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Utilization of crop residues in rural household of Bangladesh

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Abstract

This study examined the utilization of crop residues in agrarian zone of Bangladesh. Two categories of respondent participated in this study, such as old conservational agriculture research or farmer group and new conservational agriculture research or farmer group. Data were analyzed using both descriptive and inferential statistics. Crops grown within the study area includes rice, wheat, jute, pulses, oilseeds, maize, vegetables etc. Result of analysis shows that crops residues were mainly used for feeding their livestock (67.30%), cooking fuel (63.46%) and organic manure (74.04%) on the farms in old conservational agriculture research sites, where in new conservational agriculture research sites was used for feeding their livestock (68.64%), cooking fuel (57.06%) and organic manure (61.86%). It can therefore be concluded that crop residue are used within the study area as cooking fuel, animal feed, use with cow dung boll, fired at field, reuse during next cultivation and organic manure on farms.

Key words: Cooking fuel, conservational agriculture, crop residues, livestock, organic manure

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Introduction

Crop Residue is the remnant or stubble from all types of crops that includes roots, stubble, leaves and whole stalks of crops. Of the total crop residues produced in Bangladesh, paddy residues comprise about 70%. Like other developing countries, the people of Bangladesh use crop residues as a building material, fuel, and also to improve the soil.

Some factors that regulate the utilization of crop residues are depend on mainly the type and quality of the residues, the price of animal products in relation to the prices of animal feeds, the relationship between prices of bought feeds and the cost of feeding crop residues, availability of livestock to utilize the residues, type and species of livestock available to utilize the residues and the price of livestock (FAO, 1985).

An integrated crop-livestock farming system represents a key solution for enhancing livestock production and safeguarding the environment through prudent and efficient resource use. The increasing pressure on land and the growing demand for livestock products makes it more and more important to ensure the effective use of feed resources, including crop residues. The waste products of one component serve as a resource for the other. In an integrated system, crops and livestock interact to create a synergy, with recycling allowing the maximum use of available resources. Crop residues can be used for animal feed, while livestock and livestock by-product production and processing can enhance agricultural productivity by intensifying nutrients that

improve soil fertility, reducing the use of chemical fertilizers (Gupta *et al.*2012).

The use of organic fertilizers was low and most farmers used urea fertilizers in Kenya. Adoption of soil and water conservation measures was relatively low. In addition, there was poor utilization of farm by products. Thus there was poor interaction of farm enterprises and nutrient recycling subsequently leading to declining soil fertility and farm productivity (Nandasaba *et al.*2005).

The Use of household wastes and crop residues in small ruminant by livestock holders within Ogun State, Nigeria was studied by Onwuka *et al*. (1996). Predominant household wastes and crop residues were cassava, yam, cocoyam, orange peels, maize cob and stalk, cowpea vines and husk, groundnut haulm, pods, cocoa pods, cola nut pods and rice milling by-products. Crop residue was underutilized as only l%, 2%, 43% and 44% of the respondents fed, respectively, maize stover, maize cob, cowpea husk and yam peels to their sheep and goats. Large amounts of various crop residues (29-100%) were left in the field to rot away or were burnt.

Proper utilization of crop residues under conservation agriculture offers a powerful option for maintain the soil health and increased soil fertility that enhance also productivity (Washington Free Press, 2001). It was found that the utilization pattern of the crop residues was mostly carried at home for cooking as fuel. However, so far the actual scenario of crop residue utilization in rural household of Bangladesh has not been evaluate properly. Thus, the present study was undertaken to examine the scenario of retention of crop residue status, their utilization pattern in sustainable agriculture and rural household in Bangladesh.

Materials and Methods

***Study location*:** The study covered a range of soils and cropping systems for this evaluation in: Rajshahi; Mymensingh; Rajbari, and Thakurgoan.

***Source of data*:** Data collection, sampling technique and data processing were done as described previously (Islam *et al.* 2020). Briefly, data and information were gathered through focus group discussion (FGD), household survey, and case studies. Focus group were consisted of different sections of people such as sub-assistant agricultural officer, 2-wheel power tiller, machinery and spare parts sellers, owners, operators, and few conscious local community people. On the other hand, quantitative and qualitative data and information were gathered from the randomly selected users and service providers of machineries through conducting household survey using pre-tested interview schedules, some suitable case studies of successful service providers were also conducted to supplement the study.

***Sampling technique*:** A multi-stages stratified sampling adopted in the study.

a) Firstly, districts (such as Thakurgaon, Rajshahi, Rajbari and Mymensingh) were selected considering the soil type and cropping systems.
b) Secondly, the households were selected considering the level of adoption of CA through FGD.
c) Thirdly, the households were categorized by cropping systems mostly rice based pulses or oilseed cropping systems.

