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Payment Experiment for Modification of Farm Practices: A case of rice residue burning in
Nepal

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Abstract

Open-field burning of agricultural residues emits smoke, black carbon and green-house gases and drifts large proportions of plant nutrients. A payment experiment was conducted with 317 willing farmers from 18 villages in rural Nepal. Out of them 167 farmers, who quoted below a cutoff point participated in the experiment and their straw burning activity, were kept under observation. Over 86% of them respected the agreement and got paid. The results revealed that the farmers' average willingness to accept to avoid the field burning of rice straw was Rs 5592/ ha. Technological interventions and policy measures are suggested for avoiding the burning.

Key words: Field experiment, non-market valuation, Agriculture and environment, rice straw burning, black carbon, supply of ecosystem services.

JEL Classification: Q15 - Agriculture and Environment, Q52 - Pollution Control Adoption Costs.

Extended Abstract

1. Introduction

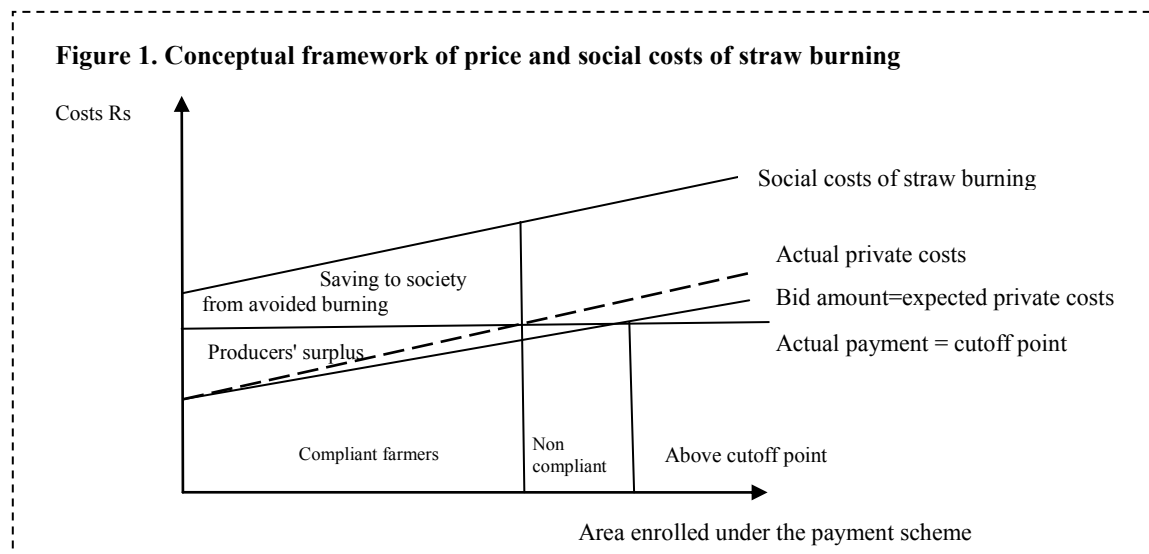
Many promising agricultural technologies are developed for increasing farm production and resource use efficiency for half a century. These modern technologies are adopted by the farmers, but at different rate of penetrations. Smallholder farmers in developing countries are still adopting traditional farming practices and modification of them is a slow process. Some of these traditional practices are environment friendly, but some others, such as burning agricultural residues, have harmful effects on the environment as well as farm production. Such practice emits smoke, black carbon and green house gases. The smoke endangers the health of local people and black carbon and GHG contribute to global warming. Discouraging environmentally damaging farm practices can generate social benefits, but such modification incurs costs to the farmers. Any external effort in modification of the farm practices needs clear understanding of the additional direct or indirect costs the farmers have to incur. Owing to non-commercial nature estimating these private costs is very difficult. The field experiment explores the effects of incentives on modification of harmful farm practices. The study assessed the on-farm rice straw utilization practices of the farmers and estimated the level of actual cash payment necessary to stop the practice of rice straw burning.

2. Method

The payment experiment was conducted with 167 farmers from Kapilvastu and Rupandehi districts in Southern Nepal where the problem of rice residue burning is severe mainly due to use of combine harvesters in rice and wheat. Assuming rationality and perfect knowledge of the households, the burning is the cheapest means of disposing such residue for those households burning the crop residues. The additional costs required for alternative use of the residue exceeds the benefits from their alternative use. Mathematically, $C_a - C_b > B_a - B_b$, where C_a is the cost for the least cost alternative use, C_b is the cost for burning (direct cost of burning is very low), B_a is the benefit out of the alternative use and B_b is the benefit out of burning. However, none of these costs and benefit items are precisely known. The farmers generally underestimate the costs of burning, particularly the indirect costs and external costs.

