



Artificial groundwater recharge in tropical soils - an unused potential

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Integrated Water Resources Management in Distrito Federal – DF
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Outline

- 1. Introduction & Aim**
- 2. Field & Column Tests**
- 3. GIS-Analysis**
- 4. Conclusion**



1

Introduction & Aim

- **Found suitable soils for soil-aquifer-recharge (SAT) in DF**
 - **Hydraulic conductivity vs. retention potential**



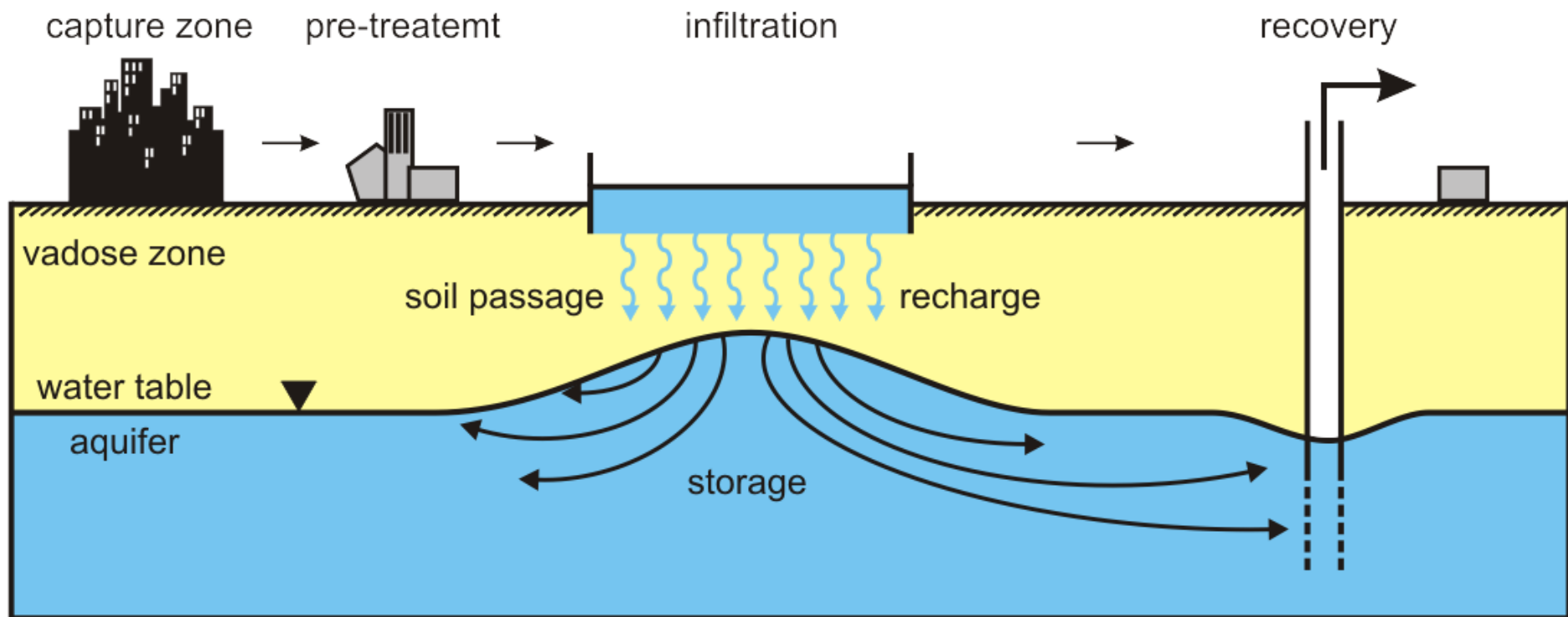
1 Introduction & Aim

- **Found suitable soils for soil-aquifer-recharge (SAT) in DF**
 - **Hydraulic conductivity vs. retention potential**

- **Define suitable sites for groundwater recharge to ...**
 - **Support decentralized waste water treatment in densely populated urban areas**
 - **Use retention potential of tropical soils of DF**
 - **Take the load off the established ETEs**



Soil-aquifer-treatment







Soil-aquifer-treatment in Brazilian soils?



