Hydrogeological Evidence

and its implications for integrated water management in Santa Cruz, Bolivia

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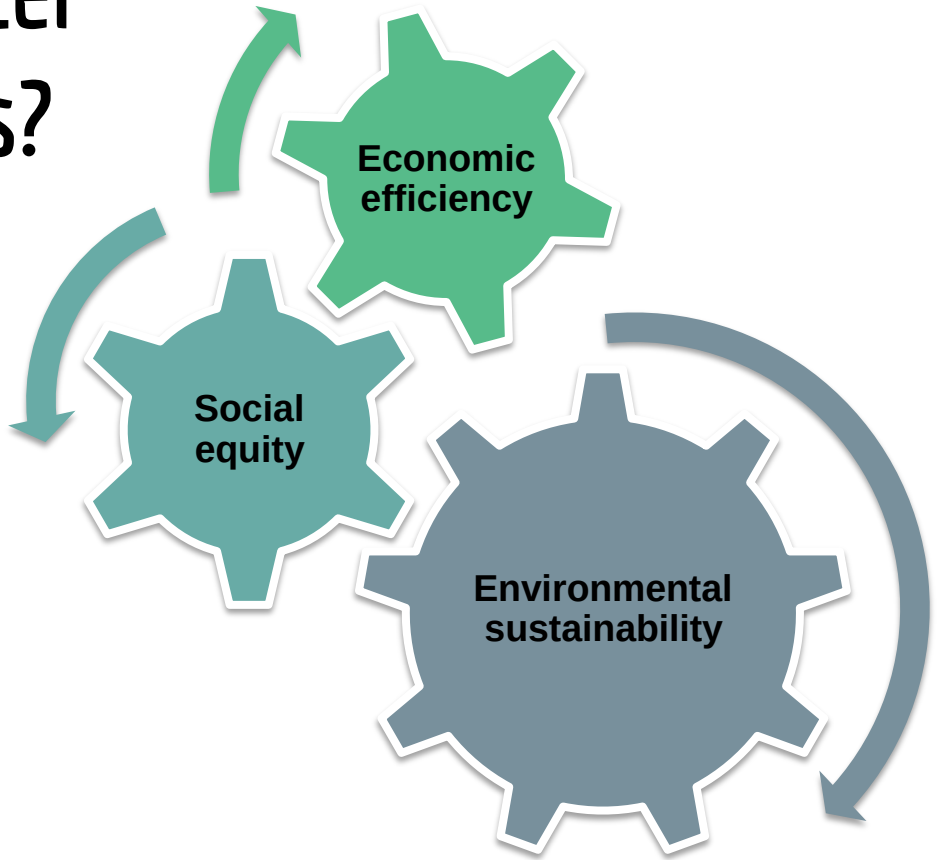
Framework

1. Introduction
2. Study area: Santa Cruz, Bolivia
3. First case study: Metropolitan aquifer
4. Second case study: San José aquifer
5. Conclusions and further work

What does integrated water management really means?

"... a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems ..."



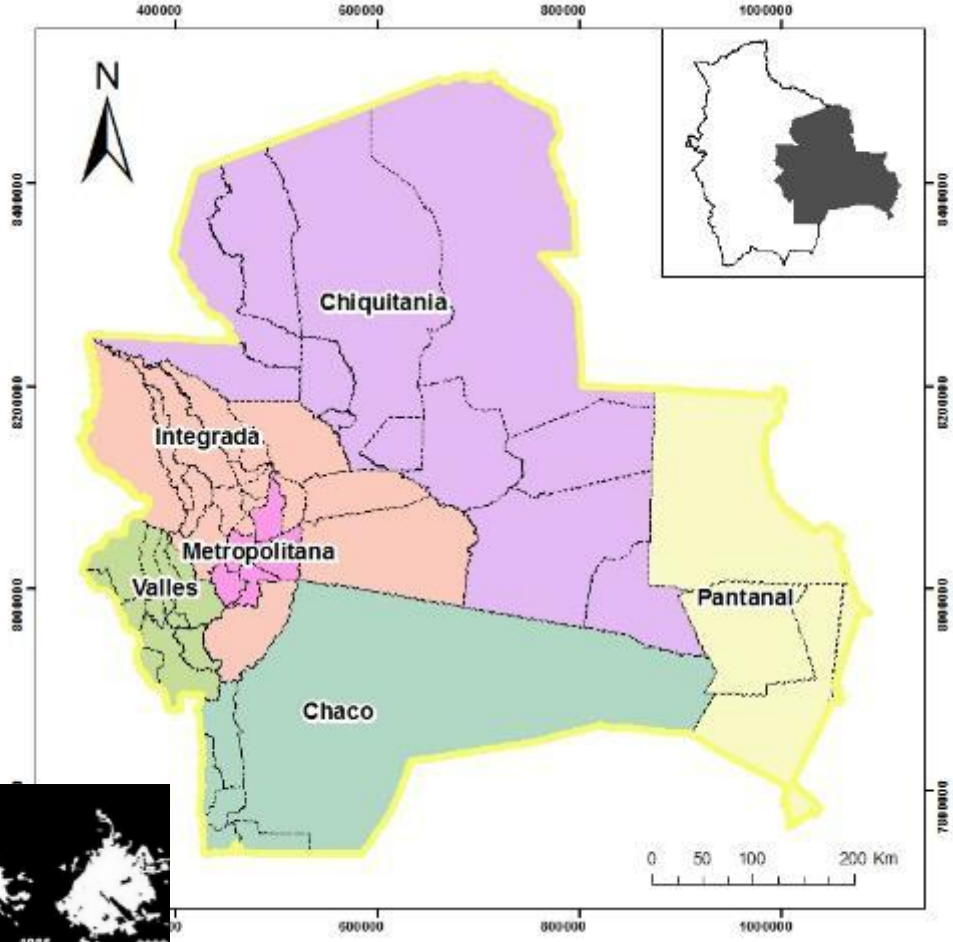
Source: Technical Committee of the Global Water Partnership (GWP)
(https://www.iwapublishing.com/news/integrated-water-resources-management-basic-concepts)

Santa Cruz, Bolivia

Figure 2.1 : Location of Santa Cruz de la Sierra, Bolivia
Ubicación de Santa Cruz de la Sierra, Bolivia

Santa Cruz, Bolivia

- 370,621 km² (143,098 mi²) of area
- 2.273.793 habitants
- 1.3% of the territory concentrates 66% of population
- 31% growth of in the last 13 years
- 15 provinces and 56 municipalities
- municipalities



Socioeconomic and institutional framework

- Place **# 14** within the fastest growing metropolis in the world (Forbes, 2015).
- Commercial, financial and industrial center of the country.
- Groundwater is the source that **supplies the entire volume of water for all sectors**.
- "Access to water and sewerage are human rights, are not subject to concession or privatization and are subject to licensing and registration, according to law." (SPC Art. 20. III)

