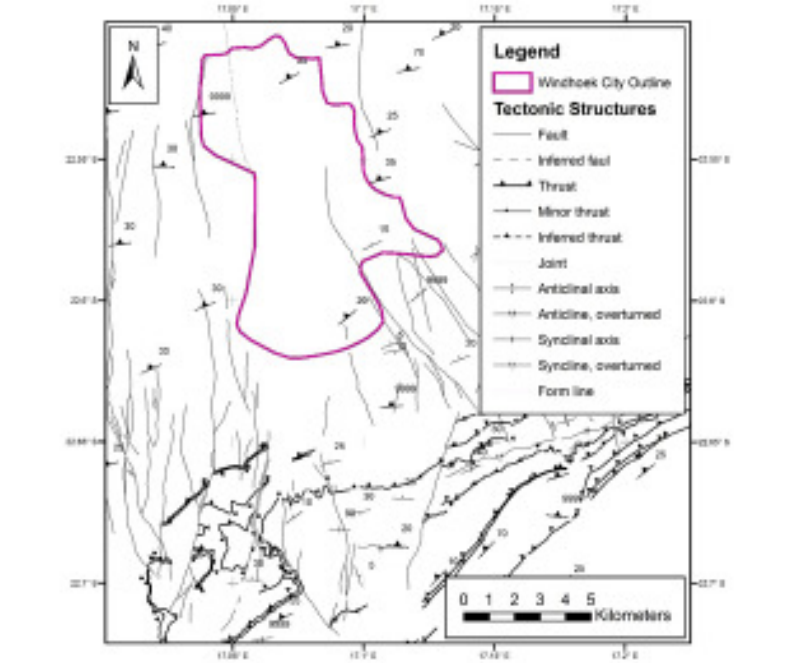




Results: Review of Existing Data - *Geology*

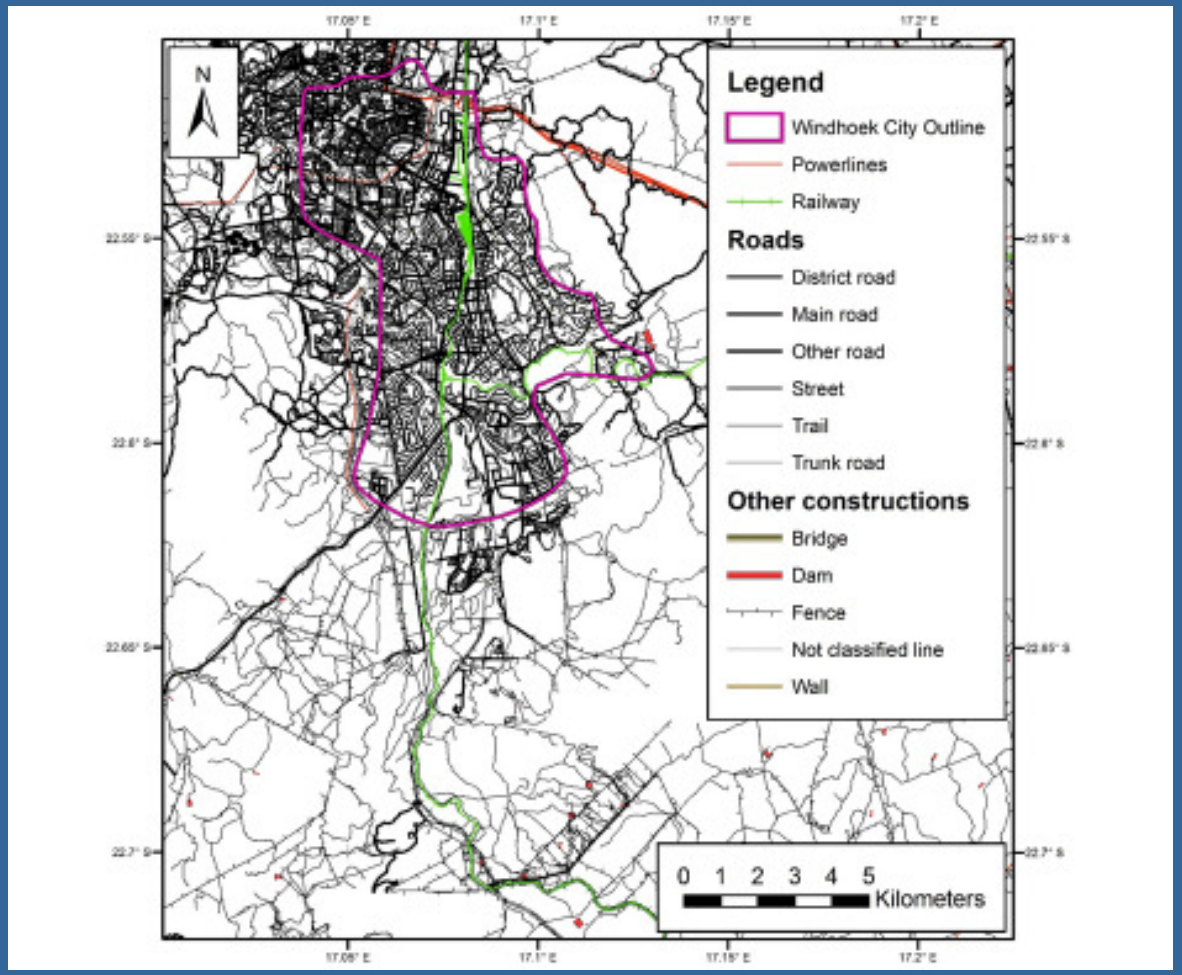
- Digital Geological Map of Namibia 1:50,000





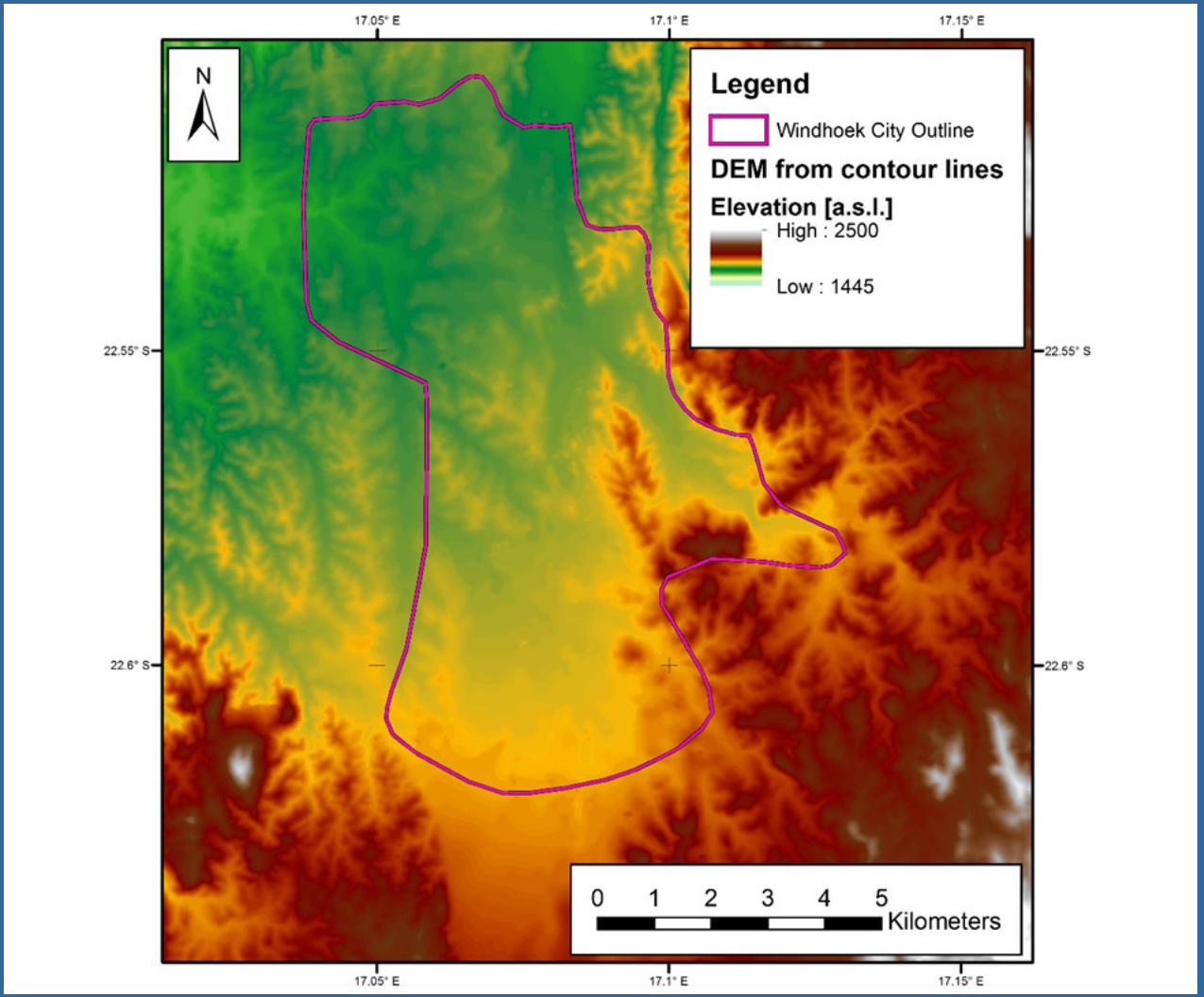
Results: Review of Existing Data - *Topography*