**Sustainable retention
of effluent ingredients**



**Hydraulic soil properties for
effective infiltration rates** 5

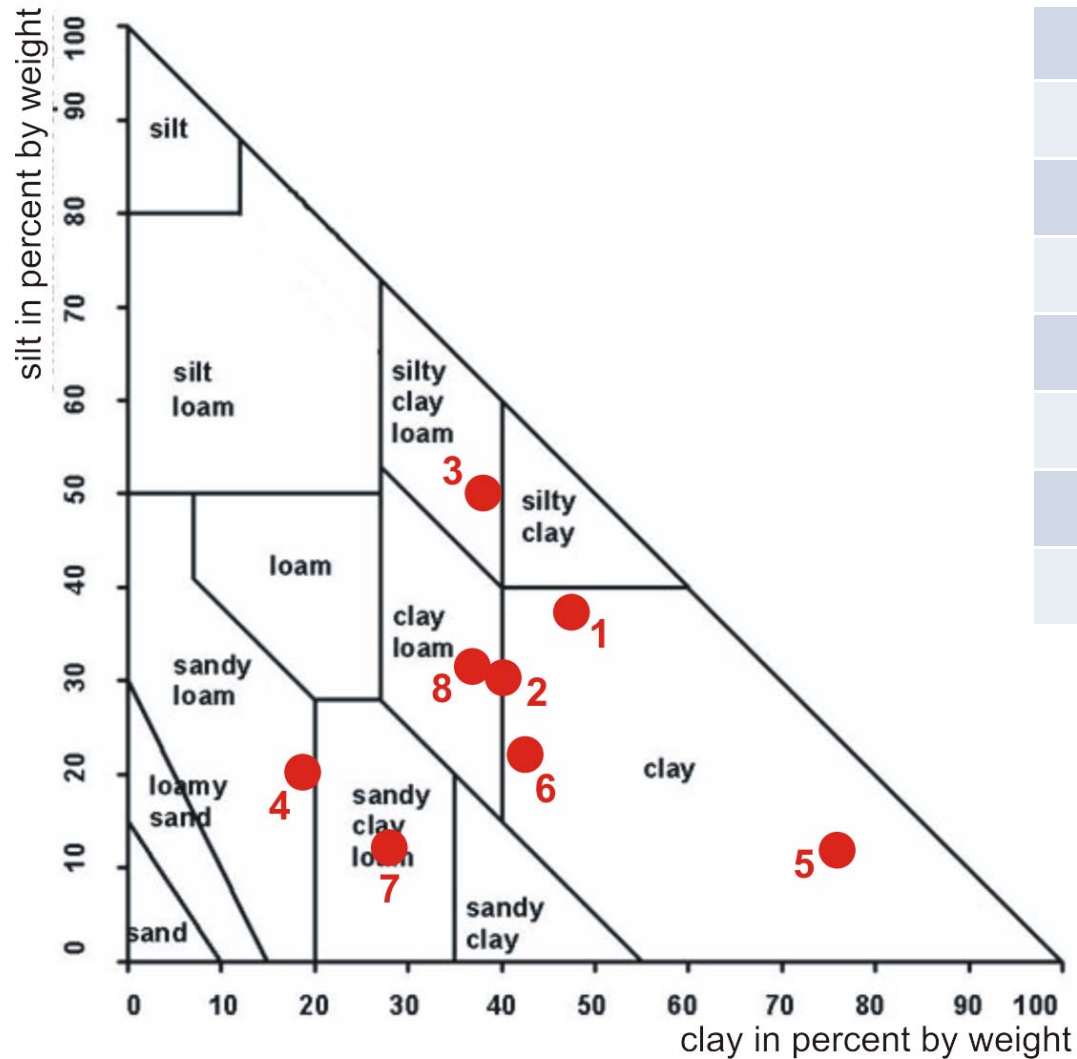


2 Field & Column Tests

No.	Soil (EMBRAPA)
1	Argissolo
2	Nitossolo
3	Cambissolo
4	Latossolo Amarelo Vermelho I
5	Latossolo Vermelho I
6	Gleissolo
7	Latossolo Vermelho II
8	Latossolo Amarelo Vermelho II



2 Field & Column Tests

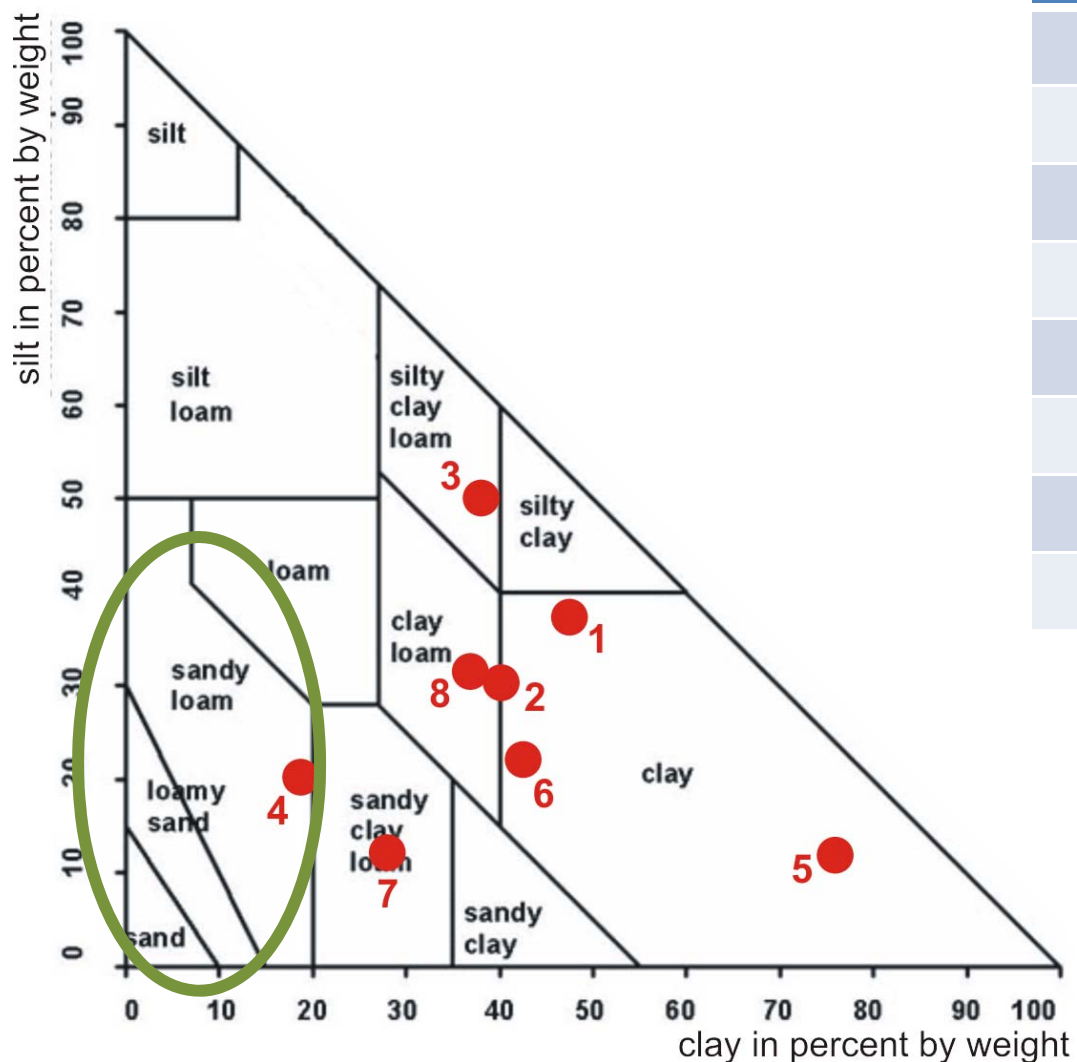


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WRB FAO 1990



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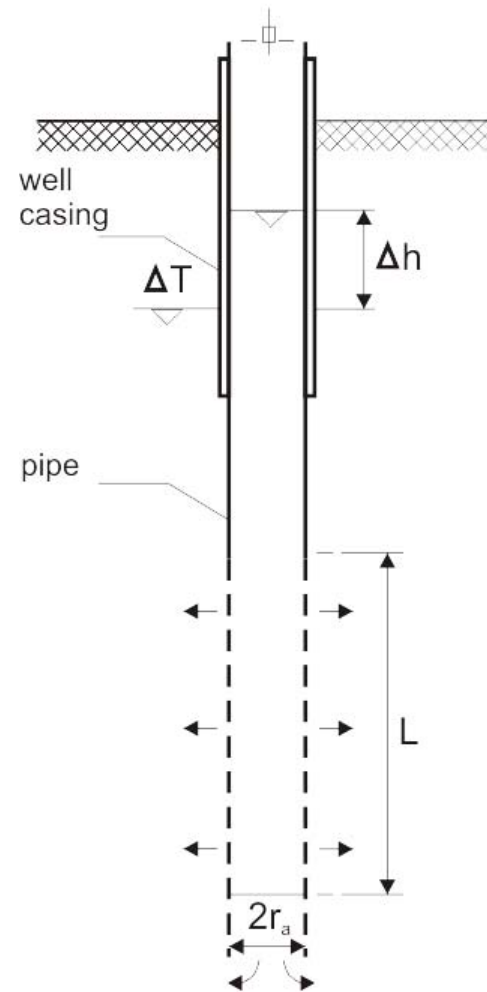
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Heitfeld test

$$k_f = \frac{\delta \times \Delta h \times Ct \times r_a}{Cu \times \bar{h} \times (t_1 - t_2)}$$

