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Monetary Incentives to Reduce Open-Field Rice-Straw Burning in the Plains of Nepal

Krishna Prasad Pant

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Krishna Prasad Pant
Principal Investigator
Economic Development and Policy Analysis Center
(EDPA Nepal)
Kuleswor, Kathmandu, Nepal

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Comments should be sent to
Krishna Prasad Pant
Principal Investigator, Economic Development and Policy Analysis Center, (EDPA Nepal)
Kuleswor, Kathmandu, Nepal
Email: kppant@yahoo.com

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Abstract

In southern Nepal, rice straw burning in open fields is common practice. This is problematic because biomass burning contributes to smoke, black carbon and greenhouse gases. While some studies have examined the reasons for burning, few have tried to identify incentives that might stop farmers from burning. In this study, we use a uniform price unit-supply reverse auction, followed by an actual payment, in order to measure the amount of incentive required to stop smallholder farmers from burning rice straw. 317 farmers from 18 villages in Rupandehi and Kapilvastu districts participated in the reverse auction and signed an agreement to avoid burning for a payment. About 86 percent of the farmers fully complied with the agreement for a median payment of NPR 5,610 per ha (USD 78/ha). We also assessed the factors affecting the bid amount and compliance with the agreement. The supply of ecosystem services by the farmers through avoided burning is unit elastic, indicating that there is a linear relationship between monetary incentives and avoided burning.

Key words: *Agriculture and environment; Rice straw burning; Payment experiment; Reverse auction; farmers; Nepal.*

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1. Introduction

Biomass burning, which is the result of both anthropogenic and natural causes, is one of the major sources of greenhouse products (GHP) that include black carbon and carbon-dioxide. In Asia, crop residue burning accounts for nearly one-third of total biomass burning (Streets et al. 2003). Black carbon is emitted when there is incomplete combustion of biomass, which mainly occurs during field burning, forest fires and household cooking fuel and diesel engines use. Black carbon is of particular concern due to its short-term effects on raising atmospheric temperature (Auffhammer et al. 2006; Bond et al. 2013). Most importantly, scientists now consider black carbon as the second largest contributor to global warming after carbon dioxide (Bond et al. 2013). Black carbon also raises the rate of snow melting in the Himalayas by increasing the heat-absorbing capacity of snow due to the accumulation of black particles on its surface (Menon et al. 2010; Ming et al. 2008, 2009 &2012; Yasunari et al. 2012). As a central Himalayan country, Nepal feels the effects of snow-melting from burning biomass more than most other countries.

Reducing agricultural residue burning can generate net benefits at the local, regional and global levels. Among the local-level benefits of avoiding straw burning are the use value of straw and reduction in the risk of fire hazards and health problems due to smoke and ash. The regional benefits, on the other hand, come from the avoided emissions of black carbon, which affects regional weather and the global benefits arise from the avoided emissions of greenhouse gases (GHG). However, as the regional and global benefits arising from avoided straw burning are not in the household decision-making framework, farmers under-invest in alternative straw management practices. Therefore, discouraging environmentally damaging farm practices such as agricultural residue[1] burning can increase the supply of ecosystem services from local to global levels.

In South Asia, farming is dominated by smallholders and agricultural residue burning is a traditional practice. Farmers mainly burn to reduce the labor costs of preparing the field for the next crop. However, there is significant variation in farmer practices. In Bangladesh, for instance, a variety of factors such as straw length, low land elevation and distance to the plot affect the farmers' decision to burn (Haider 2012). In Pakistan, the farming technology, use of rice residue as feed for animals, and turnaround time between the harvesting of rice and the sowing of the wheat crop are factors that influence the practice of burning (Ahmed and Ahmad, 2013). Gupta (2012) asserts that residue burning in India is determined by the rice variety grown and reinforces that idea that technology, particularly the use of the combine harvester to harvest non-basmati rice, affects farm decisions. In the study area for our research, rice cultivation is dominated by small sized parcels of land and the cultivation of non-basmati rice. The combine harvester is also in use for rice harvesting.

Indubitably, policies are necessary to control straw burning. However, any policy intervention to modify farm practices requires a clear understanding of the additional costs that farmers would incur in adopting such practices. Moreover, it is difficult to measure the private costs of subsistence farming due to the non-commercial nature of the farming system in the study area. In such circumstances, field experiments may provide useful insights. Collins and Maille (2008), for example, used payments as an incentive for farmers in a watershed-based field experiment to address agricultural non-point pollution. We follow this practice and also use a field experiment to understand the cost that farmers would incur from alternative management of rice residue.

In this paper, we report the results of a uniform-price unit supply reverse auction with actual payments to farmers.

[1] Agricultural residues are of two types: field residue generated during crop harvesting and process residue derived as byproducts during agro-processing. The straw, stalk and stubble are the field residues whereas rice husk, maize cob, wheat bran, etc., are the process residues. We focus on the former type in this research.

This experiment was undertaken to estimate the private costs from avoiding open-field burning of rice residue in southern Nepal. The specific objectives of the study were: a) to assess the on-farm utilization, marketing and burning of rice straw; and b) to determine the level of incentive required to stop rice straw burning in the field.

In the next section, we begin by outlining the theoretical underpinnings of the study. The third section presents the methodology along with the study site and data sources. The fourth section presents the results and discusses them while the final section concludes with attention to policy implications and recommendations.

2. Theoretical Background

In a traditional auction, a seller invites bids from prospective buyers and sells the product or service to the highest bidder. This type of auction is called a sales auction. But, a reverse auction is a type of purchase auction in which the roles of the buyers and sellers are reversed. In auction, several sellers offer their goods or services for the bidding process and compete for a price that is acceptable to the buyer (Klemperer, 1999). This type of auction induces bidders to bid according to their opportunity costs (Cason and Gangadharan, 2005; Hailu and Thoyer, 2006, 2007; Latacz-Lohmann and Schilizzi, 2005). The buyer generally accepts the lowest bid that meets a set minimum standard. The reverse auction is a particularly appropriate mechanism for addressing specific market failures in conservation that involve privately owned land (Stoneham et al. 2003; Brown et al. 2011; Jack et al. 2008; Latacz-Lohmann and Van der Hamsvoort, 1997 & 1998)) as this type of auction can allocate conservation services to the lowest bidders. Thus, it results in services being provided for the least cost (Hailu and Thoyer, 2006).

Reverse auctions generally involve two types of bidding: unit-supply bidding and multiple unit supply bidding. In unit-supply reverse auction, bidders compete on price and not quantity, whereas, in multiple unit supply auction they compete for both price and quantity. In this study, we discuss a unit-supply reverse auction, where farmers competed on how much they could be paid to not burn a fixed quantity (one hectare) of their field.

Similarly, two types of payments are used in the reverse auction: unequal price auction and uniform price auction. Under unequal price auction the levels of the payment are different for different bidders based on their own bid amount. But, under the uniform price auction (UPA), all the winners are paid at the same rate of payment irrespective of their bid amount. The payment in a uniform price auction can either be the rate of the lowest losing bid or the highest winning bid. The payment at the rate of the lowest losing bid motivates the bidders to bid the true costs. This is because every winner will get a payment that is higher than his/her actual bid amount.

In our study, we used a uniform price unit-supply reverse auction applying the lowest loser bid to all the winners, which is considered a suitable strategy for use among smallholder farmers.[2] According to the available literature, a uniform price auction in which the payment is determined by the lowest losing bid most closely resembles the single-unit Vickrey auction in terms of incentives leading to Pareto efficiency (Menezes and Monteiro, 2005).

We offered farmers the option of bidding for the service of 'not burning'. Each farmer was expected to propose *a specific bid per hectare of rice straw not burned* in his/her field. By using a UPA , we ensured that the dominant strategy of the farmers[3] is to bid their true costs for not burning. This is because farmers cannot gain by bidding higher than their true costs since the price they receive is independent of their bid and they may lose by bidding above their true costs. On the other hand, they cannot gain by bidding below their true cost either since, if they win as a result, the amount would not cover their costs. Thus, as long as farmers are aware of their true costs and with some practice in the auction process, this method can be expected to reliably elicit the *actual costs* of not burning.

It is important to understand that burning is the cheapest option for farmers who choose to burn residue. Thus, for these farmers, the costs of alternative strategies to manage residue exceed the benefits. We do not expect farmers to consider the environmental costs of residue burning when they make their management decisions since these are externalities that may not be obvious. The private costs of residue burning such as health costs (Long et al. 1998; Noonan and Balmes, 2010) and productivity loss (Mandal et al. 2004) also may not be clearly understood.

[2] Details on the design of conservation auctions are available in Brown et al. (2011).

[3] Some studies, however, have argued that the UPA discourages landowner participation in the auction because of their tendency for risk-aversion, the low expectations regarding winning on the part of high-cost landowners, and confusion on the part of landowners regarding the pricing mechanism (Latacz-Lohmann and Schilizzi, 2005).

Thus, a farmer's minimum willingness to accept (WTA) for avoiding straw burning is expected to be the difference between the private net benefit of burning and the net benefit from any alternative management strategy.

The actual private net benefits (or costs) of avoiding straw burning is expected to vary among farmers for different modes of straw management. Generally, the costs of avoided burning are dominated by labor costs – and the opportunity costs of time can be higher than any other use benefits farmers get from saving straw. We note that while the private cost per hectare from avoided burning varies from farm to farm, the social benefits are expected to be uniform among households.