- Topographic maps 1:10,000



Results: Review of Existing Data - *Elevation*

- DEM from topographic maps (from 5 m contour lines)

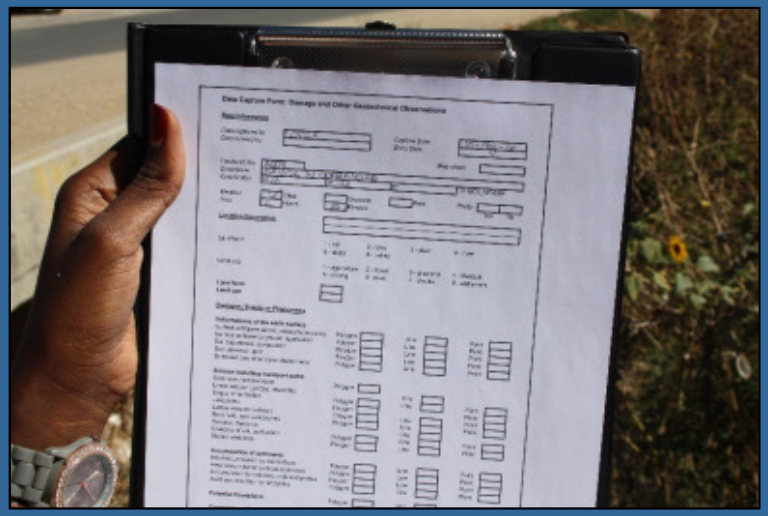


Methodology: Field Mapping – *Data Capture*

Base Information

Geological Observations

- Outcrop description
- Rock / soil description
- Geotechnical rock / soil description

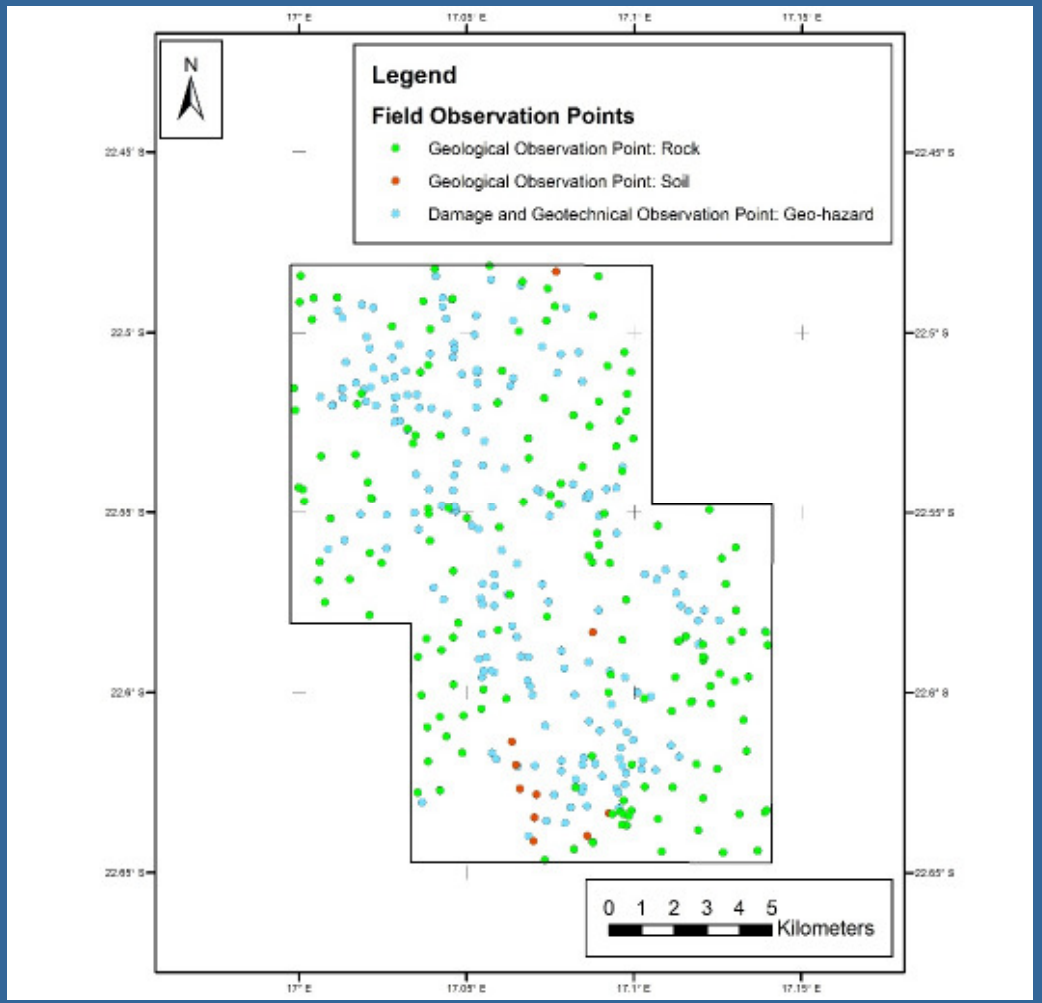


Damages and other Geo-technical Observations

Results: Field Mapping

- **Field Points**:
  - 164 rock observations
  - 10 soil observations
  - 208 damages and geo-technical observations

- **Investigation Area**:
  - 16 field mapping blocks a 4x4 km



Methodology: Map Set – *General Layout*

- 3 maps at scale 1:25,000 fitting in A0 format:
  - **Geo-hazard Map of Windhoek**
  - **Vulnerability Map of Windhoek**
  - **Risk Map of Windhoek**

Methodology: Data Processing

Input data

- Rock classification
- Faults / fault zones
- Slope classification
- Floodplains
- (Rock bedding)

Known events

- Damages
- Fault related instabilities
- Surface instabilities
- Inundation / mud flows
- Erosion gullies

Vulnerable items

- Construction
- Housing
- Roads
- Other infrastructure

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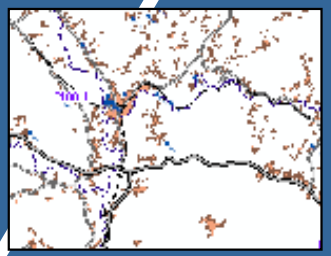
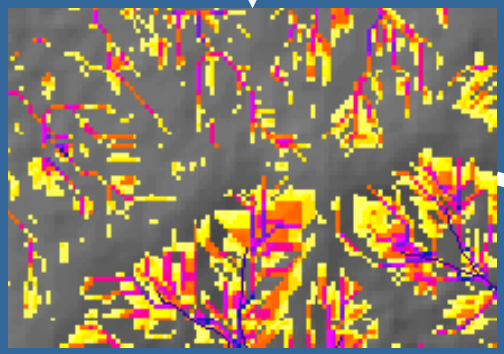
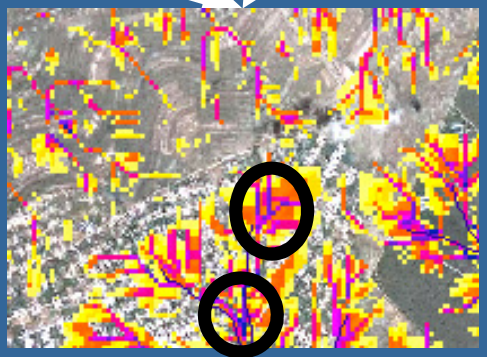