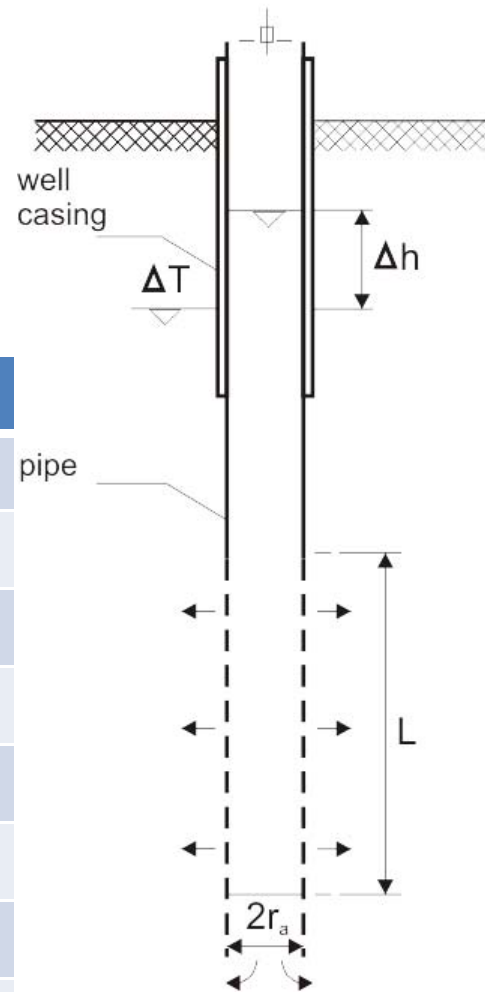




Heitfeld test

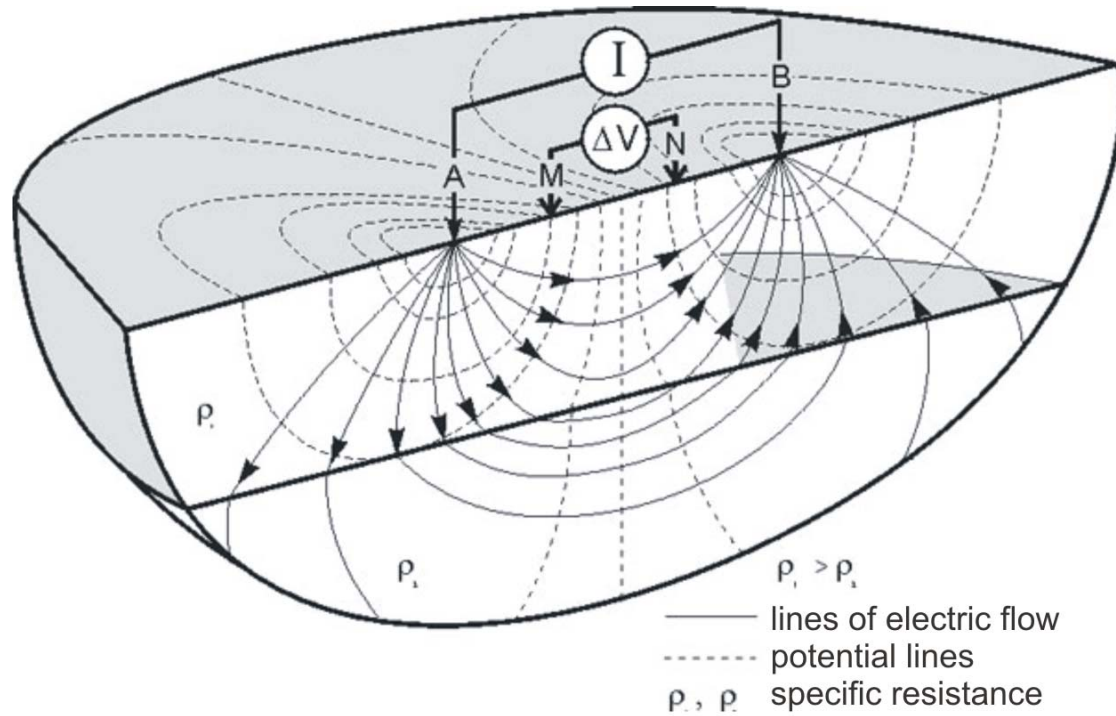
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No.	Soil (EMBRAPA)	k_f [m/s]
1	Argissolo	1.87×10^{-6}
2	Nitossolo	NA
3	Cambissolo	NA
4	Latossolo Am. Verm. I	1.37×10^{-6}
5	Latossolo Verm. I	3.11×10^{-6}
6	Gleissolo	1.12×10^{-8}
7	Latossolo Verm. II	3.01×10^{-6}
8	Latossolo Am. Verm. II	6.21×10^{-7}





