Lithium supply development in Argentina

IAIA Session 144: Impacts and Risks of Lithium and Rare Earths supply chain

Summary statement: Extraction of lithium from brines in NW Argentina affects high altitude salt flats in volcanic terrain supporting valued wildlife and traditional livelihoods of indigenous communities.

Paper Abstract:

Much of the world's lithium supply comes from Australia and China. In the past 15 years, in what's been called the "lithium triangle" on the high plains of Chile, Argentina, and Bolivia, lithium brines have been discovered and put into operation beneath the salt flats of the Andes. These are also sites of endemic wildlife, migratory birds, and traditional livestock farming carried out by ancestral communities. The benefits of lithium brine mining include stimulating local economies in these remote locations, supporting new infrastructures (roads, power lines, gas pipelines, solar and wind power generators), increasing government revenues at all levels, and enhancing the study of socio-environmental and cultural resources. Negative aspects include pressure on limited sources of fresh water, pressure on wetlands and vegetation that sustain livestock and wildlife (including many protected species), long hauls of heavy vehicle traffic on poorly designed roads, and associated dangers. It also includes conflicts over land tenure with local communities, most of whom live at subsistence levels. There are prejudices against this type of mining, and a better consensus among stakeholders should be developed. Regulation is lagging behind. There is a clear need for a specific sector study in a strategic impact assessment for the highlands of northwest Argentina, with links to competing companies in Bolivia and Chile. Regional governments, international funding agencies, academics, and socio-environmental specialists play a key role in improving the quality of socio-environmental assessment in the "Lithium Triangle."

Authors:

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Context: Lithium is an essential ingredient in the most versatile electric batteries, widely available in today's world, from mobile phones to electric cars. These uses make lithium a key mineral resource in the modern world, and its application has accelerated the displacement of traditional energy sources by renewable energy sources. It also makes lithium a highly valuable commodity at this time. Three years ago, lithium carbonate was priced at USD 5,000 per ton; by the end of 2023, it had reached USD 80,000 per ton, but currently, the price of lithium has dropped significantly. This enormous variation in prices currently that generates a lot of expectation and uncertainty.