3. Study Site and Auction Process

3. 1 Study Site

The *Terai* represents the plains in Nepal and is the area where most of the agricultural production comes from. We conducted the study in the southern *Terai* of Nepal[4] adjoining the Indian border where the problem of rice residue burning is severe.

Nepal produces 19 million metric tons of agricultural residue annually (WECS, 2010, p 101). The major sources of the residue are rice, maize, wheat, sugarcane, grain legumes and millet. Just three crops, namely rice, wheat and maize, in fact provide more than three-fourths of the total residue produced. Of the three, the largest amount comes from rice (47 percent), followed by maize (25 percent). However, a large amount of residue, particularly rice, maize, wheat and sugarcane, still continues to be burnt on the open field. The recent introduction of combine harvesters in the southern plain areas of the country for rice and wheat harvesting has only aggravated the problem of straw burning. Yang et al. (2008), Gupta (2012), and Ahmad and Ahmad (2012) have reported similar effects in China, India, and Pakistan respectively.

We chose two districts from the *Terai*–Kapilvastu and Rupandehi–for the study where the residue burning practice is severe (see map in Annex VIII). Though no precise secondary data is available on the number of farmers burning rice straw, out of 87 and 84 Village Development Committees and Municipalities (hereafter referred to as villages) respectively in the Rupandehi and Kapilvastu districts, farmers burn rice straw in nearly half of the villages, particularly villages located in the southern parts of the districts.

3.2 Auction

We employed a household survey and auctions for data collection. Out of the 85 villages identified from two districts as burning rice straw annually, we selected 18 villages randomly, using systematic sampling with a random start. Within these villages, a unit-supply and uniform price reverse auction was conducted with 317 farmers.

The study was undertaken by the principal investigator, a research assistant and four field-level monitoring staff who were available throughout the rice harvesting and straw burning seasons. The auction involved nine season-bound steps, requiring actions in the pre-harvest, during harvest and post-harvest rice seasons (see Annex I). Though the auction was a one shot experiment and the farmers were inexperienced in bidding, they were advised to bid on the basis of the costs incurred from the management change. Since a change in the management practice was easy to understand, we expected the bids to represent true costs.

On the basis of the reverse auction, 167 low bidding farmers were selected for a non-burning agreement. Out of the farmers who signed the agreement, 144 complied with the agreement and got paid for their compliance. The following subsection describes the procedure.

3.2.1 Publicity

We first publicized the auction program among the villagers through door-to-door visits to all the rice growing farmers in the sample villages. We also explained the plan to conduct the bid experiment and payment scheme (see

[4] Nepal is divided into three regions in terms of its physiographic features: *Terai* along the Indian border in the south, Mountain along the border of the Tibet Autonomous Region of People's Republic of China, and Hills in between, each region extending from east to west.

Annex II for details on publicity materials).

3.2.2 Information Meeting

We convened a farmers' information meeting separately in each sample village in the September-October period of 2010 with the meeting being open to all the rice-grower farmers in the village. At the meeting we again explained the bidding procedure and the criteria for selecting the winners. We also made it clear that cooperation in a household baseline survey was a pre-condition for participation and for winning at the auction. Full compliance with the agreement to be concluded was necessary in order to receive the payment.

3.2.3 Baseline Survey

In September-October 2010, we administered a baseline survey among all of the farmers who expressed willingness to participate in the auction process during the information meeting. None of the farmers who participated in the information meeting declined to participate in the baseline survey. The number of the farmers participating in the auction ranged from 9 to 27 per village. Thus, a total of 317 farmers from 18 villages provided baseline information.

The baseline survey gathered information on household and farm characteristics and practices. We obtained data on household characteristics such as education and age of the household decision maker, family size and employment status. The farm characteristics included farm size, livestock, cropping patterns and farm mechanization. The survey also included questions on farm practices with regard to crop residue disposal and burning practices (see the questionnaire in Annex III for further details).

3.2.4 Bidding Procedure

All the farmers who provided the baseline information readily participated in the auction. Before starting the bidding process, we explained the bidding process and the rules governing the decision. This was done at group meetings in each village during October 2010.

One obstacle we faced was the high land fragmentation in the area, with 10 parcels of land per household on average. This fragmentation is much higher than the national average of 3.6 parcels per household (CBS, 2006). Given the variety of plots available and the difference among these plots, we decided to ask for bids for the largest paddy plot of each participating farmer. Depending on the village, the average area of the largest plot under the auction ranged from 0.28 ha to 0.80 ha. As the payment was proposed and made on a per unit area basis with a fixed village budget, the larger the average plot size among the participating farmers, smaller would be the ratio of winner farmers in the village. This allowed us to conduct a single-round, unit supply uniform-price reverse auction in each village.

We conducted a single round of bidding so as not to allow the bidders to learn to capture rents through strategic behavior and to speculate over the buyer's valuation of the good (Rolfe et al. 2009; Latacz-Lohmann and Schilizzi, 2005). The uniform price auction (UPA) induces the bidders to reveal the true cost, while lowering the outlay for the buyer of the ecosystem services that comes from non-burning (Hailu and Thoyer, 2006).

We provided each farmer with a bid form during the auction meeting in October 2010. The form included the name of each of the farmers who had provided the baseline information and had expressed interest in participating in the bid (see Annex IV). Each farmer confidentially quoted his bid amount per unit of land (ha) for not burning the straw in the season that followed. Principal Investigator and Research Assistant immediately collected these forms from each individual farmer.

3.2.5 Decisions on Winners

For each village we sorted the bid amount in ascending order and determined the cutoff point based on the budget available for the village. The budget constraint[5] for each village was allocated based on the number of participants

[5] According to Latacz-Lohmann and Schilizzi (2005), the auction can either be budget-constrained or target-constrained. However, the literature is inconclusive about the performance of single round auctions with either type of constraint (see Schilizzi and Latacz-Lohmann, 2007). Therefore, for the purpose of simplicity in budgeting, we used the budget-constrained auction but without a reserve price with the fixed budget itself serving the purpose of the reserve price.

from each village. Considering the budget available to us for payments in this auction experiment (NPR 300,000) and the target number of the farmers who participated in the baseline survey (300), a village budget was calculated by allowing for a unit price NPR 1,000 per participant.[6] Thus, for example, a village with 13 participants in the auction was assigned a budget of NPR 13,000.

In each village, a budget-constrained cutoff point was chosen. The cutoff point was the bid amount that would ensure that the total payment made to all the winners in the village was close to the previously identified village budget. We rejected all the bids on or above the cutoff point. The lowest bid amount among the rejected bids was the uniform rate applicable to all the winners in the village. Under the uniform payment system, every winner farmer gets payment higher than her or his bid amount. Out of the 317 farmers participated in the auction, 167 fell below the cutoff points.

3.2.6 Agreement with Farmers

We signed an agreement individually with each of the 167 winner farmers who won the auction before the harvesting season in October 2010 (see Annex V for the agreement format). The agreement was to pay the amount agreed upon only if they complied with the condition to *not burn the rice straw* in the pre-specified plot. In order to convince the farmers, we utilized the goodwill of educated youth from the villages with whom we had established prior contact. These youths convinced the farmers that the payment will actually be made after the expiry of the burning season.

3.2.7 Recording the Coordinates

We recorded the GPS coordinates of the largest paddy plot of each selected farmer by visiting the plots along with the farmers with all selected farmers cooperating well in this process. The GPS coordinates were for the purpose of tracking the plot noted in the agreement and for verification of' not' burning.

3.2.8 Field Monitoring

We followed four steps for the field monitoring component of the research. We first appointed four village youths who helped in the auction process as local monitoring staff for the entire rice straw burning season of November and December 2010. They monitored the status of rice straw burning by the farmers who had signed the agreement on a weekly basis. Secondly, the research assistant monitored the activities of the local monitoring staff. Thirdly, the principal investigator monitored the activities of the researcher as well as those of the local monitoring staff. Finally, we used GPS tracking for field verification after the burning season was over. We checked the field to ensure that there were no signs of burning in the field (See Annex VI for the check list). The monitoring and field observation confirmed that 144 farmers complied with the agreement.

3.2.9 Follow-Up Survey and Final Payment

We conducted a follow-up survey of all the participating farmers through door-to-door visits during the first week of January 2011. The questions in the follow-up survey of those farmers who had refrained from burning included questions on the methods of straw disposal and the additional costs incurred by them for the alternative management of the straw (see Annex VII). The questions for those farmers who did not comply with the agreement included questions related to reasons for non-compliance. We paid the agreed amount in cash to all the 144 compliant farmers during the first week of January 2011.

4. Results and Discussion

4.1 Farmer Characteristics

The farmers who participated were mostly males (95 percent) with an average 5.83 years of schooling. Their average family size was 9. Only 2 percent of the households owned a combine harvester. Considering the capacity

[6] In order to reduce the chance of speculation and strategic bias, we disclosed the budget for each village only after the list of the farmers participating in the bid was finalized.

of the combine harvester to harvest rice from large areas at a higher speed (0.70 ha/hour), the month-long harvesting season, and the smaller landholdings (2.59 ha) of the farmers, it is not difficult to guess that the 2 percent of farmers who own combine harvesters can provide the necessary services to a large number of farmers in the area. A large proportion of the households do not own livestock. On average, each household keeps 0.77 adult livestock. Thus, the large farm size and the small number of livestock are the main reasons for the surplus production of rice straw and the habitual burning practice of rice residue.

