The Impact of Straw Burning on Mortality Rate: A Case Study of Northeast China

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Abstract. Northeast is one of the main grain producing areas in China and also has a large number of straw resources. However, due to the high cost of recycling and the limited level of science and technology, most of the straw resources are not recycled and are directly burned in the open. Straw burning produces large quantities of toxic gases and some suspended particles, which have a serious impact on human health and the environment. This report analyses straw burning data, air quality indices, particulate matter concentrations, and mortality rates in the Northeast, and finds that straw burning is serious in many of the more populous cities in the Northeast, and that these cities also have poorer air quality. At the same time declining air quality increases people's mortality rates. Therefore, this paper argues that straw burning can have negative externalities on the environment, thus affecting mortality rates. Government incentives can be introduced to reduce straw burning, thereby increasing social benefits.

Keywords: Straw Burning, PM2.5, Mortality.

1. Introduction

1.1. Straw Burning and Air Pollution

China has a relatively large area under grain cultivation, is rich in production, and also has the largest straw resources in the world [1]. However, like most developing countries, China has not recycled these straw resources well. Recycling straws is cumbersome for farmers, so it is common for farmers to burn crop residue in the open after harvest. Burning crop straw on site is more convenient for farmers and can reduce their disposal costs [2]. The ash produced by burning these remains can increase soil fertility levels, thereby increasing the productivity of arable land. However, some research has demonstrated that burning straw can have detrimental effects on the environment and that, in certain places, it is a major contributor to seasonal air pollution [3].

Northeastern China refers to the provinces of Liaoning, Jilin, and Heilongjiang, as well as five cities to the east of Inner Mongolia. Northeastern is the main granary of China and grows soybeans, corn, rice, and other crops. Due to the higher latitude and longer winters in the Northeast, most of the crops grown are grown in a single season. Straw burning happens mostly in October and November, when most of crops are harvested [4]. When agricultural straws are burned, hazardous materials like greenhouse gases, particulate matter (PM), and other toxic compounds are released. These pollutants pose a risk to human health, especially to the elderly, children, and people with respiratory problems [5]. At the same time, the Northeast often faces severe air pollution during the autumn and winter months, which coincides with the timing of most straw burning. This suggests that air quality in the Northeast may have a lot to do with straw burning.

1.2. Straw Management Policy

The Chinese Government attaches great importance to environmental issues. Since the 1990s, the Chinese government has been promulgating regulations against straw burning. China changed its agricultural laws in 2002, including a clause requiring crop straw to be disposed of properly in order to lower air pollution. The Circular Economy Promotion Law of 2008 placed emphasis on the encouragement of farmers to make extensive use of left straw by utilizing appropriate technology. However, this has not eliminated the burning of straw, and many farmers continue to burn straw even

when they would rather be fined [6]. Since 2016, the government has been subsidizing farmers and businesses to recycle straw. Such incentives have helped to reduce straw burning [7].

2. Data

2.1. Straw Burning Data

The MODIS (Moderate Resolution Imaging Spectroradiometer) on two satellites, TERRA and AQUA, provided the initial data on burning straw [8]. At 10:30 am, 1:30 pm, 10:30 pm, and 1:30 am, the two satellites will fly over China to gather data on fire points. The Satellite Environmental Centre of the Ministry of Ecology and Environment (MEE) differentiates fire data in MODIS based on geographic information and land use, from which it then collects data on fires caused by straw burning. Farmers don't know exactly when satellites fly over the Northeast, they don't deliberately avoid satellite surveillance, So MEE can count most of the straw burning.

2.2. Air Monitoring Station Data

The China Air Quality Online Monitoring and Analysis Platform, which provides PM2.5 and meteorological data for 367 Chinese cities, is the source of air quality information for Northeast China. Previous studies have shown that before the automation of sampling and reporting in 2013, China's air quality data were likely to be manipulated by local officials [9]. Therefore, this report focuses on collecting data from Liaoning, Heilongjiang, and Jilin provinces from 2015 to 2020. This report uses air data and city administrative planning maps to construct specific air quality distribution maps.

2.3. Mortality Rate

High levels of air pollution led to higher rates of mortality. However, the Chinese government does not publish infant mortality figures at the city level. Wang et al. constructed a panel dataset of city-level infant mortality rates and showed that Each 10 μg/m3 increase in annual PM2.5 concentrations leads to 163 deaths per 100,000 live births per year in a city [10]. And the mortality rate rises by 3.25% for every 10 μg/m3 increase in PM2.5 [6].