Thus, a total of 458 farms were selected followed by a field reconnaissance and key informants interview with different stakeholders for the study (Table 1; as described previously, Islam *et al.* 2020).

***Methods and periods of data collection*:** For collecting the necessary data, the study team explained to respondents the aims and objectives of the study before going to make the actual interview. The respondents were assured that the information given by them would not be used against their interest and that it would be useful to their households in many respects. Interviewees were requested to give correct information as far as possible. To ensure the quality of information the interview schedule was checked to

ensure that information to each of the items had been correctly recorded. If there were any items overlooked and misunderstood or found contradictory, these were corrected through re-interviewing on the spot.

Table 1. Distribution of the selected sample households in the study locations.

Major cropping systems in study location	No. of selected households
Rajshahi	
Rice-lentil-mung bean	
Rice-wheat-mung bean	120
Sub-total	120
Mymensingh	
Rice-mustard-mung bean	118
Rice- wheat-mung bean	
Rice-lentil-Aus rice	
Sub-total	118
Rajbari	
Rice-lentil-mung bean	160
Rice-lentil-jute	
Sub-total	160
Thakurgaon	
Rice-wheat-mung bean	60
Sub-total	60
TOTAL	458

***Data processing and analysis*:** All the collected data were processed and analyzed in accordance with the objectives of the study. Data processing included field and office editing, coding and tabulation. The data entry template was designed in Microsoft Excel. Consistency checks and keystroke errors were also detected and corrected accordingly before data analysis. The analysis was done using descriptive statistics like percentage, frequency distribution, mean, and rank where appropriate.

Results and Discussion

***Pattern of crop residue retention by different crop*:** The pattern of retention crop residue by locations are shown in Table 2. Here, the retention of crops was divided into three groups: wholly retention, partially retention and no retention. The main crops were boro rice, aman rice, wheat, jute, pulses, oilseeds and maize. In Rajbari study area 72.28% respondents used wholly retention method in boro rice and 31.09%, 1.98% and 73.68% in aman rice, wheat and oilseed, respectively. 18.81% respondents used partial method of retention in boro rice where 62.18%, 62.18%, 70.30%, 3.16%, 7.04% and 7.89% used aman rice, wheat, jute, pulses, and oilseeds, respectively. No retention method used by 8.91%, 6.72%, 27.72%, 96.84%, 92.96%, 18.42% and 100% respondent in boro rice, aman rice, wheat, jute, pulses, oilseed and maize, respectively. In Rajshahi 1.61% respondents used wholly retention method in aman rice and 3.33%, 7.14% and 66.67%, in pulses, oilseed and maize, respectively. 86.36% respondents used partial method of retention in boro rice where 46.77%, 35.14%, 6.67%, and 7.14% used in aman rice, wheat, pulses, and oilseeds, respectively. No retention method used by 13.64%, 51.61%, 64.86%, 100%, 90%, 85.71% and 33.33% respondent in boro rice, aman rice, wheat, jute, pulses, oilseed and maize, respectively. In Thakurgaon 38% respondents used wholly retention method in boro rice and 9.52%, 4.55%, 14.29 and 61.90% in wheat, jute, pulses, and maize, respectively. 22% respondents used partial method of retention in boro rice where 47.62%, 22.73%, and 23.81% used in wheat, jute and maize, respectively. No retention method used by 40%, 100%, 42.86%, 72.73%, 85.71% and 14.29% respondent in boro rice, aman rice, wheat, jute, pulses and maize, respectively. In Mymensingh 88.89% respondents used wholly retention method in aman rice and 8.33%, in wheat. 89.85% respondents used partial method of retention in boro rice where 8.89% and 91.67%, used in aman rice and wheat, respectively. No retention method used by 10.42%, 2.22%, and 100% respondent in boro rice, aman rice, and pulses, respectively.

In case of pattern of retention crop residue in all household Table 3 represented the crop-wise classification of whole, partial and no use of retention. For boro rice 41.63% respondent used both the wholly

and partial retention method while 16.74% didn't use any retention method. In aman rice cultivation 34.21%, 46.93% and 18.86% respondent used whole, partial and no retention method in all study area. Only 3.92% respondents used whole retention method, 61.76% respondents used partial retention method and 34.31% respondents didn't use any retention method in wheat cultivation.

Table 2. Pattern of retention crop residue by locations (% of HH).

