

## **ESTIMATION OF THE BURDEN DUE TO BIOMASS BURNING FROM SUGARCANE: AN ENVIRONMENTAL, HEALTH AND ECONOMIC APPROACH IN THE SÃO PAULO STATE, BRAZIL.**

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Economic activities contribute to development simultaneously as they can generate environmental impacts. The challenge of sustainable development is to acquire balance in the economic, environment and social aspects. In the case of the ethanol production derived from the sugarcane in Brazil, some regions still adopt the burning process previously from harvesting. The pollutants emissions of this process implicates in interfering the social aspect of sustainability justified by the harming on the health population. These impacts reflect on the reduction of cardio respiratory capacity as well as increasing hospital admissions and even mortality indexes.

In order to guarantee the development, well-being and economic growth of these regions, it is important to estimate these impacts so that to introduce measures that can directly contribute to the sustainability.

This study investigated the impacts of the sugarcane burning in two cities of countryside of São Paulo state, Brazil, analyzing health indicators related to cardio respiratory outcomes (mortality and morbidity) associated to the number of sugarcane burnings detected by monitoring satellites (NASA MODIS images counting) and meteorological variables (air humidity and temperature), considering a time-series data from 2001 to 2010. The most susceptible group to the deleterious effects of air pollution, children under 5 years old and the elderly (60 years old and over), were chosen as population in this study.

An evaluation using the production data of sugarcane in the cities of the state and the numbers of fires registered by remote sensing was conducted aiming to select two locations that had high distribution of fires throughout the harvest period (May to October - driest period of the year) compared to the amount of sugarcane produced in the last 10 years. The obtainment of these selected cities allows indirectly inferring the potentially exposed populations to the harmful pollutants' emissions due to the burnings.

Generalized Linear Model (GLM) using Poisson regression with a log-link function was performed in order to assess the association between the selected variables including controls for possible confounding factors. Akaike's Information Criterion (AIC) was used in the development of the core model for variable selection. All analysis considered a significant level of 0.05. All variables were in a monthly basis.

The health endpoints analyzed were mortality due to cardio respiratory diseases as well as morbidity due to cardio respiratory diseases (hospital admissions incurred to the public health system) in the age group: elderly (> 60 years) and children (<5 years).

The health impacts obtained were applied in terms of attributable deaths and morbidity as relative risks by the statistical model. The burden was expressed in terms of Disability Adjusted Life Years (DALYs) and finally, a monetary valuation of the burden was performed.

Sugarcane harvesting in Brazil has been done historically by manual harvesting. In this kind of process, there must be a previous burning of the crops so that to kill reptiles and insects and preventing injuries to the workers. In the recent years, a state law was established in order to diminish the burnings and stimulating the adoption of mechanized harvesting, aiming to reduce the environmental impacts of the excess air pollution.

For a comparison purpose, we estimated the harvesting costs' differences per average production of both processes - manual and mechanized - and included the result in the overall analysis.

The selected cities were Piracicaba and Jaú, and the attributable mortality obtained by the burning points totalized 382 deaths which corresponded to 4,454 years of life lost. A morbidity analysis was performed and the associated outcomes, considering cardio respiratory diseases, corresponded to 2,694 cases.

The relative risk obtained for mortality was 1.071 [95% confidence interval (CI), 1.066-1.075] for Jaú and 1.043 [95% confidence interval (CI), 1.041-1.046] for Piracicaba. The relative risk results for morbidity was 1.034 [95% confidence interval (CI), 1.033-1.036] for Jaú and 1.035 [95% confidence interval (CI), 1.034-1.036] for Piracicaba.

The total value estimated were US\$ 351,6 million concerning the valuation of the premature deaths, morbidity and the comparison of manual and mechanized harvesting.

These results demonstrate the inequity relative to the negative externalities of ethanol production due to the burning process in the countryside of São Paulo state when compared to the benefits of ethanol large scale consumption in São Paulo capital, assigned by the perceived advantage of ethanol fuel concerning environmental aspects (the reduction of pollutants emitted from vehicles in urban centers), the flex fuels vehicles production' share in Brazil reaching 90% in 2010 and the uncertainties in fossil fuels supply.