Rice is the main crop in the study area. The harvesting season for the rice crop and the planting season for the major winter crops overlap with each other (see Figure 1). The rice harvesting season in the study area starts in the third week of October and ends in the third week of November. The sowing of wheat, the main winter crop, begins in the third week of November and ends in the fourth week of December. For nearly half of the farmers (46 percent), the time gap between the rice harvesting and wheat sowing periods is three weeks whereas for one-third of the farmers it is only two weeks.

4.2 Burning Practices

The survey revealed that nearly 96 percent of the farmers burnt their rice straw in open fields while only approximately 2 percent used it as cooking fuel (see Table 1). Since only a few farmers had livestock less than 9 percent of the farmers used rice straw as animal feed. Thus, the market for rice straw was limited and mainly relied on manually harvested straw. Straw for livestock cannot be harvested when using the combine harvester because this machine cuts the straw halfway, leaving tall stubble (or the lower part of the straw) anchored in the soil, while scattering pieces of the upper part of the straw in the field.

As most of the farmers were burning straw, we asked them to mention the most important benefit of rice straw burning. The foremost reason provided by the farmers (73%) for field burning of rice straw was convenience with regard to land plowing and work relating to land preparation for the following season (see Figure 2). The second strongest reason (reported by 19 percent) was farmers' belief that soil fertility increased due to burning.

Our survey makes it quite clear that the straw burning increases with the use of the combine harvester. Moreover, the farmers preferred to use the combine harvester for the cost savings that it entails. Only two percent of the sample farmers own a combine harvester. Other farmers hire a combine harvester because it is cheaper than the manual harvesting. The average cost of the manual harvesting of rice was NPR 7,099/ha whereas the cost to farmers from using the combine harvester was NPR 5,298/ha. Thus, the cost saving in rice harvesting from using the combine harvester was 25 percent. Furthermore, both the migration of labor for jobs abroad and the reduction in labor immigration from Bihar (India) have created a labor shortage during the peak seasons of planting and harvesting (Pant et al. 2010). Among other unobservable benefits of using the combine harvester are savings in time with regard to the hiring of harvesting laborers and the risk reduction in crop damage from possible rain and hailstorms in case of a prolonged manual harvesting season. Both the social prestige and trendiness that are associated with the use of high-tech equipment might also have affected the farmers' decision to adopt the harvester.

4.3 Outcomes of the Auction

317 farmers from the 18 villages participated in the bidding experiment. On average 18 farmers per village or 11% of the total households in the study area participated in the auction. The area of the largest plot under the auction ranged from 0.28 ha to 0.80 ha. The average bid amount in the villages varied from NPR 2,896 to NPR 24,069/ha.

As noted previously, the cut-off bid was the lowest bid rejected. The average cutoff point across the 18 villages was NPR 5,592/ha (standard deviation of NPR 860), with the median at NPR 5,610 .The median value was sizable for the farmers as it constituted some 11 percent of the average farm revenues from wheat and 13 percent of the costs of the wheat crop in the area (MOAC, 2011). 167 farmers presented bids that fell below the cutoff points and were selected for the experiment.

Figure 3a presents a histogram of the bid amount, after excluding extremely high bids. The Figure shows that the

distribution of the bid amount is not normal in that it has a longer right hand tail compared to the left hand tail showing that the distribution is skewed and some bids are outliers. The kernel density curve, which is a measure of distribution, resembles the ripple effects attenuating fast that outlier bids decreases at higher levels of bids. This implies that most of the bids at average level represent the real situation of the alternative straw management costs.

We present the costs of alternative straw management obtained from follow up survey of those farmers in another histogram (see Figure 3b). The kernel density estimates are smoother for management costs than for the bid amounts meaning that the actual costs vary less than the bid amount. The take-home message here is that the bid amounts on an average truly represent the actual costs of alternative straw management, but some bids are clearly outliers. A comparison of the histograms on the bid amount and the management costs shows that these two distributions resemble each other. Thus, it can be inferred that the farmers, in aggregate, based their bid amounts on the costs that they would incur if they adopted alternative management practices of the rice straw instead of burning.

4.4 Supply of Ecosystem Services

Undoubtedly, abiding by the agreement and refraining from burning the rice residue reduces emissions and thus increases the supply of ecosystem services. The quantity of ecosystem service supplied by a farmer is the area enrolled by him under the program. An individual farmer would either win the bid, thus receiving a payment that is higher than what he quoted, or lose the auction.

The average payment made to 144 compliant farmers through the auction was NPR 5,592/ha. This was higher than the largest winning bid amount (NPR 5,400/ha) since the pay outs were on the basis of the lowest rejected bid. The payment levels varied by village and ranged from NPR 3,759/ha to NPR 8,010/ha depending on the cutoff point decided for each village (see Figure 4).

The bid amount per hectare of land represents the actual costs to farmers from avoiding straw burning, which is also the marginal cost (MC) to the farmers for supplying the ecosystem service that we get from the avoided burning. The MC curve is the supply curve for the ecosystem service. Thus, the bid curve presented in Figure 3 is the supply curve of land that is not burnt. This is similar to the allocation of farm land for, for instance, for conservation agriculture. For the farmers enrolled in the program (whose bid was lower than the cutoff point), the supply curve for the ecosystem service emanating from avoided open-field burning of rice straw is approximately linear in nature. The linear equation thus estimated is A=0.506+0.012P (t=65.59 and adjusted R20.963) where A is the area enrolled under the burning avoidance program and P is the rate of the payment.

The price elasticity of supply measures how sensitive the supply of the ecosystem service is to a price change. The price elasticity of supply is estimated using the formula ∂A/∂P*P/A, which measures the relationship between the percentage change in price and the percentage change quantity supplied. . The estimated elasticity of the ecosystem service supply curve was 0.993, which means that the price elasticity of supply is almost unitary. This suggests that farmers, on average, are willing to increase land enrolled in a program to avoid burning in the same proportion as the rate of the payment increases. This is understandable in villages where most of the locally available resources are almost fixed. We can increase the elasticity by providing new technology and training to the farmers to avoid burning residue.

4.5 Factors Affecting the Bid Amount

What made some farmers to bid high and some others in the same village to bid low? Are such factors observable? To answer these questions, we assessed the factors affecting the bid level using ordinary least square (OLS) regression.

$$B = \beta_0 + \beta_1 P + \beta_2 L + \beta_3 A + \beta_4 E + \beta_5 M + \beta_6 J + \beta_7 H + \beta_8 W + \beta_9 S + \beta_{10} I + \varepsilon \quad (1)$$

The bid amount (*B*) of the farmers in NPR was regressed on the size of the largest plot (*P*) in hectare, farm labor (*L*) per hectare of the total farm size, livestock (*A*) number per hectare, years of schooling (*E*), a dummy for Muslim (*M*) (Hindu as a base), a dummy for joint decision making (*J*) of the household head (1 for the head usually consulting the family members for household related decisions and 0 otherwise), dummy for hinterland (*H*), i.e. these were households one kilometer or more away from the road head, expected wage rate (*W*) of the farm labor in NPR/day as reported by the household, straw yield (*S*) tons/ha and household income (*I*) in NPR 1,000/year. One can argue that the bid level can also be affected by the actual costs of alternative straw management. But the actual cost is visible only with a small fraction of the sample that complies with the agreement and manages the straw alternatively.

For this analysis, bid amounts above NPR 8,000/ha were considered outliers. This is because the standard deviation of the bid amount is twice the average bid amount (Table 2). After removing the outliers, the standard deviation of the bid amount is much smaller than the average bid amount and the variable becomes homoskedastic.

Table 3 presents the regression results. It is clear that direct cost of alternative straw management is not the only reason for burning. Socio-economic and cultural factors can also affect the practice of burning and the rate of bidding. Thus, in addition to the wage rate, plot size, level of education, ethnicity, practice of joint decision making and the amount of straw produced affect the rate of the bid positively and significantly.[7]

With every rupee increase in the wage rate in the village, the bid amount increases by nearly six rupees (see Table 3). In addition, every hectare increase in the plot size increases the bid rate by NPR 1,068/ha. This is because the larger the plot size, the more difficult it is to manage the straw from the family labour and hiring labour results in out-of-pocket expenses. Similarly, every one year increase in schooling of the bidder increases the rate of bidding by NPR 61/ha. This can be due to the fact that educated farmers are more able to accurately estimate their opportunity costs in the bid amount than those with less schooling. The farmers who subscribed to the practice of joint decision-making in the family for other day to day household decision making bid NPR 478/ha higher than those who enjoyed sole decision-making in the family. This suggests that those farmers who needed to obtain the consent of their family members to decide on non-burning got no chance to consult them at the time of bidding and generally bid higher amounts to convince their family members against burning. Finally, the larger the amount of straw produced in the farm, the larger was the bid amount, with every ton increase in straw production increasing the bid amount by NPR 130/ha. This is because the larger the amount of straw produced, the larger is the labor needed to remove it from the field to avoid burning. Household income and livestock holding do not affect the bid rate. This may be due to the more or less homogenous nature of the income and livestock holding of participant households.