Crops	Rajbari			Rajshahi			Thakurgaon			Mymensingh		
	Whole	Partial	No	Whole	Partial	No	Whole	Partial	No	Whole	Partial	No
Bororice	72.2	18.8	8.9	-	86.3	13.6	38.0	22.0	40.0	-	89.5	10.4
Aman rice	31.0	62.1	6.7	1.6	46.7	51.6	-	-	100	88.8	8.8	2.2
Wheat	1.98	70.3	27.7	-	35.1	64.8	9.5	47.6	42.8	8.3	91.6	-
Jute	-	3.1	96.8	-	-	100	4.5	22.7	72.7	-	-	-
Pulses	-	7.0	92.9	3.3	6.6	90.0	14.2	-	85.7	-	-	100
Oil seeds	73.68	7.8	18.4	7.1	7.1	85.7	-	-	-	-	-	-
Maize	-	-	100	66.6	-	33.3	61.9	23.8	14.2	-	-	-

In case of jute cultivation 0.77%, 6.15% and 93.08% respondent used whole, partial and no retention method, respectively. 1.80%, 6.31% and 91.89% respondent used whole, partial and no retention method in all study area for pulses. 55.77% respondents used whole retention method, 7.69% respondents used partial retention method and 36.54% respondents didn't use any retention method in oilseed cultivation. For maize 57.58%, 15.15% and 27.27% respondent used whole, partial and no retention method, respectively.

Table 3. Pattern of retention crop residue HHs

Crops	% of HHs		
	Whole	Partial	No
*Boro*rice	41.63	41.63	16.74
Aman rice	34.21	46.93	18.86
Wheat	3.92	61.76	34.31
Jute	0.77	6.15	93.08
Pulses	1.80	6.31	91.89
Oilseeds	55.77	7.69	36.54
Maize	57.58	15.15	27.27

Table 4 shows the pattern of retention crop residue by distance of plot in all study area. Cropping lands in study areas were classified into three groups: i) No distance to HHs; ii) Little far distance to HHs; and iii) Far distance to HHs and the methods used in crop retention were whole, partial and no retention. In case of No distance to HH whole retention method was used 28.91%, 27.74%, 1.84%, 2.04%, 52.27% and 43.75% for boro, aman, wheat, pulses, oilseed and maize, respectively. Partial retention method was used by 59.38%, 48.54%, 69.59%, 6.72%, 7.14%, 18.18% and 37.50% for boro, aman, wheat, jute, pulses, oilseed and maize, respectively. 11.72%, 23.72%, 28.57%, 93.28%, 90.82%, 29.55% and 18.75% respondent didn't use any retention method for boro, aman, wheat, jute, pulses, oilseed and maize, respectively. In case of little far distance to HH whole retention method was used 34.21%, 32.39%, 3.92%, 0.77%, 1.80%, 55.77% and 57.58% for boro, aman, wheat, jute, pulses, oilseed and maize, respectively. Partial retention method was used by 46.93%, 32.39%, 61.76%, 6.15%, 6.31%, 7.69% and 15.15% for boro, aman, wheat, jute, pulses, oilseed and maize, respectively. 18.86%, 13.03%, 34.31%, 93.08%, 91.89%, 36.54% and 27.27% respondent

didn't use any retention method for boro, aman, wheat, jute, pulses, oilseed and maize, respectively. For far distance to HHs retention method was used 46.91%, 36.21%, 13.77%, 5.61%, 6.38%, 72.09%and61.11% for boro, aman, wheat, jute, pulses, oilseed and maize, respectively. Partial retention method was used by 41.98%, 53.45%, 59.88%, 5.61%, 5.32%, 6.98% and 5.56% for boro, aman, wheat, jute, pulses, oilseed and maize, respectively. 11.11%, 10.34%, 26.35%, 88.79%, 88.30%, 20.93% and 33.33% respondent didn't use any retention method for boro, aman, wheat, jute, pulses, oilseed and maize, respectively.

Table 4. Pattern of retention crop residue by distance of plot to the HHs (% of HH).