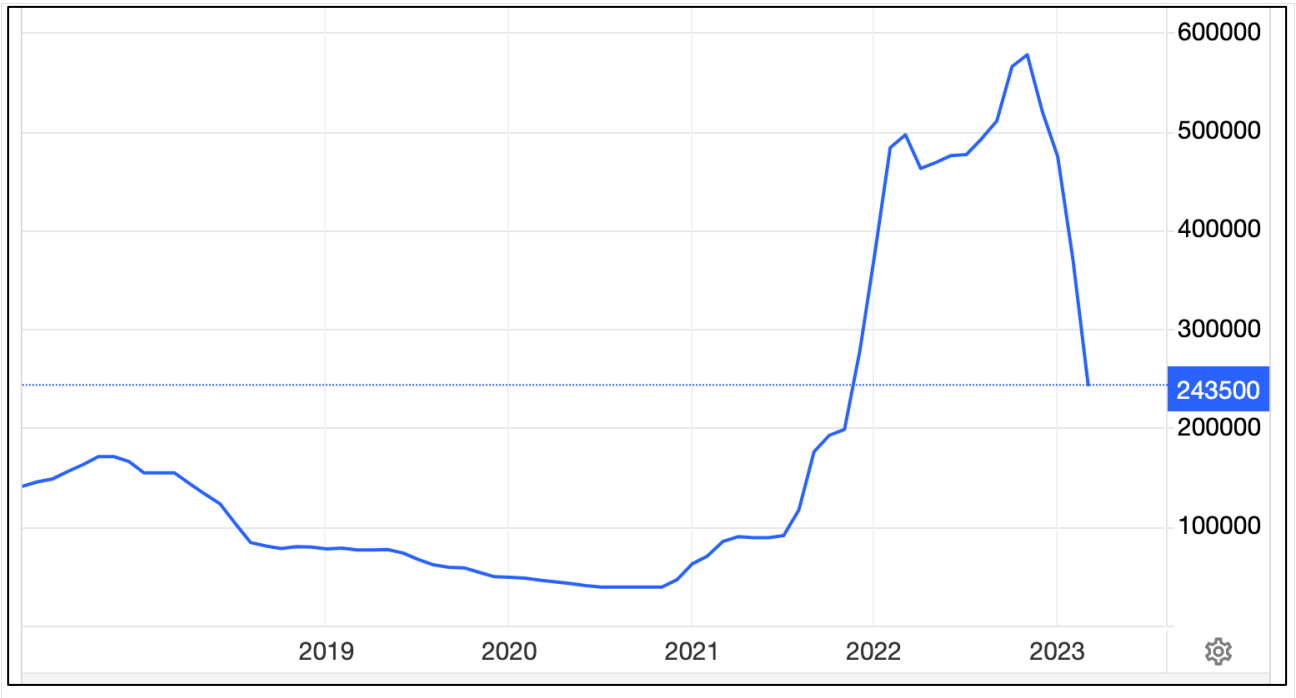

Figure 1. Lithium price variation in CNY (USD ~ 7 CNY) Source: Trading Economics-Forex.com

The growth in lithium demand is changing the geopolitical landscape. While lithium is fairly abundant in the Earth's crust, economically viable mineral deposits are concentrated in a few regions of the world: notably Australia, China, and the plateau shared by Argentina, Bolivia, and Chile known as the Lithium Triangle.

Mineral deposits

The larger lithium mineral deposits are of two types:

- Hard-rock, lithium bearing pegmatites associated with granitic intrusions. Spodumene is the sought-after mineral.
- Lithium bearing brines hosted by unconsolidated sedimentary sequences, typically found associated with salt flats in volcanic terrains. The source of the lithium ions is in the hydrothermal fluids originating from the volcanic activity.

Our experience is in the lithium brines of NW Argentina, which shares common features with the brine deposits of Bolivia and Chile. Bolivia’s deposits are the largest by volume, but are low grade. Chile’s deposits are the richest, but are not so widespread as those of Argentina. Argentina has numerous, endoreic basins with salars, surrounded and in some places intruded by Quaternary volcanoes.