Problems

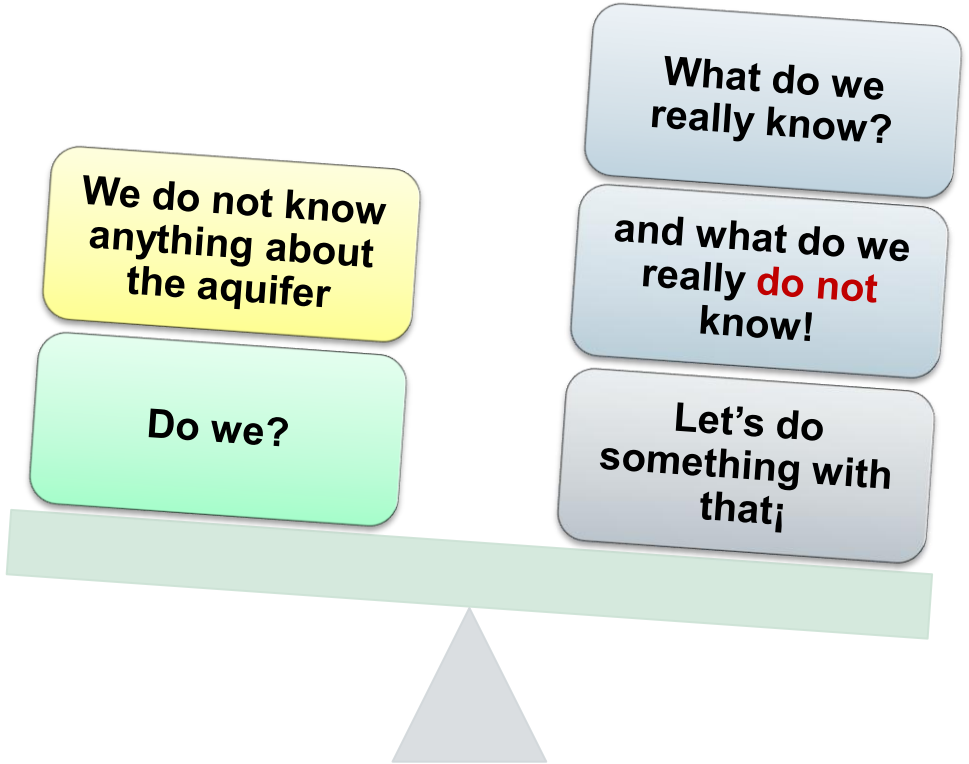
First big obstacle:

We do not have a “Water Law”

Based on the hydrogeological evidence that we obtain, decisions can be made.

We can not make decisions about something we do not know

But we are making decisions although we believe that we do not!



Hydrogeological conditions of the Santa Cruz aquifer

- Some institutions had conducted partial hydrogeological studies.
- Some studies were **contradictory** and some of this information **was not available.**
- Everyone agreed that the water supplier company had lead important hydrogeological studies.

First meeting of the Metropolitan Groundwater Committee of Santa Cruz.

Physical and geological framework

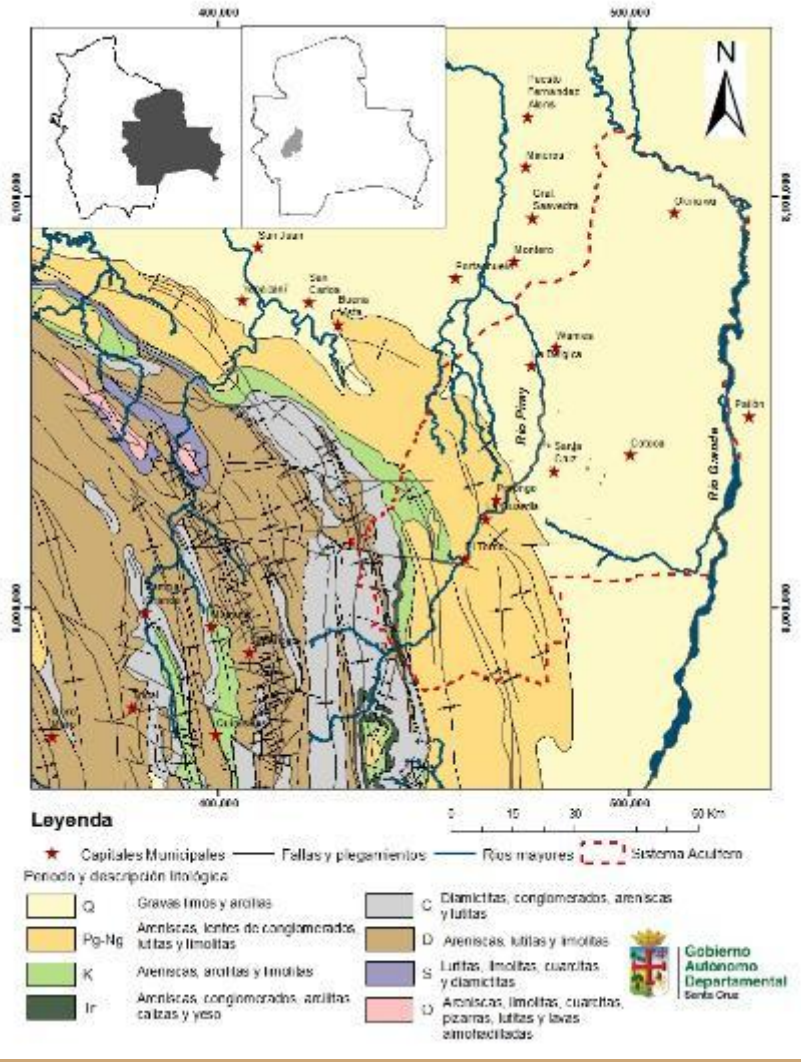
1,330 mm (52.36 in) average annual precipitation and temperature 26 (78.8°F) and 30°C (86°F)

Relief between 1,500m (4921ft) and plain of 470m (1542ft)

Cretaceous and sedimentary rocks outcrops

Sedimentary rocks of predominantly fine granulometry.