Vulnerable items



Geo-hazard areas



Risk areas

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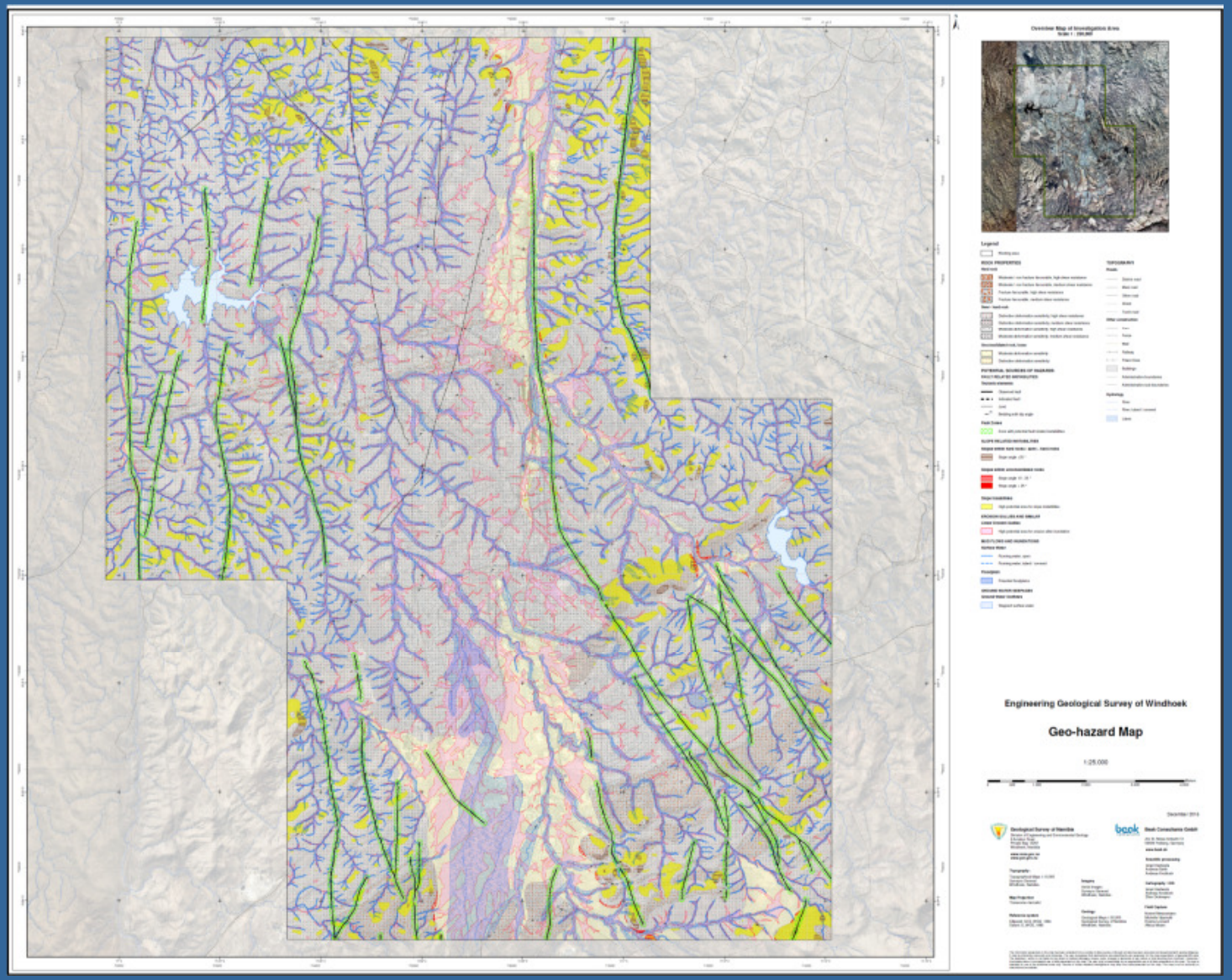
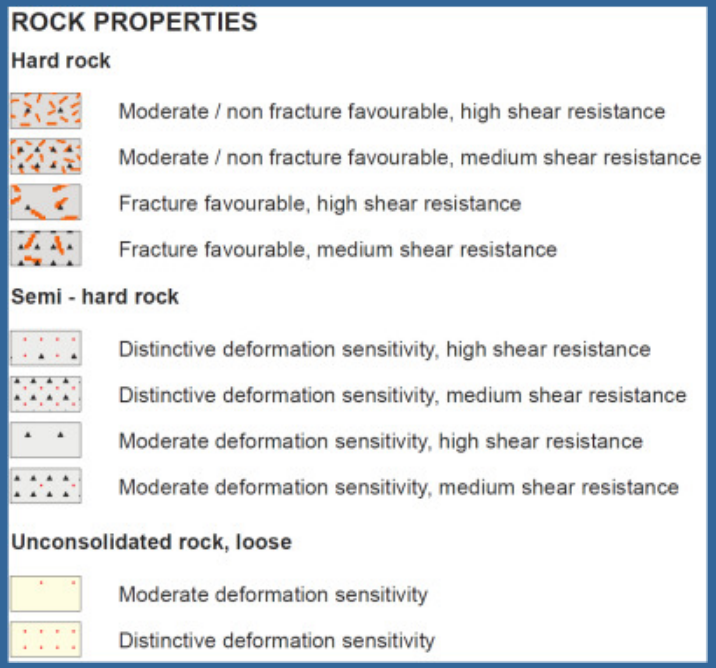
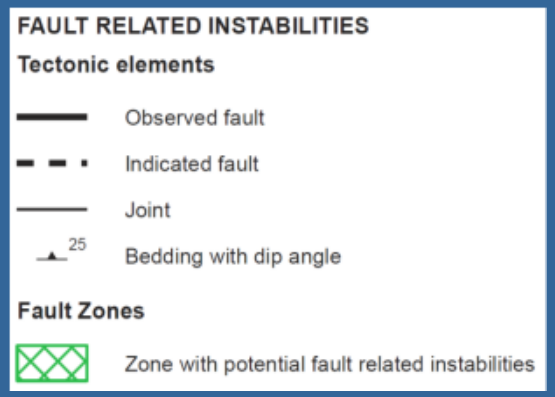
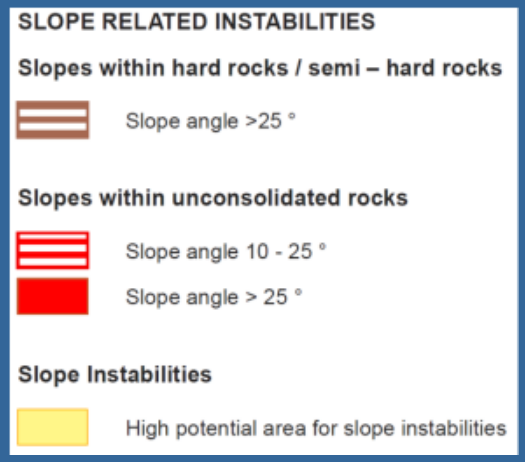
Results: Map Design – *Geo-hazard Map*