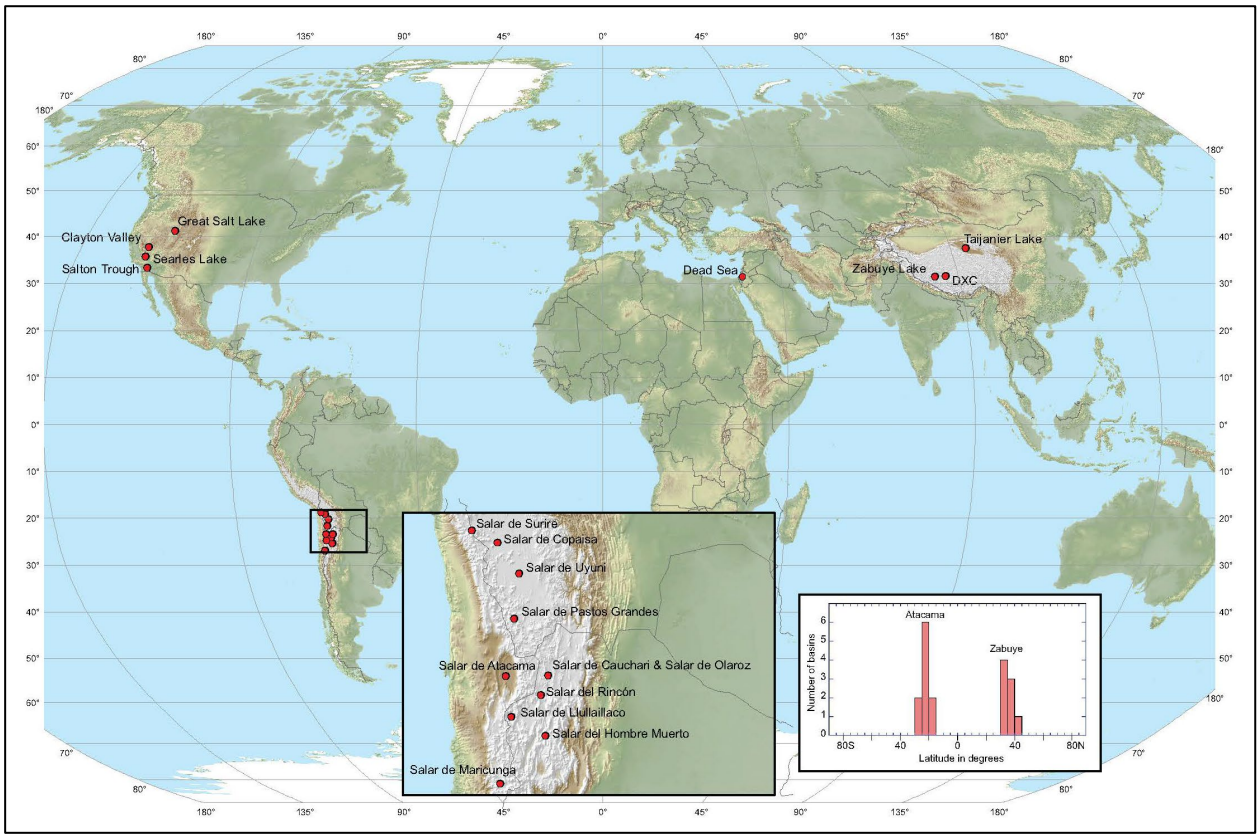

Figure 2: Major lithium brine deposits of the world, from Munk 2016, Lithium brines global perspective.

Natural concentration of lithium in brine

The climate is arid, a mountain desert with low precipitation and high rates of evaporation (radiation and wind). The climate of the Arid Andes and the Puna has shown a clear trend towards aridification, higher temperatures, and lower precipitation.

The melting of snow in endorheic basins with locally sourced sediments progressively fills these basins, creating unconsolidated sedimentary packages hundreds of meters thick. Surface evaporation concentrates the saline and lithium content in these waters, which simultaneously mix with runoff from volcanoes, and likely mingle with deeper circulating hydrothermal fluids. The saline fluids become buried with the host sediments and form the brine reservoir. Some horizons of the sedimentary package are composed of high proportions of evaporitic minerals such as halite. Freshwater entering surface ponds over the denser brine develops a transitional brackish zone between the two. This is critical because the freshwater body sustains vegetation and much of the wildlife, as well as subsistence farmers and their communities. Brackish and saline lakes support the unique wildlife of this habitat, especially migratory and gregarious birds like the Andean flamingo. This has led to many of these locations being designated protected areas or Ramsar sites.

Table 1. Summary comparison of lithium mining in countries of the Lithium Triangle

Topic	Chile	Bolivia	Argentina
Exploration and operation	Earlier	Recent	Very intense the last 10 years
Quantity and characteristics	Few salars / high concentration / deep	Few salars / low concentration / shallow (Uyuni)	Many salars, variable concentration / deep
State participation	New contracts 51 % participation	All contracts with 51% participation	Some contracts with regional participation (<15%)
Development and technology	High development and technology, increasing production	Low development and only pilot plant	High development and technology, rapidly increasing production

Our question is: What are the socio-environmental effects of this new dependency on lithium?

Mineral extraction:

To some extent, the effects depend on the extraction method that is employed.

Through sequential evaporation systems: Typically, brine is extracted via wells and pumped to open-air evaporation ponds to concentrate the salts. Concentrated brines are chemically processed to separate out salt, potassium, magnesium, and boron components and combine the remaining lithium with carbonate. Unwanted components precipitate as sulfate salts and form semi-solid waste deposits. The precipitated salts in the ponds are periodically harvested and disposed of in stacks of dry waste/subproducts. The concentration and chemical purification process require the use of freshwater.