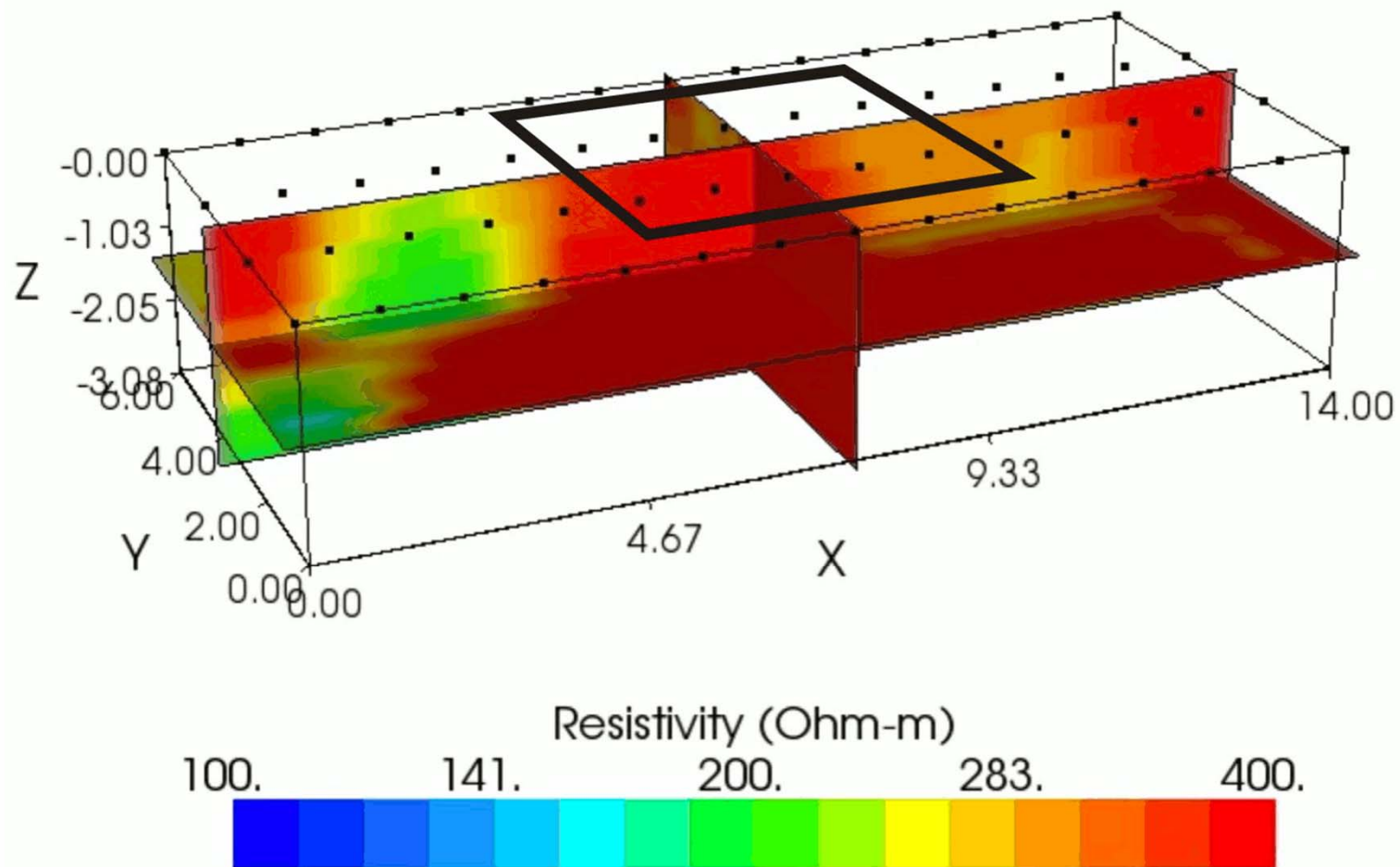
ETE São Sebastião



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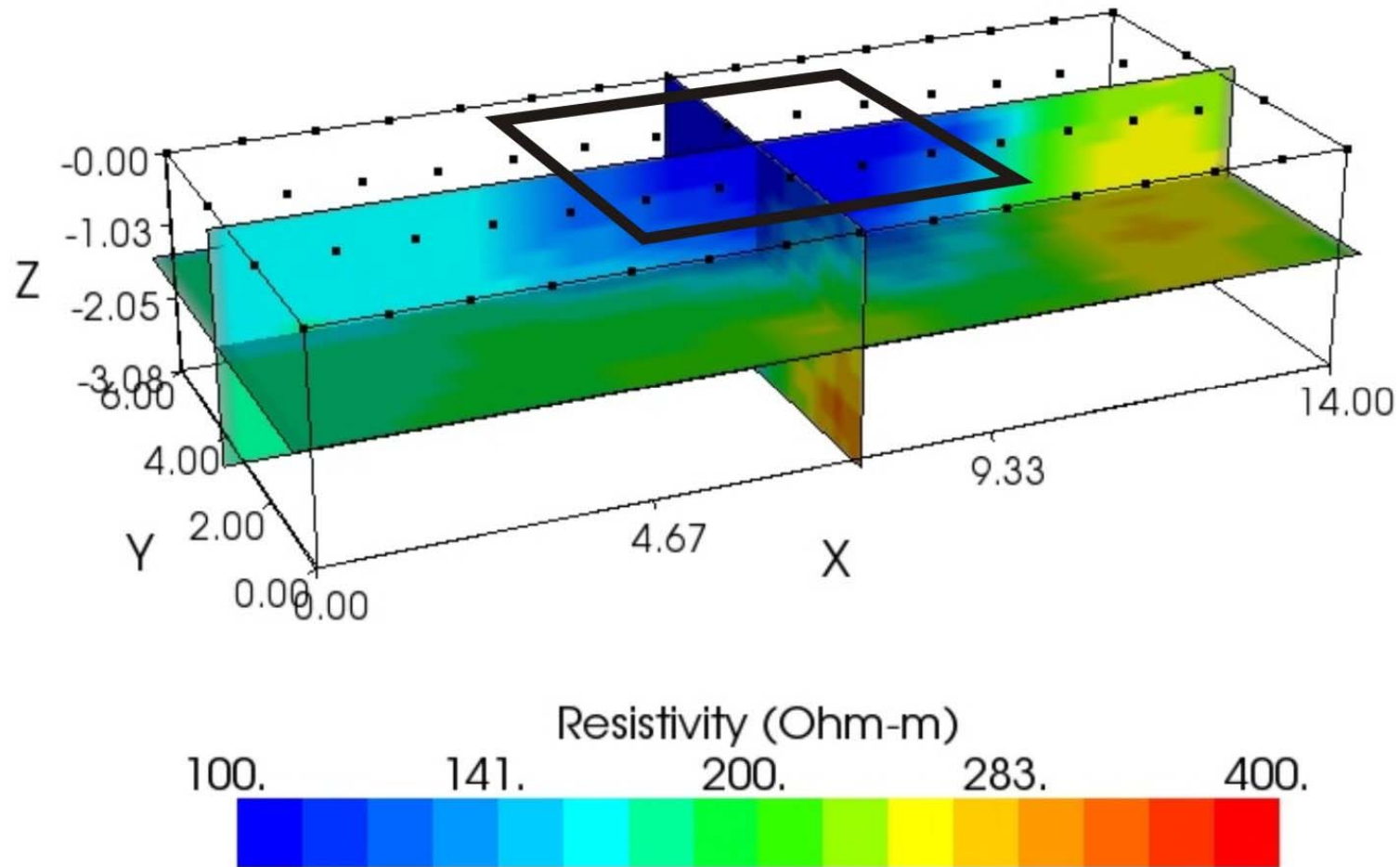