Quaternary alluvial soils



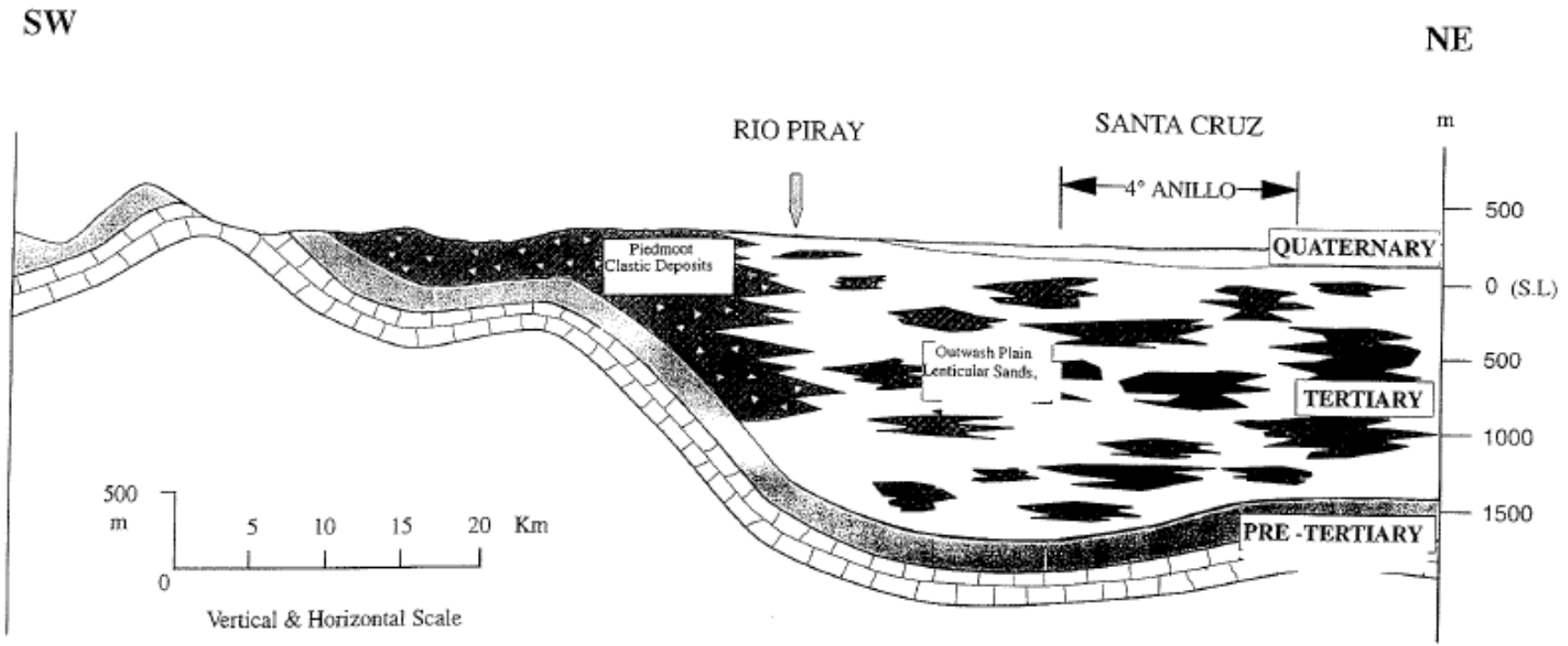
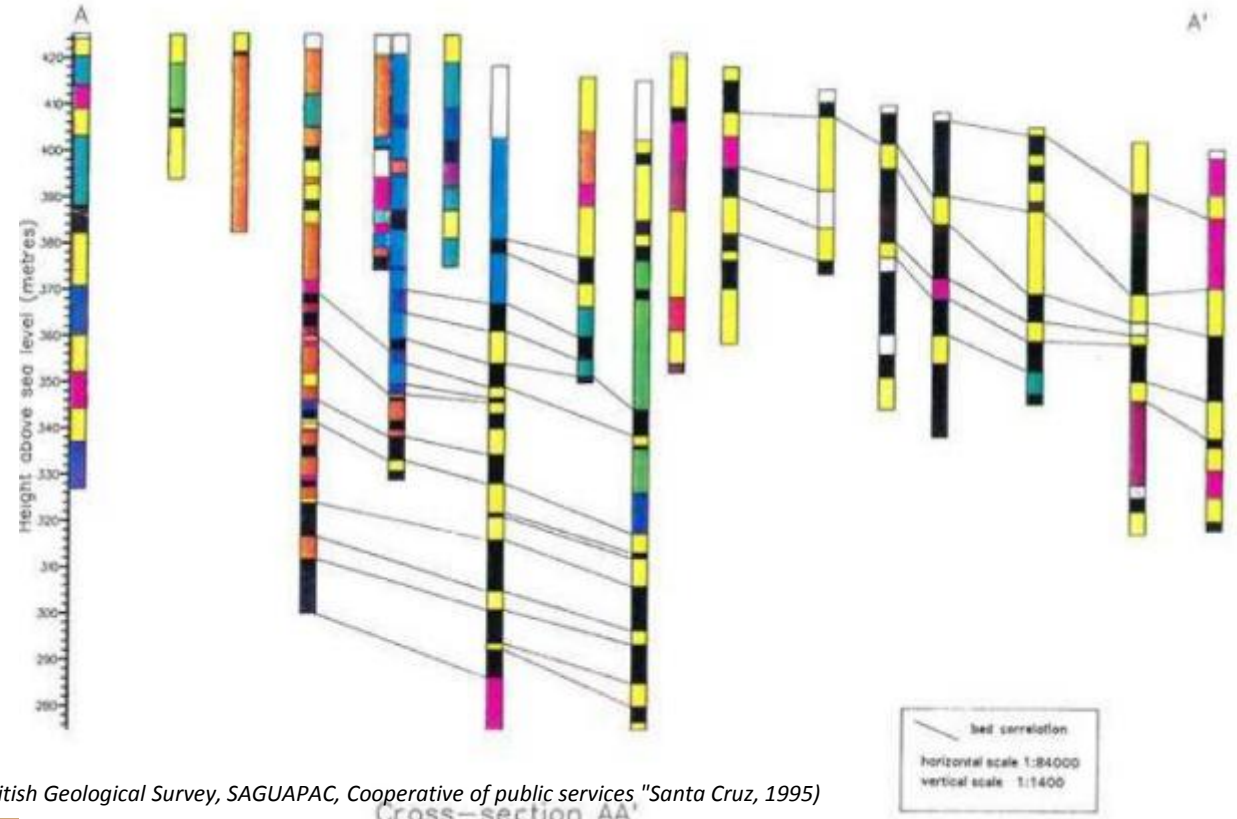
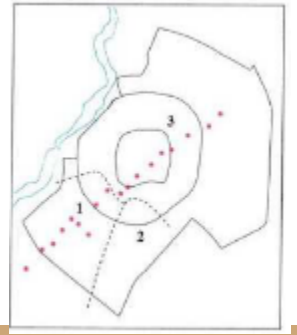


Figure 2.4 : Sketch geological cross-section across Santa Cruz aquifer system (After GITEC, 1982)
Seccion transversal del sistema acuifero de Santa Cruz (GITEC, 1982)