3. Research findings

Figure 1 and figure 2 show the distribution of straw burning in October 2016 and November 2016, where red dots indicate specific burning locations. There were 883 incidents of straw burning in October (702 in Heilongjiang, 73 in Jilin and 58 in Liaoning) and 779 in November (715 in Heilongjiang, 39 in Jilin and 25 in Liaoning). Meanwhile, the majority of straw burning took place in central Liaoning Province, central and western Jilin Province, and western and northeastern Hei Longjiang Province. Although straw burning is prohibited, the data show that in 2016, the situation of straw burning was still relatively serious. Figure 3 shows the average air quality distribution from October 2016 to November 2016, where darker colors indicate poorer air quality. Combining Figures 1, figure 2 and figure 3, it can be found that the areas of poorer air quality highly overlap with the areas of straw burning, which suggests that straw burning does have a negative external effect on air quality.

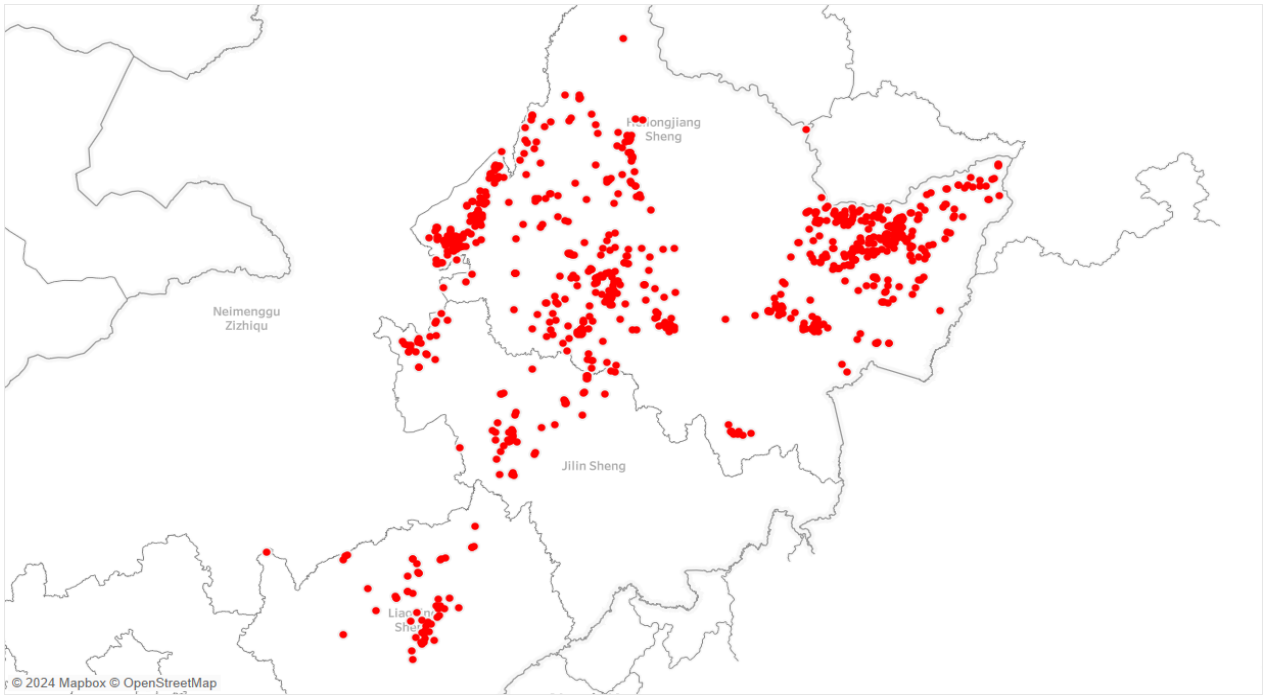

Figure 1. Straw burning distribution from 1 October to 31 November 2016 (Photo Credit: Original)