Background measurement - 0 hrs



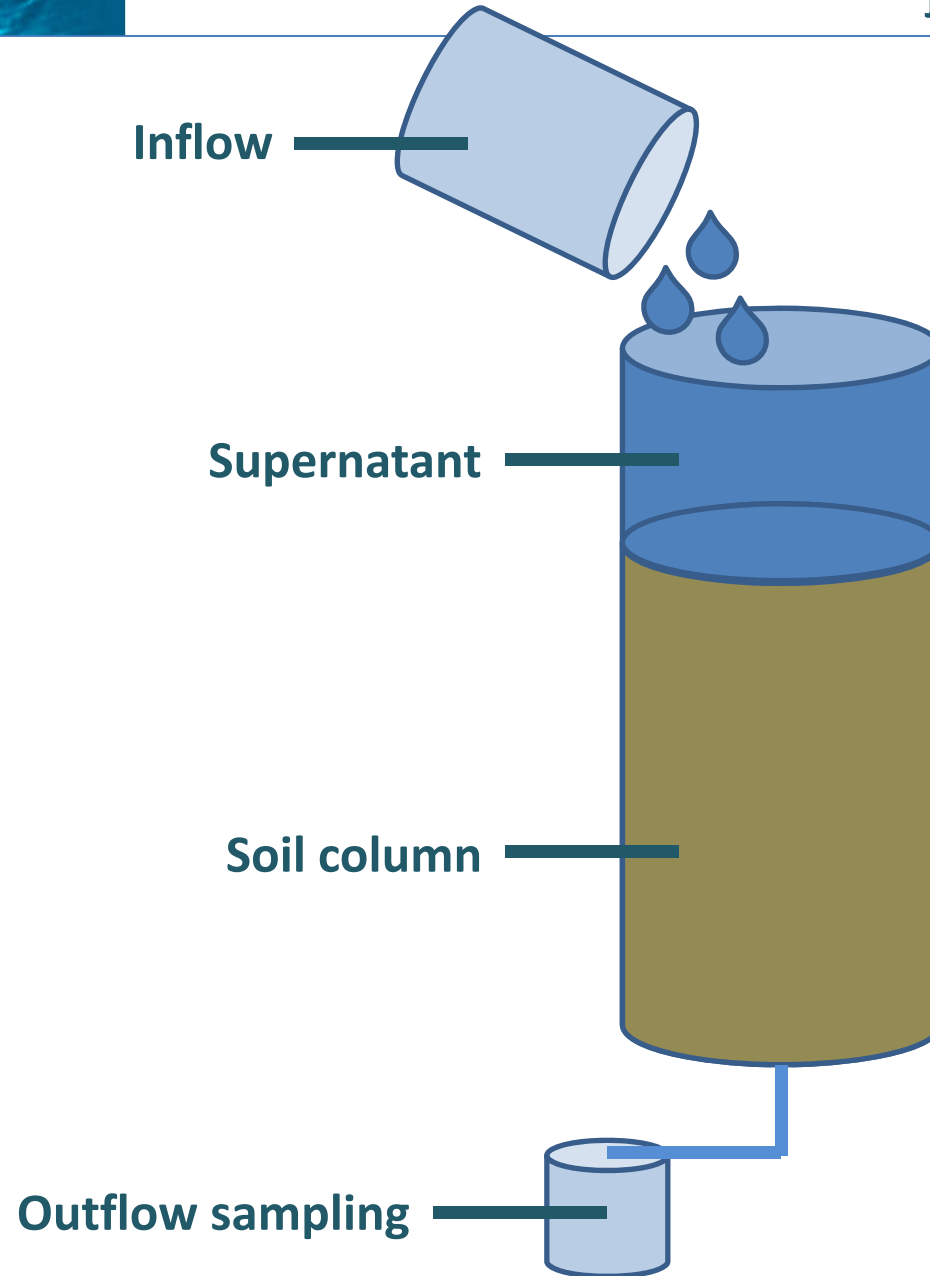


96 hrs





Column test

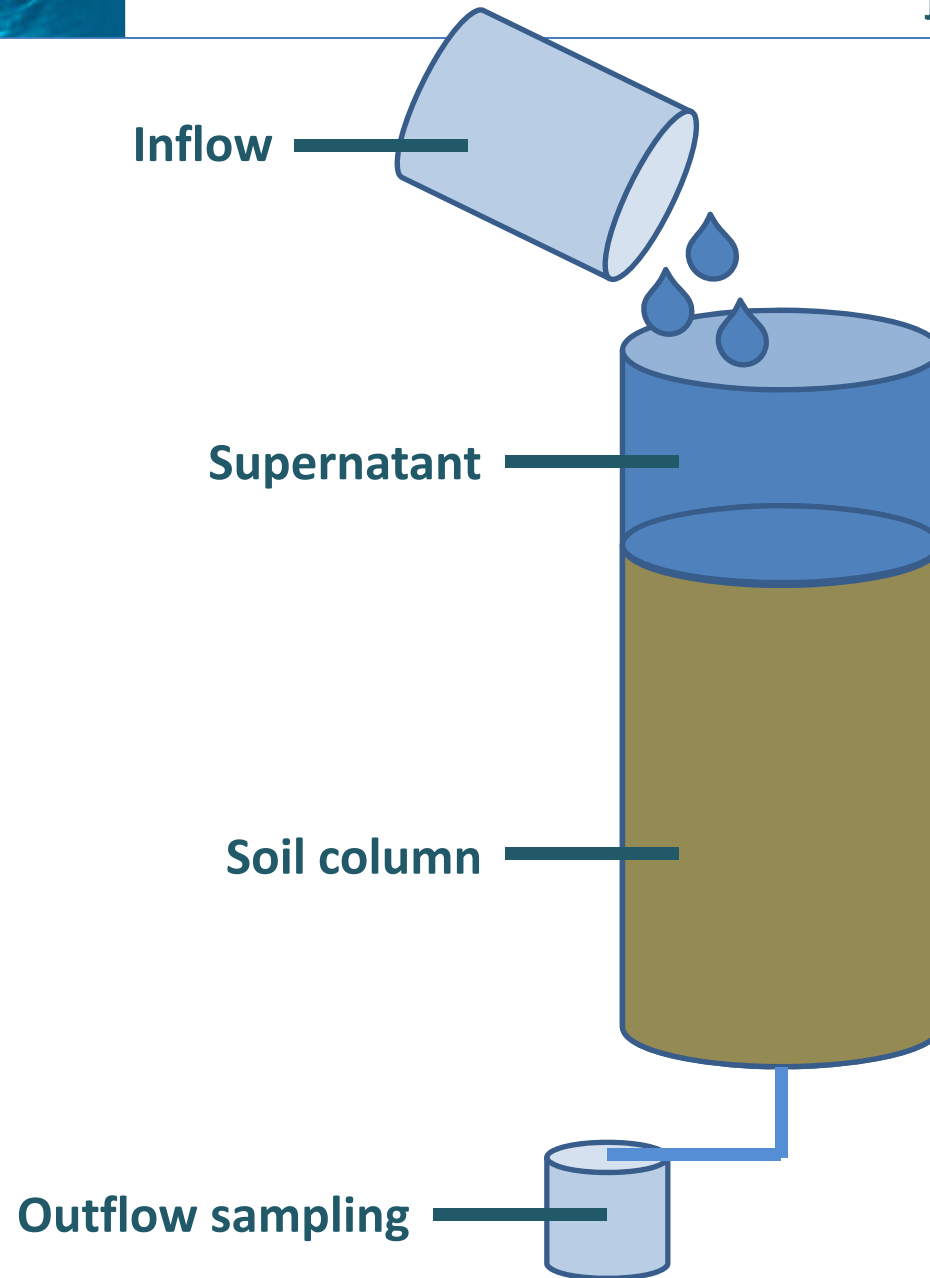




Column test

Standard wastewater

Ingredient	Concentration
TOC	130 mg/l
N _{total}	44 mg/l
PO ₄ ³⁻	15 mg/l
NO ₃ ⁻	136 mg/l
salt load	930 µS/cm