Crops	No distance to HHs			Little far distance toHHs			Far distance to HHs		
	Whole	**Partial**	**No**	**Whole**	**Partial**	**No**	**Whole**	**Partial**	**No**
Boro rice	28.91	59.38	11.72	34.21	46.93	18.86	46.91	41.98	11.11
Aman rice	27.74	48.54	23.72	32.39	32.39	13.03	36.21	53.45	10.34
Wheat	1.84	69.59	28.57	3.92	61.76	34.31	13.77	59.88	26.35
Jute	-	6.72	93.28	0.77	6.15	93.08	5.61	5.61	88.79
Pulses	2.04	7.14	90.82	1.80	6.31	91.89	6.38	5.32	88.30
Oilseeds	52.27	18.18	29.55	55.77	7.69	36.54	72.09	6.98	20.93
Maize	43.75	37.50	18.75	57.58	15.15	27.27	61.11	5.56	33.33

Resource conserving technologies (RCT) are being introduced to the farmers and they are showing interest to grow crop with RCT because, it reduces cultivation cost, protects degradation of soil and saves water without yield sacrifice. Zero-till, bed planting, strip tillage and minimum tillage by power tiller operated seeder with residue retention are known as resource conservation technology (RCT). Hossain *et al.* (2019) reported that, the yield and yield component of crops with an intensive wheat-mungbean-rice cropping pattern was achieved more under different tillage options with 30% straw retention over conventional. From two years study it was revealed that raised bed and strip tillage systems with 30% straw retention affected in terms of yield and yield components for all three crops which ultimately produced maximum yield due to its more border effect.Wheat-Mungbean-Amanrice along with residue retention more effective for sustainable crop production (Alam *et al*. 2019). In this study we found that most of the HH maintained crop retention either whole or partially in the study area, thus it might help to increased crop production to the farmers.

***Use of retention crop residues*:** Use of retention crop residues by study areas were described by Table 5. In all study areas the residual crops were used as sell, feed, fuel and reuse. The residue of boro rice sold 15% in old CA research sites, 22% in new CA research sites, used as feed 75% in both old and new sites, no one used the residue as fuel, 10% old and 3% new sites household reuse as cultivation of the retention of boro rice. The residue of aman rice sold 25% in old sites household and 20% in new sites household, used as feed 70% in old and 78% in new sites household, 70% and 65% used the residue as fuel in old and new sites household, respectively, no one in old and new sites household reuse the retention of aman rice. The residue of wheat used as sell 30% in old and 35% in new sites

household, no one used as feed in old and new sites household, 70 households under old sites and 65% under new sites household used the residue as fuel, no one in old sites and new sites household reuse the wheat residues as further cultivation. In case of reuse of jute, pulses, oilseed and maize under old sites households used to sell 40%, 0%, 5% and 0% respectively while new sites households used 45%, 0%, 10% and 5%, respectively.

Table 5. Use of retention crop residues by locations (%).

Crops	Sell		Feed		Fuel		Reuse	
	Old CA research sites	New CA research sites	Old CA research sites	New CA research sites	Old CA research sites	New CA research sites	Old CA research sites	New CA research sites
Boro rice	15	22	75	75	0	0	10	3
Amanrice	25	20	70	78	0	0	5	2
Wheat	30	35	0	0	70	65	0	0
Jute	40	45	0	0	60	55	0	0
Pulses	0	0	80	85	10	10	10	5
Oilseeds	5	10	20	23	80	77	0	0
Maize	0	5	60	70	25	15	15	10

In case feed, the residue of jute, pulses, oilseed and maize were used by the old sites households respectively 0%, 80%, 20% and 60% while new sites households reused them as feed 0%, 85%, 23% and 70%, respectively. The residue of jute used as fuel and reuse for further cultivation under old sites household used respectively 60% and 0% while new sites households used 55% and 0%, respectively. The residue of pulses used 10% by the old and new sites household used the residue as fuel, 10% old and 5% new household reuse the retention of pulses. The residue of oilseeds used 80% old and 75% new sites household used the residue as fuel, 0% old and new sites household reuse the retention of maize.

***Benefits of using crop residues*:** Table 6 represents the benefits of retention crop residue in the study areas. The respondent was benefited by improve soil health, add soil nutrients, add organic matter, soil structure, beneficial microbial factor, increase soil worm, increase water conservation, less use of fertilizer and improve farm environment. For all respondent 97.16%, 92.63%, 47.60%, 74.02%, 44.10%, 39.52%, 41.92%, 67.03%, 62.23% and 44.10% were benefited by improve soil health, add soil nutrients, add organic matter, soil structure, beneficial microbial factor, increase agaricus mushroom *(benger chata)*, increase soil worm *(kechor bongso)*, increase water conservation, less use of fertilizer and improve farm environment, respectively. It indicates that all the

households had knowledge on the benefit of the retention of crop in the land.

Soil organic matter in surface soil had increased by 0.12% after two years crop cycles with 30% residue retention from rice, wheat and full residue retention from mungbean crop. Residue retention is an important component of soil management and may have long term positive impacts on soil quality (Hossain *et al*. 2019). Minimum soil disturbance together with incorporation of a legume/green manure crop into the rice–wheat system as well as the retention of their residues increased soil organic carbon status, improved soil properties and maximized grain yields (Alam *et al*. 2017).