Direct extraction method - DLE: Alternative methods being developed on an industrial scale do not require evaporation ponds. Instead, they involve the electrochemical concentration of lithium directly from the brine, so that spent brine can be returned to the deposit (on the surface or underground). The recovered lithium solution is purified and also produces semi-solid salt residues. Environmental protection mainly involves avoiding disturbance to freshwater bodies and wetlands, and saline lakes with their fauna. At the social level, it is essential to simultaneously maintain subsistence agriculture/livestock farming, supporting local communities, often of indigenous ethnicity, community relations work, expectation management, territory governance, and promoting local suppliers from the early stages of the project to its closure.

General impacts and benefits:

Potentially Negative:

- Freshwater disturbance
- Disturbance of wetland habitat - vegas and salt flats
- Cultural conflict - subsistence economies and market frenzy

- Upsets in governance of basins where multiple projects converge

Potentially Positive:

- Increased knowledge of natural resources
- Access of local communities to markets/connectivity
- Improvement of roads and energy supply
- Improvement of health services, housing, and government services
- Enhancement of awareness of health and safety practices
- Improvement of educational and training opportunities

Currently, the socio-environmental governance of lithium mining has been overwhelmed by the economic urgencies of Argentina and its regional governments. In this process, very sensitive systems of freshwater, biodiversity, and indigenous communities have been compromised.

What effect has lithium mining had on water management?

The main sources of fresh water in the Puna are some streams, springs and the majority are groundwater near salt flats. The contact area between the lower zone (salar-lake) is an area of very high sensitivity. The extraction of water for lithium projects represents a possible impact on this area and the recharge levels. The edge area is the most sensitive system, at the freshwater/saltwater interface zone, wetland/salt, foraging area/lake and saturated/unsaturated zones. This edge zone can condition the suitability of the wetland area for use by livestock and wildlife.

