BLACK CARBON
TACKLING CROP-RESIDUE BURNING IN SOUTH ASIA

In South Asia, crop-residue burning is a regionally significant source of black carbon or soot – a pollutant that affects human health and climate. **Aisling Irwin** reports on recent work in the region that explains why farmers choose to burn their fields and which incentives might encourage them not to.

Every year a brownish haze envelops South Asia and its fringing seas during the dry season. Extending up to three kilometres high this atmospheric brown cloud is a cocktail of pollutant gases and particles. An important ingredient is black carbon, or soot, which is produced in the region mostly from human activities and is implicated in warming the lower atmosphere. It is the second most important contributor to global warming, next only to carbon dioxide, according to a comprehensive assessment published last year by Tami Bond and colleagues[1].

Black carbon has emerged as an attractive candidate for mitigating climate change in the short term. Diesel engines, which are the dominant source of soot in Europe and the Americas, provide the most promising avenue in terms of technological and institutional feasibility[1]. In South Asia, however, biomass burning has been shown to be just as important a source[2]. Biofuels are widely used for cooking in rural parts of the region, and it is also common to observe farmers burning rice stalks and residue after harvest. The Bond *et al.* synthesis suggests that the burning of crop residues contributes just over 10% of South Asia's black carbon. But it also releases significant quantities of organic compounds that tend to have a cooling effect: as a result this process contributes little to the global warming signal in the near term[1].

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Relatively little is known about this source, though, and we cannot rule out significant impacts at the regional scale. Indeed, the unusually sooty brown cloud over South Asia and its environs has been linked to changes in rainfall patterns and the melting of Himalayan glaciers[3]. According to one estimate, burning residues is responsible for about a quarter of India's emissions of carbon-rich particles[4]; it is thus a potential target of mitigation measures. The mixture of black carbon and other fine particles – often arising from the same sources – has been linked to adverse health effects such as respiratory problems and heart disease[5].

We need answers to several questions so as to test the feasibility of targeting crop burning to mitigate climate and improve respiratory health in the region. Why do farmers burn residues? What might discourage them from doing so? Would the same incentives work across the region characterised by diverse cultures, institutions and practices? We now have answers to some of these questions thanks to a series of surveys undertaken by researchers from the South Asian Network for Development and Environmental Economics (SANDEE) in Nepal. The surveys were undertaken in parts of Pakistan, India, Nepal and Bangladesh[6-9].

Testing financial incentives

Once rice has been harvested, farmers across South Asia burn tens of millions of metric tonnes of leftover stalks each year to make way, quickly and cheaply, for wheat. The volumes of smoke have worsened in recent years with the advent of the combine harvester, a machine that leaves the stalks scattered in the field at a time when the race is on to plant wheat. "Once the combine harvester became popular, residue burning increased," says Priya Shyamsundar, Executive Director of SANDEE and a member of IGBP's Scientific Committee.

The farmers burn for compelling reasons and there is no easy, cost-effective way to tackle the problem. Burning leaves a soil that is easy to plough in readiness for the next crop and rids farmers of a material that has little current use. It might have been used for animal fodder but the need for this has diminished with the advent of the motorised tractor. Many farmers believe burning rids the land of weeds, pests and diseases and that the ash is good for the soil, which does seem to be the case in the short term. In the longer term, studies show it is far better to plough the residue back into the soil or compost it: but this is labour

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intensive and hence expensive.

Would financial incentives encourage farmers not to burn their fields? How much do farmers save when they burn? To find out, Krishna Prasad Pant, of Kathmandu University in Nepal, recruited farmers from the country's southern lowland Terai region (Figure 1). He invited them to submit sealed bids for compensation for refraining from burning for a season. He found that the median value of the bids was around 78 US dollars (USD) per hectare; farmers were willing to accept this amount to stop burning rice straw in their fields. Some 170 farmers bid for this amount or less and were selected for a follow-up experiment in which a majority complied with the agreement reached to not burn and accepted payment.

Pant's team trained the farmers either to plough the stalks back into the soil (which necessitated hiring a bigger, more costly tractor) or to cut them by hand and compost them in a corner of the field (for which they needed to hire more labour). About 85% stuck to their agreement and did not burn that season: many, in a follow-up survey, requested a repeat of the intervention. Based on these results Pant thinks the government should pay farmers not to burn, alongside educating them on soil fertility and composting of residue. "Once we know the cost of non-burning, the government can do something for an alternative," he says. He is not convinced that other options, such as an outright ban on burning, are feasible. "Putting a legal ban is very difficult to do because it is their traditional right."

Shyamsundar isn't convinced, though: "I don't think we want to take away from this that we want to pay farmers not to burn. This strategy may be un-implementable. But these numbers give us an idea of how big the problem is, and what needs to be done."

How much do farmers save when they burn?

Exploring technologies

Shyamsundar thinks subsidised new technologies might be a better option: "New technologies don't need to be monitored across the board so it's an easier solution. Regulations such as bans don't always work well but technology does, if adopted."

One possibility is to subsidise access to the Happy Seeder – a miraculous machine that cuts and lifts rice straw, sows the wheat seed, and deposits the straw on top of it as mulch. Ridhima Gupta, from the Indian Statistical Institute in Delhi, considered its potential in Punjab, the only state in India to be using it at the time of the research. She found that the machine allows the earlier sowing of wheat as the rice residue can be removed while still green. The rice mulch reduces the need for herbicides and fertilisers. Overall, the costs and benefits balanced each other and using the Happy Seeder made no tangible difference to profits.