4.6 Factors Affecting Compliance

Field monitoring and verification confirmed that all farmers under the agreement decided on the fate of the rice straw within the month of December. Out of the 167 farmers who signed the agreement, 144 farmers (or 86 percent) complied with the agreement and did not burn the straw in the field.

Farmers who complied with the agreement managed the rice straw alternatively. While avoiding the burning, the largest fraction of the compliant households (34 percent) incorporated the entire straw into the soil by plowing the field with a rotavator with the ordinary disc plow though the latter procedure entailed more difficulty. Another 25 percent of the households, who complied, collected and used the top part of the straw that was cut and scattered by the combine harvester for alternative purposes. They incorporated the stubble still anchored[8] to the field into the soil. About 23 percent of compliant farmers left the straw to be decomposed or composted for use as manure, while nearly 17 percent collected the top part of the straw to sell it for fodder incorporating the rest into the soil.

[7] The Ramsey RESET test using powers of the fitted values of the bid rate is not significant (p = 0.660) and that leads to an inference that the equation fitted has no omitted variable. Similarly, Breusch-Pagan / Cook-Weisberg test for heteroskedasticity is not significant (p=0.294) leading to an inference that the fitted value of the bid rate is homoskedastic.

[8] The combine harvester cuts the straw some half way leaving tall stubble anchored in the field and scatters the top part cut into smaller pieces making it difficult to collect them.

Twenty-three farmers (or 14 percent) breached the agreement and burnt the rice straw (see Figure 5). It is useful to first note that the average amount of the payment that had been agreed upon with the non-compliant farmers (NPR 5,592) was not significantly less {Pr (T < t) = 0.302} than that agreed upon with compliant farmers (NPR 5,591). When asked for the most important reason for burning, nearly 22 percent of them cited labor shortage as the reason though some others reported lack of time. Some of the burnings were actually inadvertent. What was important was that none of the farmers identified insufficient payment to cover the costs of avoided burning as the reason for non-compliance.

In order to determine the factors affecting the compliance of farmers with the agreement not to burn the straw, we conducted a probit analysis, regressing a dichotomous variable, Compliance (1=compliant, 0 =otherwise) on a number of independent variables.

$$Pr(compliance = 1) = \beta_0 + \beta_1 P + \beta_2 L + \beta_3 A + \beta_4 E + \beta_5 M + \beta_6 J + \beta_7 H + \beta_8 W + \beta_9 S + \beta_{10} I + \beta_{11} G + \varepsilon \qquad (2)$$

All the explanatory variables in equation (2), except for one, are the same as equation (1). The difference between the agreed amount and the individual bid amount (*G*) is the additional variable. We expect that the larger the *G*, the more likely that farmers are going to comply. Compliance can also be affected by the actual costs of alternative straw management, but we could not use this variable in the model as the non-compliant farmers do not incur such costs.

The results of the probit regression presented in Table 4 show that compliance is significantly affected by the wage rate and the amount of straw produced per hectare). The higher the wage rate identified by the farmer the less probability there is of compliance with the agreement. This is understandable since higher wages increases the costs of alternative management. However, the larger the amount of straw yield per hectare, the higher is the probability of compliance. This may be because with larger quantities of straw yield the combine harvester makes better heaps of straw, making the straw more amenable to collection. Farmers in the hinterland also showed a higher probability of respecting the agreement because in these interior villages the chances of farmers earning cash income is lower s than in the case of farmers close to roads and markets. The design of the auction ensured that the amount which was agreed upon was always larger than the bid amount. The variable G is positive and significant – thus, the larger the gap between the agreed upon amount and the bid amount (the surplus), the larger was the probability of compliance.

5. Conclusions and Policy Recommendations

In this study, we used a uniform price reverse auction to estimate the private costs to farmers of avoiding rice residue burning. We also examined the effects of actual cash payments on rice straw burning practices.

Our results show that performance-based payment mechanisms can be quite effective in creating incentives to reduce environmental externalities, particularly in the context of crop residue burning. In the reverse auction we undertook in rural Nepal, the mean payment was NPR 5,592 and the median WTA of farmers to stop burning was NPR 5,610/ha (US$ 78). More than 86 percent of the farmers, who agreed to accept these payments, stopped rice straw burning for a season. Thus, compliance was high.

Haider (2012), based on a recent analyses of farm profits in Bangladesh, reports that farmers who burn rice straw save US$ 108 to 113/ha per season relative to those who do not burn. Thus, our numbers on willingness to accept to stop burning from the reverse auction (the median bid being USD 78) are within the same order of magnitude as Haider's estimates.

The estimate of the WTA in our study is the aggregate of the many poorly quantifiable and unobservable costs such as time preferences in planting the next season's crops, fertility and insect pest controlling effects of burning, and the opportunity costs of labor for straw management. While these estimates suggest that rural farmers will need to be paid to give up burning practices, since the sample is not representative of the rice-growing Southern belt of Nepal, further research is needed in order to generalize these results.

Many factors affect farmers' willingness to avoid burning. These include size of the plot, availability of farm labor, ownership of a tractor, and practice of joint decision-making and a higher wage rate in the villages. Moreover, ownership of a tractor and proximity to the road head also increase non-compliance. Such information may be helpful in designing a low cost monitoring plan to prevent or stop the practice of burning.

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Tables

Table 1: Use of the Rice Straw before and after the Agreement

	Use of Rice Straw	% Households
A	**Before the agreement (in the previous year 2009)**	
1	Used as fodder	8.52
2	Used as cooking fuel	2.52
3	Composted	5.68
4	Incorporated in soil	0.95
5	Thrown away	0.95
6	Burnt open field	95.58
7	Sold	2.52
	Total	**116.72***
B	**Alternative Management of Straw by compliant farmers**	
1	Incorporated into the soil by using a rotavator to plant the next crop	20.14
2	Incorporated into the soil by plowing with tractor and heaped soil, created and managed manually	13.88
3	Left in the field to get decomposed	13.89
4	Piled in a corner or middle of the field	9.03
5	Composted	0.69
6	Top part collected for feeding animals, the bottom part plowed	10.42
7	Top part collected by neighbors for feed, bottom part plowed	15.28
8	Top part collected and sold, bottom part plowed	16.67
	Total	**100**

Note: *Multiple uses were reported by nearly 17 percent of the households.
Source: Field Survey, 2010.

Table 2: Descriptive statistics of study variable

	Variables	Full Model			Outliers Removed		
		n	Mean	Standard deviation	n	Mean	Standard deviation
1	Size of the largest plot	317	0.46	0.46	228	0.41	0.41
2	Farm labor (no/ha)	314	2.02	3.46	227	2.11	3.81
3	Livestock (no/ha)	314	0.77	2.57	227	0.63	1.32
4	Years of schooling	316	5.83	4.70	228	5.93	4.80
5	Muslim (as opposed to Hindu)	317	0.47	0.50	228	0.48	0.50
6	Joint decision-making	316	0.52	0.50	228	0.51	0.50
7	Hinterland	317	0.50	0.50	228	0.47	0.50
8	Wage rate	317	178.19	37.57	228	176.86	38.27
9	Straw yield (t/ha)	313	5.28	1.87	225	5.48	1.93
10	Household income (NPR 1000/year)	317	113.03	176.52	228	115.90	192.56
11	Bid amount (NPR/ha)	317	8,405	16,623	228	3,326	2,042

Table 3: Factors Affecting the Bid Amount

	Variables	OLS Full Model	OLS Outliers Removed	OLS, Outliers Removed, with Village Fixed Effects	Robust OLS, Outliers Removed, with Village Fixed Effects
1	Size of the largest plot	6635.226*** (2284.035)	1068.353*** (371.367)	939.191*** (377.594)	847.821** (404.874)
2	Farm labor (no/ha)	-248.451 (297.588)	-25.921 (37.448)	-54.300 (37.883)	-65.904 (40.620)
3	Livestock (no/ha)	171.250 (387.526)	138.189 (104.733)	125.526 (105.043)	129.905 (112.632)
4	Years of schooling	-91.707 (215.942)	61.597** (29.635)	46.285 (30.117)	48.886 (32.293)
5	Muslim (as opposed to Hindu)	1826.499 (1997.897)	577.119** (276.083)	743.216** (327.151)	678.523** (350.787)
6	Joint decision-making	1372.686 (1914.950)	478.551* (267.420)	678.189*** (270.021)	628.294** (289.530)
7	Hinterland	4797.433*** (1906.731)	-171.015 (263.660)	-189.342 (434.994)	-208.201 (466.422)
8	Wage rate	-5.933 (26.631)	5.768* (3.496)	9.539** (4.238)	10.456** (4.545)
9	Straw yield (t/ha)	-567.000 (523.000)	129.794* (70.113)	123.188* (71.00)	158.785** (76.316)
10	Household income (NPR 1000/year)	-2.798 (5.53346)	-0.519 (0.687)	-0.326 (0.701)	-0.275 (0 .752)
11	Constant	6744.299 (6000.727)	345.489 (804.440)	-730.246 (1157.159)	-1099.569 (1240.761)
	N	311	224	224	224
	F (10, 300) /213)	F (10, 300) = 2.07**	F (10, 213) = 3.21***	F(27, 196) = 2.37***	F(27,196) = 2.22***
	Adjusted R2	0.034	0.090	0.142	

Notes: Figures in parentheses are standard errors.
*** significant at 1% level, ** at 5% level and * at 10% level.
Data Source: Field Survey, 2010, and Auction, 2010