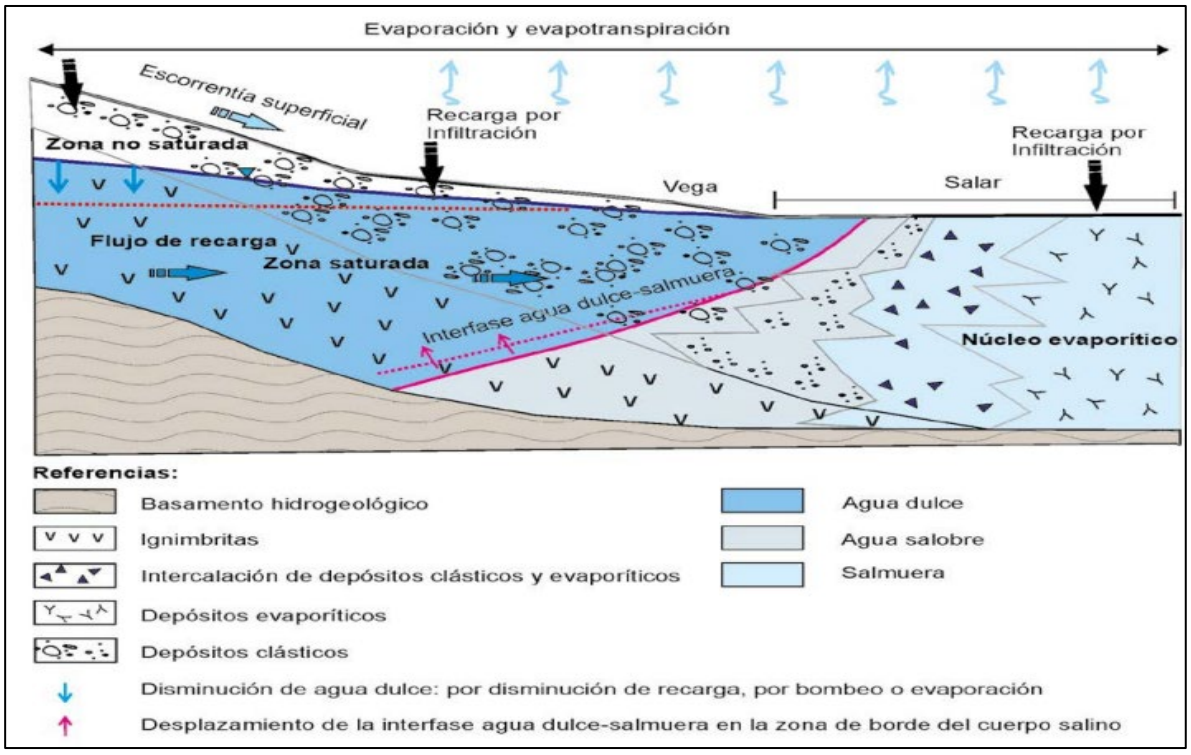

Figure 3. Idealized section through a lithium brine deposit. (Source: Rodolfo Garcia)

There are discrepancies in the understanding of the interactions of fresh water and brines. The lithium deposits are located at the hydrographic base level where fresh and brackish water systems mix with brine. They are desert systems with low aquifer recharge capacity for long-life projects There are wetlands (vegas) associated with these systems where livestock and wildlife come together.

What effect has lithium mining had on biodiversity?

The salt flats and some areas with the presence of lakes and wetlands are small areas of high biodiversity - mostly seasonal. Migratory birds, especially flamingos and waders, are indicators of the state of these wetlands.