Table 6. Benefits of retention crop residue in the study areas (%).

Benefits	Mymensingh	Rajbari	Rajshahi	Thakurgaon	All HHs
Improve soil health	93.22	98.75	95.00	100.00	97.16
Add soil nutrients	94.07	85.63	93.33	100.00	92.36
Add organic matter	30.51	26.88	91.67	45.00	47.60
Soil structure	63.56	62.50	91.67	88.33	74.02
Beneficial microbial factor	28.81	13.13	95.00	51.67	44.10
Increase agaricus mushroom (*bengerchata*)	31.36	10.63	75.83	60.00	39.52
Increase soil worm *(kechorbongso)*	31.36	10.00	90.00	51.67	41.92
Increase water conservation	62.71	44.38	94.17	76.67	67.03
Less use of fertilizer	61.02	41.25	94.17	51.67	62.23
Improve farm environment	61.86	5.00	94.17	13.33	44.10

Utilization of Crop Residues

***Level of knowledge on crop residues*:** Table 7 represents the extent of knowledge on crop residue in the study areas of Mymensingh, Rajbari, Rajshahi and Thakurgaon. From the table it can be concluded that the extent of information and training is higher for Rajbari region which is 48.15 and 66.67%, respectively. On the other hand, there is almost no access to information and training in Thakurgaon region. The extent of information was comparatively higher for Mymensingh region than the Rajshahi regions which was 38.89% and while the extent of training was higher for Rajshahi which was 19.05%. By comparing all households, it can be concluded that the extent of information and training was higher for Rajbari region compared to the other regions due to previous CA research practiced by BARI.

Table 7. Extent of knowledge on crop residue in the study areas.

	% of HH	
Locations	Information	Training
Mymensingh	38.89	9.52
Rajbari	48.15	66.67
Rajshahi	12.04	19.05
Thakurgaon	0.93	4.76
All areas	100.00	100.00

***Utilization of crop residues*:** The general uses of the crop residues are also presented in Table 8. Farmers in Bangladesh mostly used crop residues wither for cooking fuel and/or animal feed. In addition, it was found that mostly cop residues also used as organic fertilizer too.

Table 8. Utilization of crop residues in the study areas (% of HH).

Uses	All HHs (N = 458)	
	Old CA Research sites	New CA Research sites
Cooking fuel	63.46	57.06
Animal feed	67.30	68.64
Organic fertilizer	74.04	61.86
Use with cow dung boll	2.88	0.28
Fired at field	1.92	1.13
Cut during harvest	11.54	16.38
Reuse during next cultivation	42.31	11.86

***Pattern of crop residue as cooking fuel*:** Table 9 describes the extent of using crop residue as cooking fuel in the study areas. It is obvious from the Table 6 that the whole proportion of own fuel wood is used by the higher60.2% household of Rajbari region for cooking purposes while lower 1.99% households use others crop residues in whole amount. For Rajshahi region the lower proportion of own fuel wood is used by 85.7% household and the whole proportion of others fuel wood and purchased fuel wood is used by 0.50% households. In case of Thakurgaon region 57.14% household use their own cow dung in partial amount for cooking purposes while 1.30% households use others crop residues in whole amount, respectively. Further it can be concluded that 84.06% households use their own fuel wood in whole amount for their cooking purposes while 0.72% households use others fuel wood in whole amount for the same purposes, respectively.

Table 10 represents the extent of using crop residue as cooking fuel in the study areas by the category of households. Here also the sources of cooking fuels are own fuel wood, others fuel wood, purchased fuel wood, own crop residues, others crop residues, own cow dung and others cow dung. Table 11 reveals that for Old CA research sites households, the highest number of households who use whole amount of own crop residues are 30.23% while the lowest number of households who use whole amount of others fuel wood and purchased fuel wood are 0.58% respectively. On the other hand, for New CA research sites households the highest number of households who use whole amount of own crop residues are 30.23% while the lowest number of households who use whole amount of others fuel wood are 0.68%, respectively. For all households, the highest number of households using the whole amount of their own fuel wood is 52.44% while the lowest number of households using the whole amount of the purchased fuel wood is 0.16%.