Litological Section SO-NE.
Intercalation of sand, gravel and clays





Source: (BGS, British Geological Survey, SAGUAPAC, Cooperative of public services "Santa Cruz, 1995)

Problematic

Para conseguir agua sana ahora se debe cavar más profundo

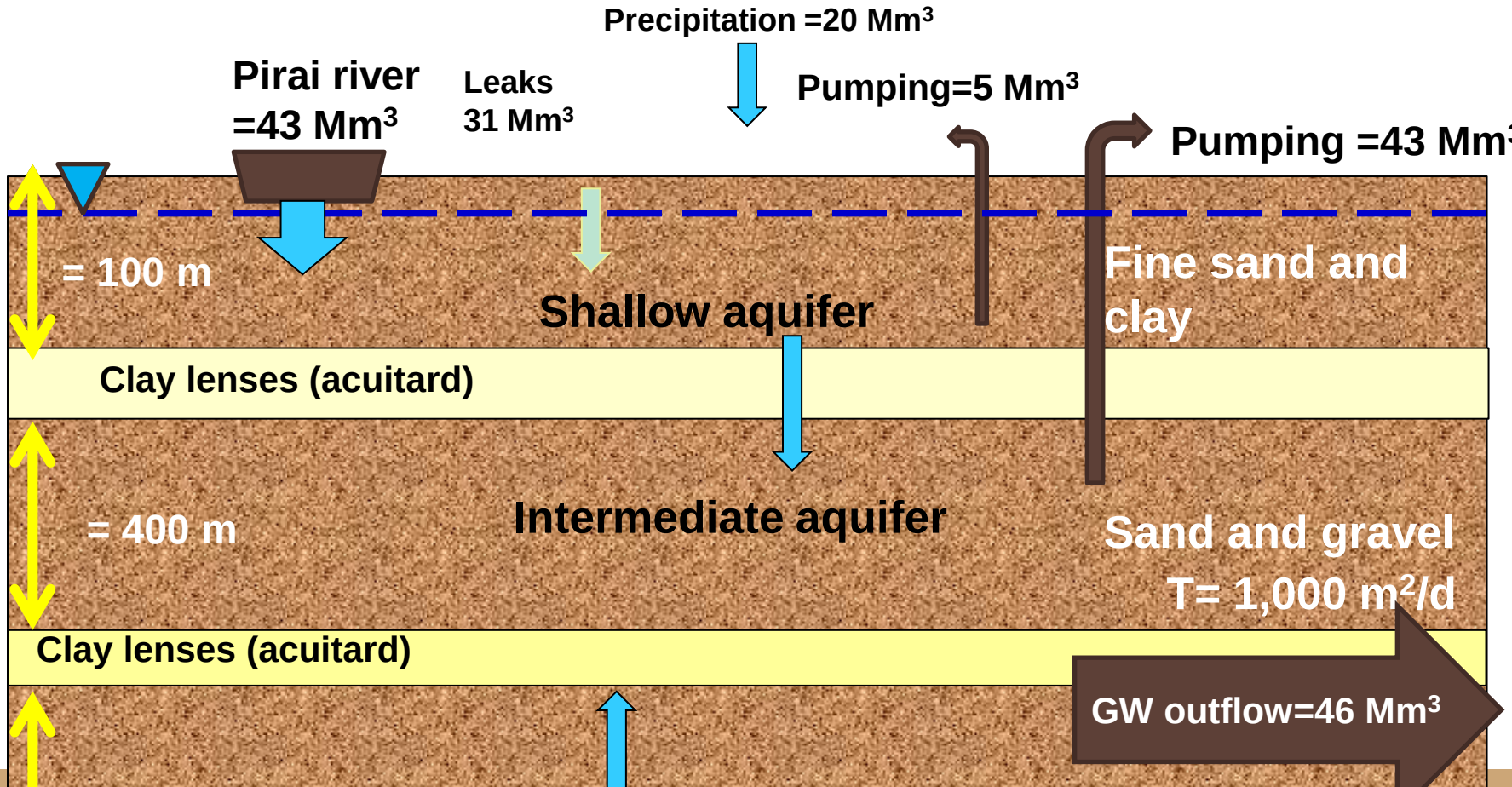
At the end of the 90's depth of supply wells reached 80 m depth

To date, new wells require >250 m depth to capture good quality water

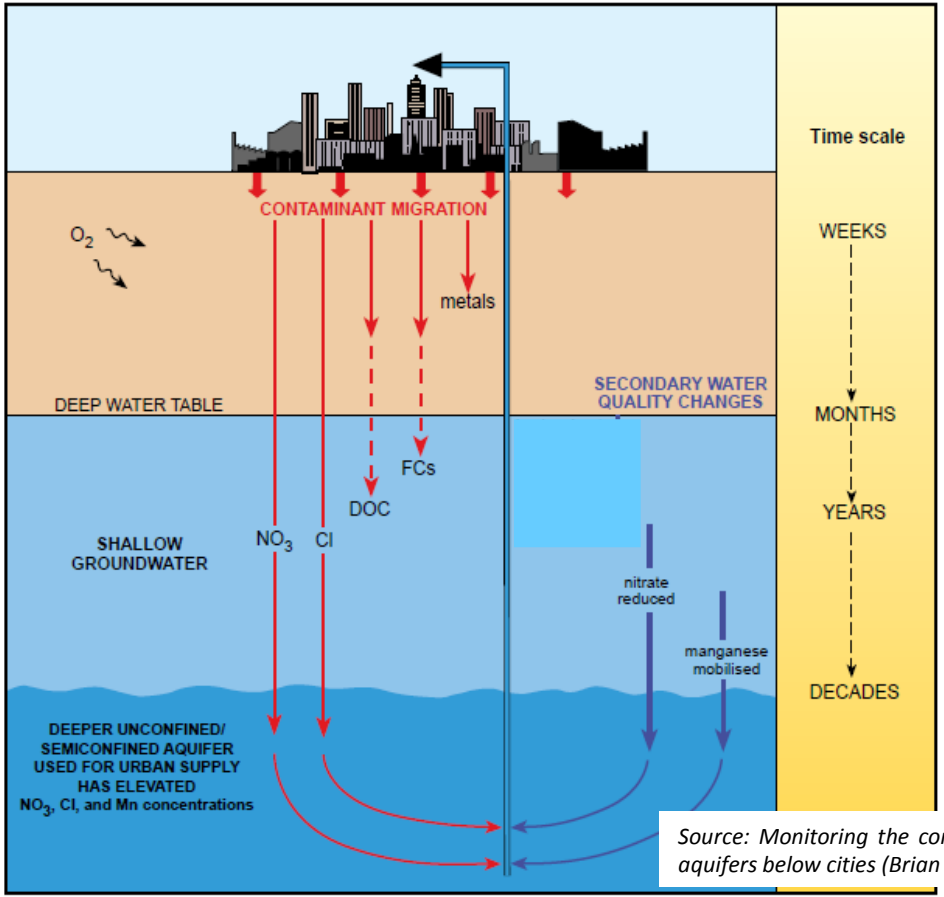
"To get safe water we have to drill deeper and deeper wells"

