Land use changes and anthropogenic impacts due to rice fields in Santa Fe (Argentina)

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Introduction

The paleochannel plain of the Bajo de los Saladillos (PPBS), a subtropical freshwater wetland system in Santa Fe province, Argentina (2200 km2), has undergone significant environmental transformations due to the expansion of rice cultivation.

These crops use water from the San Javier River for irrigation, and discharge excess water into the Saladillo Dulce stream, along with intensive use of agrochemicals, and controlled burning after harvest.

We aimed to analyse land-use changes associated with rice production, and assess the impact on water quality.

Land use and land cover transformation

Field surveys: July-August 2021 and February 2022

Vegetation characteristics. Water conditions. Productive land use.

Landsat 4-MSS scenes: 12-04-1986 and 08-01-1987

Landsat 8-OLI scenes: 01-18 and 07-29 of 2021

Google Earth and Sentinel-2 satellite imagery: 01-21 and 07-20 of 2021

MODIS satellite data (MCD64A1, period 2002-2022)

Cover types

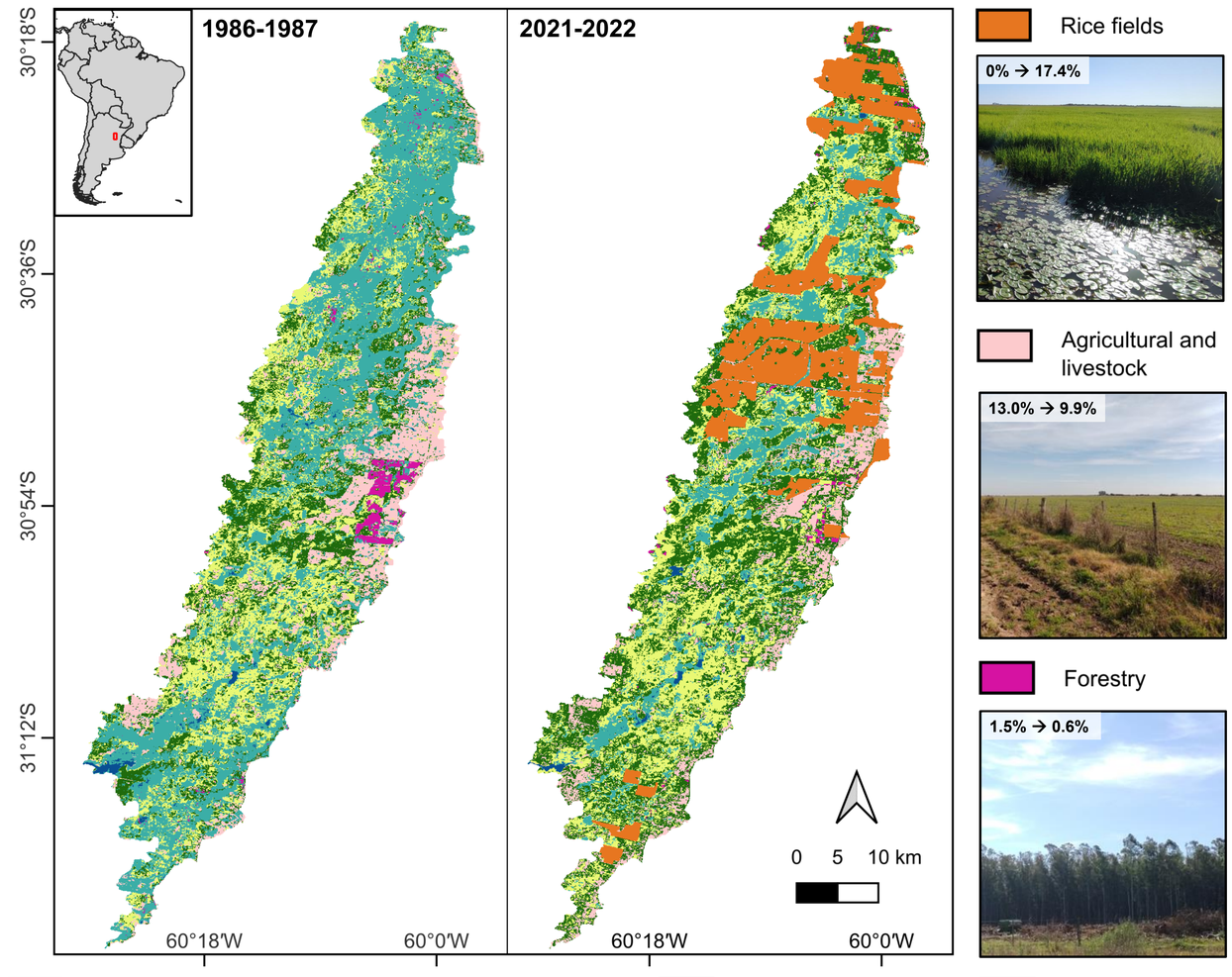
Rice field delineation

Unsupervised k-means classification: 50 classes; 1000 iterations

Burned areas inside and outside rice fields (2002-2022)

Land use and land cover classification (2021-2022)