Retention potential of the soils

No.	Soil	TOC [%]	N _{total} [%]	PO ₄ ³⁻ [%]	NO ₃ ⁻ [%]	salt load [%]
1	Argissolo	-37	-24	-60	-25	-25
2	Nitossolo	-86	-91	-100	-92	-16
3	Cambissolo	-96	-89	-100	-82	-84
4	Latossolo Amarelo Vermelho I	-55	-22	-100	-23	-1
5	Latossolo Vermelho I	-36	-22	-100	-23	-30
6	Gleissolo	-99	-98	-100	-95	-81
7	Latossolo Vermelho II	-53	-33	-100	-76	-18
8	Latossolo Amarelo Vermelho II	-50	-38	-100	-7	-18



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Utility analysis

Category of suitability	Retention potential TOC, PO ₄ ³⁻ , NO ₃ ⁻ , N _{total} , salt load [%]	k _f [m/s]
good	≥ 50	≥ 10 ⁻⁶
moderate	50 - 25	10 ⁻⁷
poor	≤ 25	≤ 10 ⁻⁸



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poor	≤ 25	≤ 10 ⁻⁸

Parameter	Weighting [%]
TOC	20
PO ₄ ³⁻	5
NO ₃ ⁻	5
N _{total}	5
salt load	5
k _f	60



Utility analysis

Category of suitability	Retention potential TOC, PO ₄ ³⁻ , NO ₃ ⁻ , N _{total} , salt load [%]	k _f [m/s]
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Parameter	Weighting [%]
TOC	20
PO ₄ ³⁻	5
NO ₃ ⁻	5
N _{total}	5
salt load	5
k _f	60

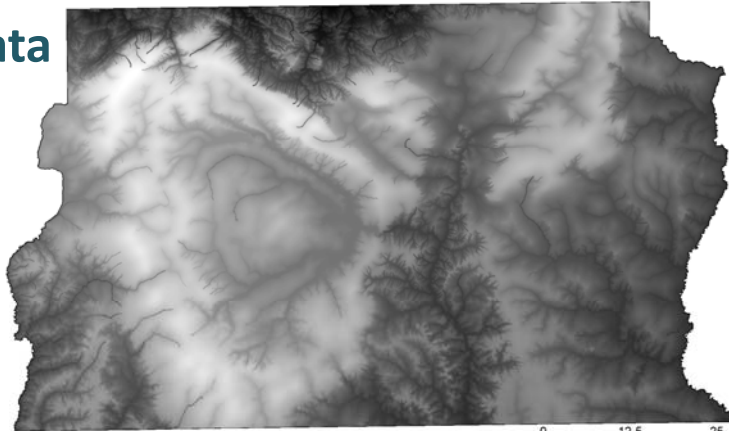
No.	Soil (EMBRAPA)	Category of suitability
7, 5	Latossolo Vermelho I + II	good
1	Argissolo	good
4	Latossolo Amarelo Vermelho I	good
3	Cambissolo	moderate
2	Nitossolo	moderate
8	Latossolo Amarelo Vermelho II	moderate
6	Gleissolo	moderate



