Soil erosion and associated pollution and siltation compromise the food, water energy and security nexus. A river basin study case in central Chile

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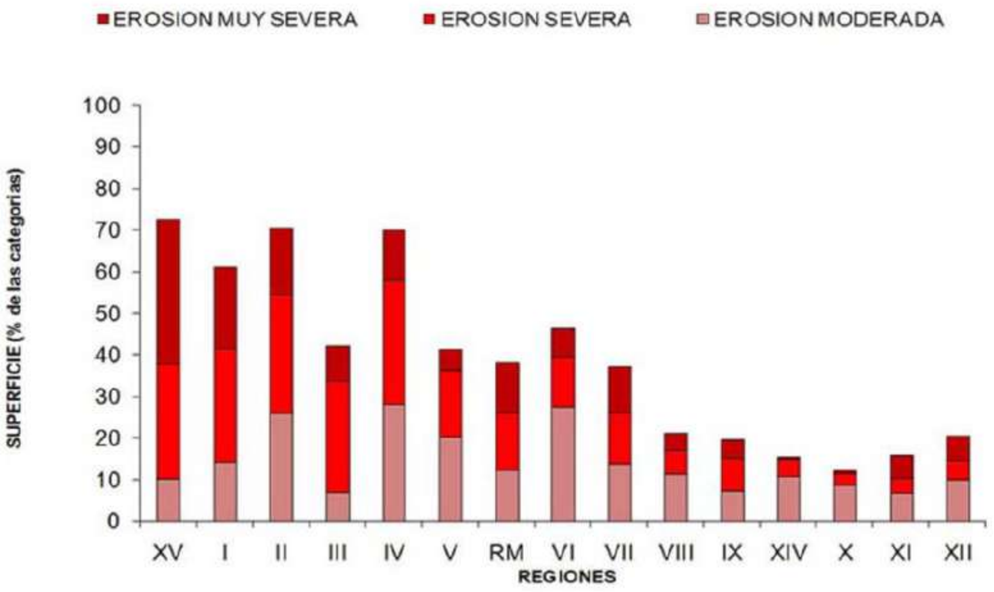
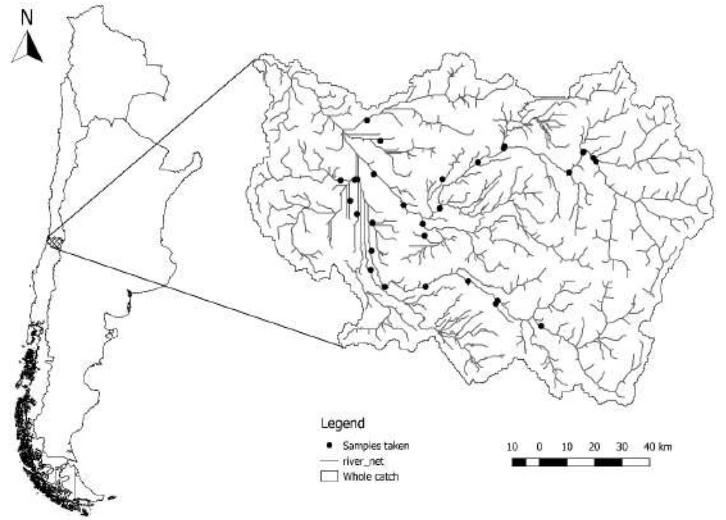
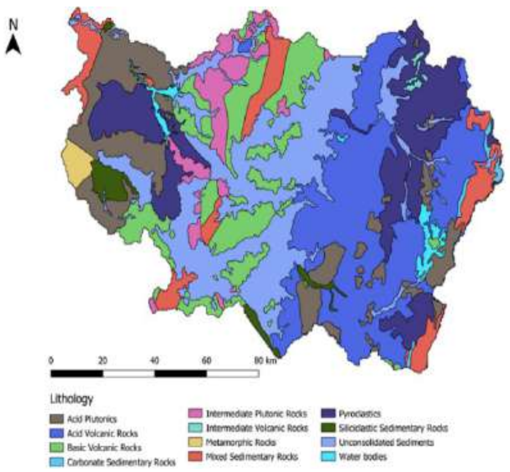
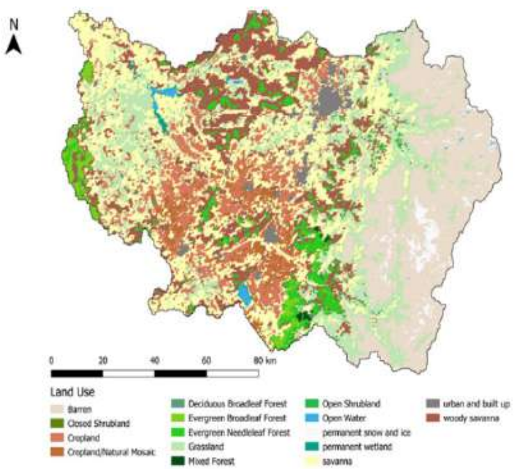
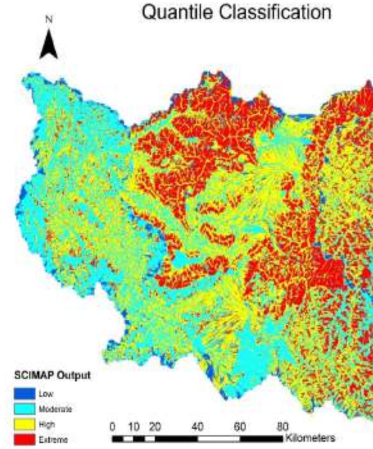


Figura 54. Porcentaje de superficie regional afectada por erosión moderada, severa y muy severa.