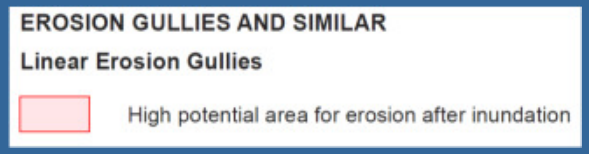


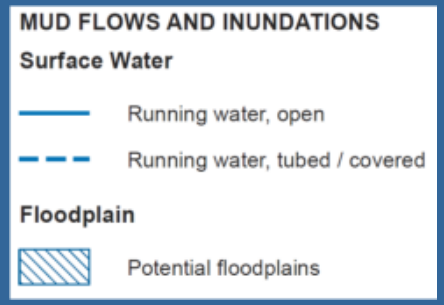
Results: Map Legend – *Geo-hazard Map*











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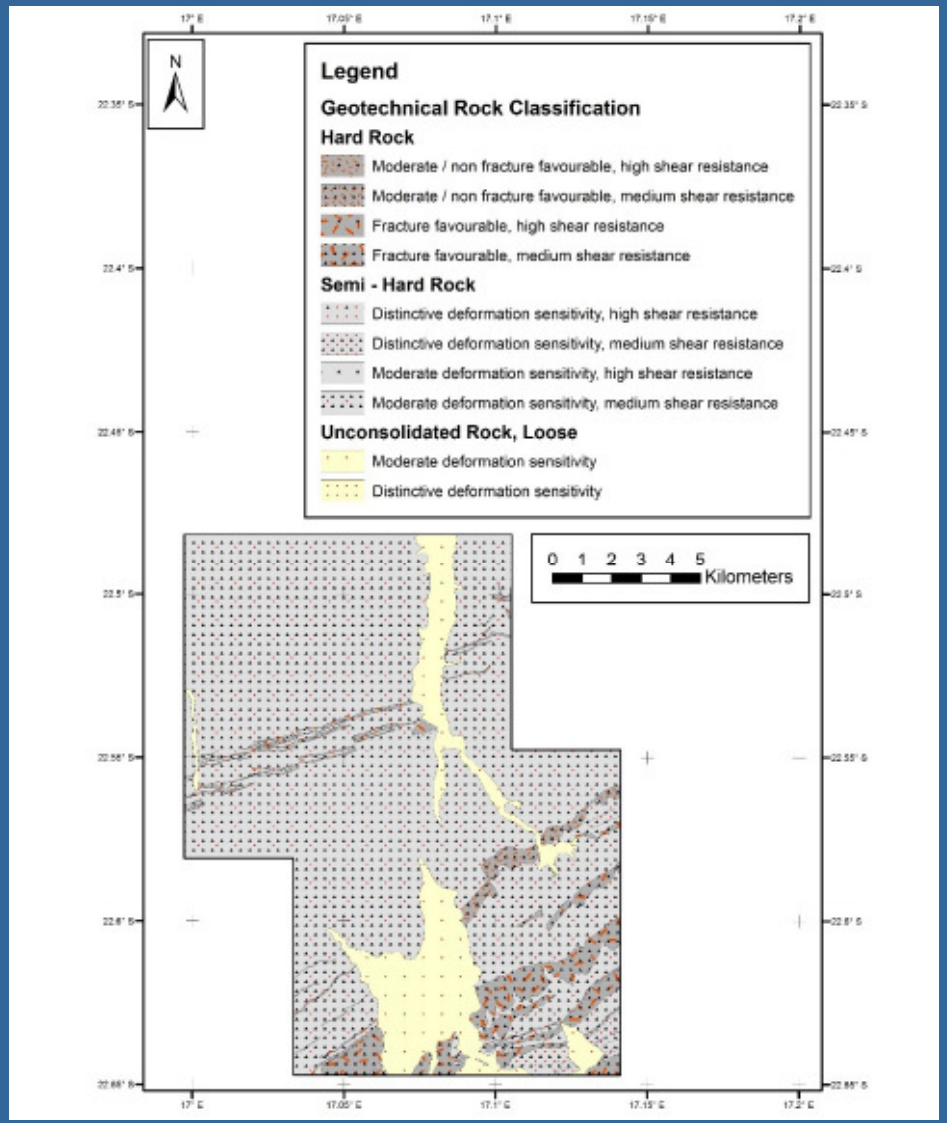
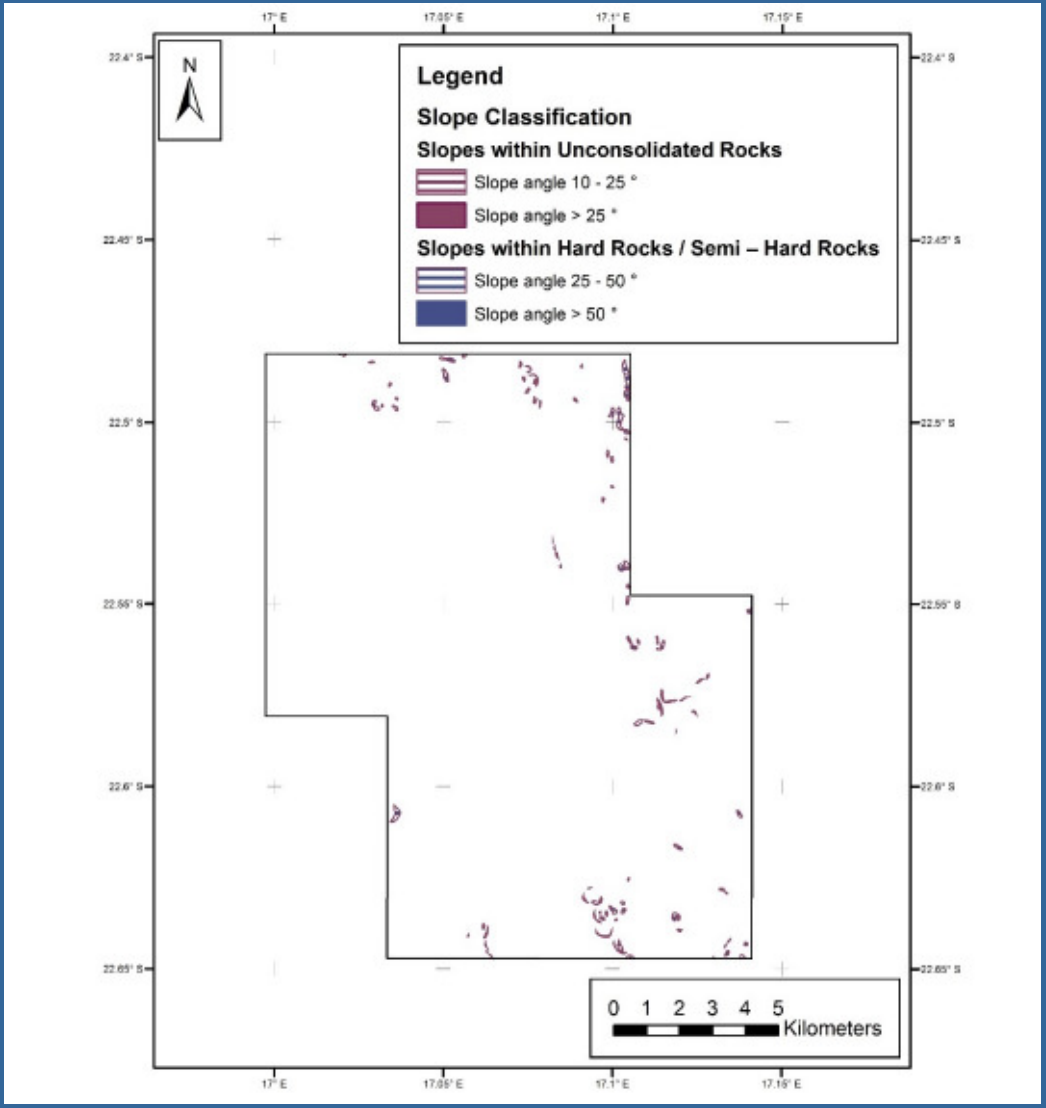
Result: GIS Processing

- **Geotechnical Rock Classification**
  combining
  Rock class
  Fracture favourability
  Shear resistance
  Deformation sensitivity



