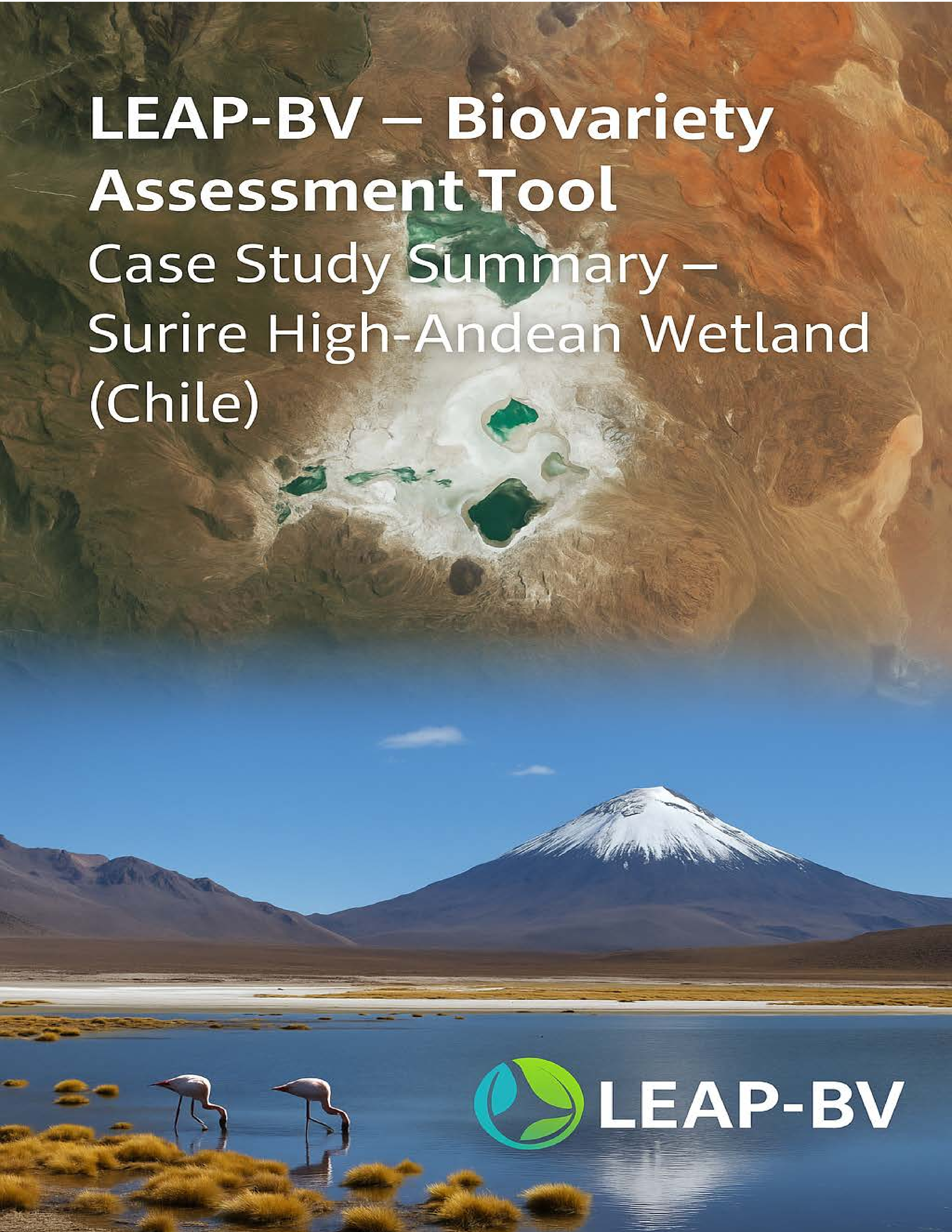
LEAP-BV – Biovariety Assessment Tool

Case Study Summary – Surire High-Andean Wetland (Chile)



LEAP-BV

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Surire High-Andean Wetland (Chile) LEAP-BV – Biovariety Assessment Tool

The Surire Salt Flat, a high-Andean wetland located in northern Chile at over 4,200 m a.s.l., is a critical ecotone where salt flats, peatlands (bofedales) and volcanic landscapes meet. Its mosaic of hypersaline lagoons, wet meadows and saline plains supports important populations of Andean and James's flamingos, wild camelids and a flora adapted to high solar radiation, low oxygen pressure and extreme aridity. At the same time, Surire is under pressure from mining, salt extraction, truck traffic and climate-driven changes that affect water availability and ecological connectivity.

