PAN AMERICAN BIOFUELS AND BIOENERGY SUSTAINABILITY
AN NSF RESEARCH COORDINATION NETWORK

IMPACTS OF SUGARCANE EXPANSION ON WATER RESOURCES IN AREAS OF SÃO PAULO STATE

Marjorie M. Guarenghi
Arnaldo Walter

University of Campinas - UNICAMP
Faculty of Mechanical Engineering - FEM

UNICAMP

Summary

1. Introduction

2. Database and areas of study

3. Methods of analysis

4. Results and discussions

5. Conclusion

Introduction

➢ The expansion of sugarcane cropping for bioethanol production can impact:

    - quantity of water resources
    - quality of water resources

➢ The consumption of water associated to sugarcane and ethanol production has decreased during the last years due to:

- reduction of water withdraws for the industrial phase through the optimization of some processes and water reuse;
- use of fertirrigation

Introduction

➤ However:

Land use changes

Different management practices
} can modify the runoff processes in the watersheds and the river flows
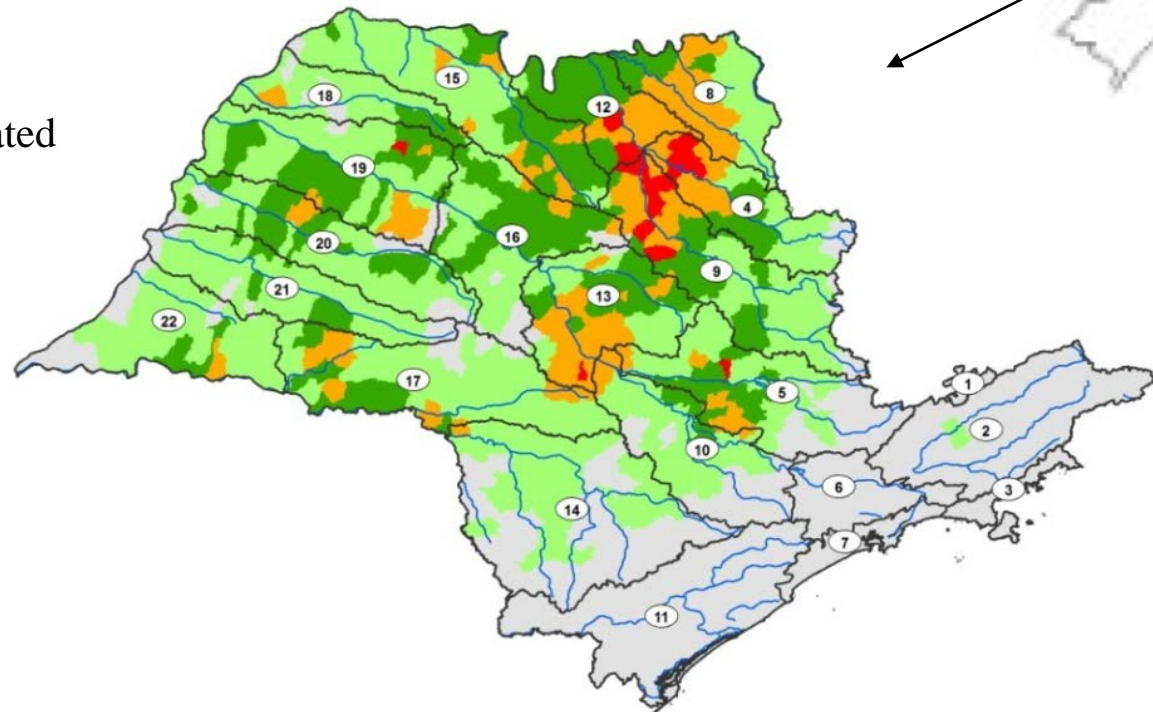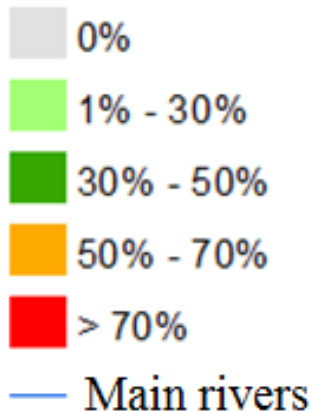
Vinasse (fertirrigation)

Use of agrochemicals
} contribute to the pollution of water bodies

Introduction

➢ The state of São Paulo:

  → main producer of sugarcane and ethanol in Brazil

  → is supposed to be the one with the largest water monitoring
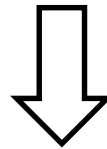   network

Percentage of area cultivated
  with sugarcane (2010)

Brazil

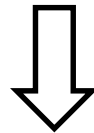|	
▢	0%
▢	1% - 30%
▢	30% - 50%
▢	50% - 70%
▢	> 70%
—	Main rivers

5

Objective

➤ To evaluate whether it is possible to observe **impacts of sugarcane** expansion both on the **quantity** and the **quality** of water bodies.