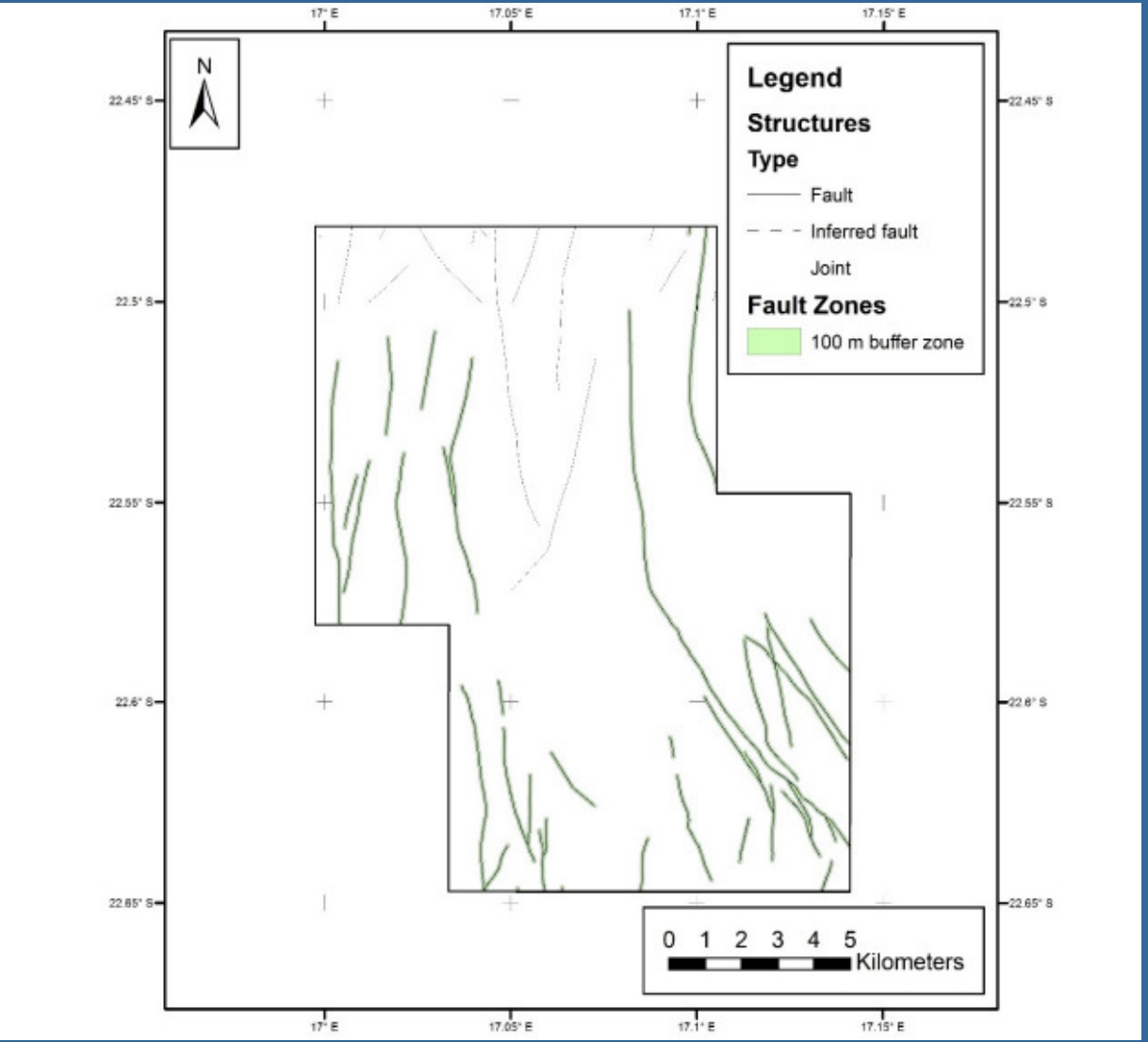
Results: GIS Processing

- **Slope classification**



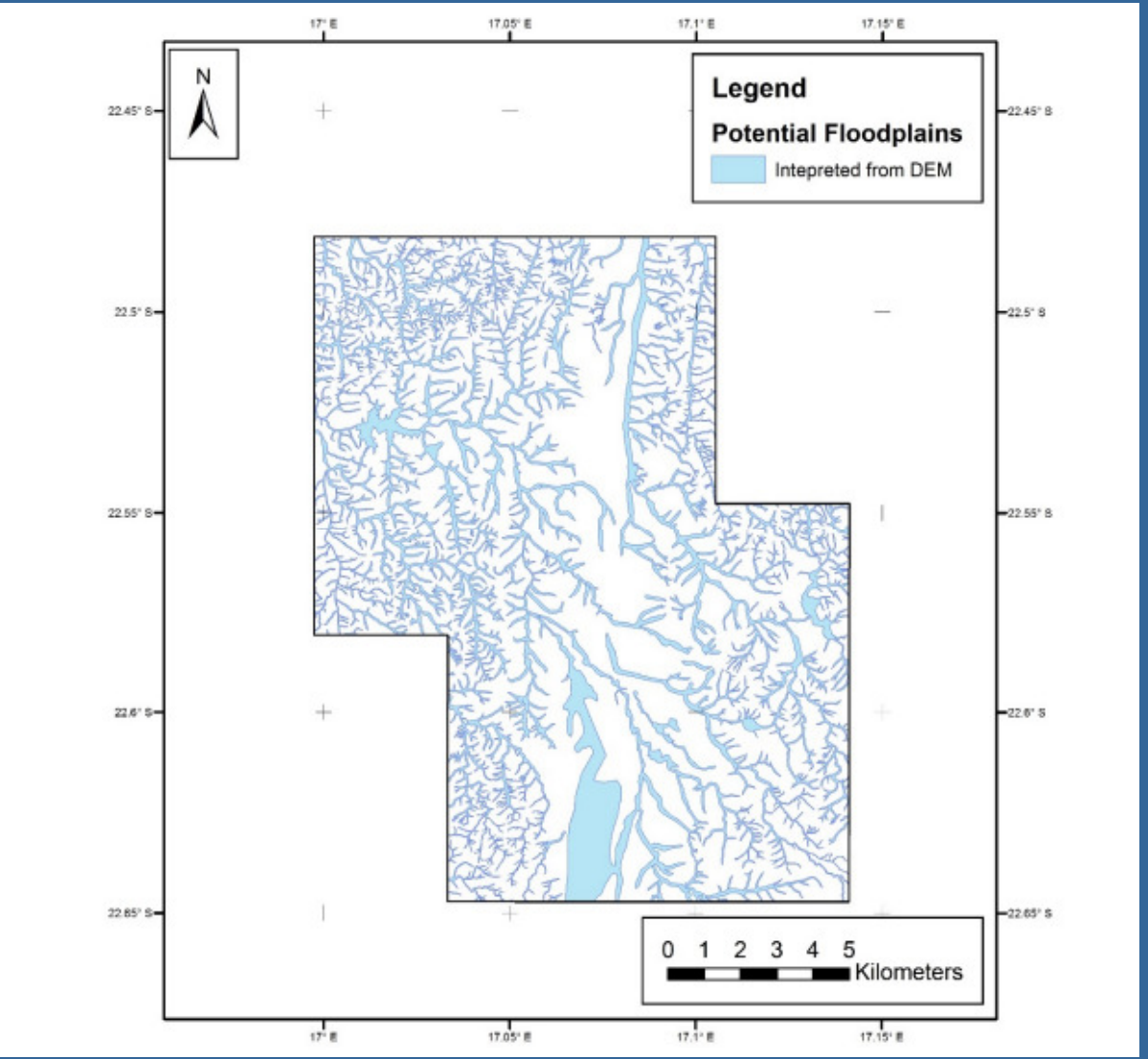
Results: GIS Mapping

- **Faults / fault zones**

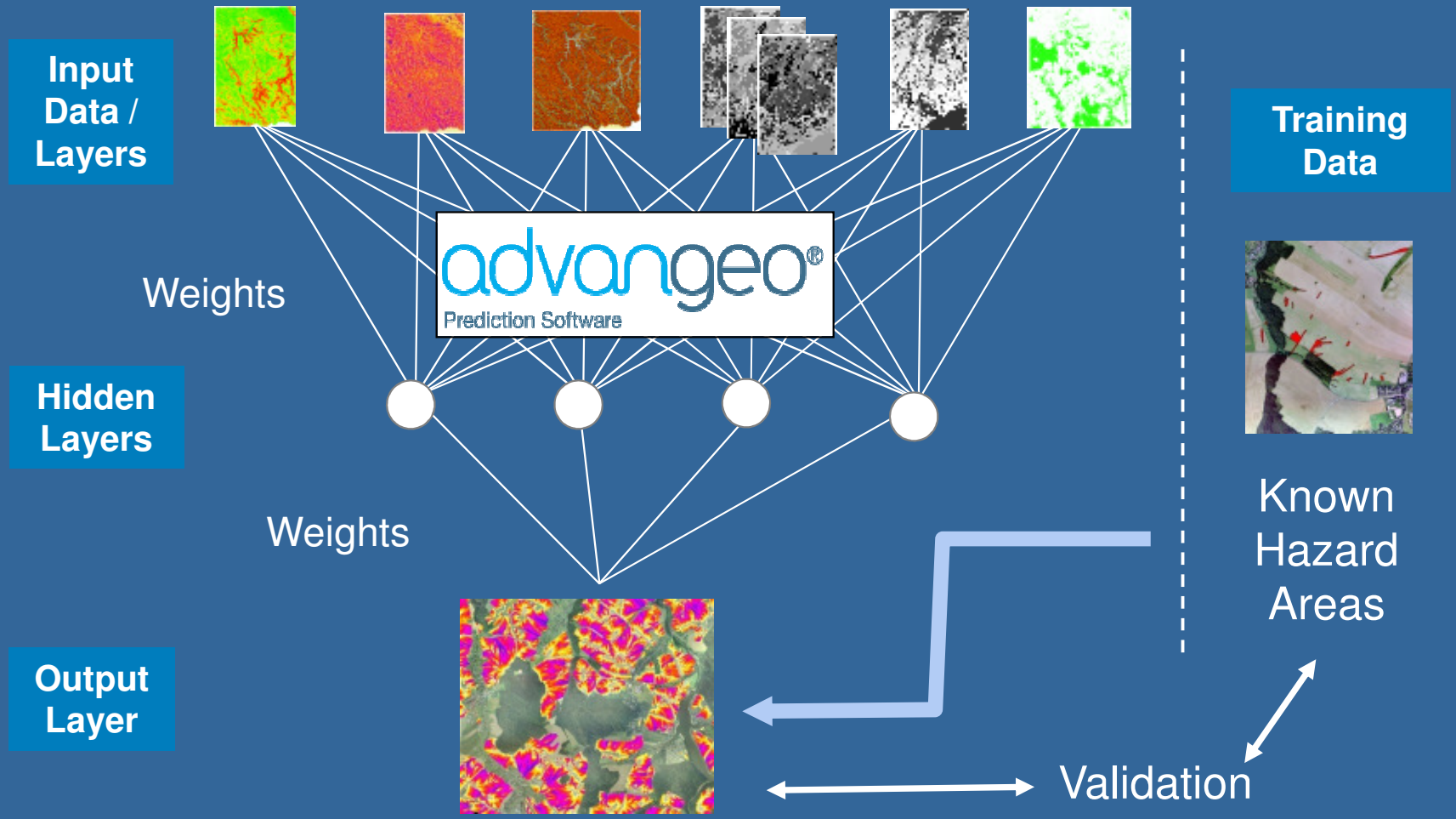


Results: GIS Mapping

- **Potential floodplains**



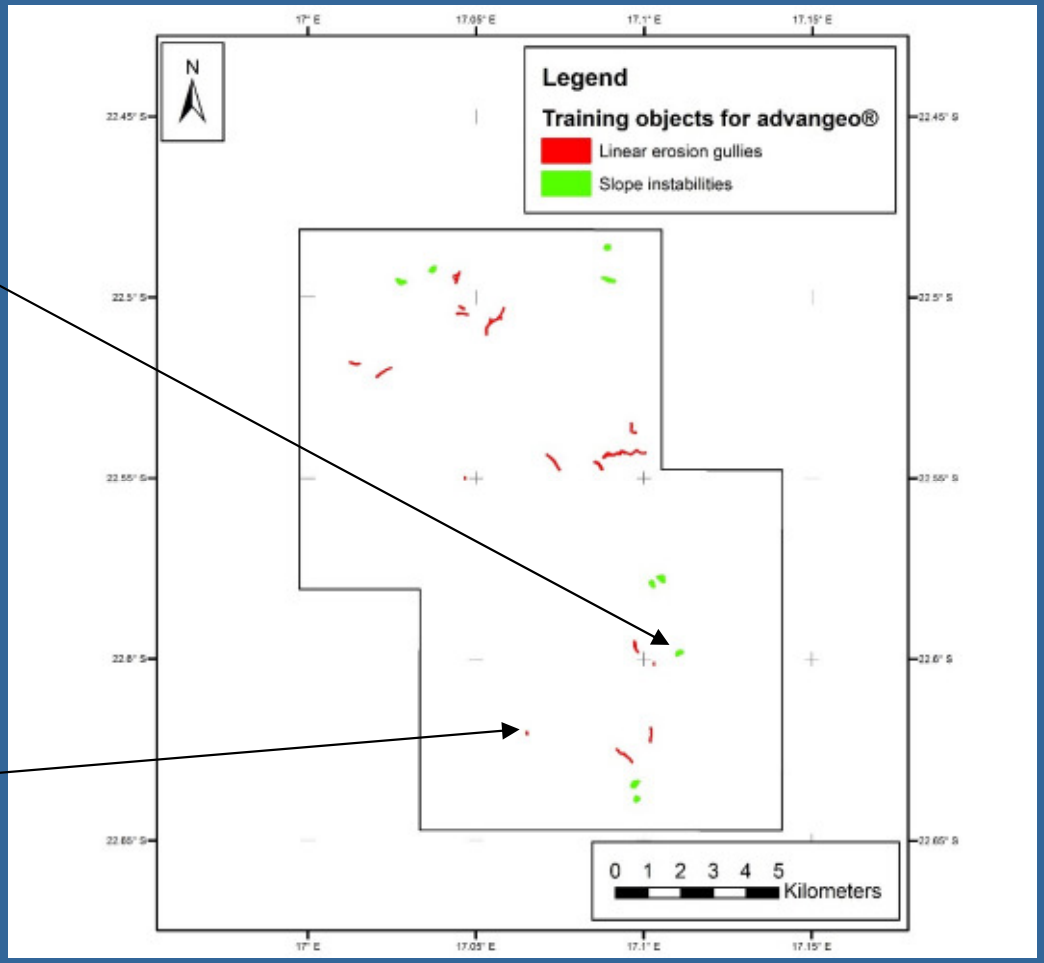
Methodology: Predictive Mapping – *ANN with advangeo®*