Source: El Deber newspaper (2014)

Summary of GW balance and aquifer representation



Conceptual diagram of groundwater quality degradation

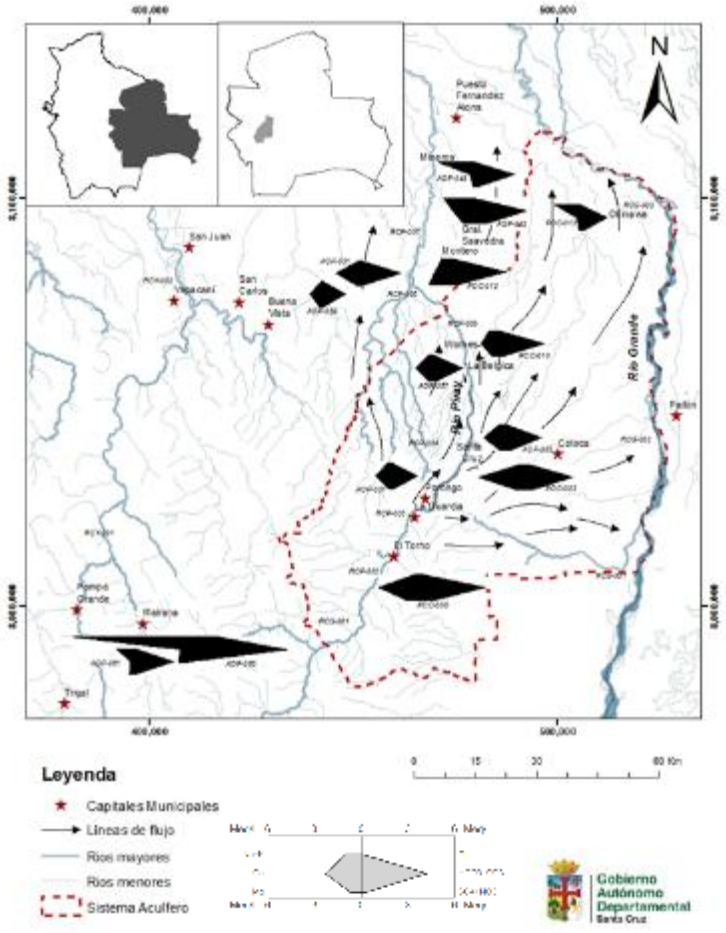


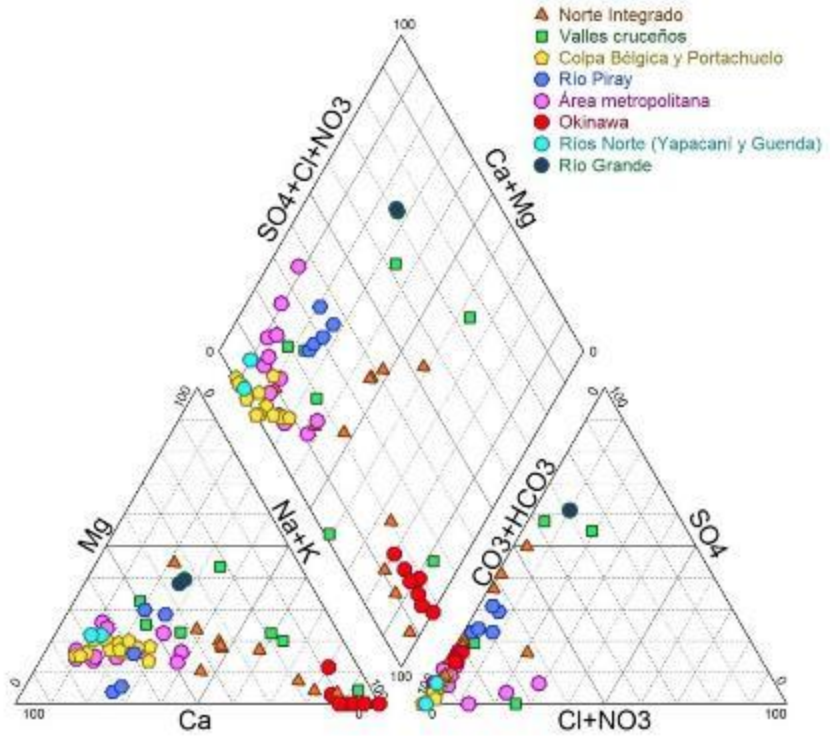
Source: Monitoring the contamination of aquifers below cities (Brian Morris)

Concentrations of:

- 11 mg/L of Cl in deep wells and up to 73 mg/L in shallow wells
- 6.3 mg / L NO3 (1.4 NO3-N) in deep wells and 94 mg / L (21.2 NO3-N) in shallow wells
- 0.85 mg / l of Mn in monitoring wells located at the apex of the aquifer system

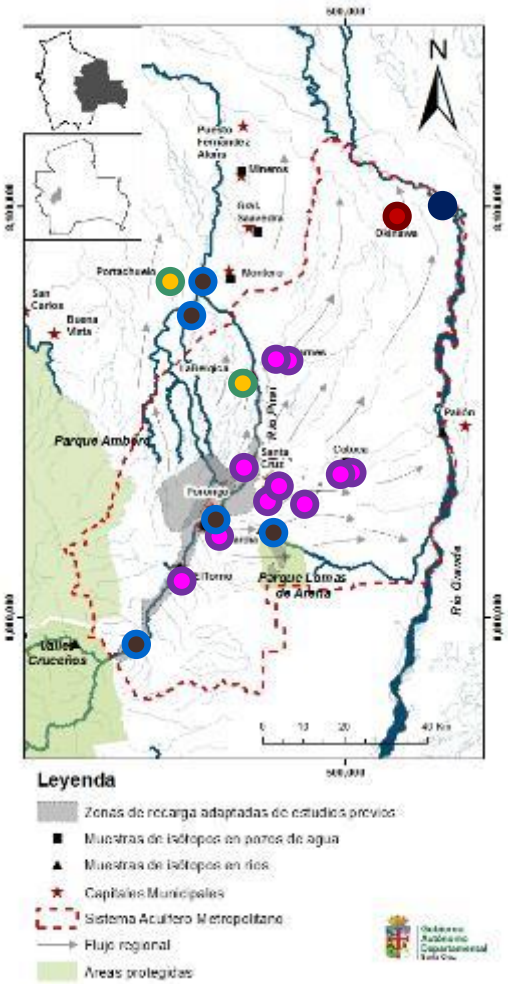
Hydrogeological and Hydrogeochemical framework of AMSCZ