⇩

Using database publically available of water monitoring in the state of São Paulo

⇩

What can be understood from the data publically available?

Database and areas of study

➢ **Database:**

Monitoring stations regarding **precipitation, discharge** and **quality parameters** provided by:

- Brazilian Water Agency (ANA)

- Department of Water and Energy of the State of São Paulo (DAEE)

- Environmental Agency of the State of São Paulo (CETESB).

> **Selection of studied areas:**

<u>Discharge monitoring stations</u>:

      - with the longest historical series (above 15 years);

      - with less than 10% of failures;

      - located in areas with significant expansion of sugarcane over the years;

      * stations located near hydroelectric plants were avoided;

        small scale rivers basins were prioritized

<u>Water quality stations</u>:

      - availability of parameters related to agrochemical inputs and vinasse.

Potassium,
Total phosphorus,
Nitrogen series
(nitrate, nitrite, ammonium)

Database and areas of study

➢ **Limitations:**

→ unavailability of long time series of discharge and variables of water quality in
    areas with growing sugarcane cultivation.
→ many data of monitoring stations have several failures, mainly in small
    scale basins

➢ The methodology for evaluating the effects of land use change in river flow is
    more conclusive in small-scale basins

➢ However, the hydrological monitoring network in small-scale basins has constrains
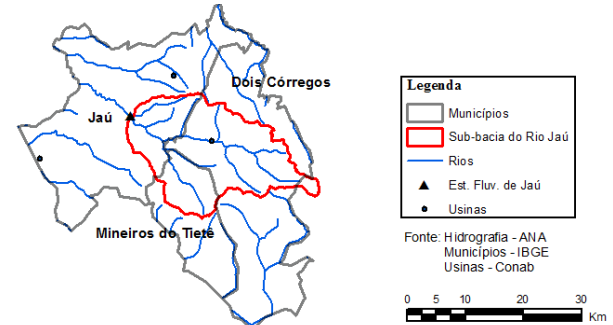   → data is available for just few years
    → the series have several failures.

➢ In Brazil, the implementation of a water monitoring network was motivated by the
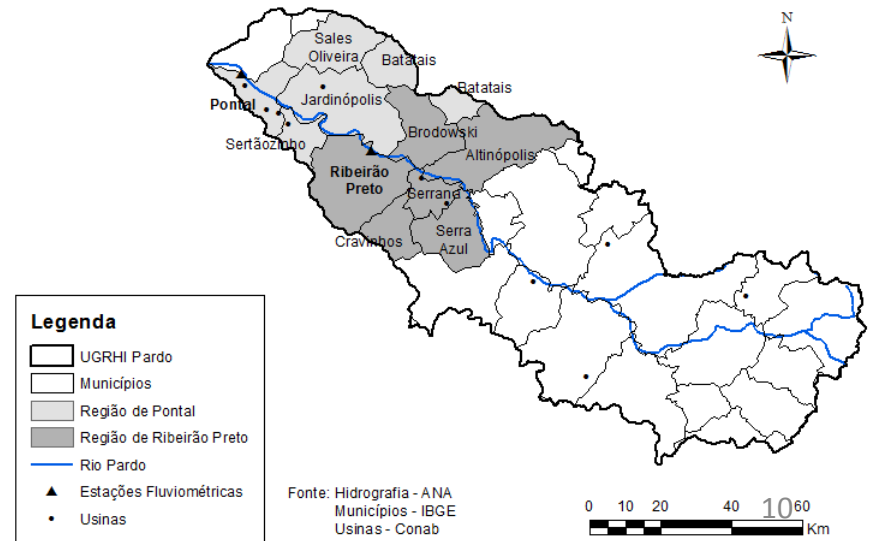   importance of hydroelectric plants
    → shortage of monitoring stations in basins with less than 500 km^2
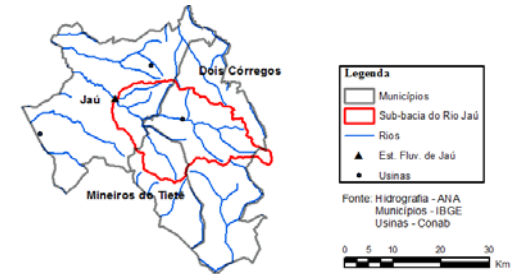
Areas of study

> **Region of Jaú River**

> **Region of Pontal and Ribeirão Preto**

Areas of study

➤ **Region of Jaú River**

- Jaú River
- Drainage watershed of 417 km^2
- Period of evaluation:
  1982 – 1999 (discharge) → the area planted with sugarcane increased
  20% (regarding the total area)

- Three mills of sugar/ethanol are placed close to the Jaú River.