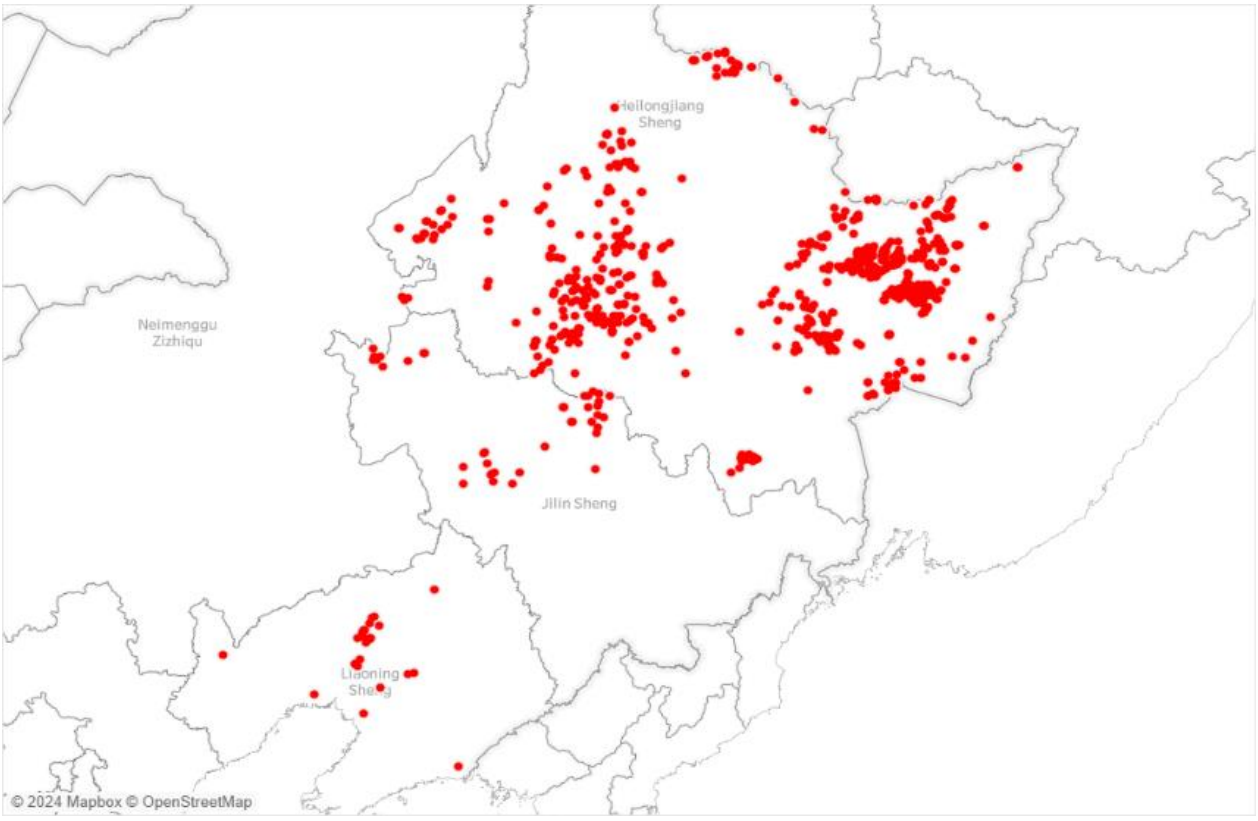

Figure 2. Straw burning distribution from 1 October to 31 November 2016 (Photo Credit: Original)