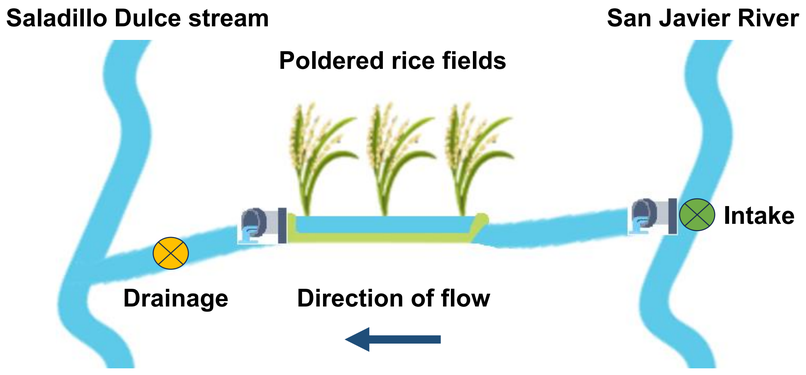
Land use and land cover classification (1986-1987)



Physicochemical variables, agrochemicals, and metals

Sampling: rice sowing (spring) and harvesting (summer) in the period 2022-23 and 2023-24.

In water intakes and drainages, three rice fields complexes (see QR).



In situ

Physicochemical variables (multi-parameter water quality checker)

Lab

Nutrients (HACH protocols)
Agrochemicals (SPE, GC-MS/MS and UHPLC-MS/MS)
Metals (TXRF, S2 Picofox Bruker)

Physicochemical parameters (mg/L)	**Phosphate** > sowing: 0.3-2.1 < harvesting: 0.2-0.8	**Ammonium** > sowing: 0.1-2.5 < harvesting: 0.1-0.4	**BOD in 22-23** > intakes: 2.6-7.8 < drainage: 1.0-5.0	**COD in 23-24** > intakes: 26-85 < drainage: 1.5-9
Agrochemicals < variety in intakes than in drainages	**2,4-D (µg/L)** < intakes: 0.2-1 > drainages: 0.03-2	**Glyphosate (µg/L)** Sowing: intakes 0; drainages 0.8-22 Harvesting: intakes 0.25-1.2; drainages 0.15-5.3	**AMPA (µg/L)** Sowing: intakes 0; drainages 0.3-5 Harvesting: intakes 0.15-0.25; drainages 0.2-1.2	
Metals < values in intakes than in drainages	**Cr (mg/L)** < intakes: 0-0.03 > drainages: 0.01-0.10	**Cu (mg/L)** < intakes: 0.01-0.02 > drainages: 0.01-0.05	**As (mg/L)** < intakes: 0-0.006 > drainages: 0.006-0.015	

Water Quality Index (WQI) and Integrated Biomarker Response Index (IBRI)

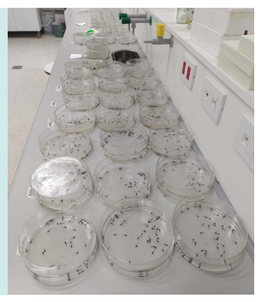
Water Quality Index (WQI)

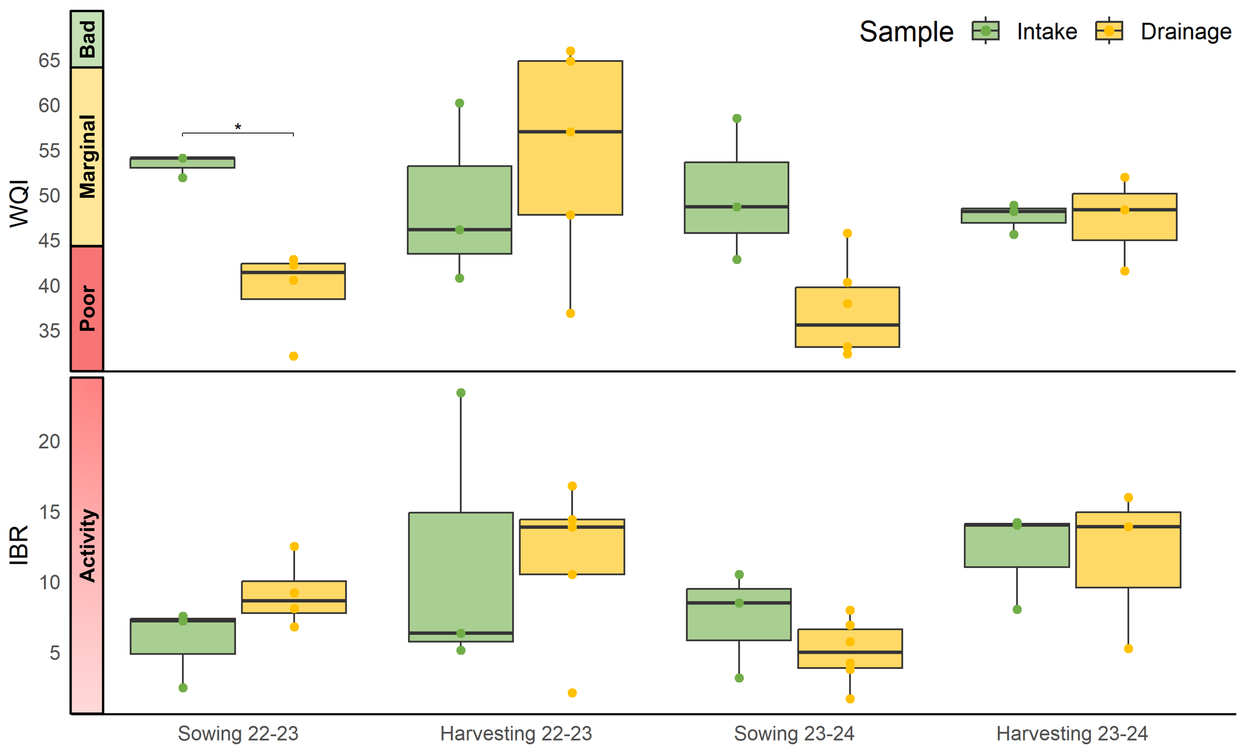
pH: 5-9
EC: < 1250 uS/cm
DO: > 4.7 mg/L
TSS: < 81.25 mg/L
BOD5: < 11.63 mg/L
Nitrate: < 17 mg/L
Nitrite: < 0.06 mg/L
Ammonium: < 1.29 mg/L
Phosphate: < 0.4 mg/L
Cr: < 0.002 mg/L
Cu: < 0.002 mg/L
As: < 0.05 mg/L
Zn: < 0.03 mg/L
Mn: < 0.1 mg/L
Ni: < 0.025 mg/L
Pb: < 0.001 mg/L