The minimum willingness to accept (WTA) for avoiding the straw burning or the minimum incentive required by the households to stop crop residue burning is the difference between the net benefit of burning ($B_b - C_b$) and average net benefit of alternative use ($B_a - C_a$). The field experiment is conducted for estimating the minimum WTA. Levitt and List (2008) present an overview of modern field experiments and their usage in economics. Relative to traditional empirical economics, field experiments provide an advantage by creating exogenous variation in the variables of interest, allowing us to establish causality rather than mere correlation (List and Reiley 2008). The field experiment was conducted to find the effects of incentives on straw burning behavior. The conceptual framework of private and social costs of straw burning is presented in Figure 1. Actual private cost of avoiding straw burning is the supply curve for the ecosystem services from the avoided straw burning. The private cost per hectare varies from farm to farm whereas the social costs are expected to be uniform for a village. Some efficient farmers can manage the straw more efficiently and receive producers surplus out of the uniform payment provided in the village whereas less

efficient farmers bid higher amount (above cutoff point) to cover the costs of alternative straw management and have likelihood of getting excluded from the bidding experiment. If the level of the actual payment falls below the social costs of burning, the result is efficient saving something to the society.



The main research question was that what level of payment would deter the rice farmers from burning the rice straw. The hypotheses tested include (a) monetary incentive to the farmers with a request not to burn residues reduces their rice straw burning practice; and (b) availability of the family labor and wage of the hired labor affects the level of minimum WTA of the farmers for not burning.

The field experiment was completed in several steps. On the basis of information collected from reconnaissance survey and pilot surveys 18 villages were randomly selected for the study and pilot surveys were conducted to refine the field instruments for the experiment. The actual experiment was completed in 10 steps and many of them were season bound requiring the actions pre-harvest, harvest and post harvest season of rice. The first step of the payment experiment was informing the farmers and publicity of the auction procedure. The second step was a meeting with the farmers in each village. At the third step, a baseline survey was conducted only with those farmers who were found desirous to participate in the payment experiment after receiving the information about the experiment. The other steps include bidding, signing agreement, recording global positioning system (GPS) coordinates of the farms, monitoring and field verification of burning, follow-up survey and the payment to the compliant farmers.

It is necessary to understand the differences among those farmers who can stop burning at lower price and those who cannot. The test statistics were estimated for the difference in means of personal, household and village characteristics across the high bidders and low bidders. For finding the factors that made the farmers with an agreement non-compliant, the differences of the means were tested across compliant and non-compliant farmers. The descriptive statistics of the bid amount and the rate of the payment were used to see at what level of the payment can stop the burning of rice straw.

3. Results

Harvesting season for the rice crop and planting season for the winter crop overlapped each other. The rice harvesting season in the study area was for one month starting from the third week of October. Sowing of the major winter crop wheat started at the third week of November and ended in December. For nearly a half of the farmers (46.36%) the time gap between the rice harvesting and wheat sowing was of three weeks and for one-third of the farmers it was of only two weeks. There were only a few farmers (0.66%) who plant wheat in the same week of rice harvesting.

The survey revealed that nearly 96% of the farmers burnt their rice straw in open field and over two percent of them as cooking fuel. Less than nine percent of the farmers used the rice straw as animal feed. Market for rice straw was very limited and that too for manually harvested straw and not for the combine harvested. Combine harvesters cut the straw halfway leaving tall stubbles and throwing the upper part of the straw on the field. The strongest reason stated by the farmers for field burning of rice straw was easiness for land plowing and work (stated by 73%) in land preparation for the following season. The second strongest reason was the belief of the farmers about increase in soil fertility due to burning. When asked separately 17.67% of the farmers reported that burning rice straw increased production of the next crop.

Straw burning was increasing with the use of combine harvester. The farmers preferred to use combine harvester for saving the costs. The average cost of manual harvesting of rice was Rs 7099 per ha. The farmers opted for combine harvesting because it was cheaper (Rs 5298/ha). The cost saving in rice harvesting by using combine harvester was 25.37%. There are other unobservable benefits of using combine harvester such as time-saving in managing the laborers and reducing the risks of rain and hailstorms damaging the crops. Fashion and social prestige of using high-tech might also have affected the farmers' decision.