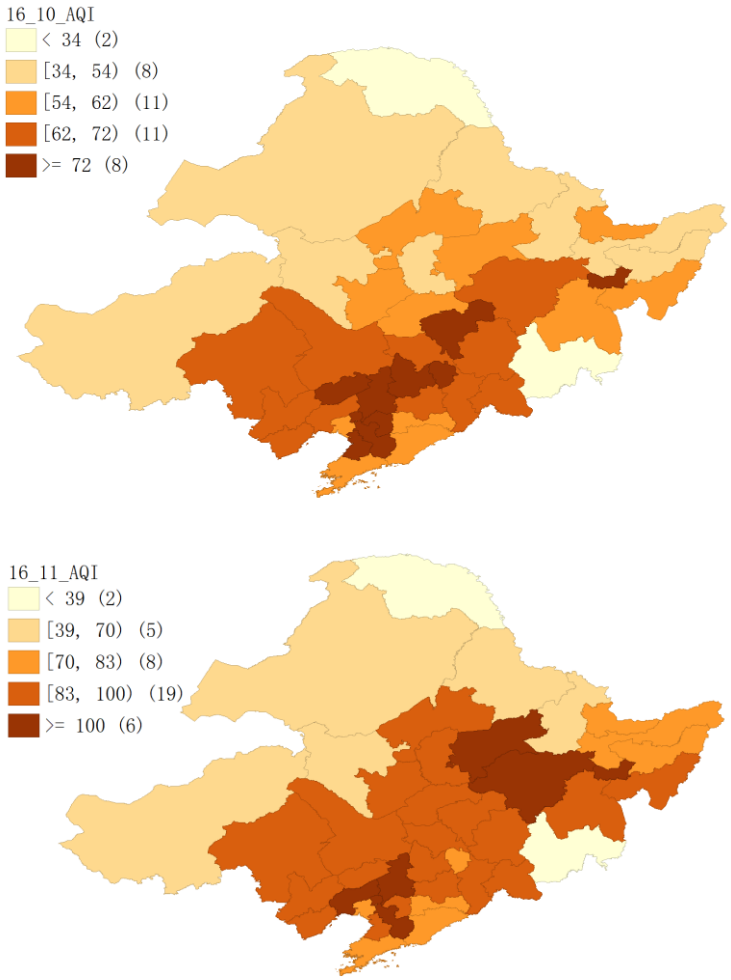

Figure 3. Air Quality Index Distribution from 1 October to 31 November 2016 (Picture credit: Original)

Straw burning causes serious pollution, and the smoke produced after burning contains many toxic and harmful gases. This is one of the causes of air pollution in autumn and winter in the Northeast [11]. Figure 4 shows the change in AQI from January 2015 to December 2020 for Jilin, Liaoning and Heilongjiang provinces. The changes in AQI in all three provinces vary with the seasons. Compared to fall and winter, the AQI is lower in the spring and summer. This suggests that air quality in the North East is significantly worse in autumn and winter than in spring and summer. Figure 5 shows the AQI, PM2.5, and PM10 from January 2015 to December 2020 for Heilongjiang Province. In figure 5, PM2.5 concentrations are significantly elevated in October and November each year and burning straw significantly increases the concentration of PM2.5 [6]. Therefore, this paper think that this elevation in PM2.5 is partly due to straw burning. Studies have already shown that the pollution caused by burning straws can affect people's health and even increase mortality rates [10]. Figure 6 shows the population distribution in the North East, with darker colors indicating a larger population. At the same time, these highly polluted areas are also where the population of the Northeast is more widely distributed, so the impacts from straw burning are likely to be greater. Reducing straw burning therefore has significant social benefits in terms of reducing air pollution and thus population mortality.

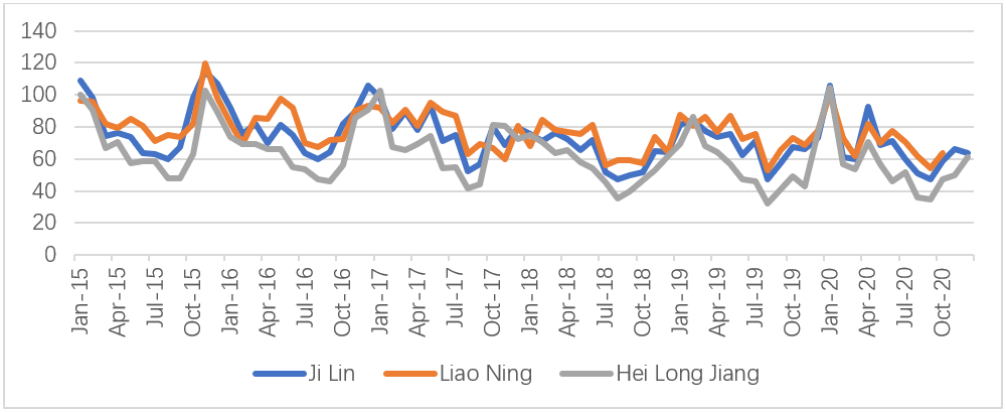

Figure 4. Changes in AQI in the three northeastern provinces (Picture credit: Original)