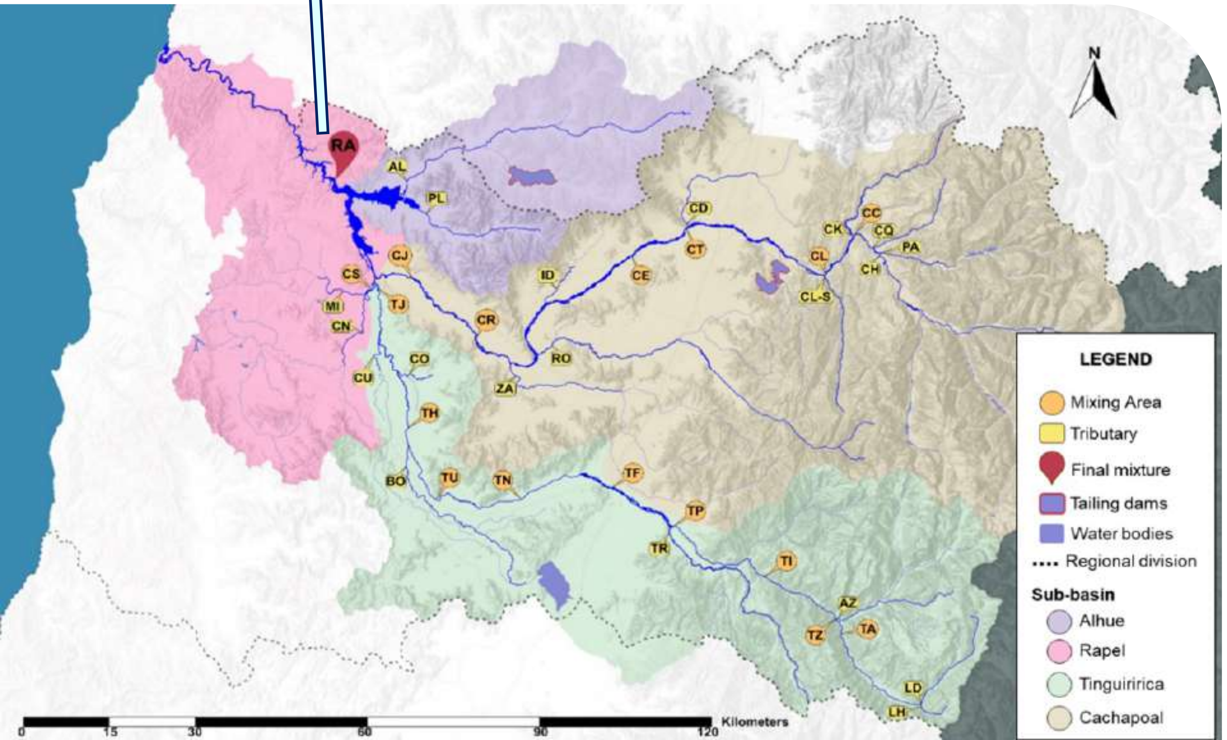




Rapel Catchment
Central Chile

Surface of ~13,000 km^2

Dam has lost the 36% of the water storing capacity



Eco-Systemic Governance of River Basins (ESGRIB)

A participatory model of water, soil and biodiversity intervention for climate resilience

Government institutions (Environmental, Agricultural)
ONGs
Enel (The energy company)
FAO
Universities
Local farmers and producers
Agroecology associations, etc

Action Map: **System for Reversing Soil Erosion in the Rapel River Basin**

Key: Upper case = Established line of action (with responsible actors, permanent activities and, impact). Lower case = Non-established line of action.

A. Integrated river basin management

A-1 Permanent strategic governance mechanism for the basin, with public, private, citizen and academic participants
A-2 Linkage of the erosion reversal process with the debates about regional development
A-3 Characterisation and dimensioning the basin's ecosystem services with reference to soil
A-4 Identification and measurement of impacts of soil erosion upon other activities
A-5 Integrated platform with public access for measuring, monitoring and evaluating soil and water quality
A-6 Development of policy instruments for territorial management in rural areas
A-7 Zoning for reforestation and recovery of biodiversity
A-8 Regional risk map for building and operating infrastructure associated to climate change
A-9 Development of strategies for resilience and protection against vulnerabilities
A-10 Mitigation strategy vis-à-vis extreme events or natural disasters
A-11 Monitoring the impacts of infrastructure built in riverbeds upon the erosion of riverbanks
A-12 Integrated management of the disposal of mining waste

B. Incentives and promotion of sustainable soil management

B-1 Creation of public-private-citizen-academic mechanism for promoting the reversion of soil erosion
B-2 Plan for reforestation and recovery of biodiversity
B-3 Promotion of the recovery of vegetal covers
B-4 Mechanisms for incentive, promotion and protection of agroecological production
B-5 Mechanisms for incentive, promotion and protection of organic production
B-6 Regional seal for sustainable soil use in agricultural and forestry production
B-7 Incentive system for management of drinking water supplying micro-watersheds
B-8 ORIENTATION TO SUSTAINABILITY OF ENTREPRENEURSHIP INCENTIVES FOR THE RURAL YOUNG
B-9 Generation of minimal standards for business ventures that impact upon soil
B-10 Incentives to the use of sustainable techniques for crops on slopes
B-11 Widening the spectrum of practices considered in SIRSD-S
B-12 Revision of the access requirements of SIRSD-S in order to expand its coverage

C. Cultural transformation towards understanding soil as an ecosystem

C-1 Restatement of the soil-water link in Chilean culture and norms
C-2 Promotion and dissemination of the concept of river basin as a unit of action
C-3 Communicational strategy about the importance of soil
C-4 Programme to generate ecological management competences for farmers, and for professionals and technicians in agriculture and forestry
C-5 Awareness raising for citizens, government and business
C-6 Formal and informal education at all levels
C-7 Updating of curricula and graduation profiles in related programmes
C-8 Education plans in rural schools that consider local and regional sustainability
C-9 Awareness raising for tourists, sports people and others about responsible use of the territory