➤ **Region of Pontal and Ribeirão Preto**

- Pardo River
- Drainage watershed of 12.445 km^2 (Pontal)
  10.679 km^2 (Ribeirão Preto)
- Period of evaluation:
  1974-2011 (discharge) →sugarcane increased 40%
  1989-2011 (water quality)
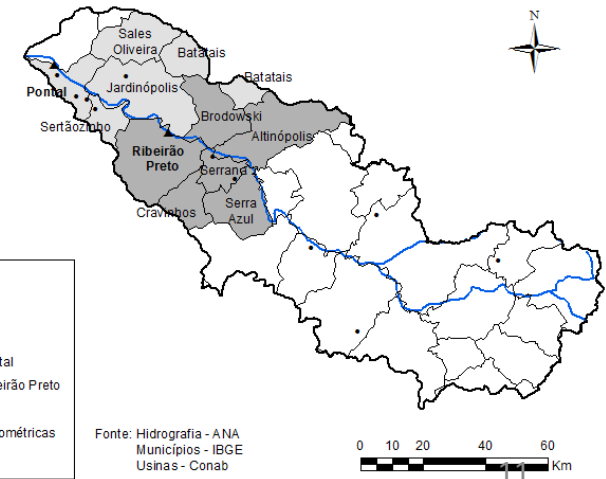
- Seven sugar/ethanol mills are located near the discharge and water quality stations analyzed.

Methods of analysis

➢ The historical time series provided by the monitoring stations were analyzed using nonparametric procedures.

Nonparametric tests

Mann-Kendall's test → to detect trends
Pettitt's test → to determine abrupt changes

➢ Correlation tests : Kendall's correlation

Discharge data ⟶ correlated with ⟶ - sugarcane planted area

Concentrations of water quality variables ⟶ correlated with ⟶ - sugarcane planted area

- population growth.

Results - Discharge analysis

Quantity analysis:

➢ Mann-Kendall's test → Pettitt's test   no trend and no changing point were detected in total annual discharge of the rivers analyzed.

➢ The discharge time series presented better correlation to precipitation series.

➢ No significant correlation was observed between sugarcane growth and the river flows.

Quality parameters series in Pardo River:

	Station of Pontal			Station of Ribeirão Preto		
	Trend test	**Correlation test**		**Trend test**	**Correlation test**	
	(MK/MKS)	Population	Sugarcane	(MK/MKS)	Population	Sugarcane
Potassium	-	-	-	-	-	-
Phosphorus	-	-	-	**T(+)**	sign	-
Nitrite	**T(+)**	sign	sign	**T(+)**	sign	sign
Nitrate	**T(+)**	sign	sign	**T(+)**	sign	sign
N_{amon}	**T(+)**	sign	sign	**T(+)**	sign	sign

 T(+): significant increasing trend . Significant level at 5%

➢ The increase on concentrations can be associated to the
  → fertilizers leaching;
  → discharge of sewage and industrial effluents without appropriated treatment from urban areas

➢ Pettitt's test → 1998/1999 → not correspond to years of increase of sugarcane planted area

Conclusions

Quantity analysis:

➢ According to the tests, **no significant results were observed**

➢ The stations with the largest time series correspond to **meso- or large-scale basins**.
   → **several** anthropogenic, climatic and geographical **factors impact** on water resources
   → it is difficult to isolate the effects of sugarcane expansion on catchment hydrology

Quality analysis:

➢ Water quality **parameters related to sugarcane activity** showed **significant increasing** trends in general, but it is difficult to isolate the effects of sugarcane from the effects of residues from urban areas

➢ Impact assessments on **water quality** were also **constrained** by the **shortage** of important monitoring **parameters related to agriculture practices**

➢ The bulk of **quality monitoring** stations are in **large rivers**

➢ Several time series have **failures** that constrain the assessment along the time.

Conclusions

➢ Among the biggest sugarcane producers, the state of São Paulo is supposed to be the one with the largest water monitoring network.
→ time series are poor for analyzing the relationship between land use changes and its effects on water resources.

➢ For the proper evaluation of impacts on water resources caused by the expansion of sugarcane activity, using statistical procedures:
→ it would be necessary to monitor specific areas in small-scale watersheds.

➢ This would allow proper data gathering in regions where the influence of other factors could be reduced.

➢ Investments are required for the installation of new gauging stations to expand the network of water controlling stations.

Thank you!

Marjorie M. Guarenghi * and **Arnaldo Walter**

*marjorie@fem.unicamp.br

Faculty of Mechanical Engineering
University of Campinas – UNICAMP
Campinas, SP - Brazil

Laboratório Nacional de Ciência e Tecnologia
do Bioetanol - CTBE/CNPEM