Results: Predictive Mapping – *Training Data*

Erosion gullies

Slope instabilities



Results: Predictive Mapping – *Slope Instabilities*

Input Data

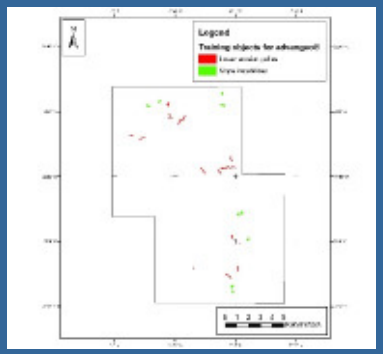
Elevation model and its derivatives:
- Slope
- Aspect

Bedding of the geological units:
- Dip angle
- Dip direction

- Difference angle between dip vector of geological units and slope vector of elevation model

Training Data

Slope instabilities



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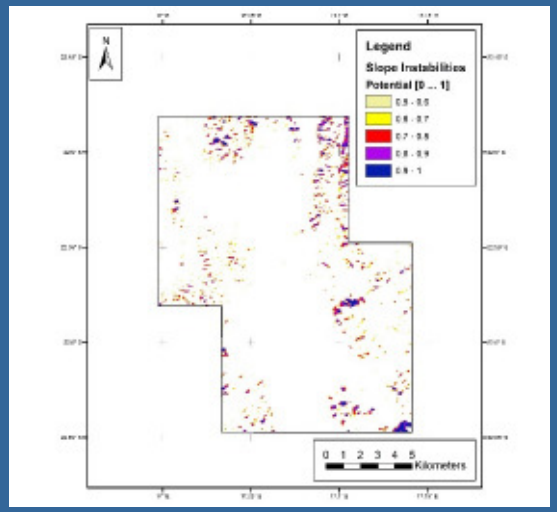

Result

Potential for slope instabilities

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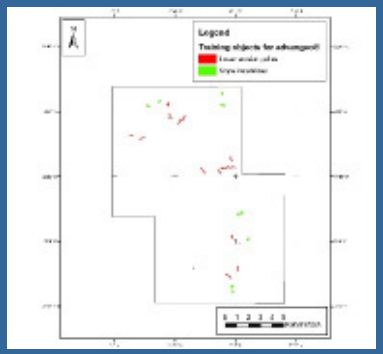
Results: Predictive Mapping – *Erosion Gullies*

Input Data

Elevation Model and its derivatives:
- Slope
- Flow accumulation

Training Data

Erosion gullies



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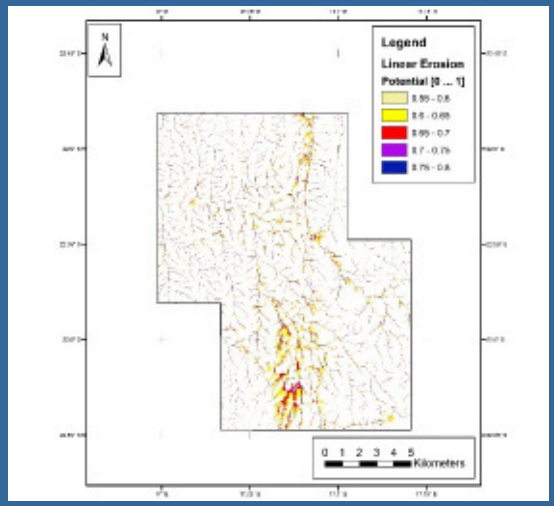

Result

Potential for erosion gullies

Methodology: Data Processing

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Known events

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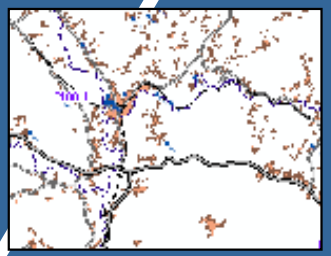
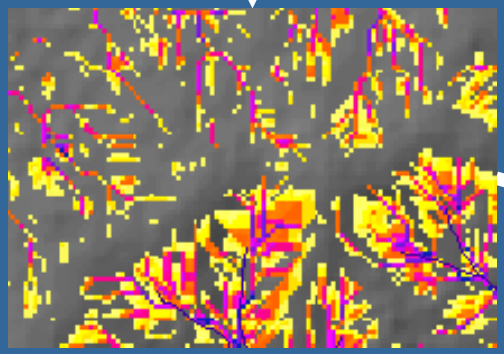
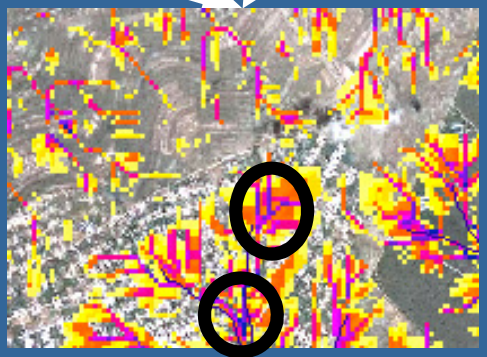