The LEAP-BV approach applies the Biovariety Index (BV) to read Surire as a relational system, integrating three dimensions: Position (BP), Function (BF) and Meaning (BS). In the Locate phase, the wetland is divided into landscape units (lagoons, peatlands, transport corridors, extraction areas) that define the interface between operations and nature. In Evaluate, structural, abiotic and vegetation connectivity are measured, together with basal processes (productivity, water regulation, nutrient cycling) and CO4 functional capacity—cohesion, communication, coordination and conduction of key species. The Meaning dimension incorporates cultural legitimacy, community values and the ecological-symbolic significance of the wetland.

In the Assess phase, BV is calculated as a weighted combination of BP, BF and BS and compared to a viability threshold (Vreq) defined from pre-operational or reference conditions. The difference VNRe = BV – Vreq is interpreted as adaptive margin: if positive, it indicates resilience and opportunity; if negative, it signals increasing material risk and the need for restoration and operational adjustment.

Finally, in Prepare, LEAP-BV translates results into concrete action pathways: operational changes, prioritization of restoration in critical corridors, design of monitoring indicators and disclosure guidelines consistent with TNFD. Surire thus becomes a demonstrative case of how Biovariety can operate as a common language between science, communities, regulators and companies to manage nature-related risks and opportunities in an anticipatory and relational way.

LEAP-BV Case Study

Surire High-Andean Wetland (Chile)
Tool: LEAP-BV – Biovariety Assessment Tool

1. Site and user context

The Surire Salt Flat is a high-Andean wetland located in the Region of Arica and Parinacota (Chile), within a protected area that is both a Biosphere Reserve and a Ramsar site. The area combines very high ecological relevance (migratory birds, flamingos, peat bogs and high-Andean wetlands) with increasing pressure from mining, road infrastructure and climate change.

The study was carried out by an applied ecology consulting team that advises mining companies and public agencies on the implementation of international standards for biodiversity risk reporting.

Overall objective
To test the applicability of the **LEAP-BV** tool as a relational indicator of ecosystem integrity and TNFD-compatible risk in high-Andean wetlands exposed to mining pressure.

2. L Phase – Locating the interface with nature

The tool was used to structure the **L (Locate)** phase of the LEAP approach:

- **Operational unit:** Metal mining project with extraction and transport activities near the salt flat (company name omitted in this confidential pilot).
- **Sector:** *Metals & Mining*.
- **Ecological unit:** "Surire ecotome", defined as the set of saline flats, shallow lagoons and associated peat bogs over an area of ~12,000 ha.
- **Spatial disaggregation:** LEAP-BV was configured with four landscape units:
    1. Core lagoons and saline flats.
    2. High-Andean peat bogs and wetlands.
    3. Transition areas with roads and other infrastructure.
    4. Catchment and groundwater recharge areas.
- **Reference scenario (Vreq):**
    - Historical information prior to the expansion of mining operations (Landsat/Sentinel images 1985–2000) was combined with a better-conserved analogue site.
    - This scenario was used to set minimum viability thresholds **BP, BF and BS** (Vreq).

This phase allowed the interface between operation and nature to be documented explicitly in terms of **ecological position**, not only in terms of administrative boundaries, as required by TNFD.

3. E Phase – Evaluating priority dependencies and impacts

In the **E (Evaluate)** phase, the LEAP-BV tool was populated with data from:

- NDVI time series and vegetation cover (Landsat and Sentinel).
- Hydrological information (conductivity, pH, flow, temperature).
- Records of key species (flamingos, camelids, macrophytes of peat bogs).
- Qualitative information from local communities on cultural uses of water and landscape.

The assessment is structured around the three dimensions of the Biovariety index:

3.1. Ecological Position (BP)

- **Ecological connectivity (Ce):**
  - Structural connectivity of the landscape, continuity of water bodies and movement corridors for species.
  - Aggregated into a value of Ce ≈ 0.63 (0–1 scale).
- **Basal processes (PB):**
  - Productivity of peat bog vegetation, nutrient cycling and water regulation in each landscape unit.
  - Computed using the geometric mean of basal processes, yielding PB ≈ 0.58.

The calculation module of the tool produced a **current BP ≈ 0.60**, compared to a reference BP ≈ 0.72.