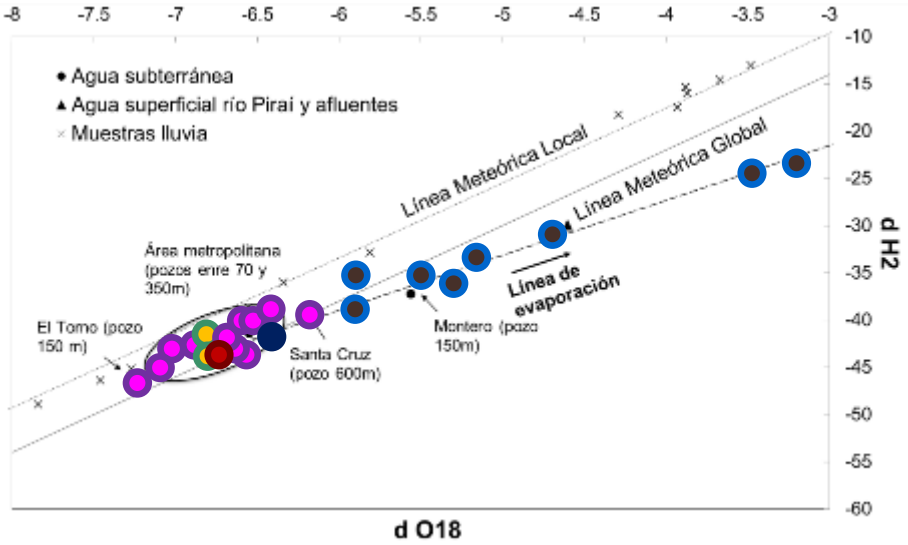




Map of the aquifer system that supplies the AMSCZ and stiff diagram showing the chemical evolution of groundwater (left). Piper diagram showing the type of water in the zone (right).

Recharge and discharge areas



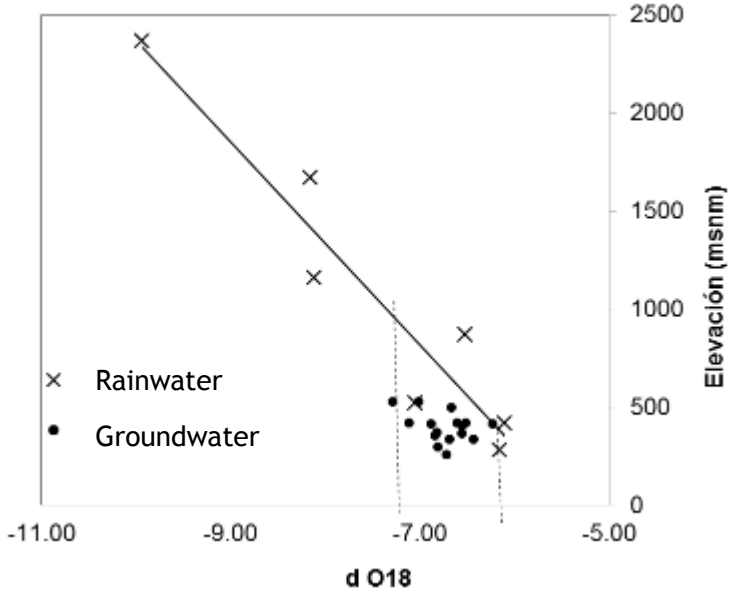


The isotopic values of groundwater (between -6.3 and -7.3 / in δ180 and -50 / and -40 / in δ2H)

Map of the aquifer system that supplies the AMSCZ, showing the recharge zones adapted from previous studies (SAGUAPAC, FAN), and the isotope sampling network of groundwater and surface waters (GAD-SCZ).

Map of the aquifer system that supplies the AMSCZ, where the isotope sampling network of rainwater, groundwater and surface water (GAD-SCZ) is shown.

Theorical high of recharge



Local altitudinal line obtained for d18O from rain samples in the Piraí river basin (GAD-SCZ, 2015).

- Samples taken at a topographic level between 250 and 550 meters above sea level, have the composition of rainwater falling between 450 and 1000 masl: local, non-regional recharge.

Forward

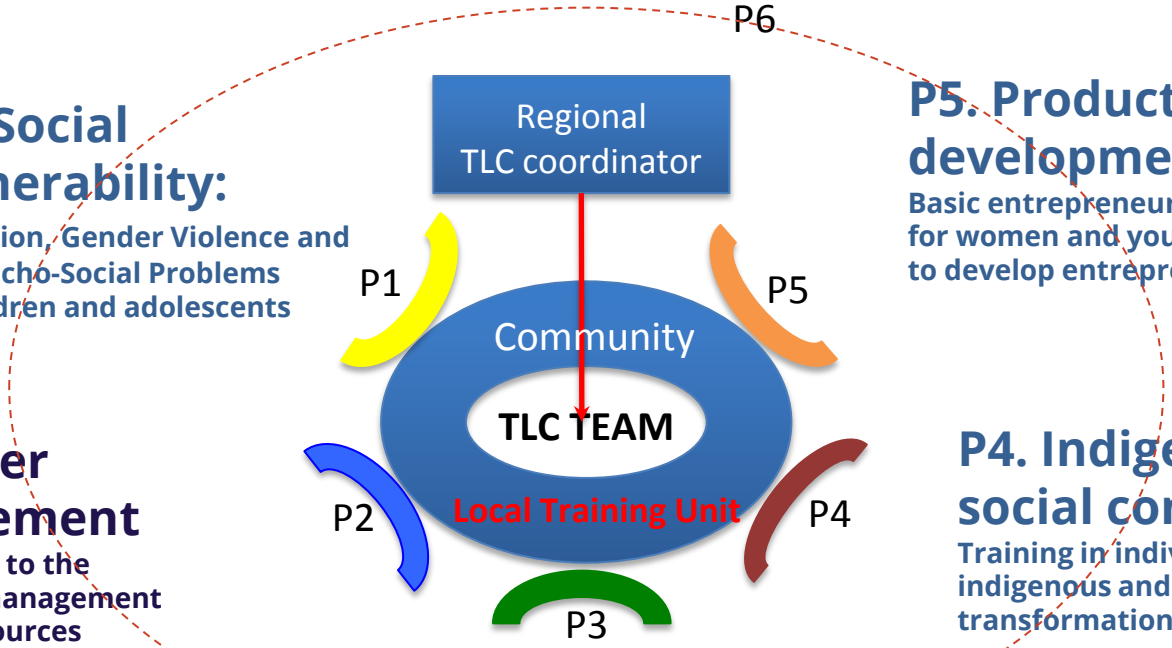
- 2015: Strategies for protection against pollution in the recharge areas of the aquifer that supplies the metropolitan area of Santa Cruz, Bolivia.
- 2016: The municipality approves and promulgates the **"Law of protection and conservation of water sources"** No. 431
- 2016: Closure of the groundwater monitoring network.
- 2017: An **administrative break** was declared on some 14,000 hectares (64 mi^2) of Urubó for possible damage to the aquifer. The environmental audit begins
- 2018: The environmental audit investigating the expansion of Urubó was interrupted.