Out of the 317 farmers participated in the bidding experiment, 167 farmers falling below the cutoff points of the bid amount were selected for the experiment. The average bid amount varied from Rs 2,896 to Rs 24,069/ha. Altogether 54.8 ha of land came under the agreement with a commitment of the farmers not to burn straw. The total payment agreed was Rs 299,408.

What made the farmers to bid high? Are such factors observable? To answer such questions test of mean differences were made between the high bidders and low bidders. The farmers who quoted high bid were having lesser farm labor, having ownership of tractor, and larger size of the largest plot of the land as compared to the lower bidders. In addition, the high bidders reported higher wage rate and higher labor costs of harvesting than those who quoted lower bids. In addition, those farmers who were having a practice of joint decision making in their family tended to bid higher amount than those who had practice of sole decision making by the head of the family. There was no difference among the age, education and religion of these two groups of the farmers. There might be some unobservable factors making the farmers to bid high.

Out of the 167 households participated in the payment experiment and signed agreement, 144 farmers (86.23%) complied with the agreement and did not burn the straw in the field. Those farmers who complied with the agreement managed the rice straw alternatively. While avoiding the burning, largest fractions of the households (34%) incorporated the entire straw

into the soil by plowing the field with a rotavator and with some difficulty using the ordinary disc plow. Similarly, over 25% of the households used the top part of the straw for alternative purposes and incorporated the stubble anchored to the field. About 23 percent of the households left the straw to get decomposed or composted for using as manure. Nearly 17% of them collected the top part of the straw and sold for fodder and incorporated rest to the soil. The additional costs including expected loss of the yield of the next crop due to delay in sowing was Rs 1611/ha. The minimum WTA of the farmers or the actual payment made (Rs 5592/ha) to them was much higher (347%) than the observable costs incurred by the farmers. The large divergence between the actual costs incurred and the WTP is due to some other unobservable costs of the farmers for avoiding the straw burning.

Even the amount paid to the farmers was more than three times of the observable costs of the alternative management of the straw some of the farmers (14%) did not comply with the agreement. When asked for the most important reason of burning nearly 22% of them showed the labor shortage and some other reported time shortage. Some of the burnings were inadvertent. Non-of the farmer stated that the amount agreed was insufficient for covering the costs of avoided burning. Test of mean differences between the compliant and non-compliant farmers showed that more proportion of Muslim farmers were non-compliant as compared to Hindu farmers. The farmers who owned tractors were more prone to be non-compliant as compared to those without a tractor. Higher wage rate increased the rate of non-compliance. The farmers residing nearer to the road head were more likely to be non-compliant as compared to those living in hinterlands. This might be due to higher opportunity cost of their labor. Age, education, family labor and livestock holding were having no association with non-compliance.

Observable landholder characteristics have low explanatory power for the costs revealed by the bidding (Jack et al. 2009). The WTA per ha of land representing the actual costs of the farmers for avoiding the straw burning is the marginal costs (MC) of the farmers for the supply of ecosystem services that we get from avoided burning. The positive portion of MC curve is the supply curve for the ecosystem services. The supply curve approximates closely to an exponential curve. It means the supply curve for ecosystem services emanating from avoided open field burning of rice straw is exponential in nature. The exponential equation thus estimated is minimum $WTA = 659.8e^{0.0113x}$, where x is the area enrolled under the burning avoidance program. Thus, the elasticity of supply (E_s) = 0.0113x varies with the change in the area covered under the program. Up to 88 ha of the land enrolled under the program the supply is inelastic and above this area of the land the supply becomes elastic. High outlier bids were excluded from the analysis.

4. Discussions and Conclusions

The study found the effects of the actual cash payment on rice straw burning practice of the farmers. The cash payment drastically reduced the straw burning from the plot with the agreement with over 86% farmers complying with non-burning. The WTA is the estimate of the additional private costs the farmers—observable and unobservable—have to incur to avoid the open field burning of rice residues and providing ecosystem services thereof. Private cost of avoiding straw burning is found to be non-linear. For some farmers, the private cost can even go higher than what actually they predicted during the bidding time leading to their non-compliance.

The estimate of the WTA is the aggregate of many poorly quantifiable and unobservable

costs like time preferences in planting next season crops, fertility and insect pest controlling effects of burning, opportunity costs of labor for straw management, use and option values of straw, cultural values of the farmers, risk preferences of fire and many other hard to understand subjective beliefs of the farmers regarding straw burning practices. A set of policies on agricultural burning is necessary along with technological interventions for compensating the farmers to avoid burning.

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