D. Dissemination of agronomic practices that activate soil's life

D-1 Systems of transition from monocultures to policultures
D-2 Agronomic practices that regererate soil's life in highly eroded zones
D-3 Keeping vegetal covers in zones of slope
D-4 Use of machinery and equipment that do not damage the soil
D-5 Use of irrigation techniques that avoid soil losses
D-6 Building of infiltration ditches, stockades, terraces and other containment works
D-7 Rescue and revaluation of ancestral and peasant knowledge and practices about ecological use and management of the territory

E. Mechanisms for technological innovation, development and demonstration

E-1 Development of new parameters for classification of soil use capacity that consider sustainability factors
E-2 Alternatives to agricultural burning
E-3 Alternatives to the use of synthetic fertilisers
E-4 Alternatives to conventional management of plagues and diseases
E-5 Promotion of landscape redesign (keyline)
E-6 Integration of animals into soil recovery (holistic management)

F. Promotion of a law of general bases for soil conservation and use in Chile

F-1 Norm that defines degradation, erosion, fertility, health, functionality, use capacity, soil quality, etc.
F-2 Definition of norms about parameters and indicators for measuring soil erosion
F-3 Consideration of citizen participation as binding in Environmental Impact Assessments
F-4 Limitation of the conversion of forest to agricultural soil for sustainability considerations
F-5 Mechanisms of compensation to society due to loss of rural soil to urban expansion, its equipment and other uses
F-6 Specifications for soil protection and use in the norms for rural property subdivision (DL 3516)
F-7 REGULATION OF THE USE OF AGROCHEMICALS IN RURAL AND URBAN AREAS
F-8 REGULATION OF THE USE OF HARMFUL CHEMICAL SUBSTANCES IN AGRICULTURL AND FORESTRY MANAGEMENT
F-9 Restriction of soil degrading practices
F-10 Regulation of crops in steep slopes
F-11 Prohibition of agricultural burns
F-12 Regulation and enforcement of the extraction of ground leaves
F-13 Regulation and enforcement of river bank ecosystems
F-14 Regulation and enforcement of excavations in watershed slopes for infrastructure, tourism and other activities

G. Sufficient and effective enforcement of norms for soil conservation and use in Chile

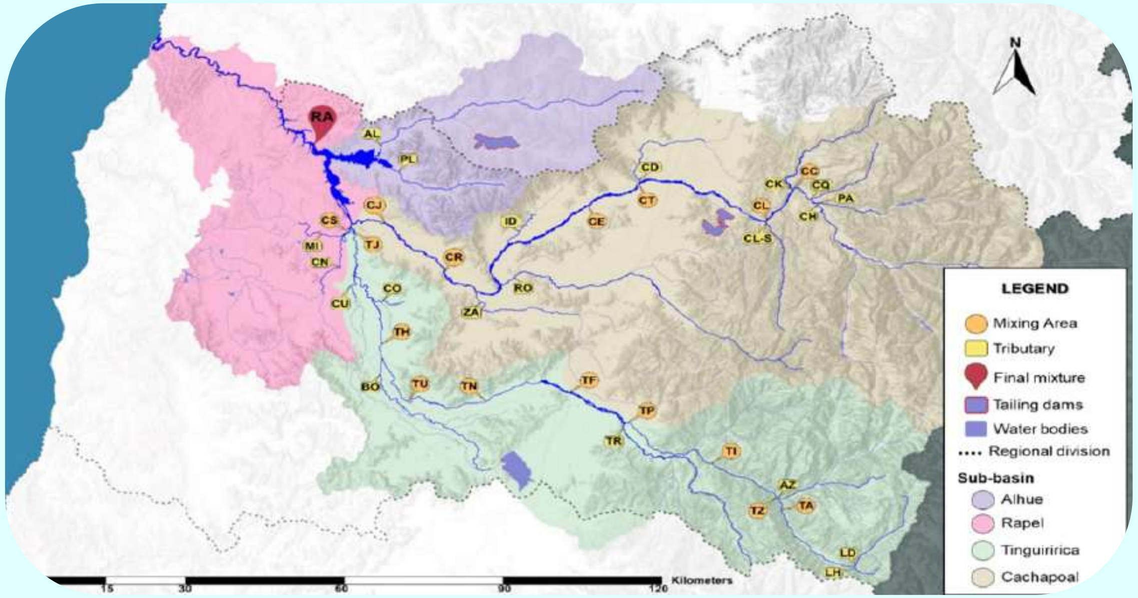
G-1 Norm enforcement of minimal ecological water flows
G-2 Norm enforcement of extraction and recharge of underground water
G-3 Norm enforcement of the exploitation of aggregates in rivers and quarries
G-4 Norm enforcement in the use of agrochemicals in urban and rural areas
G-5 Norm enforcement in the use of harmful chemical substances in agricultural and forestry management