The availability of crop residues as animal feed in the study areas are described by Table 11. Here, the sources of animal feed are own crop, others crop, purchased feed, own crop residues, others crop residues and available grass. The status of the amount of crop residues that were used for animal feed was divided into three categories, viz. whole, partial and low. In Rajbari, whole amount of own crops which is highest 59.30% was used for animal feed where the whole amount of only 2.51% of available grass was used as animal feed. The partial amount of available grass which is highest 53.51% was used for animal feed where the whole amount of only 3.51% of own crop was used as animal feed. Again, among the sources of animal feed 100% of purchased feed is used in lower amount Rajbari region. In Rajshahi, whole amount highest 52.75% of own crops was used for animal feed where the 1.10% of the whole amount of others crop residues and available grass were used as animal feed.

60.87% of the partial amount of available grass was used for animal feed where the 1.45% of others crop was used as animal feed. Again, among the sources of animal feed 57.14% of purchased feed was used in lower amount and 14.29% of own crop residues was used in Rajshahi region.

Table 9. Extent of using crop residue as cooking fuel in the study areas (%).

Sources	Rajbari			Rajshahi			Thakurgaon			Mymensingh		
	Whole	Partial	Low	Whole	Partial	Low	Whole	Partial	Low	Whole	Partial	Low
Own fuel wood	60.2	9.4	-	28.5	45.6	85.7	37.6	-	28.5	84.0	1.0	-
Others fuel wood	-	18.8	25.0	0.5	5.2	7.1	2.6	-	14.2	0.7	5.3	3.70
Purchase fuel wood	-	13.6	50.0	0.5	12.2	-	-	-	14.2	-	3.2	70.3
Own crop residues	22.3	17.0	-	25.5	8.7	-	35.0	28.5	-	1.4	44.0	18.5
Other crop residue	1.9	6.8	-	4.5	-	-	1.3	14.2	-	-	21.5	7.4
Own cow dung	7.9	28.2	-	39.5	5.2	-	16.8	57.1	28.5	11.5	19.3	-
Otherscow dung	7.4	5.9	25.0	1.0	22.8	7.1	6.4	-	14.2	2.1	5.3	-

Table 10. Extent of using crop residue as cooking fuel in the study areas (%).

Crops	Old CA research sites			New CA research sites			All HHs		
	Whole	Partial	Low	Whole	Partial	Low	Whole	Partial	Low
Own fuel wood	33.72	16.50	53.33	59.68	12.28	16.22	52.44	13.87	26.92
Others fuel wood	0.58	16.50	20.00	0.68	7.60	2.70	0.65	10.95	7.69
Purchase fuel wood	0.58	11.65	6.67	-	8.19	56.76	0.16	9.49	42.31
Own crop residues	30.23	17.48	-	16.44	29.24	13.51	20.29	24.82	9.62
Others crop residues	4.07	5.83	-	1.58	13.45	5.41	2.27	10.58	3.85
Own cow dung	24.42	26.21	6.67	18.47	18.13	2.70	20.13	21.17	3.85
Others cow dung	6.40	5.83	13.33	3.15	11.11	2.70	4.06	9.12	5.77

***Pattern of crop residue as animal feed*:** In Thakurgaon, whole amount of own crops which is 92.31% was used for animal feed where only 1.92% of the whole amount of own crop residues and others crop residues were used as animal feed (Table 11). 81.48% of the partial amount of available grass was used for animal feed where the 1.45% of own crop was used as animal feed in Thakurgaon region. Again, among the sources of animal feed and 50% of purchased feed was used in lower amount in Thakurgaon region. In Mymensingh, whole amount of own crops which is 35.94% was used for animal feed where only 1.56% of the whole amount of others crop residues was used for animal feed in that region. Partially highest 35.94% of

own crops and the lowest 1.56% of others crop was used as animal feed. Again, among the sources of animal feed highest 42.86% of available grass was used in lower amount and lowest 1.19 % of own crop and others crop residues were used in Mymensingh region. The use of crop residue as animal feed in the study areas by category of households is presented in Table 12.

Table 11: Availability of crop residues as animal feed in the study areas (%).

Sources	Rajbari			Rajshahi			Thakurgaon			Mymensingh		
	Whole	Partial	Low	Whole	Partial	Low	Whole	Partial	Low	Whole	Partial	Low
Own crop	59.3	3.5	-	52.7	27.5	28.5	92.3	18.5	-	79.1	35.9	1.19
Other crops	-	9.6	-	-	1.4	-	-	-	-	0.8	4.6	-
Purchased	16.5	12.2	100	3.30	10.1	57.1	3.8	-	50.0	0.8	9.3	34.5
Own crop residues	21.6	13.1	-	41.7	-	14.2	1.9	-	-	17.3	23.4	20.2
Other crop residues	2.5	7.8	-	1.1	-	-	1.9	-	-	1.7	1.5	1.1
Available grass	-	53.5	-	1.1	60.8	-	-	81.4	50.0	-	25.0	42.8

Table 12. Extent of using crop residue as animal feed in the study areas (%).