3

GIS-Analysis

Input data

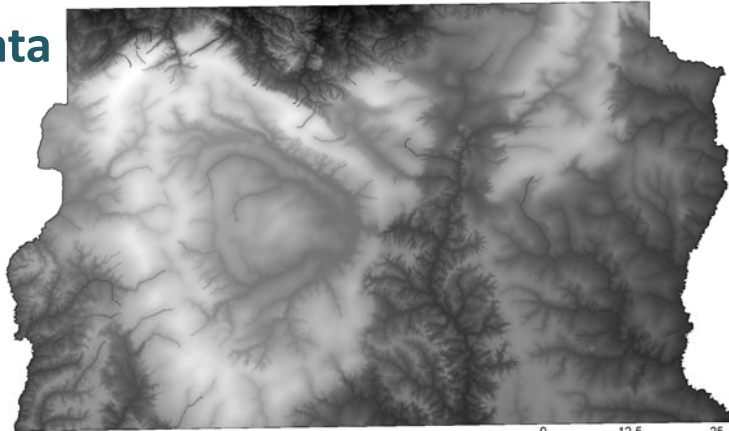


digital elevation model



3 **GIS-Analysis**

Input data



digital elevation model

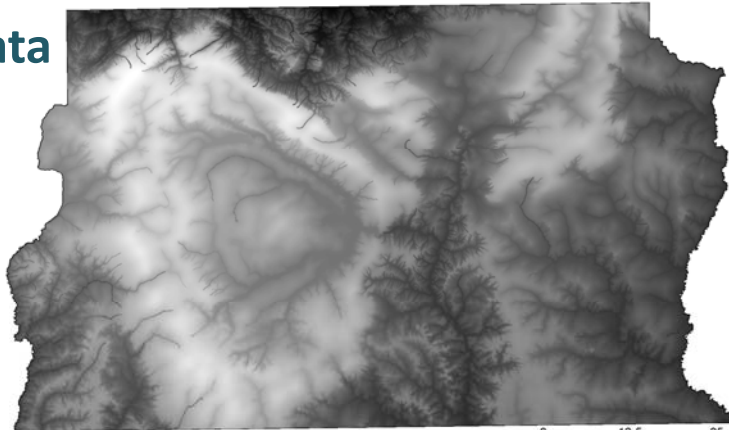


**land use / land cover classification
(LU/LC)**

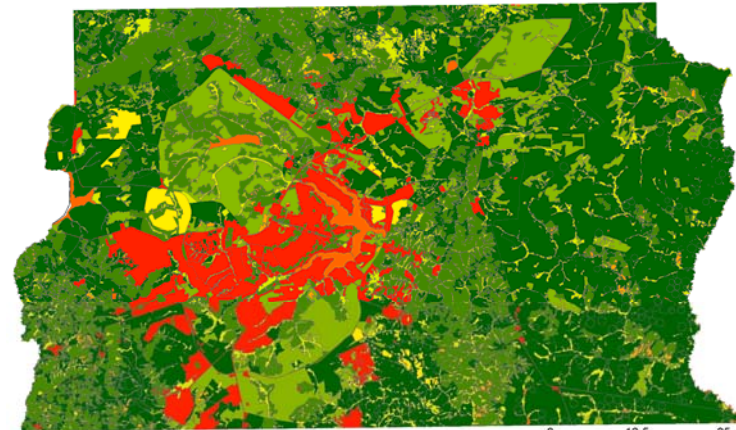


3 GIS-Analysis

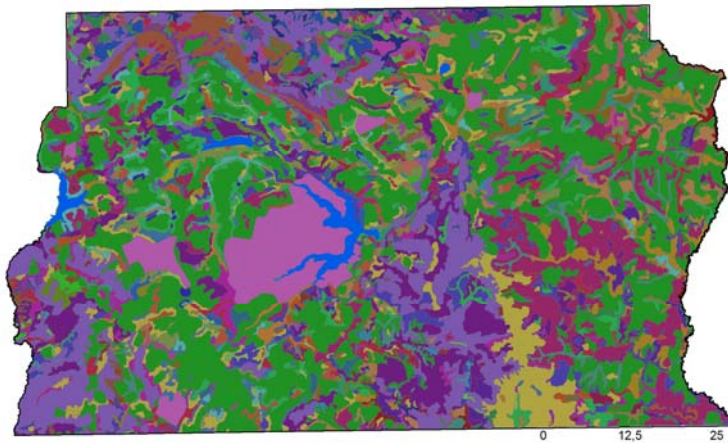
Input data



digital elevation model



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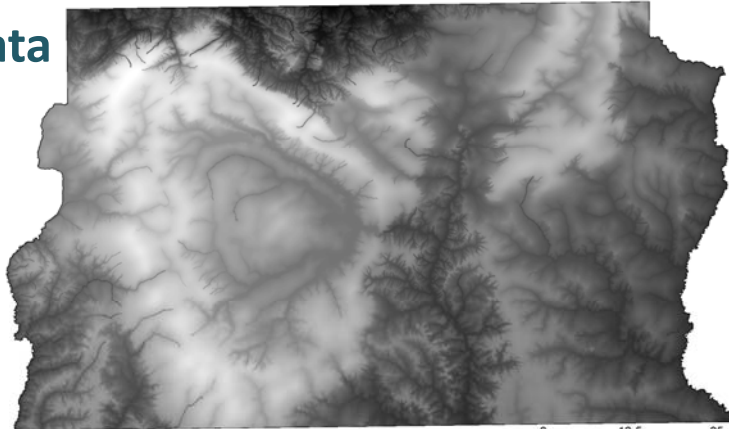


soil map (EMBRAPA)

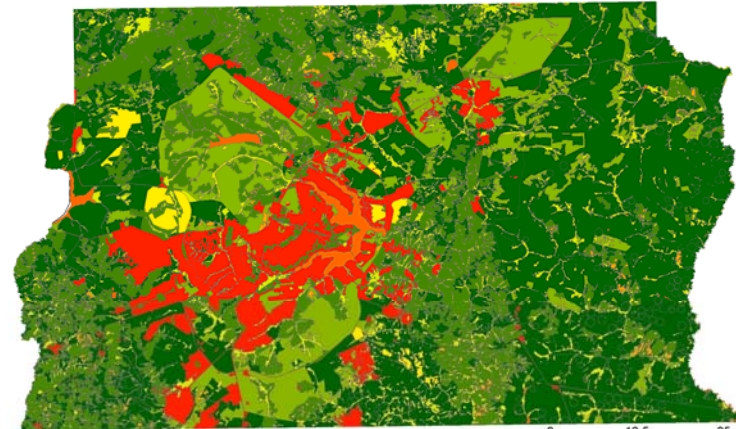


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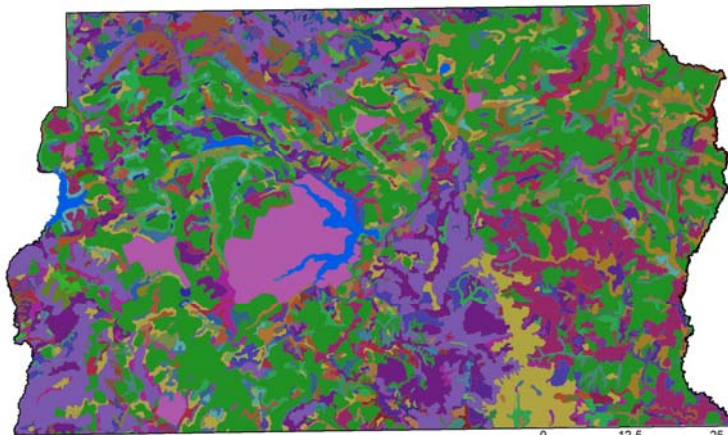
Input data



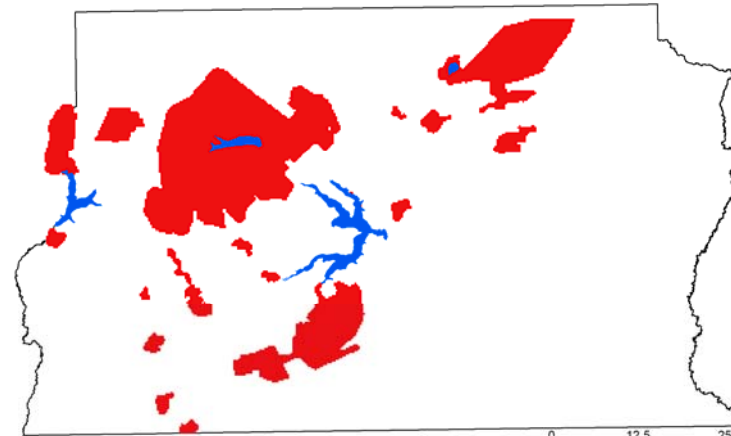
digital elevation model



**land use / land cover classification
(LU/LC)**



soil map (EMBRAPA)



restricted areas and surface water



Methodology



Slope	Category
≤ 3 %	good
3 – 5	LU/LC
≥ 5	Cerrado, campo ...
	good
	Soil (EMBRAPA)
	Latossolo Vermelho, ...
	good
	Cambissolo, ...
	moderate
	...
	poor