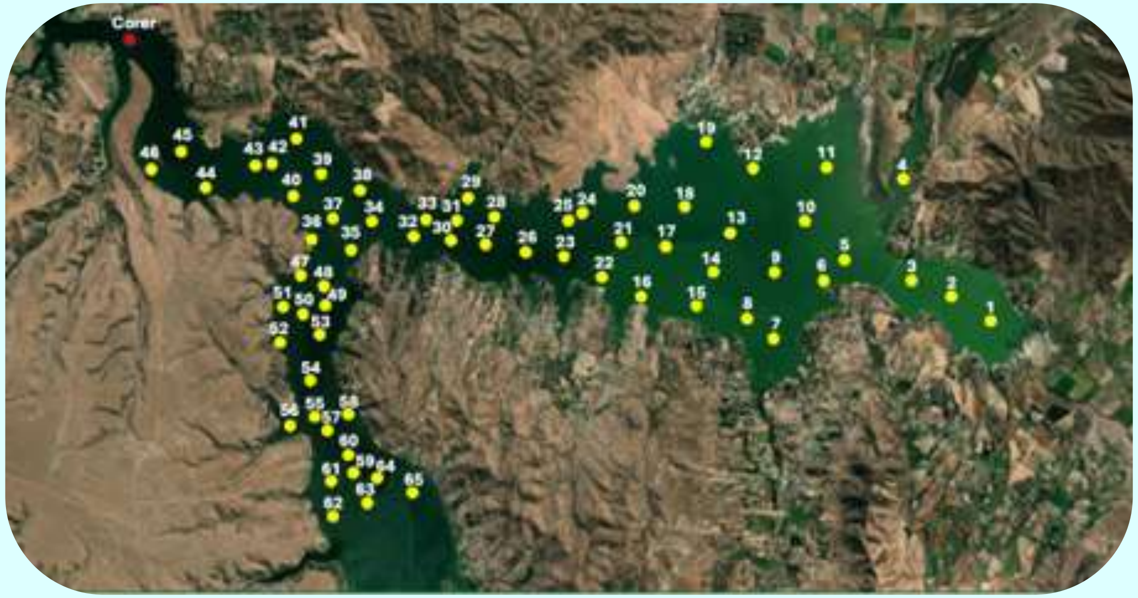
This generated research questions regarding natural Sciences

From where do the sediments are coming from?

First Survey

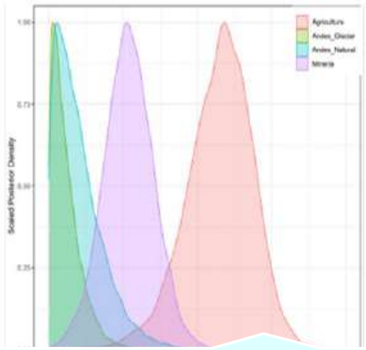
We decided to use a tributary approach to identify main sources of sediments