Integrated Biomarker Response Index (IBRI)

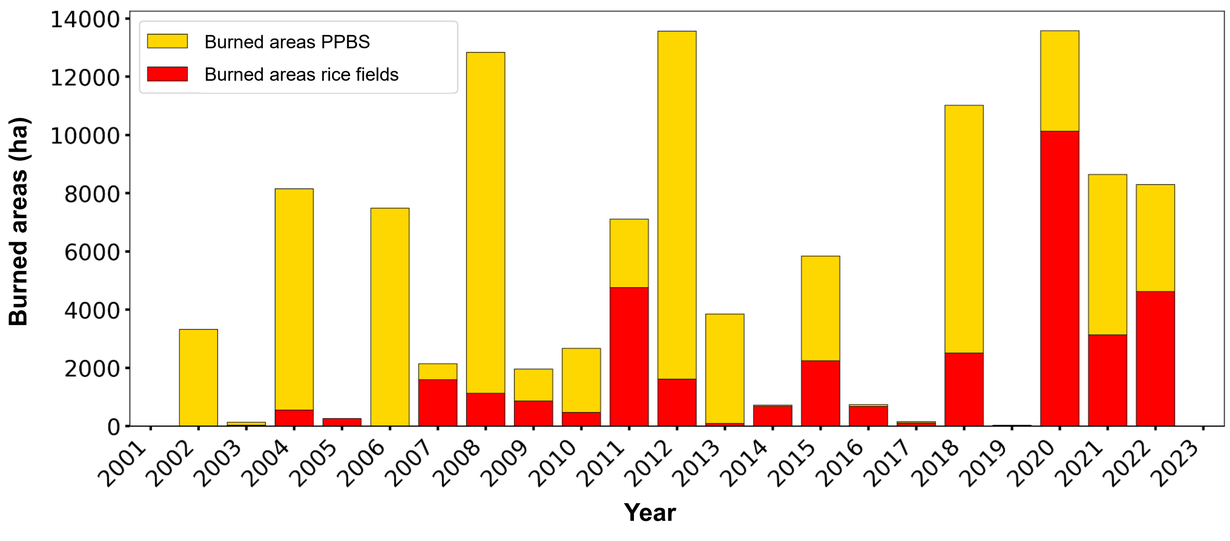
Water samples + *Rhinella arenarum* larvae (stadium 25)

Biomarkers: acute (96 h). Glutathione S-transferase, reduced glutathione, catalase, acetylcholinesterase and butyrylcholinesterase activity.





Burned areas inside and outside rice fields



Conclusions

A change in land use was detected in the last decades in the Bajo de los Saladillos. There was an increasing conversion to rice fields, more than half of which had previously been estuaries and marshes, indicating the loss of natural wetlands. Fires have increased in recent years, mainly in rice fields for post-harvest stubble removal.

The physicochemical characteristics of the water varied according to the time of sampling. A water quality index (WQI) generally showed lower values at drainage points, where we also found higher concentrations and diversity of agrochemicals (e.g. glyphosate, 2,4-D) and metals (Cr, Cu, As). Oxidative imbalance was observed in *R. arenarum* larvae exposed to samples from both intakes and drainages samples in both seasons and periods.

We conclude that rice fields have significant multiscale impacts on the Bajo de los Saladillos wetland ecosystems, underscoring the need for this diagnosis to inform environmentally sustainable rice production measures.