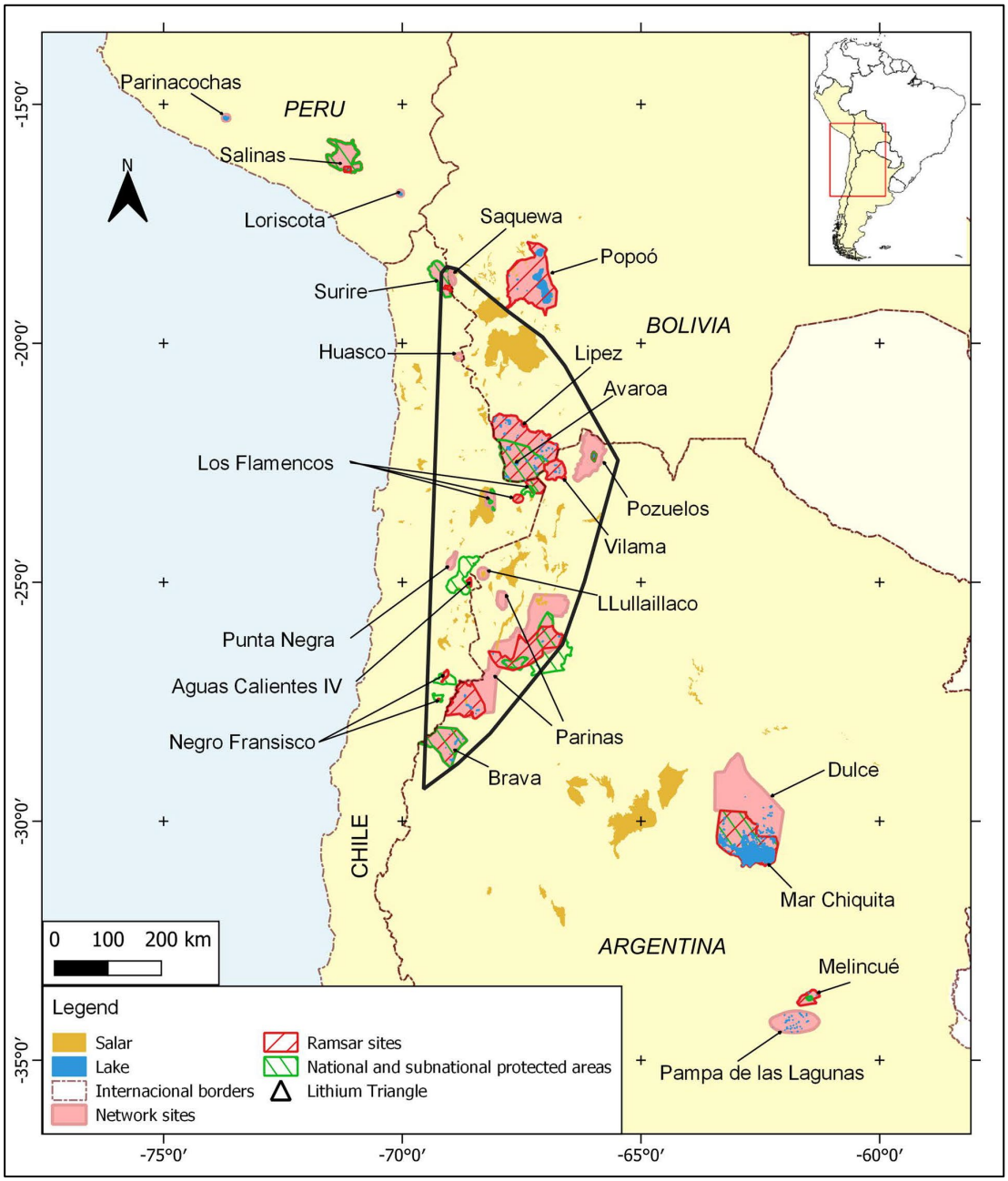

Figure 4: The "Lithium Triangle" and its relationship with Ramsar sites and Flamingo monitoring sites of the joint andean monitoring program, from Marconi 2022 – The Arid Andean Plateau Waterscape.

Possible impacts

- Impacts to wetlands and lake water levels
- Impacts to wildlife - areas of refuge, foraging/feeding and reproduction
- Possible changes in migration systems?
- Reduction of the irrigated area due to consumption of fresh water
- Affectation of vegetation cover and diversity, potential soil salinization due to aquifer depression or brine intrusion.
- Affectation of the Andean Microbial Ecosystems

However, it must be recognized that unrestricted livestock farming as well as industrial lithium extraction are the main stressors.

What effect has lithium mining had on the communities?

Local communities in the vicinity of many of the lithium deposits subsist on herds that feed on vegetation that develops at the fresh-water discharge zones. Their economy is based on subsistence farming, services to local tourism and employment in local government. Effects that they experience with the arrival of industrial scale mining include:

- Cultural shock, market system and subsistence
- Demand for work from companies and for training from the communities
- Intensive use of public services; routes/security/health/education
- Shared territory and fresh-water resources
- Possibility of employment and local development and youth permanence
- High sensitivity of heritage and ancestors, vindication of indigenous peoples

Cumulative Impacts: However, what is at stake is not just a single location, but the impact of an industry on an entire region of the continent. This goes beyond the capacity of a single company or regional administration to govern. For this reason, the authors are convinced that concerted efforts must be made by entities across the industry, multilateral bodies, and national/regional governments to promote responsible development of lithium mining in the South American Puna. This requires broader studies and analysis strategies covering:

- A regional knowledge base of habitats, food chains, migratory species, and protected species.
- A regional knowledge base of socio-economic conditions and ethnicity.
- An understanding of groundwater processes in the salt flat and wetland environment.
- An understanding of the regional supply of equipment, suppliers-entrepreneurs, consumables, and workforce.
- The cumulative effects of a number of lithium mining enterprizes.

This should be addressed with a strategic impact assessment for lithium in the Puna.

For how long? What comes afterwards?

As with most extractive industries of non-renewable resources, the longer term concern is how the transition is made once the resource is economically exhausted. A single deposit may last 20, 50 or 100 years, and then it will leave some legacy. On that timescale, the demand for lithium may reduce as alternatives are found or recycling become the dominant mode of supply. We also have to build in the flexibility to downsize at relatively short notice. The lifetime of the group of deposits in the South American Puna may last 100's of years, and in that time we must ensure that we do not deteriorate the environment, and that we leave the communities better off than before.