Crop residue burning by farmers causes serious environmental pollution in many parts of the world, including Pakistan and India. In order to help find a solution to this challenge, this policy brief assesses farmer residue management practices in two districts in the rice-wheat cropping area of Punjab, Pakistan.

Residue burning is a common practice in Punjab and a quick way to prepare the rice field for wheat crops. In fact, burning is the cheapest residue management option that farmers have. Yet, not all farmers burn their residue. However, burning increases for many practical reasons — it increases when the time between the harvesting of rice and sowing of the subsequent wheat crop is short, and also when farmers use a ‘combine harvester’ to harvest the rice field. On the other hand, farmers who have livestock are more likely to not burn and use their residue for feeding their animals. Thus, both financial incentives and technological innovations are required to encourage farmers to stop burning and switch to other less polluting alternatives.

This policy brief is based on the work of Tanvir Ahmed from Forman Christian College, Lahore and Bashir Ahmad, University of Agriculture, Faisalabad, Pakistan.

The Rice Residue Problem

Rice residue burning is an environmental problem, because it generates black carbon. Black carbon is now considered the second largest contributor to global warming after carbon dioxide. Black carbon emissions and other types of aerosols also give rise to atmospheric brown clouds (ABCs) in Asia. The aerosols in ABCs decrease the amount of sunlight reaching the earth’s surface by 10-15% and enhance atmospheric solar heating by as much as 50%.

In Punjab, Pakistan, a great deal of rice residue is burned to prepare the land for a second crop. Approximately 80% of the wheat crop in Punjab is grown in fields after a rice crop. Thus, rice residue has to be burned, removed or incorporated into the soil in order to prepare fields for the next wheat crop.

In order to understand the reasons underlying residue burning, Ahmed and Ahmad ask three key questions: 1) How much do rice residue burning and alternate residue disposal options cost? 2) What are the factors that determine farmers’ decisions to burn rice residue? And 3) what are farmers’ perceptions regarding different rice residue management practices? To answer these questions, the study focused on Gujranwala and Sialkot districts in the rice-wheat cropping system in Punjab.

Two Districts in Punjab

Gujranwala and Sialkot are the most important districts in the wheat-rice system in Punjab, in terms of rice acreage. Farms in this area are small and a majority of farmers cultivate less than five acres of land. Further, there is often widespread late planting of wheat, especially when basmati rice is the preceding rice variety. Super Basmati is grown in 71% of the study districts’ total rice area. Basmati 386 and other varieties cover 21% and 8% of rice area, respectively.

This policy brief is based on SANDEE working paper No. 76-13, ‘Why do farmers burn rice residue? Examining farmers’ choices in Punjab, Pakistan’ by Tanvir Ahmed, Associate Professor, Department of Economics, Forman Christian College (A Chartered University), Lahore, Pakistan. Email: tanvirah@yahoo.com and Bashir Ahmad, Professor Emeritus, University of Agriculture, Faisalabad, Pakistan Email: bashiruaf@gmail.com. The full report is available at: www.sandeeonline.org
In order to survey farmers in the study districts, ten villages were first randomly selected from each district using a sampling frame from the Federal Bureau of Statistics. Farmers within each village were categorized into small (with less than 5 acres), medium (between 5 and 7.5 acres) or large farmers (with 7.5 acres and above). Twenty farmers were randomly selected from each village in proportion to their total number in each farm size. Data were collected on a variety of factors through a farm survey in 2010 from 400 farmers.

Key Residue Management Methods

Farmers in Punjab adopt three main residue management practices. These include: 1) the burning of rice residue after the rice harvest or ‘full burn’, including the top part (pural) and the lower parts; 2) the removal of rice straw; and 3) the partial or complete incorporation of rice residue into the soil using farm machinery such as rotavators and disc harrows.

Complete removal of rice residue appears to be the dominant practice among farmers as it is practiced by some 48% of all sampled farmers (see Figure 1). The ‘full burn’ of rice (i.e. burning of pural and lower parts of the rice plant) was carried out by 36% of farmers. Very few farmers removed only the pural and then burned the lower parts of the rice plant. A negligible percentage of farmers followed option 3, i.e. incorporation of rice residue into the soil.