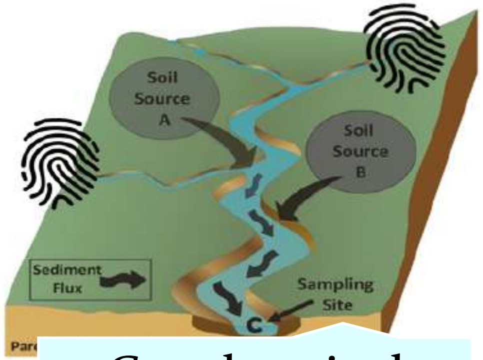


We collected over 850 samples

WD-XRF



Mixing Model MixSIAR

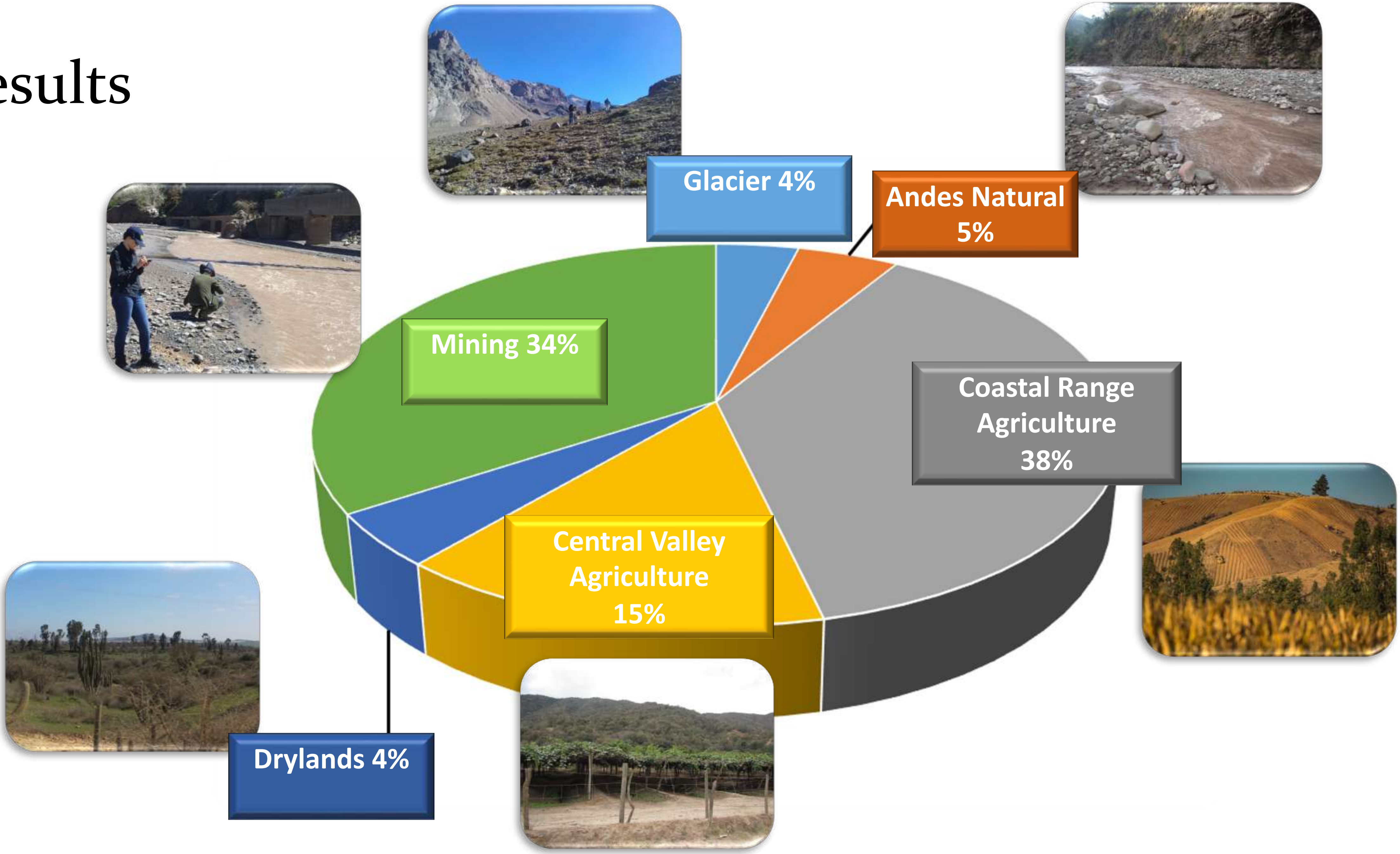


Geochemical Fingerprinting

Source Sampling

Mixing area Rapel Lake

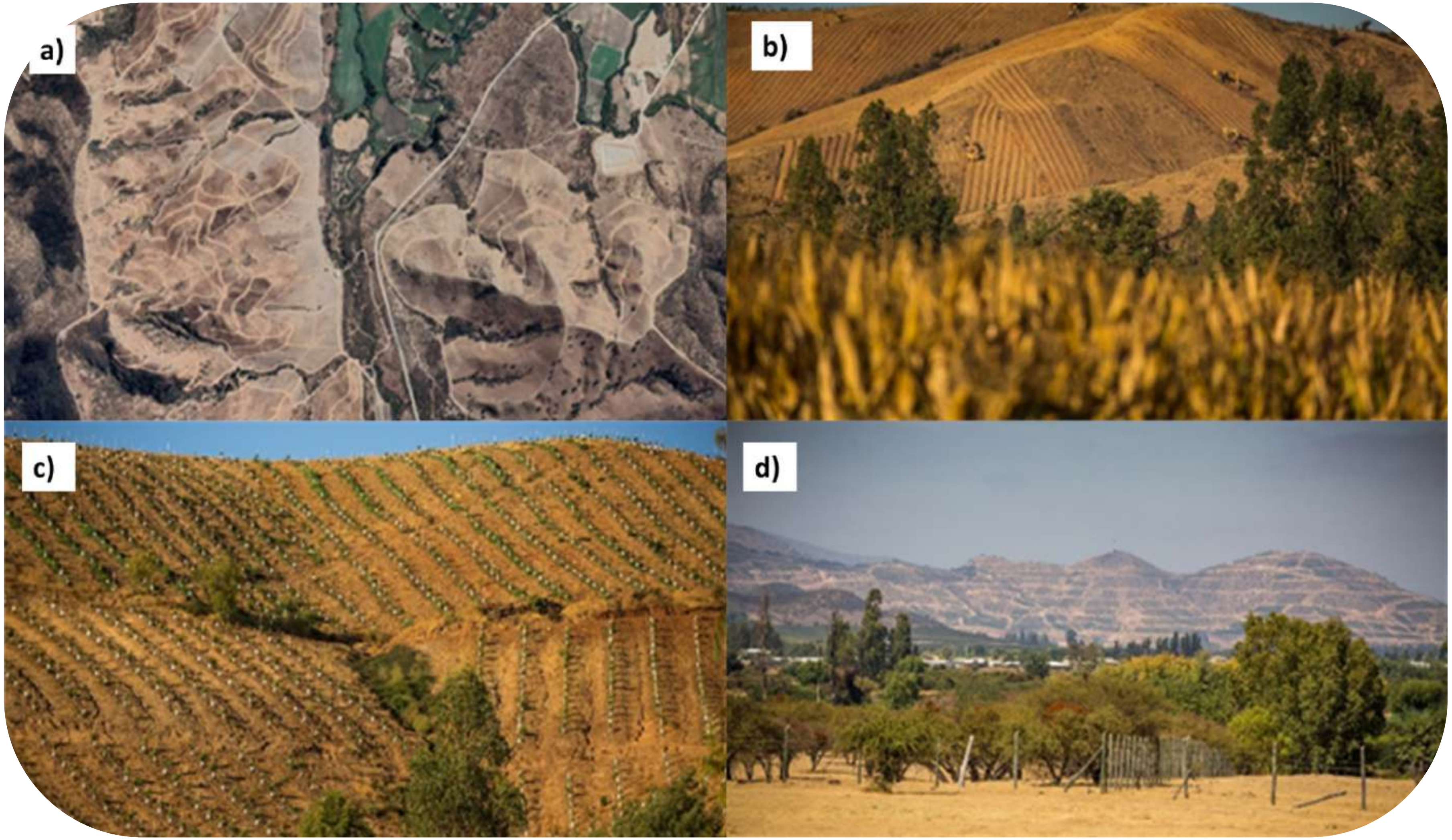
Results



Contemporary Source contribution

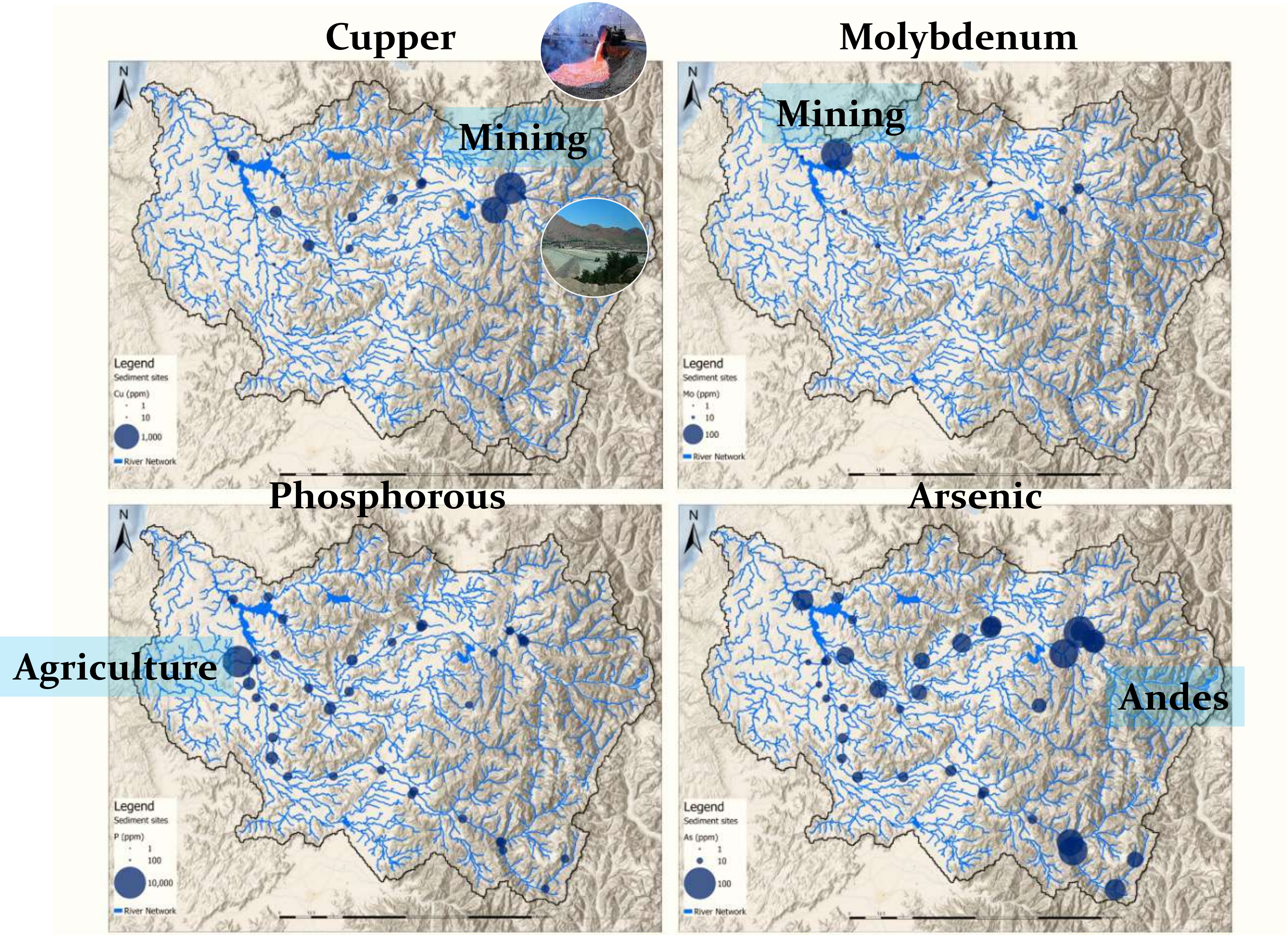
Satellite Image
Land Use Conversion

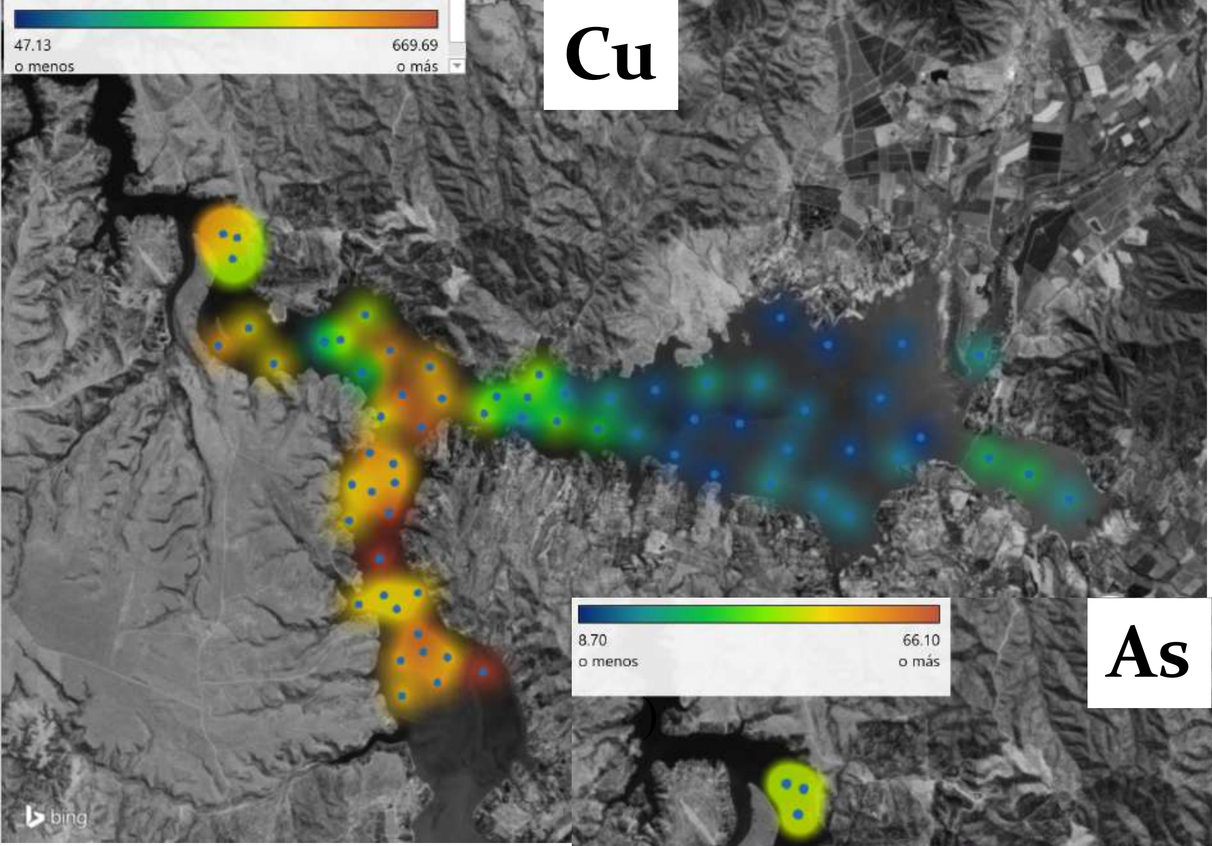
Ploughing parallel to slope

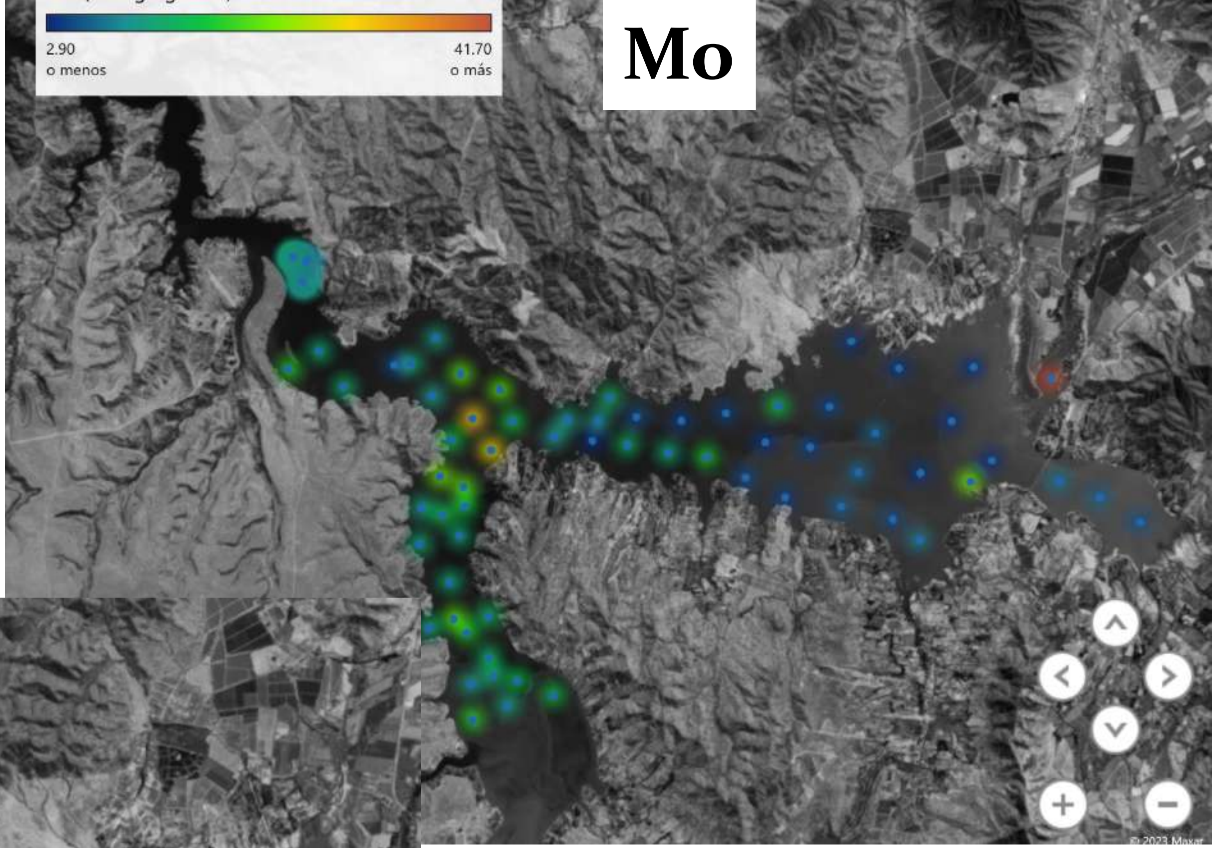


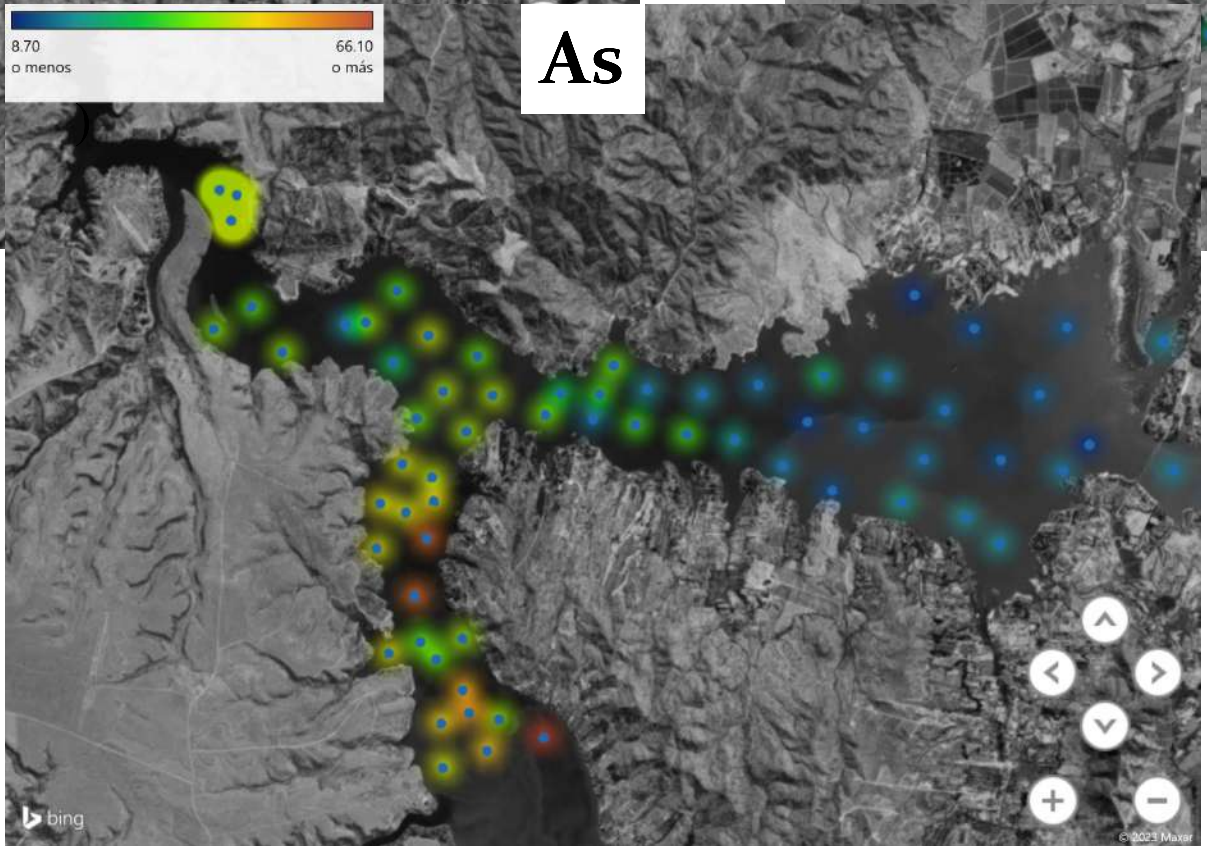
Native forest conversion to new crops (Avocado, citrus and olives)

Sediment Associated Contaminants (SAC)





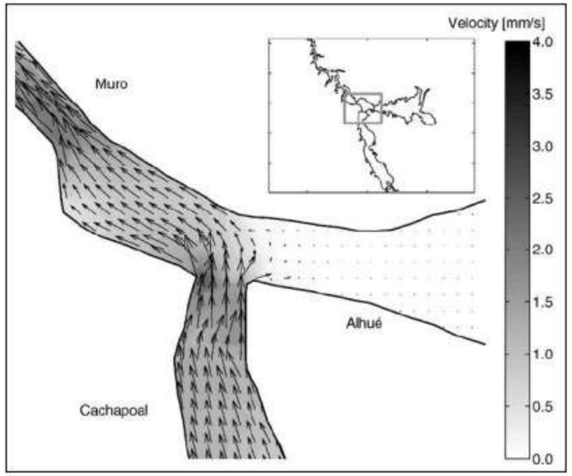




Probable Effect Concentrations (PEC)

Cu: 149 mg kg^{-1}