Let's build something more than a hydrogeological model

vliruos
SHARING MINDS, CHANGING LIVES

"Inclusive community development to improve the quality of life for families, children and adolescents in poor rural and urban communities by building transdisciplinary learning communities"

What are we going to do?



P1. Social vulnerability:

Migration, Gender Violence and Bio-Psicho-Social Problems in children and adolescents

P5. Production development

Basic entrepreneurial education for women and young people to develop entrepreneurship

P2. Water management

<u>Contribution</u> to the Integrated management of water resources

P4. Indigenous rights & social conflict

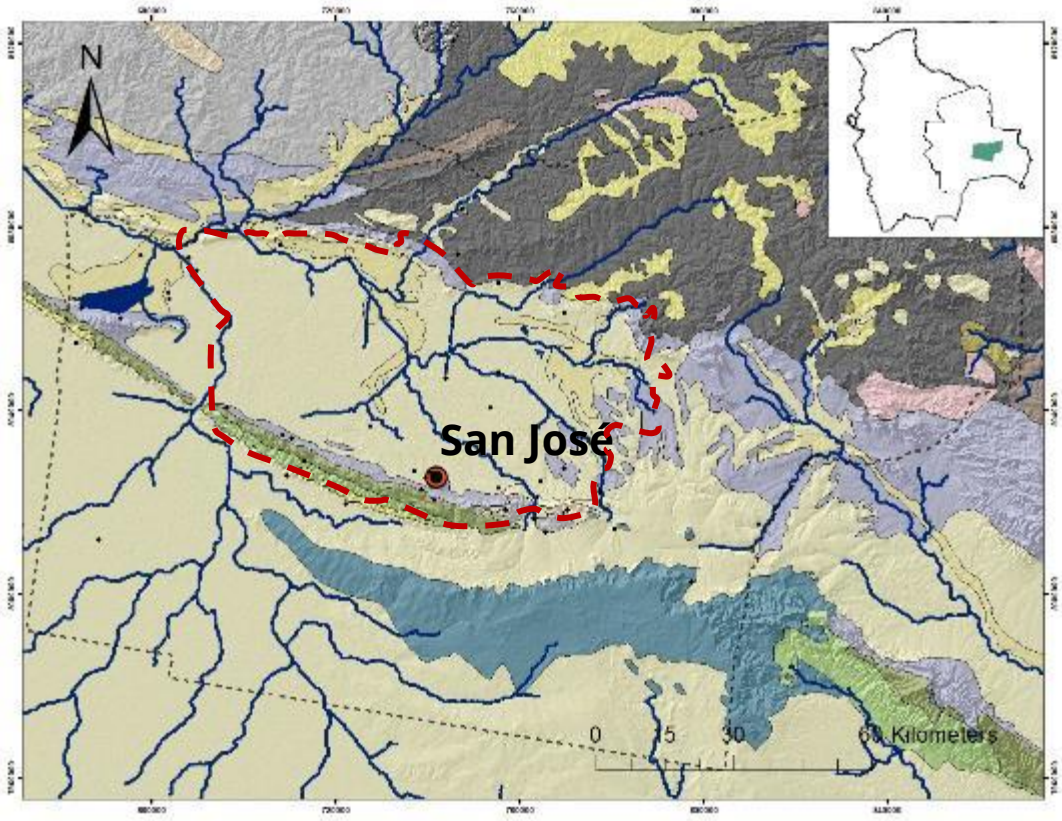
Training in individual, collective and indigenous and human rights and transformation of social conflicts.

P3. Food sovereignty

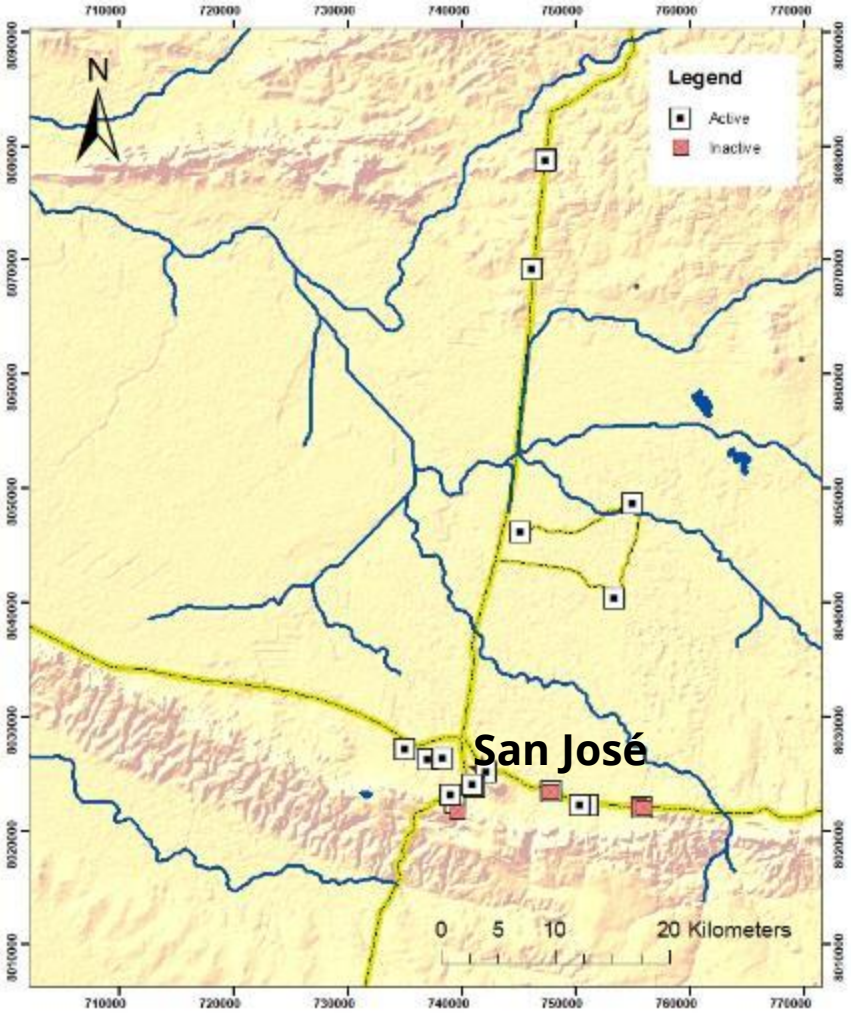
Food production market –oriented, nutritional security, natural resource management and socio-economic drivers for food sustainability

Study area: San José de Chiquitos

- 28.922 inhabitants in 22,268 km^2 (8597.7mi^2).
- Rainfall and temperature about 1,026 mm (40,4in), 20-217mm/month (0.8-8.5 in) and 25°C (77°F), 0.3-41°C (32.54-105.8°F) .
- Altitude from 300 m (984 ft) to 600 m (1968.5 ft).
- Alluvial fans overlie the precambrian (Brazilian shield).