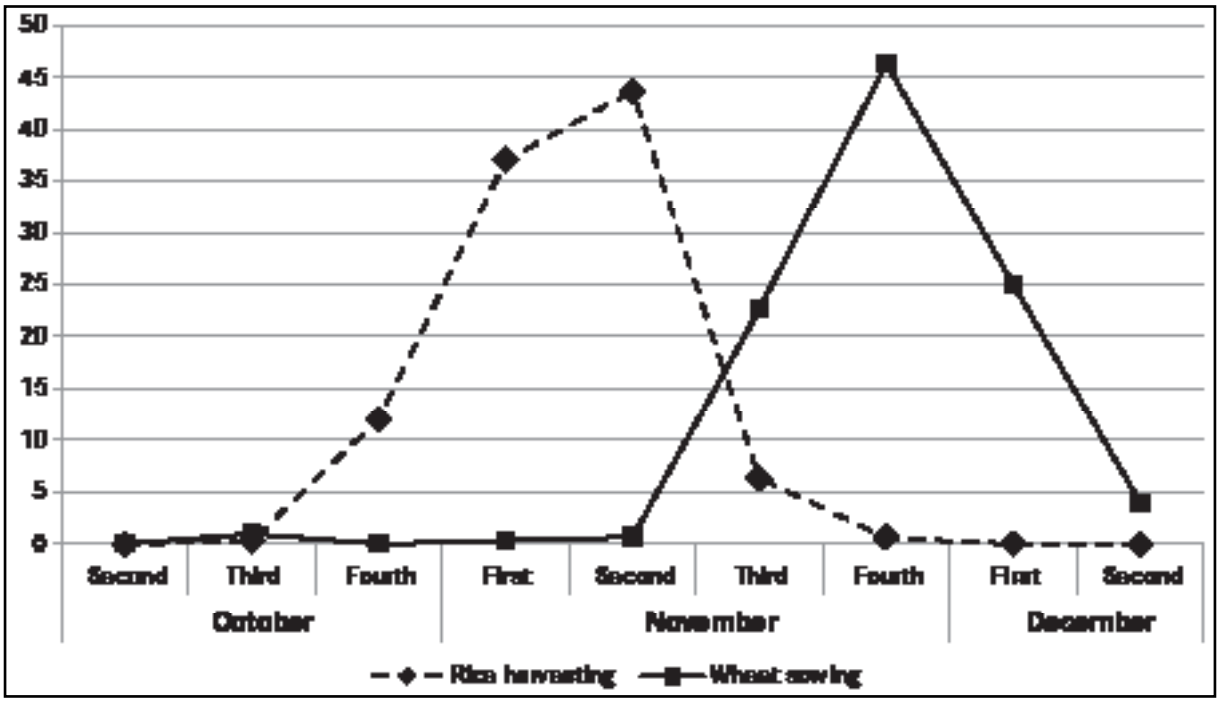
Table 4: Factors Affecting Compliance with the Agreement (Probit Model)

	Variables	Coefficient	Marginal Effect (dF/dx)	Coefficient with Village Fixed Effect	Marginal Effect (dF/dx) with Village Fixed Effect
1	Size of the largest plot	-0.311 (0.859)	-0.049 (0.136)	0.401 (1.086)	0.075 (0.203)
2	Farm labor (no/ha)	-0.022 (0.049)	-0.003 ((0.008)	0.033 (0.062)	0.006 (0.011)
3	Livestock (no/ha)	0.035 (0.113)	0.005 (0.018)	0.103 (0.157)	0.019 (0.029)
4	Years of schooling	0.012 (0.030)	0.002 (0.005)	0.028 (0.039)	0.005 (0.007)
5	Muslim (as opposed to Hindu)	-0.509* (0.299)	-0.084* (0.050)	-0.938* (0.497)	-0.169* (0.083)
6	Joint decision-making	0.188 (0.303)	0.030 (0.048)	0.197 (0.365)	0.036 (0.067)
7	Hinterland	0.563* (0.299)	0.089* (0.046)	0.490 (0.758)	0.087 (0.127)
8	Wage rate	-0.006* (0.004)	-0.001* (0.0006)	-0.017*** (0.006)	-0.003*** (0.001)
9	Straw production (t/ha)	0.272*** (0.091)	0.043*** (0.013)	0.270*** (0.098)	0.050*** (0.018)
10	Household income (NPR 1000/year)	-0.001 (0.001)	0.000 (0.000)	-0.002 (0.001)	-0.0004 (0.0003)
11	Excess of the agreed amount to the bid amount	0.006* (0.003)	0.001* (0.000)	0.0001 (0.0002)	0.00002 (0.00003)
13	Constant	0.375 (0.995)		3.539** (1.816)	
		N =167, LR chi2(11) = 23.57**, Log likelihood = -55.15, Pseudo R2 = 0.176		N =125, LR chi2(12) = 33.14**, Log likelihood = -43.105 Pseudo R2 = 0.278	

Notes: Figures in parentheses are standard errors.
*** significant at 1% level, ** at 5% level and * at 10% level.
Source: Field Survey, 2010