As: 33 mg kg^{-1}

MacDonald et al. (2000)



Conclusions

- Geochemistry allows apportionment of sediment sources at the river basin scale
- Conversion of steep land from native vegetation to agriculture promotes soil erosion
- Mining contributes equivalent to 34% of total sediment deposited in the hydropower lake
- Sediment-associated Cu and Mo dominate reservoir contamination
- Participatory process highlighted the idea of perform studies at Basin Scale for better comprehension of the erosion problems

Thanks for your Attention












Project RLA5064
Project FONDEF-NEXUS NER0155971
Project Fondecyt 1210813

HISTORICAL CONTRIBUTION OF SEDIMENTS TO A HYDROPOWER RESERVOIR: A CASE STUDY IN CENTRAL CHILE

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1. Background

Hydropower reservoir with:

- Soil erosion intensification with land conversion to agriculture
- Reduction of water storage capacity of the dam ~36%
- Water pollution by sediment and associated pollutants due to anthropogenic activities

2. Research questions

- What are the main sediment sources within the catchment?
- How have source dynamics changed through time since dam construction?

3. Methods

Sampling

Sources

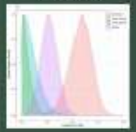
Mixture

Sample Analysis

Elemental analysis via WD-XRF

Data Analysis

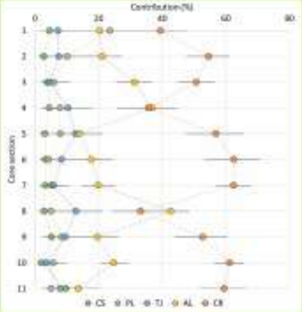
Mixing Model MixSIAR



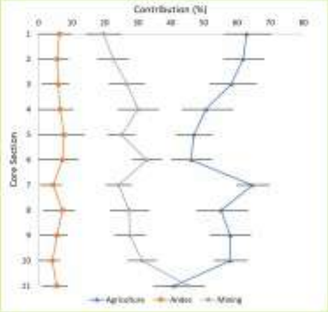
Geochronology

4. Results

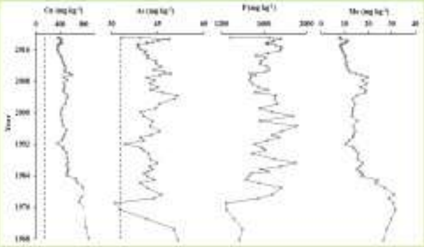
Sediment contribution by main tributaries



Sediment contribution by main activities



Sediment-associated contaminant profiles



5. Conclusions

- Sediments originating from anthropogenic activities contributed more than the 60% of sediments in the lake sediment column.
- Agricultural contributions have increased in the recent years due to land use changes within the catchment – especially conversion of natural vegetation to avocado and other orchard crops.
- Contribution of P has steadily increased with evidence of episodic contributions linked to major storm events
- Contaminants derived from mining activities show an inverse relations ship (proportionally) to agriculture implying dilution by increased soil erosion

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