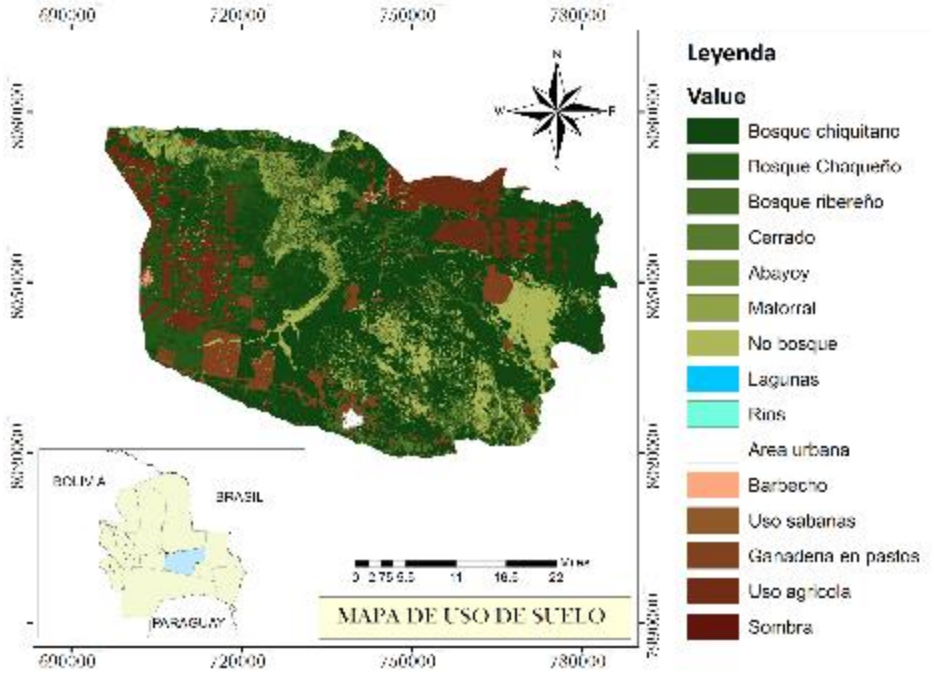


Implementation of a groundwater monitoring network

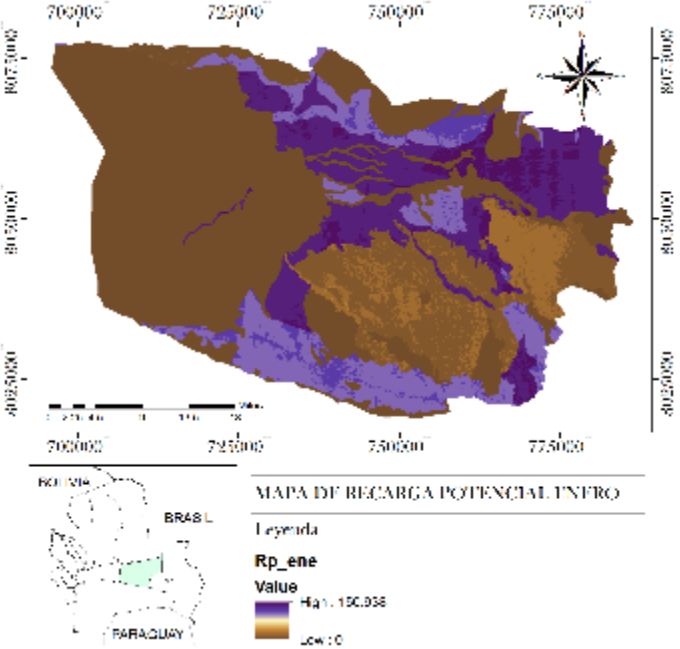


Systematization of different levels of information

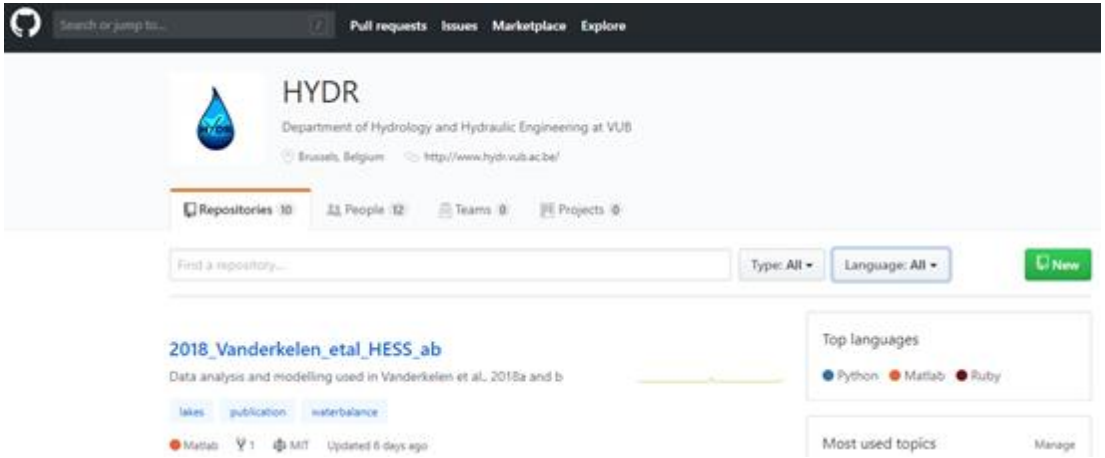
First Level: Primary information



Second level: Secondary information



What about Knowledge management?



First conclusions and further work

- The potential monthly recharge by infiltration was estimated applying a **water budget on the soil** (Schosinsky method), this information is preliminary and should be updated in light of new data since it constitutes an important input of the hydrogeological model.

- The hydrogeological information available to date is been systematized and it is available for the local technicians, this process will continue in the coming years.

Thank you very much for your attention!

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