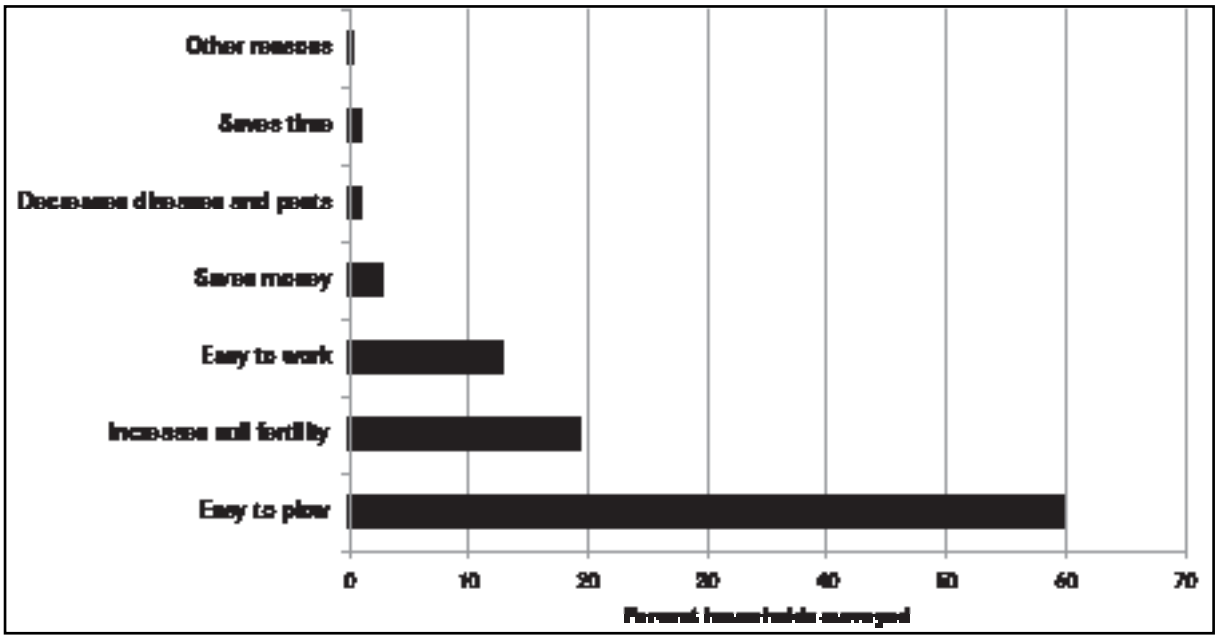
Figures

Figure 1: Seasonal Overlaps in Rice Harvesting and Wheat Sowing



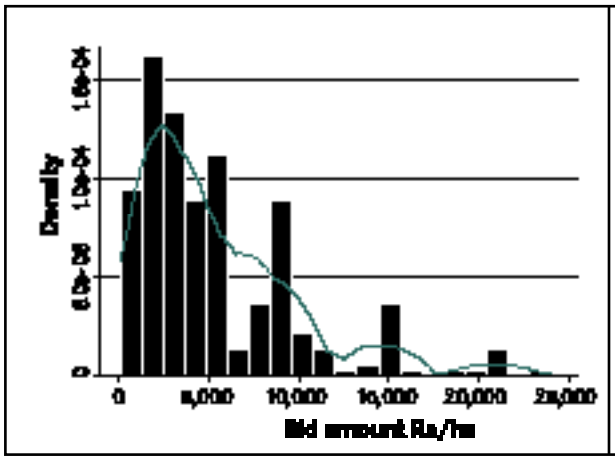
Source: Field Survey, 2010

Figure 2: Reasons for burning rice straw



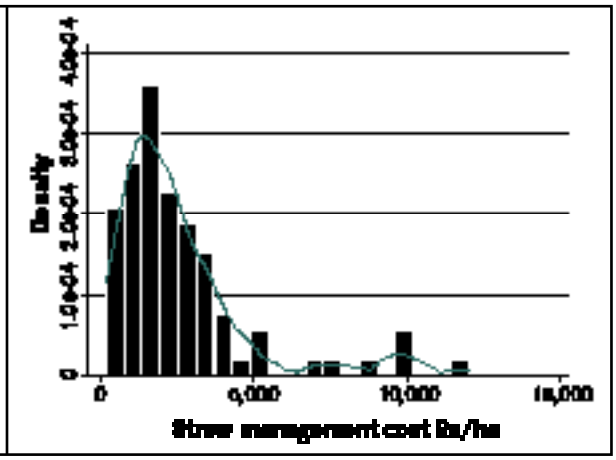
Source: Auction, 2010

Figure 3a: Histogram of Bid Amount



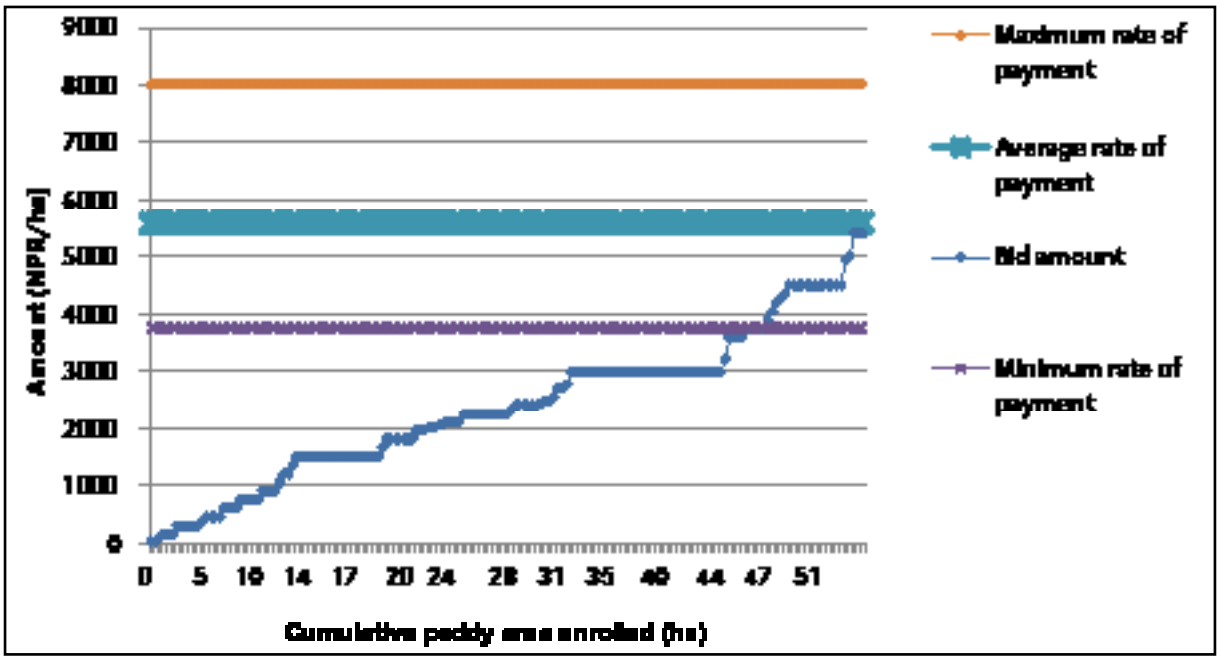
Source: Auction, 2010

Figure 3b: Histogram of Alternative Management Cost



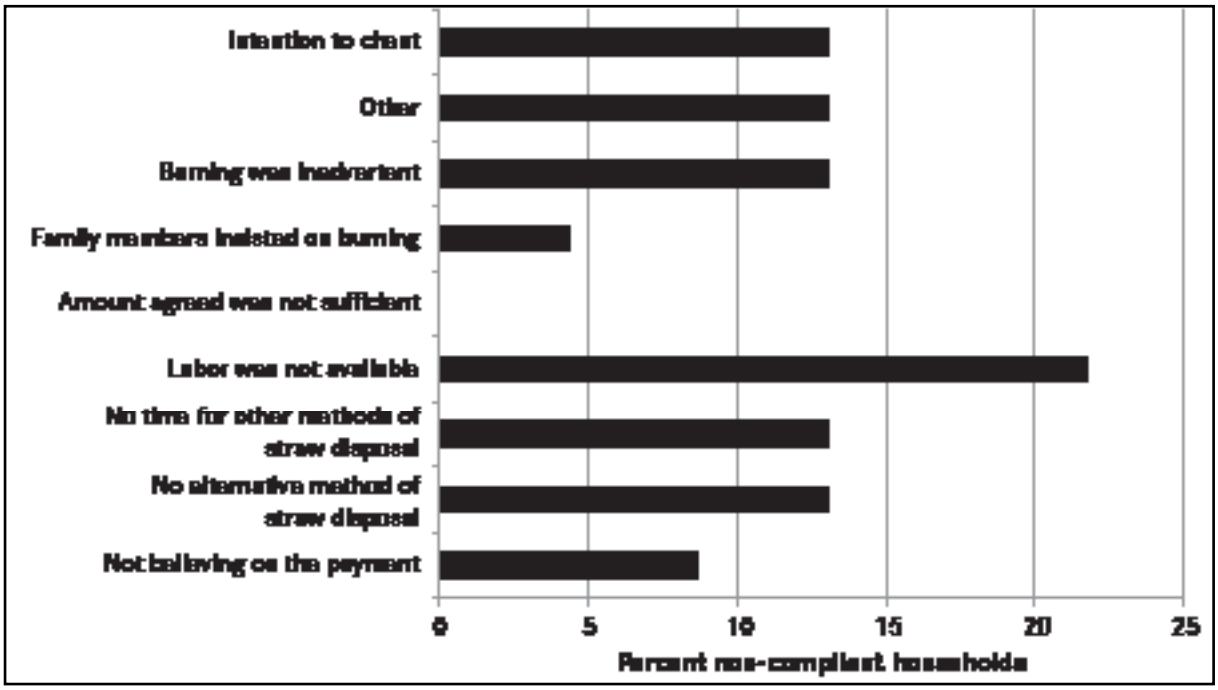
Source: Survey, 2011

Figure 4: Comparison of Rate of Payment with Bid Amount (the supply curve)



Source: Auction, 2010

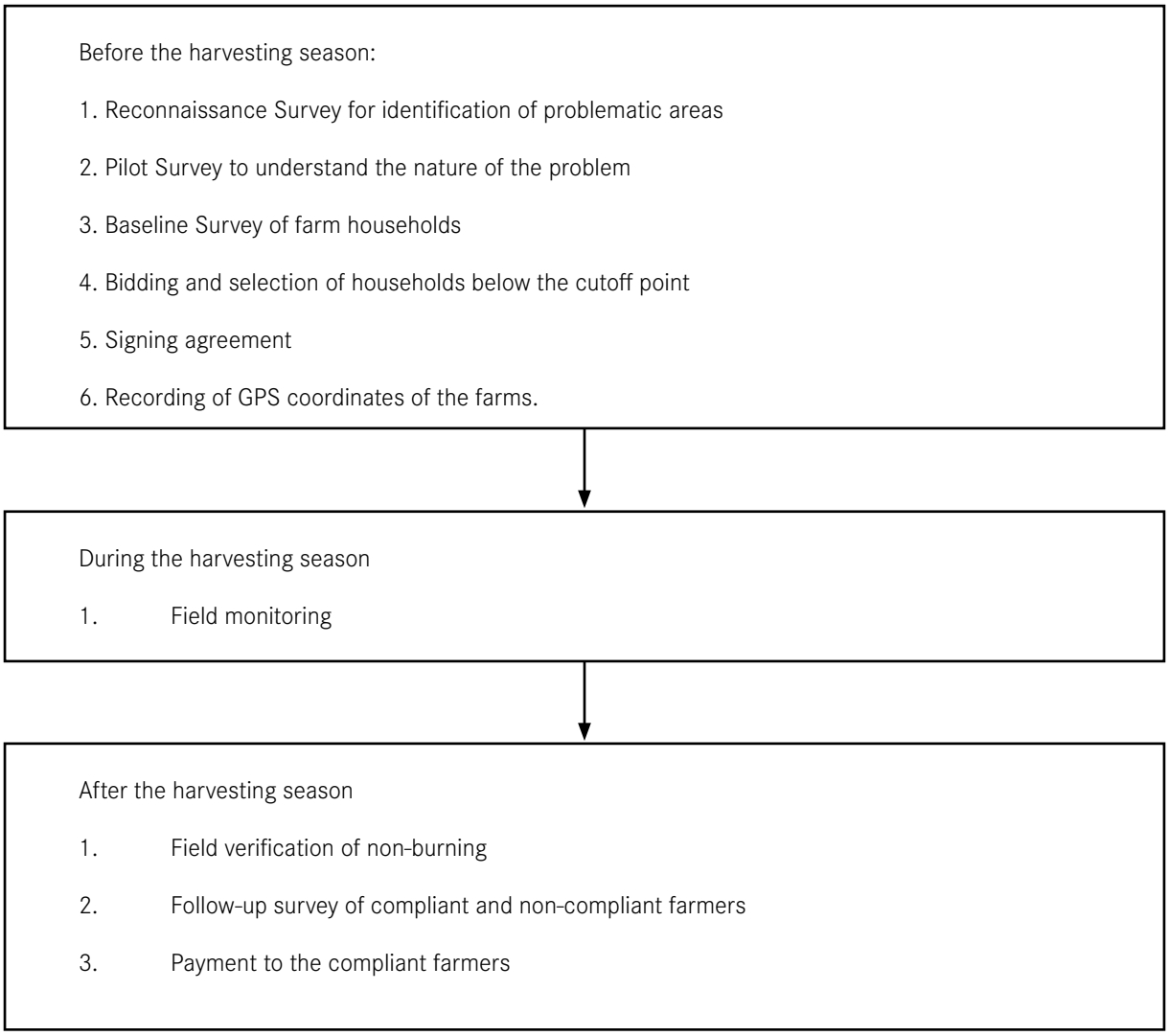
Figure 5: Reasons for non-compliance to the agreement



Source: Auction, 2010

Annexes

Annex I: Season-bound Steps of Field Experiment



Annex II: Information Provided to the Farmers before the Bidding Game

Namaste! We are from the Economic Development and Policy Analysis Center (EDPA) here to study the burning of rice straw. As you know, we visited you earlier also and you told us at that time that you burnt your rice straw in the field every year. This year we want to pay you some money in order for you not to burn the straw. But we do not know how much money you need to avoid burning. Therefore, we request you to participate in a bidding process tomorrow at xx.xx at xxxxx (place).