Sources	Old CA research sites			New CA research sites			All HHs		
	Whole	Partial	Low	Whole	Partial	Low	Whole	Partial	Low
Own crop	38.99	37.04	66.67	70.17	26.72	1.01	51.41	30.00	2.94
Other crops	-	18.52	-	0.28	4.31	-	0.17	8.82	-
Purchased	5.66	12.96	-	8.52	17.24	74.75	6.49	15.88	72.55
Own crop residues	25.16	16.67	33.33	17.61	18.10	17.17	16.97	17.65	17.65
Other crop residues	-	14.81	-	2.56	1.72	1.01	1.50	5.88	0.98
Available grass	30.19	-	-	0.85	31.90	6.06	23.46	21.76	5.88

Here also the sources of animal feed are own crop, others crop, purchased feed, own crop residues, others crop residues and available grass. The status of the amount of crop residues that were used for animal feed was divided into three categories, viz. whole, partial and low. It is obvious from the table that for all households, the whole amount of 51.41%, 0.17%, 6.49%, 16.97%, 1.50% and 21.76% of animal feed comes from own crop, others crop, purchased feed, own crop residues, others crop residues and available

grass, respectively. The partially used amount of own crop, others crop, purchased feed, own crop residues, others crop residues and available grass as animal feed are 30%, 8.82%, 15.88%, 17.65%, 5.88% and 21.76%, respectively. Further, own crop, purchased feed, own crop residues, others crop residues and available grass are used respectively 2.94%, 72.55%, 17.65%, 0.98% and 5.88% which was found lower amount as animal feed in the study areas.

Uddin and Fatema (2016) found that farmers of Mymensingh district utilize crop residue as organic fertilizer, mulching, animal feed, cooking fuel, stall feeding, animal bedding, sold for cash, and burned at field at a rate of 76.1, 65.3, 58.3, 42.7,12.4, 8.2, 3.2 and 1.1 percent of farmers followed, which is similar to our present study.

***Causes of damages of crop residue*:** Table 13 describes the causes of damage of crop residues in the study areas by the adopter and non-adopter households. From this table we can conclude that 18.12% household says that causes of damages of crop residues is not harvesting or late harvesting of crops while 2.84%, 5.02% and 0.44% perceives that causes of crop residues damage are crop residues nature, incorrect preservation method and the other causes.

Table 13. Causes of damages of crop residues in the study areas (% HH).

Causes of damages	Old CA research sites	New CA research sites	All HH
For not harvesting	13.46	19.49	18.12
Nature of crop residues	5.77	1.98	2.84
Incorrect method of preserving	10.58	3.39	5.02
Others	-	0.56	0.44

In case of adopter and non-adopter households, 13.46% and 19.49% claims that the cause is not harvesting or late harvesting of crops while among the non-adopters only 1.98% claims that the cause is nature of crop residues.

Processing of crop residues

***Methods of threshing and status of threshed crops*:** Table 14 describes the method of threshing of crops by locations. From this table it is clear that farmers use two methods to thresh the crops after harvest.

Table 14. Methods of threshing of crops by locations.

Locations	By hand beating		By machine	
	No. of HH	% of HH	No. of HH	% of HH
Rajbari	18	11.25	142	88.75
Rajshahi	15	12.71	103	87.29
Thakurgaon	11	18.03	50	81.97
Mymensingh	8	6.72	111	93.28
All HHs	52	11.35	406	88.65

They are threshing by hand beating and threshing by machine. Table 15 represents that 11.25%, 12.71%, 18.03% and 6.72% households used hand beating method in Rajbari, Rajshahi, Thakurgaon and Mymensingh regions while 88.75%, 87.29%, 81.97% and 93.28% HHs used machine to thresh the crops. This mean that machine method is more popular in all the regions but it is more preferable in Mymensingh region compared to the other regions. So, it is obvious that large number of HHs prefer to use machine for threshing.

Status of threshed crop residue by the respondent HHs is presented in Table 15. Here only three crops have been considered for this. They are rice, wheat and maize. Also the status of crop residue is categorized into two categories such as whole part and cut piece. We see that highest number of HHs found their crop residue after threshing as whole part which constitutes 36.62%, 94.02% and 99.11% for rice, wheat and maize crops. On the other hand, a large number of HHs found their residues as cut piece only for rice crops which

occupy 63.38% while very few HHs found it as cut piece for wheat and maize crops which stood 5.98% and 5.98%, respectively. Overall it can be concluded that whole part of crop residue is more common for crops which the HHs get after threshing in all locations while cut piece is only common for rice crops.