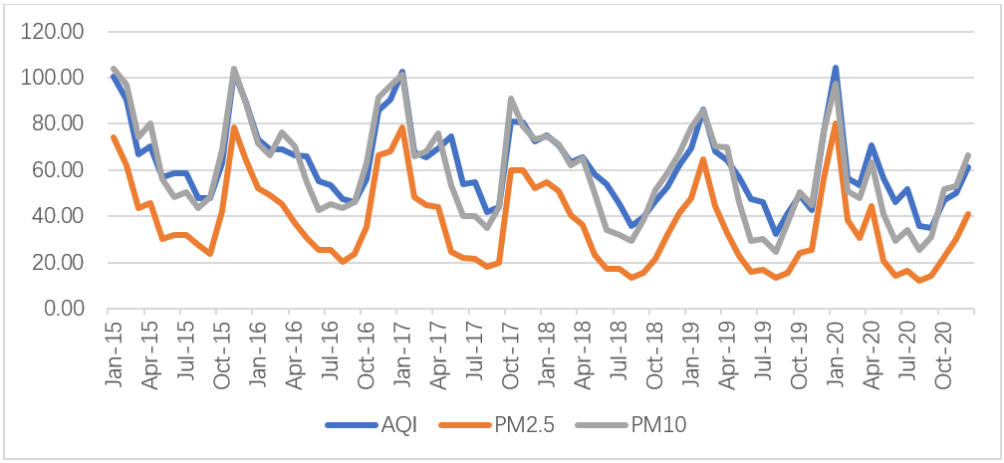

Figure 5. Air Quality Change in Hei Long Jiang Province (Picture Credit: Original)

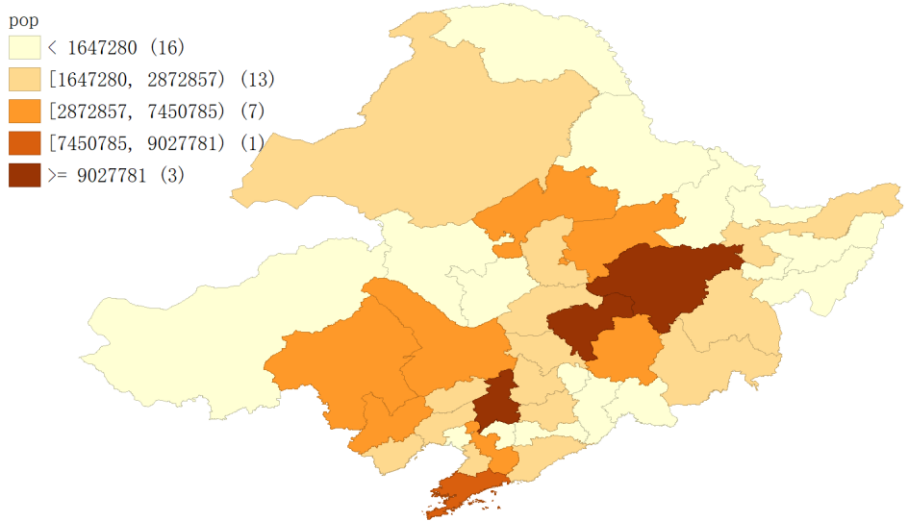

Figure 6. Population distribution map of the north-eastern region (Picture credit: Original)

4. Suggestion

Although China has banned straw burning since the 1990s through the Air Pollution Prevention and Control Law of the People's Republic of China (2018), straw burning has not been eliminated. The cost of using environmentally friendly methods to dispose of straw can be more than a fine for most farmers. In this case, the adoption of innovative incentives is fruitful [7]. The Government

should continue to adopt incentive policies, such as giving farmers subsidies or providing straw recycling services. It should also strengthen publicity and education for farmers, so that they can understand the hazards of straw burning and the alternatives, as well as the advancement of eco-friendly technologies like reusing straw in the field, pulping straw, and producing power from straw.

5. Research Limitation

The data on straw burning comes from local fire data detected by NASA satellites. However, it is not possible to monitor an area around the clock, so it is not fully representative of straw burning in that area, and the actual straw burning data may be higher [11]. There is also a lack of official data on infant mortality rates at the county and municipal levels, so the actual rates may be skewed. At the same time, this report does not exclude the influence of the season and the geography of the north-east on-air quality. Additionally, there is a connection between the process of high air pollution and changes in the weather; the haze is more intense when a cold snap comes before it.

6. Conclusion

By analyzing local fire data, air quality indices, particulate matter concentrations, and mortality rates, this report finds that places with frequent fires and straw burning, such as Liaoning Jilin and Heilongjiang, tend to have worse air quality and higher PM2.5 concentrations, and that mortality rates are higher where PM2.5 concentrations are higher. Therefore, it can be inferred that straw burning increases mortality to some extent. To enhance societal benefits and lessen the detrimental externality of burning straw on air quality, the government can continue to adopt incentive policies. At the same time, awareness-raising and education of farmers should be strengthened, and new environmentally friendly technologies should be promoted and appropriately subsidized.

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