We have limited funds and cannot pay everybody. We can only pay those farmers who bid lower amounts. If the ceiling of the budget for your village is NPR 4,000, the process for finding the successful bidders is as follows.

	Name of the Farmer	**Bid Amount Quoted by the Farmer (NPR/*kattha*)**	**Plot Size (*kattha*)**	**Cumulative Size *kattha***	**Farmer Selected or not**	**Rate Payable if not burnt (NPR/*kattha*)**	**Amount Payable if not burnt (NPR)**
1	DhanKewat	2	28	28	Selected	20	560
2	Ramdhan Roy	3	12	40	Selected	20	240
3	NajiBullah	5	18		Selected	20	360
4	Aqbal Ahmad	5	27		Selected	20	540
5	Ram Pandey	5	9		Selected	20	180
6	Ram LakhanYadav	7	23		Selected	20	460
7	SyamBhuj	10	20		Selected	20	400
8	BinduGiri	10	18		Selected	20	360
9	BholaChaudhury	10	25		Selected	20	500
10	Ganesh Lal	12	20		Selected	20	400
11	Dinesh Kurmi	20	28		Not selected	0	Get nothing
12	Raju Kafle	23	35		Not selected	0	Get nothing
13	HariTripathi	25	18		Not selected	0	Get nothing
14	Kaman Viswokarma	25	20		Not selected	0	Get nothing
15	DhansinghMukhiya	30	30		Not selected	0	Get nothing
16	Umesh Lama	100	25		Not selected	0	Get nothing
	Total						**4,000**

Annex III: Baseline Survey Questionnaire

SURVEY OF RICE STRAW BURNING 2010

(*Please write all the figures in English and words in Nepali*)

1. Village Name:_____ VDC: _____ Ward No: _____
2. District (tick ✓ appropriate) ☐ Rupandehi ☐ Kapilvastu
3. Nearest Road Head:_____ Distance to the Road Head: _____km

   Condition of the Road: (tick ✓ appropriate) ☐ black top ☐ gravel ☐ muddy
4. Household Number :_____
5. Respondent:_____Telephone Number:_____
6. Name of the Father of the Respondent:
7. Date of Interview (year, month, day) 2067 / _____
8. Interviewer: _____, Signature of Interviewer:_____

A. HOUSEHOLD CHARACTERISTICS

9. Household Size: _____
10. Religion (tick ✓ appropriate)

    ☐ Buddhism ☐ Hinduism

    ☐ Islam ☐ Christianity

    ☐ Other ☐ No religion
11. Social Group (tick ✓ appropriate)

    ☐ Brahmin/Chhetri ☐ Tharu
    ☐ Madishe ☐ Dalit
    ☐ Other ☐ Do not believe in social group

This section is to be filled in by the interviewer after finishing the interview

Completed (✓) ☐ Yes ☐ No

Time of Meeting

(a) Start Time: .....

(b) Finish Time: .....

Monitored (✓) ☐ Yes ☐ No

Monitoring Result (✓)

Survey completed

Survey not completed

Monitor's Name _____

Monitor's Signature _____

Date of Monitoring (day, month, year)

Note: Sequence of Identification Code Starts with Household Head, then Spouse, Children, Others and then Servants

CODE	12. What is the relationship of ……. (ID) to the head of the household? Head ……..1 Wife or Husband …….2 Son/daughter ...3 Grandchild ...4 Father /mother..5 Sister/brother 6 Niece/Nephew..7 Son/daughter-in-law ...8 Brother/sister-in-law ...9 Father/mother-in-law ...10 Other family relatives...11 Servant/servant's relative ..12	13. What is the sex of ….. (ID) Male .1 Female 2	14.How old is (ID)? Years (If less than one year, write zero)	19 What was the highest class that ... (ID) completed? No school ……0 Class 1 ……..1 Class 2 ……..2 Class 3 ……..3 Class 4 ……..4 Class 5……..5 Class 6……..6 Class 7 ……..7 Class 8 ……..8 Class 9 ……..9 Class 10 ……10 Class 11 ……11 Class 12 ……12 Bachelor ……..13 Masters ……..14 Ph D,Professional 15	15.What is the present marital status of …… (ID)? Unmarried U Married…..M Divorced... D Separated ...S Widow/widower ….W	16 Is he/she a permanent resident of the village? Yes=1 No = 2	17. What is the primary occupation of …. (ID) ? Ownfarm worker..O Employee ...SA Casual laborer ...C Unemployed U Student ...S Housewife....H Business...B Other (specify)	18.What is the secondary occupation of ….(ID) if any? Ownfarm worker..O Employee ...SA Casual laborer ...C Unemployed U Student ...S Housewife....H Business...B Other (specify)
1								
2								
3								
4								
5								
6								
7								

20. Who makes the decisions related to farming in the household such as which variety of rice to sow, choice of the harvesting method or straw disposal?

☐ Head of the Household

☐ Head of the Household along with other members of the family

☐ Other members of the family

B. OWNERSHIP OF LIVESTOCK

21. Do you own any livestock? ☐ Yes: ☐ No:

If yes, please fill the following

	Type of Livestock	Number
1	Cows	
2	Calves	
3	Bullock	
4	Buffalo	
5	Baby Buffalo	
6	He-buffalo	
7	Other Livestock (Specify)	

C. HOUSEHOLD ASSETS AND LAND

22. What assets do you have?

SN	Item	Yes=1, No =0
1	TV	
2	Air Conditioner	
3	Motor Cycle/Scooter	
4	Car	
5	Tractor	
6	Power Tiller	
7	Thresher	
8	Combine Harvester	
9	Pump Set	

23. What is the total area of agricultural land owned and operated?

	Pakkabigha	*Kachabigha*	*Kattha*	*Dur*
Own land operated by HH				
Other's land operated by HH				
Own land operated by others				

24.How many plots of land do you have? .....

25. What is the size of the largest plot? ..... *katta*

26. What is the major irrigation source on your land? (tick ✓ all applicable)

☐ Tubewell ☐ Canal

☐ Pond/tank ☐ Other natural resource

D. WAGE AND RENT

27. Wage of daily labor during rice harvest: NPR ..... per day

How many *katta* can one harvest per day? .....

28. Rent of combine harvester NPR ..... per hour

How many *katta* can it harvest per hour? .....

29. Rent of tractor or plowing NPR ..... per hour

How many *katta* can it plow per hour? .....

E. RICE STRAW AND ITS DISPOSAL

30. Which crops did you grow during the last winter? (tick ✓ appropriate)

☐ Rice (main season) ☐ Rice *Chaite*

☐ Wheat ☐ *Tori*

☐ Lentils ☐ Potato

☐ Other winter crops (specify).....

34. When will you harvest rice and plant wheat in the largest plot?

	Aswin			*Kartik*				*Magsir*			
	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week	1st week	2nd week	3rd week	4th week
Rice harvesting											
Wheat sowing											

35. How did you use (main season) rice residue during last year?

Variety	Fodder	Cooking fuel	Composting	Buried in the soil	Thrown away	Burnt in field	Sold
Basmati							
Other							

36. What is the foremost reason for burning or not burning? tick ✓ the most important one)

		Benefit of Straw Burning	Benefit of Rice Straw Burying	Benefit of Straw Removal from the Field
1	Increases soil fertility			
2	Decreases diseases and pests			
3	Saves Time			
4	Saves Money			
5	Easy for plowing			
6	Easy to work			
7	Other (specify)			

37. Does the burning of the rice straw in the farm increase wheat yield? ☐ Yes: ☐ No:

If yes, by how much? _____ %

F. HOUSEHOLD INCOME

38. May I askyou about your household income?

	Source	Monthly Income (NPR)	Yearly income (NPR)
1	Salary (of members residing at home)		
2	Income from family members working abroad or in the city*		
3	Contract/piece rate work		
4	Daily wage (including the value of wages received in kind)		
5	Pension		
6	Self-employment		
7	Rent of building/shutter/ equipment/bullock, etc.		
8	Interest/dividends, etc.		
9	Sales of crop products (grain, vegetable, fruits, etc.)		
10	Sales of livestock products (milk, meat, egg, live animals, etc.)		
10	Any other (specify)		
* Take into account only the part of income received at home.			

THANK YOU FOR YOUR HELP!

Coordinates of the largest plot in which straw was burnt last year

Waypoint _____

Latitude N _____ _____ _____

Longitude E _____ _____ _____

Annex IV: Bid Form

Important! Confidential Please!