Vulnerable items



Geo-hazard areas



Risk areas

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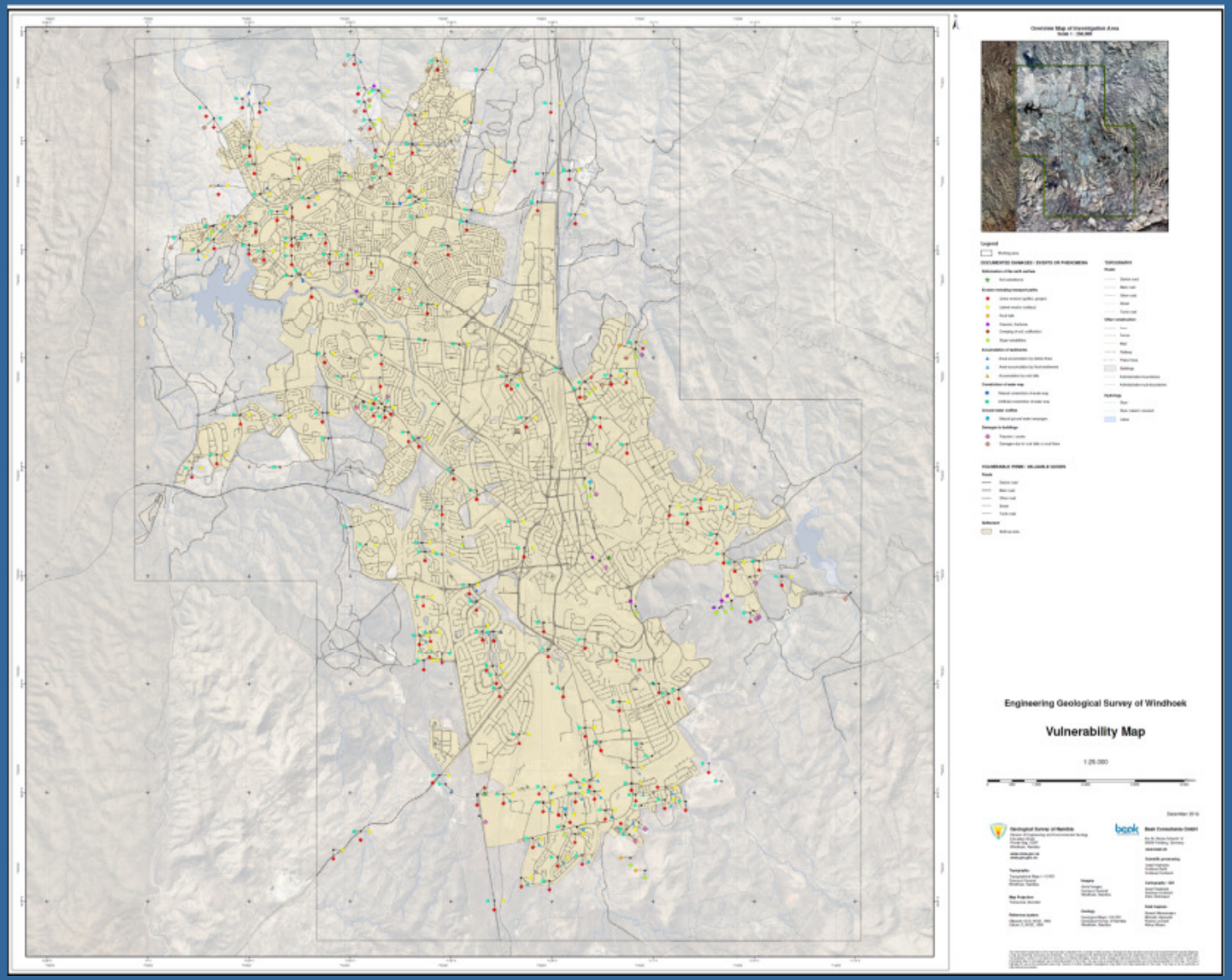
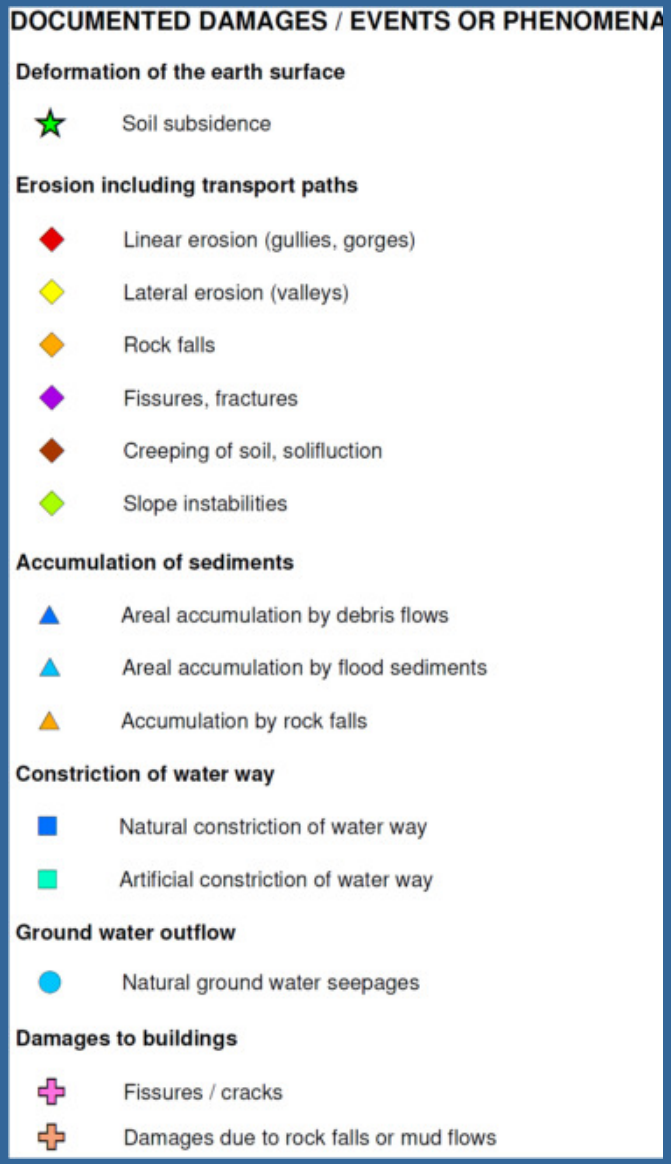
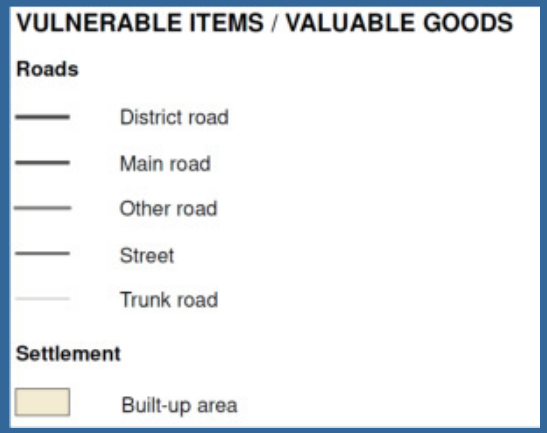
Results: Map Design – *Vulnerability Map*



Results: Map Legend – *Vulnerability Map*





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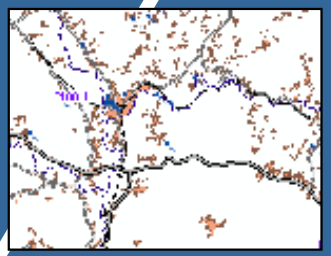
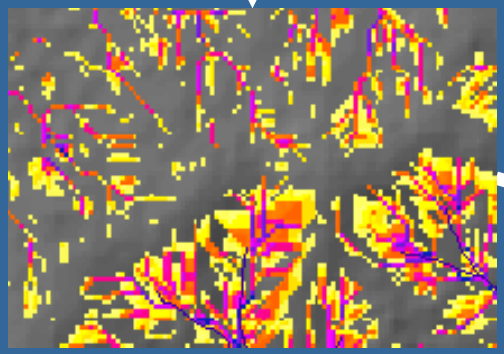
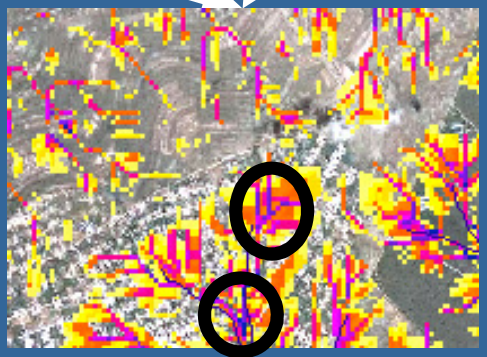


Vulnerable items



Geo-hazard areas



Risk areas

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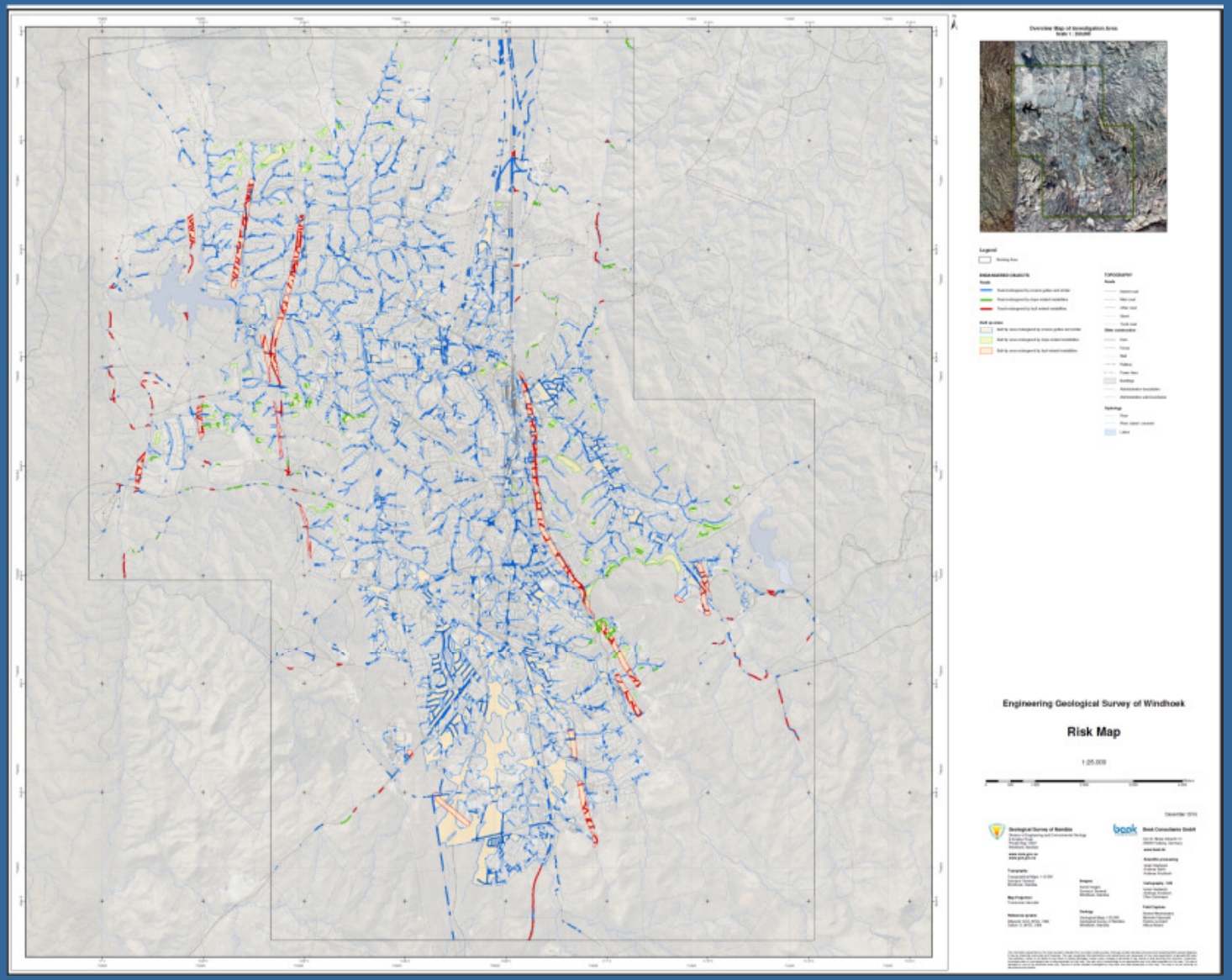
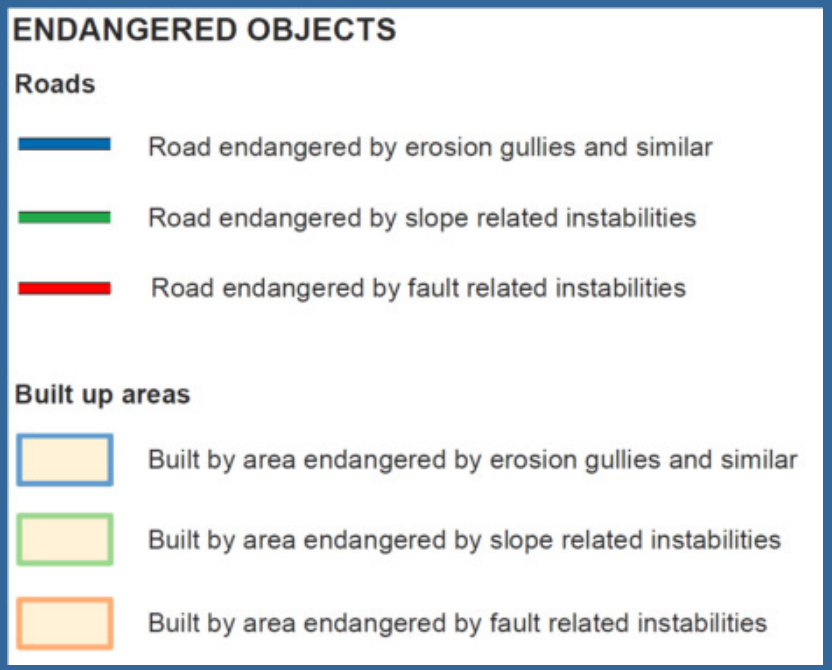
Results: Map Design – *Risk Map*