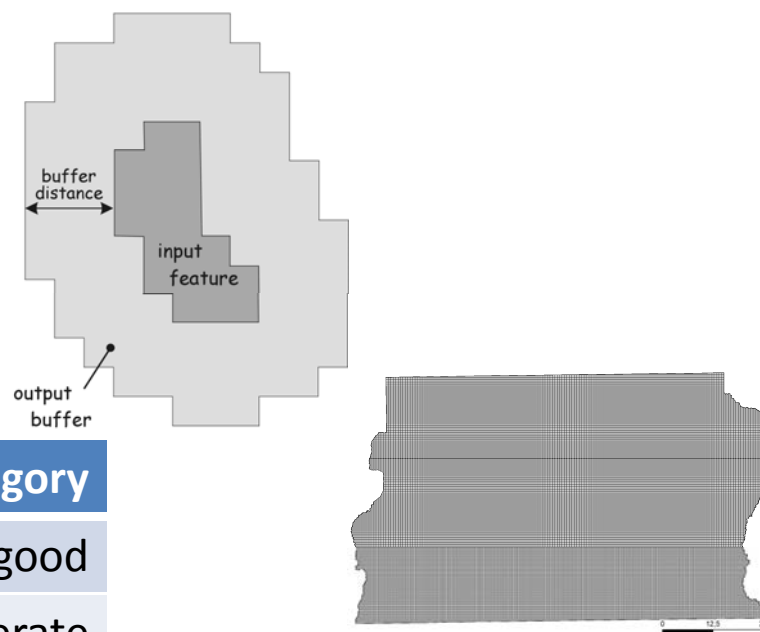


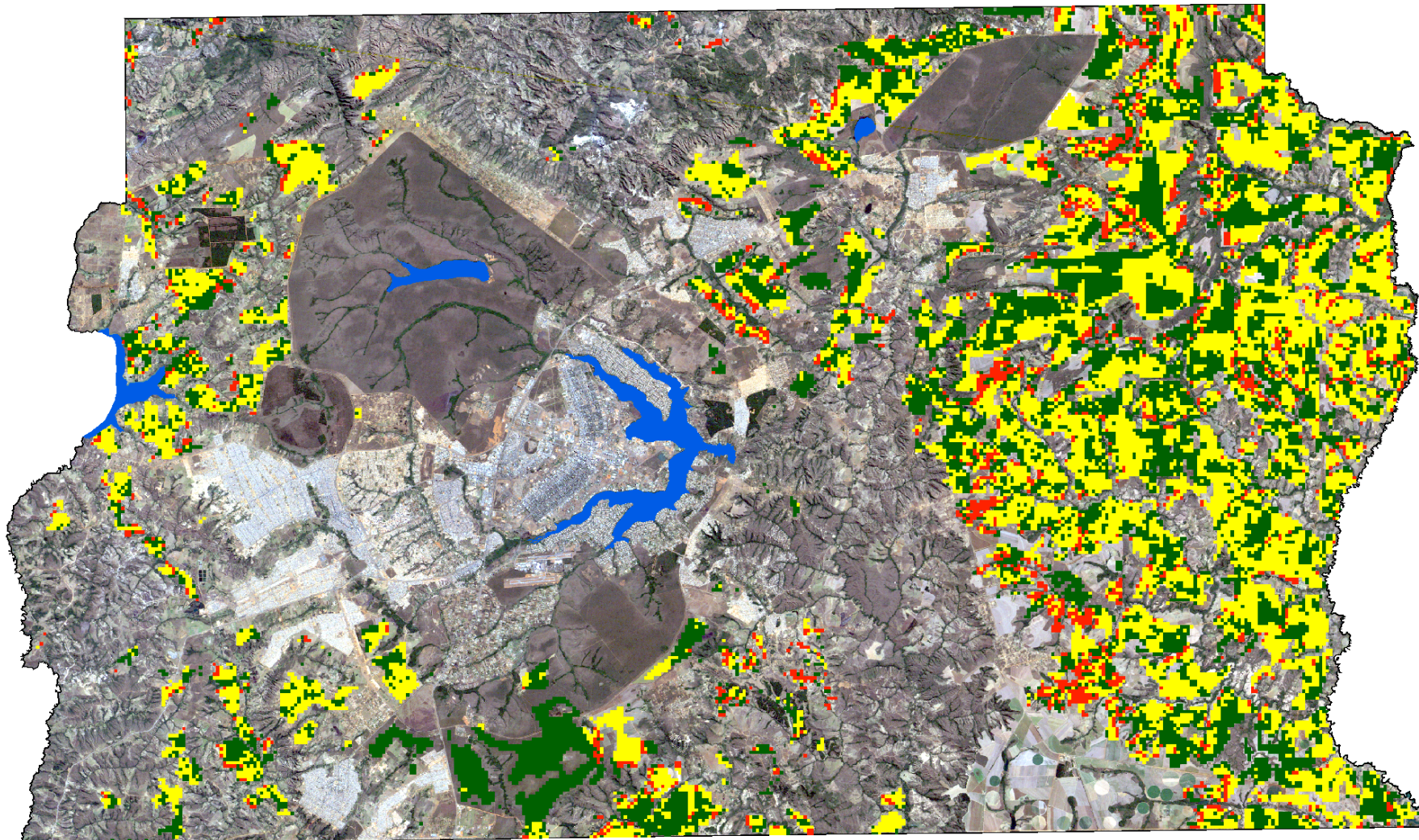
Methodology



Slope	Category
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Soil (EMBRAPA)	Category
Latossolo Vermelho, ...	good
Cambissolo, ...	moderate
...	poor





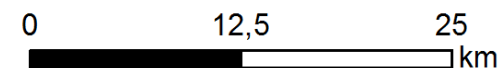
Legend

- Administrative limit Federal District
- Main water bodies

Suitable sites for groundwater recharge

good	moderate	poor
59,138 ha 10 %	68,475 ha 12 %	13,325 ha 2 %

Background image:
Landsat TM 2007-06-11





4

Conclusion

- **3D resistivity monitoring**
 - **extensive non-invasive hydraulic characterization**



4

Conclusion

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 - **extensive non-invasive hydraulic characterization**
- **found suitable soils for SAT-approach**
 - **determination of retention potentials**
 - **Latossolo Vermelho I + II – most suitable soil for SAT-approach, regarding hydraulic conductivity vs. retention potential**



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Conclusion

- **3D resistivity monitoring**
 - **extensive non-invasive hydraulic characterization**
- **found suitable soils for SAT-approach**
 - **determination of retention potentials**
 - **Latossolo Vermelho I + II – most suitable soil for SAT-approach, regarding hydraulic conductivity vs. retention potential**
- **define suitable sites for groundwater recharge**
 - **merge geographical and pedological data**



Thanks to:

- **BMBF for funding**
- **CAESB for support of the field research**
- **UnB for support of geoelectric measurements**

... and you – for your attention!