A detailed assessment[10] by the Australian Centre for International Agricultural Research (ACIAR) found long-term economic and environmental benefits of using this technology.

Yet, Gupta's farmers haven't adopted this technology wholeheartedly. Start-up costs and conservatism are undoubtedly among the reasons. But, the ACIAR study suggests, subsidies for electricity and herbicides may also play a part: they nullify the benefits of long-term reductions in electricity and herbicide use that would result from adopting the Happy Seeder. Gupta is urging the Indian government to subsidise the machine, a process the ACIAR study says is already under way.

Regional perspectives

South Asia is a vast region characterised by different landscapes, agricultural practices, technologies and levels of awareness. Mitigation measures need to be flexible enough to accommodate this diversity. Two studies from opposite ends of the region, Pakistan and Bangladesh, are instructive in that regard.

In Pakistan, researchers looked at 400 farmers in two districts in Punjab who do not have Happy Seeders. Removing the residue by hand pushes the farmer's costs up by over a third (from just over USD 100 per hectare for burning to just over USD 136 for removal) – and is only worth it if there is a market for the residue, for example to feed livestock. Over 80% of the farmers did not even know that technologies such as the Happy Seeder existed – in contrast, it is used widely across the border in the Indian Punjab.

Until the technology penetrates this region, however, "the farmers would need to be subsidised to avoid residue burning practices," say the study's authors, Tanvir Ahmed, an economist at Farman Christian College in Lahore, and Bashir Ahmad, president of Innovative Agriculture in Faisalabad. They estimated that the cost of the subsidy need only be USD 20-27 per hectare for incorporating the residue back into the soil; however, this is based on only looking at the costs of the various interventions, rather than the overall profit of the farmer.

A detailed study of 300 farms in southwest Bangladesh by Ziaul Haider of Khulna University did consider farmers' overall profit rather than just the costs of production. In this area, where the Happy Seeder also has yet to penetrate – researchers found that the farmers' profit is as much as USD 111 higher per hectare if the residue is burnt rather than

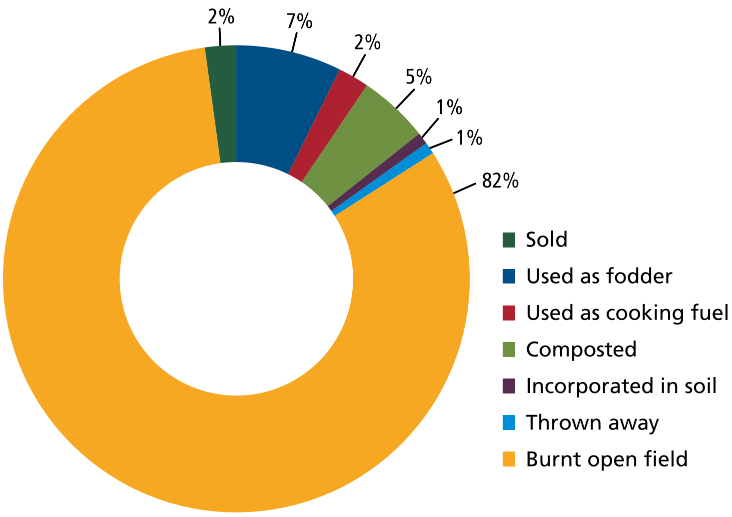

Figure 1. Different uses of crop residue prior to the reverse auction experiment in Nepal as inferred from a survey. Each slice depicts the percentage of farmers that disposed of crop residue in a particular manner.

removed. This happens because productivity is higher in fields where burning occurs (although the effects in the longer term are unclear), whereas the costs of rice harvesting are lower. Paying farmers throughout the nation to abstain from burning would cost the government of Bangladesh USD 2.1 million a year – about 4% of current subsidies available to farmers for inputs such as fertilisers.

The breed of rice grown by farmers has an effect too. Long-stalk rice can poke its head above flooding and is thus apt for low-lying fields. But its residue is voluminous and of low quality – not wanted for animal feed – and is thus largely burnt. Haider found that farmers are growing the cheaper, long-stalk rice at higher elevations as well: subsidising and educating farmers to switch to short-stalk varieties at higher elevations might be a promising way forward.

At low elevations farmers should instead be educated, and perhaps subsidised, to incorporate the long-stalk residue into the soil rather than burning it. Haider also thinks there is scope for science to come up with a better variety of rice, for example one with a shorter growth period that would increase the time available after harvest before it is necessary to plant the wheat. That would leave enough time to deal with the residue in ways other than burning.

Whatever the solution, Shyamsundar says, the research shows that the problem is more tractable than dealing with other causes of climate change. This is because it's a behaviour that is not just contributing to climate change but is also causing local pollution, which can produce local incentives to change. "Planes can't take off or land because of this really crazy smog that descends during the winter," she says. "That's enormously costly." Perhaps the private sector could be encouraged to get involved in technology subsidies, she suggests.

She underscores the importance of fine-textured work such as that undertaken by SANDEE. "Big-picture studies are very powerful to us who work at a micro level – it's a place to hang our hats on. But, on the other hand, if there is to be change it has to happen at the local level, there's no other way of doing it. We have got to understand the behavioural issues at the local level." ▮

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