Results: Map Legend – *Risk Map*



Summary

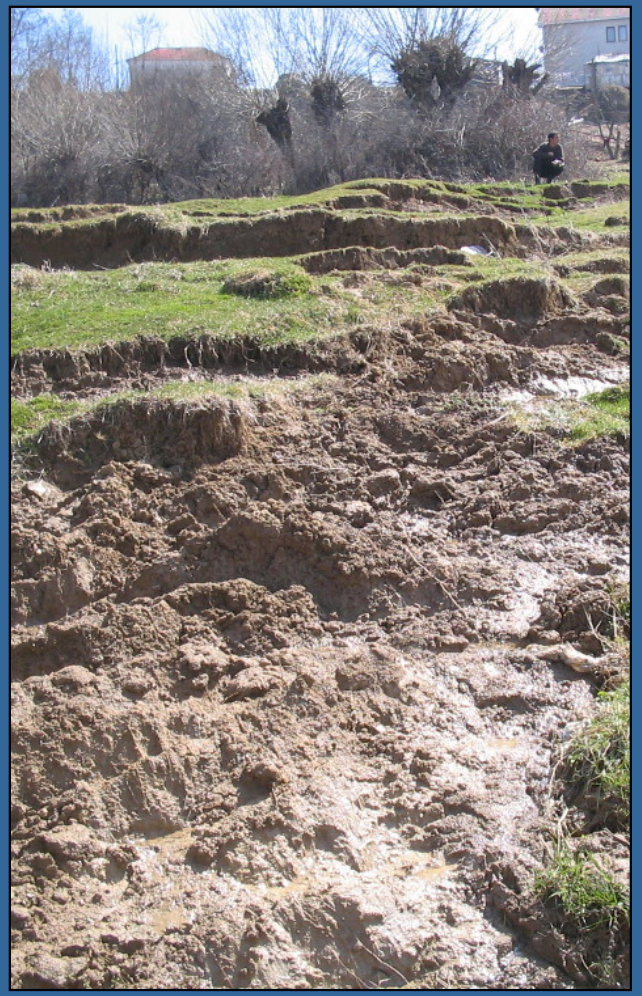
- **Windhoek is mainly endangered by following two types of geo-hazards:**
  - Mud flows and inundations and
  - Fault related instabilities of the underground

Conclusion

- **Methodology available for:**
  - Field Mapping
  - GIS Analysis & Overlay
  - Map Set / Cartography
  - Predictive Mapping (using Artificial Neural Networks)

  of Geo-hazards

→ **We look forward to your questions, suggestions and comments and hope for future knowledge sharing and collaboration!**



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Thank you

Thank you provision of data

- Geological Survey of Namibia
  - Mapping Division
  - Geophysics Division
- Windhoek City Council
- Survey General

Thank you for cooperation

- Ministry of Energy and Mines of Namibia
- Geological Survey of Namibia
  - Engineering and Environmental Division

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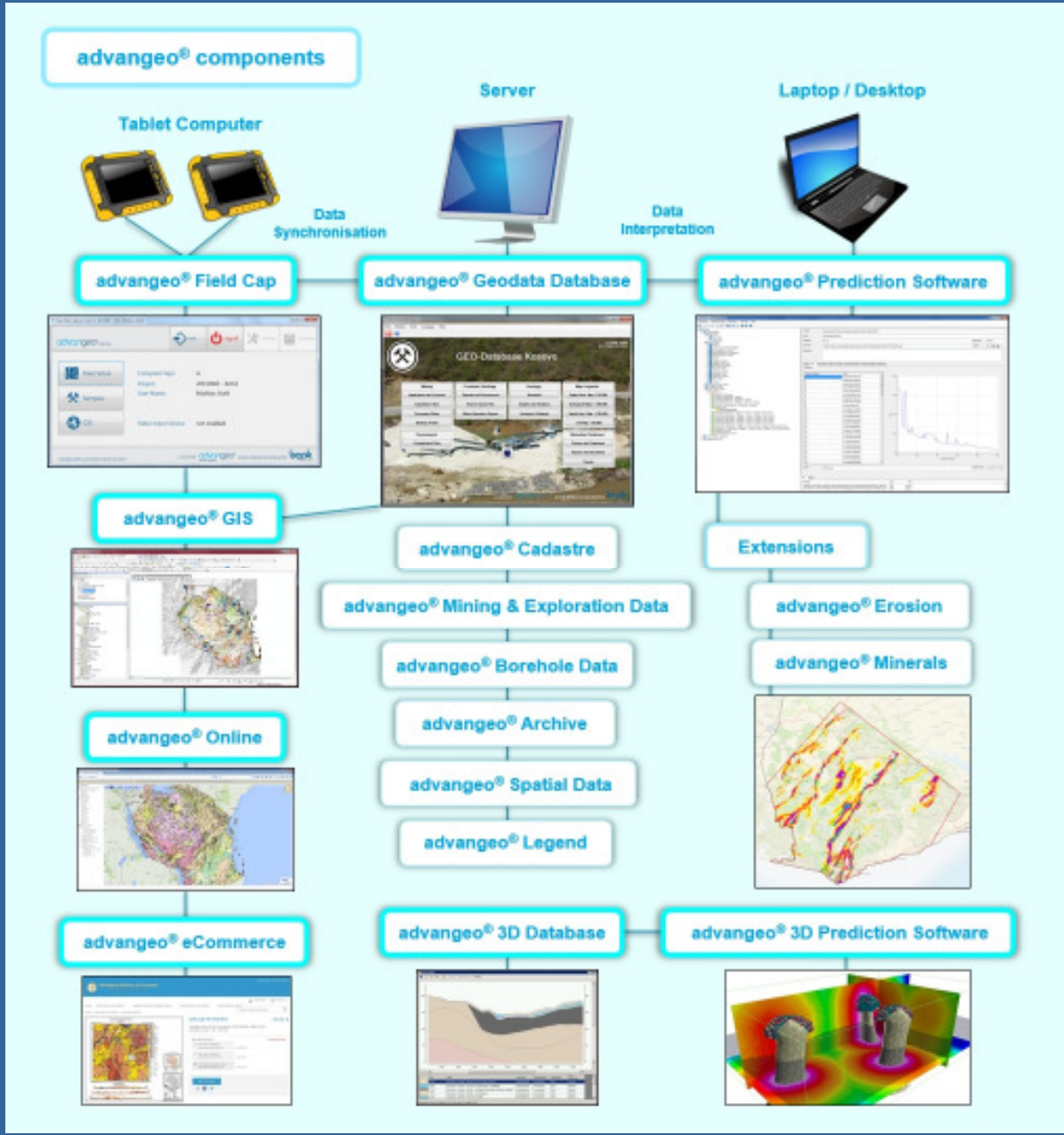

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