Name of the farmer: _____

Bid amount in NPR: _____

Approved Rejected

Annex V: Agreement

Memorandum of Understanding between the PI and the Farmers

We, Krishna Prasad Pant, PI, Economic Development and Policy Analysis Centre, Kuleshwor Kathmandu (First Party) and the farmer whose name and address appear below (Second Party) agree to the following:

1. The First Party will not burn the straw and stubble of rice this year in the field or elsewhere and will not allow family members or anybody else to burn them.
2. The Second Party will allow the First Party and his staff to observe the designated field and also provide necessary information.
3. In case the Second Party respects the conditions in No. 1 and 2 fully, the First Party will pay the Second Party the following amount to cover partially the costs of alternative management of the rice straw:

   NPR: _____

   In words: _____
4. In case of discrepancy in the language in the above Articles, the Nepali text will prevail.
5. In case of any dispute, the decision of Economic Development and Policy Analysis Center shall be final.

Dated

Signature:

Name of the Farmer:

Village: .....

Signature:

Krishna Prasad Pant, PI

Annex VI: Field Monitoring Checklist

Format for Monitoring and Final Survey:

District: _____ Village: _____ HH No: _____

Household Name: _____

Coordinates of the Field Longitude: _____ Latitude: _____

Size of the Plot: _____

Records of Monitoring

Month	Week of Monitoring	Rice Straw Burning (yes/no)	If Used Alternatively, What Is the Use?*	Date of Visit	Name of Monitoring Staff	Remarks
Aswin	2nd week					
	3rd week					
	4th week					
Kartik	1st week					
	2nd week					
	3rd week					
	4th week					
Magsir	1st week					
	2nd week					
	3rd week					

* 1=Composted, 2= Incorporated into the soil, 3= Removed for feed, 4=Removed for other purposes

Annex VII: Follow-upSurvey Questionnaire

Questionnaire for Final Survey of Rice Straw Burning (Dec 2010-Jan 2011)

1. Sr. No. of the Farmers: _____

2. Name of the Farmer: _____ (Please take Sr. No and name from the roster)

3. How did you harvest rice from the largest plot?

   ☐ Using a combine harvester ☐ Manual ☐ Using a reaper

4. Will you plant the next crop in the largest field? ☐ YES ☐ NO

5. If NO, what will you do in this plot?

   ☐ Leave fallow during winter

   ☐ Plant a crop later on

   ☐ Other (specify)

6. If YES, what will you plant in the largest plot?

   ☐ Wheat

   ☐ Lentils

   ☐ Potato

   ☐ Other (please specify)

7. Are the bunds of the field straight? YES/NO

8. Are the bunds of the field higher than one foot? ☐ YES ☐ NO

9. Did you burn straw in the largest plot?

   ☐ YES, GO TO #10

   ☐ NO (Please verify from the records of the monitoring) GO TO #11

10. If YES (you burnt), please give reasons for burning (Tick all applicable)

    ☐ Not believing that the payment will actually be made;

    ☐ No alternative method of straw disposal;

    ☐ No time for using other methods of straw disposal;

    ☐ Labor was not available;

    ☐ The amount you committed to give me was not sufficient to cover the cost of alternative management;

    ☐ Family members insisted on burning;

    ☐ It was burnt inadvertently (by children, family members, plowman, tractor operators, neighbors, etc.);

    ☐ Any other (please mention).

STOP **********

11. If NO (you did not burn), what did you do with the straw?

- ☐ Will be burnt later on;
- ☐ Left in the field to get decomposed;
- ☐ Piled in a corner or middle of the field;
- ☐ Rotavator was used for planting the next crop;
- ☐ Removed straw using reaper;
- ☐ Plowed into the field and heaping of the soil were managed manually;
- ☐ Buried in the field;
- ☐ Composted;
- ☐ Collected for feeding animals;
- ☐ Collected by neighbors for feed;
- ☐ Collected and sold;
- ☐ Any other (please specify).

Please explain in detail how you managed the straw: _____

_____

_____

12. If YES, what was the additional cost of straw management (or avoiding burning)?

- Labor used (self): _____ days
- Hired labor: _____ days
- Wage paid for hired labor: NPR _____
- Wages paid in kind (please specify): _____
- Increased cost of plowing: NPR _____
- Increased cost of irrigation; NPR _____
- Other costs:

13. Is there any delay in planting the next crop due to non-burning of straw? YES/NO

14. If YES, the days delayed: _____,

15. How much will be the decrease in production due to this delay? _____kg,

What will be the price of the product? NPR _____ per kg

16. We will not pay next year for not burning. Will you burn next year? YES/NO

17. Any other suggestion for not burning rice straw? _____

_____

_____

18. Telephone (If different than that in the roster): _____

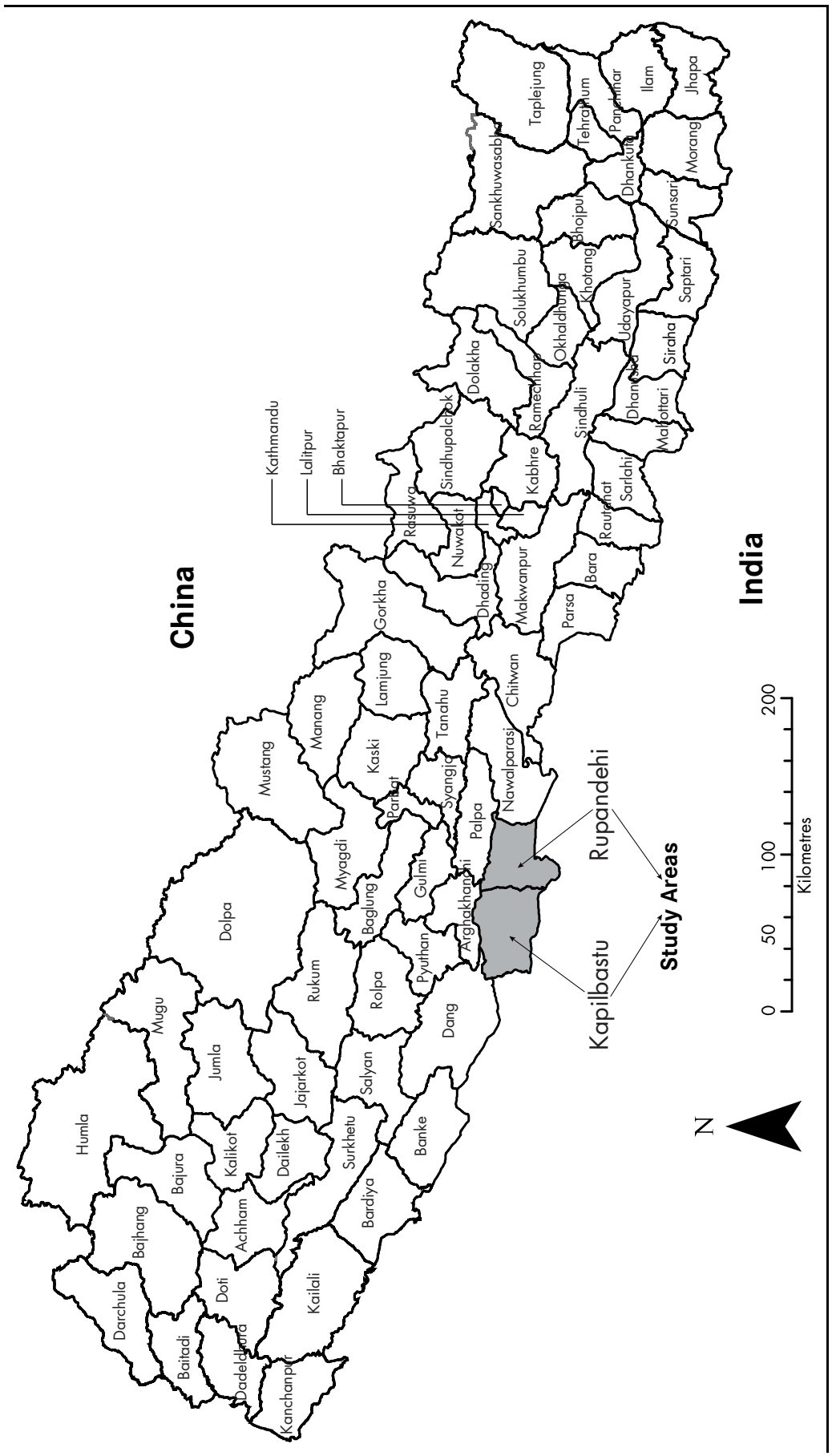
Thanks!

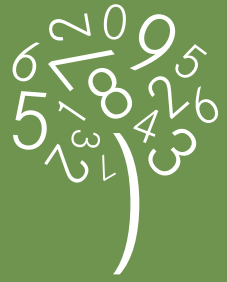
For enumerator:

19. Field verification: Waypoint _____

- Any evidence of burning? ☐ YES ☐ NO
- If YES (please state) _____

Annex VIII: Map of the Study Area





SANDEE

P.O. Box 8975, E.P.C 1056, Lalitpur, Nepal

Street address: c/o ICIMOD, Khumaltar, Lalitpur, Nepal

Tel: 977 1 5003222**, Fax:** 977 1 5003299**, Email:** info@sandeeonline.org **Web:** www.sandeeonline.org

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