This picture about residue burning, however, changes when the area of rice burned is considered (Figure 1). If assessed by area, the ‘full burn’ method ranks first. Some 58% of the area under rice cultivation was fully burned, while the full removal of rice residue was carried out only in 25% of the rice area. The remaining area was either partially burnt or had rice residue incorporated into the field.

Similar patterns of residue management were observed for the different varieties of rice (Figure 1). Thus, the two dominant residue management strategies that emerge are ‘full removal’ and ‘full burn’.

Figure 1: Rice residue management practices by area of crop and farmer practice (%)
Factors that Cause Farmers to Burn Residue

There are many reasons why farmers burn their rice residue. Some 46% of the farmers reported that the short turn-around time between the harvesting of the rice crop and the sowing of the wheat crop was the main reason for burning. A large proportion of farmers also felt that the inconvenience of using farm machinery for wheat field preparation was one of the reasons they burnt their rice residue.

A majority of farmers reported that they increased the amount of rice residue burnt when they started to use a ‘combine harvester’. To cite a local farmer, “Farmers started burning of rice residue with the introduction of “PAROHLA” (combine harvester)” This technology allows farmers to harvest their rice crops more quickly and efficiently but leaves straw on the ground. This straw is most easily disposed by farmers by burning. The use of this machine encourages farmers to burn rice residue because of labor shortages during the period when rice is harvested and wheat subsequently sown.

Statistical analysis shows that the area in which rice residue are completely removed increases when farms are owners and livestock numbers were high. Indeed, when farmers removed residue, it was pre-dominantly because they used it to feed animals. Some 63% of farmers stated that they used rice straws for animal feed, while 45% said they removed residue because it made it more convenient for them to use farm machinery to prepare their wheat fields.

When it came to alternatives to burning, some 84% of respondents were unaware of any alternative technology.

The Costs of the Different Options

In order to understand how costly the various residue management options were, the study estimated the costs of different practices. The total cost of land preparation for the next crop was cheapest when farmers burn rice residue. The land preparation cost was PKR 3424 (USD 41) per acre (Figure 2) when farmers burn rice residue. The incorporation of rice residue, the next least costly alternative, costs 20% more than the cost of a full burn. Full residue removal was, on average, some 34% more costly than simply burning the residue.

Many farmers remove residue, even though it is an expensive option. Why is this the case? Although the study was unable to document farmers’ net profits, it may be that overall annual profits are higher when residue is removed and...
that this acts as an incentive. It is also possible that farmers who need the residue for animal feed maximize their joint returns from livestock and crop production by removing residue rather than burning it.

The Need for Incentives

The study shows that farmers who are burning their residue will need some form of incentive to adopt a less polluting, but more costly, option. For example, rice residue incorporation is the next best alternative cost wise; however, it requires investing in new planting equipment. The average subsidy required to incentivize farmers to move towards residue incorporation would be in the range of PKR 674-908 (US$ 8-11) per acre. This is the difference between the average cost of fully burning and the average cost of partially or fully incorporating residue into the soil.

Overall, it is clear that farmers in Pakistan currently face short-term private costs from ‘not-burning’ rice residue. However, if they do stop burning there may well be longer-term private benefits in terms of soil quality (see side bar). There will also be public benefits related to air quality. Thus, policy makers should consider the steps they can take to reduce rice straw burning.

How to Discourage Burning

Rice residue can be used for other purposes, but commercial markets for residue will need to be strengthened. Another option is to introduce and consider subsidizing equipment that incorporates rice residue into the soils. For example, the Government could promote machines such as the Happy Seeder that is currently in use in Indian Punjab. This machine helps to sow wheat immediately after the rice harvest, using rice straw as mulch. It does not increase the cost of wheat field preparation and precludes the need for burning rice residue. Finding a technological solution to the residue burning problem may be the most feasible way forward.

Research suggests that, in the long run, the incorporation of residue, as compared to burning, improves soil quality (see side bar). In the light of this, the study recommends that agricultural scientists in Punjab more carefully examine the productivity impacts of different residue management practices. In the meantime, agricultural extension services should highlight the climate and air pollution related damages associated with residue burning, as well as the long-term benefits of residue incorporation.