3.2. Ecological Function (BF)

Key functional groups were identified (ecosystem engineers, filter feeders, primary producers, dispersers) and their **CO4 capacities** were evaluated:

- Cohesion
- Communication (interactions and flows between units)
- Coordination (synchronisation of processes)
- Conduction (capacity to drive and reorganise the system)

Using the soft-max operator implemented in the code ($\tau = 0.5$), the system computed:

- Current BF ≈ 0.55
- Reference BF ≈ 0.68

Crucially for TNFD, the **business dependencies** (regulated water supply, maintenance of wetland habitat for protected species) are explicitly linked to these CO4 capacities, rather than only to descriptive metrics of species richness or abundance.

3.3. Meaning / cultural legitimacy (BS)

The tool integrated:

- Cultural value of emblematic species for Aymara communities and for nature-based tourism.
- Legitimacy of each landscape unit (lagoons, peat bogs, catchment areas) in terms of cultural meanings and traditional uses of water.
- Symbolic value of water and the wetland for local organisations and for protected-area policy.

Using the geometric mean of cultural value of species, habitat legitimacy and process significance, the tool obtained:

- Current BS ≈ 0.62
- Reference BS ≈ 0.75

4. A Phase – Assessing material risks and opportunities

With current values for BP, BF and BS, the integrated Biovariety index was calculated as:

$$BV = 0.4 \cdot BP + 0.4 \cdot BF + 0.2 \cdot BS$$

- **Reference BV:** ≈ 0.71
- **Current BV:** ≈ 0.58

Minimum viability thresholds (**Vreq**) derived from the reference scenario were:

- $BP_{min} = 0.50$
- $BF_{min} = 0.50$
- $BS_{min} = 0.45$

Using the methodological weights (0.4–0.4–0.2) this yields:

- **Vreq ≈ 0.49**

The **Ecological Non-Required Variety (VNRe)**, understood as adaptive margin, is calculated as:

$$VNRe = BV - Vreq$$

- **Surire VNRe ≈ +0.09**

Interpretation according to the tool's risk matrix:

- VNRe in the range **0 < VNRe ≤ 0.10 → medium risk**, with a positive but limited adaptive margin.
- The ecosystem remains viable, but small additional pressures could quickly push it towards the relational collapse threshold.

The tool translated this result into TNFD categories:

- **Physical risk:** medium (estimated probability of operational restrictions 5–20%).
- **Transition risk:** medium, associated with restoration requirements and biodiversity commitments.
- **Reputational and social risk:** medium–high, given the cultural relevance of the wetland and its Ramsar status.
- **Opportunities:** potential for "nature-positive" projects to increase BV above 0.65, with options for value creation (e.g. biodiversity credits or ESG reputation gains).

5. P Phase – Preparing response and disclosure

Based on the diagnosis, the **P (Prepare)** module of LEAP-BV suggested:

1. **Operational adjustments**
   - Reducing water abstraction in periods that are critical for the reproduction of aquatic birds.
   - Reviewing transport routes to decrease fragmentation of peat bogs.
2. **Restoration and monitoring programme**
   - Restoration of degraded peat bog vegetation.
   - Annual monitoring of BV and VNRe as an integrated "environmental balance sheet".
3. **TNFD metrics and targets**
   - Incorporating BV and VNRe as internal metrics linked to TNFD core indicators L-1/L-2 (land area and condition) and D/I-1/D-2 (dependencies and impacts on ecosystem services).
   - Publicly committing to maintain **VNRe** > **0.10** over a 5-year horizon.
4. **Governance and participation**
   - Establishing working groups with local communities to validate the "Meaning" dimension (BS) and co-design restoration actions.
   - Linking BV results to corporate governance of environmental and social risks at board level.

6. Key outcomes of using the tool

- The tool enabled a shift from a fragmented reading (isolated physical indicators) to a **single relational index (BV)** and an **adaptive margin (VNRe)** directly usable in corporate risk matrices.
- LEAP-BV facilitated **alignment between environmental specialists and finance/risk teams**, translating VNRe ranges into probabilities of operational restrictions and approximate magnitudes of restoration CAPEX.

- In the Surire case, the user company gained a quantitative justification for investing early in restoration and mitigation, instead of waiting for sanctions or loss of social licence to operate.
- The case showed that the LEAP-BV approach is replicable to other salt flats and high-Andean wetlands using the same data sources (satellite images, water and fauna monitoring, local cultural information).

7. Conclusion

The Surire Salt Flat case demonstrates that the **LEAP-BV – Biovariety Assessment Tool** is:

- **Operationally usable** by environmental and risk teams in mining companies.
- **Methodologically consistent** with the TNFD LEAP approach, explicitly covering phases L, E, A and P.
- **Able to integrate position, function and meaning** of the ecosystem into a single indicator (BV) and an adaptive margin (VNRe) that can be directly translated into financial risk and opportunity.