Table 15. Status of threshed crop residue by the respondent HHs.

Crops	Whole part		Cut piece	
	# HH	% HH	# HH	% HH
Rice	119	36.62	206	63.38
Wheat	110	94.02	7	5.98
Maize	111	99.11	1	0.89

***Processing methods of threshed crops*:** Table 16 represents the methods of processing of crop residues by locations. The methods that were used for processing of crop residues are roasting, boiling, soaking, chopping and cooking. The result shows that out of 268 HHs in all areas 8.30%, 11.57%, 13.54% and 24.45% used roasting, soaking, chopping and cooking method while only 0.66% used boiling method of processing. This means that among the five methods cooking method is mostly used method of processing while the HHs dislike the boiling method for this.

Table 16. Methods of processing of crop residues by locations.

Methods	All HHs	
	No. of HH	% of HH
Roasting	38	8.30
Boiling	3	0.66
Soaking	53	11.57
Chopping	62	13.54
Cooking	112	24.45

Constraints and opportunities of crop residues retention

***Constraints*:** The constraints to crop residue retention and their uses by locations are described in Table 17. The study identified that the constraints faced by the farmers were harvesting, carrying, labour deficit, economic loss, difficulties in use, difficulties faced in land preparation and attack of disease and pest infestation. Further, the problem has been given a rank of 1-7. Rank 1 is for the problem that are seemed to be the most serious and rank 7 is for the problem that seemed by the farmers as not so serious. The problem also can be grouped into high, medium and low. The table describes that in old CA research sites, 25.22% farmers claimed that labour deficit is the high constraints, 18.18% told that economic loss is the medium constraints and 29.27% HHs claimed that problem faced in carrying is the low constraints that are faced by highest no. of HHs in the old CA research sites. In new CA research sites, 28.71%, 24.64% and 21.36% HHs respectively claimed that economic loss, problem faced in harvesting and carrying were the high, medium and low level of constraints that were faced by the highest number of HHs in that area. In case of all HHs, 22.22%, 21.48% and 18.82% HHs claimed that problem faced in carrying, harvesting and the problem of insect and pest infestation were the high, medium and low level of constraints that were faced by the highest number of HHs in all the study area. Overall it can be concluded that carrying problem was the most serious problem in the study areas that deserve the highest rank 1 while rank 7 was land preparation problem that were faced by the responding HHs in the study areas.

***Opportunities*:** Opportunities to crop residue retention and their uses are presented by Table 18. Here, the opportunities were ranked into 1-5. Rank 1 is for the highest rank and 5 are for the lowest rank. The item that field should be processed accordingly attained the lowest rank which occupy 6.73% of the total among the 73 households. The highest rank 1 was given for

the item that training should be provided at the farm level which occupies 29.81% of the total among the 73 households. Rank 2, 3 and 4 were given to the items that suitable methods should be developed for each crop, laborer should be trained up accordingly and residues should be cut at a little bit longer which occupies 14.42%, 11.54% and 7.69% among the 73 households.

Table 17. Constraints to crop residue retention and their uses by the sample HHs (%).

Constraints	Old CA research sites			New CA research sites			All HHs			Ranks
	H	M	L	H	M	L	H	M	L	
Harvesting	22.61	11..96	11.38	6.22	24.64	8.62	12.04	21.48	9.12	5
Carrying	20.00	13.40	29.27	23.44	22.26	9.34	22.22	20.05	12.94	1
Labor deficit	25.22	13.40	23.58	14.83	19.55	12.39	18.52	18.02	14.41	3
Economic loss	7.83	18.18	9.76	28.71	4.93	20.29	21.30	8.23	18.38	2
Difficulties in use	9.57	14.83	8.13	4.31	11.92	13.46	6.17	12.65	12.50	6
Land preparation	10.43	13.40	10.57	3.35	11.45	14.54	5.86	11.93	13.82	7
Insect and pest infestation	4.35	14.83	7.32	19.14	5.25	21.36	13.89	7.64	18.82	4

Table 18. Opportunities to crop residue retention and their uses.

Items	No. of HH	% of total	Ranked
Training should be provided to the farm level	31	29.81	1
Suitable methods should be developed for each crop	15	14.42	2
Field should be processing accordingly	7	6.73	5
Labourer should be trained up accordingly	12	11.54	3
Should be cut little bit longer	8	7.69	4

Conclusions

The different types of crops farmers use different retention method (whole, partial and no retention) which also vary by different distance to plot. Households normally use their crop residues for selling, feeding, fueling, and reuse purposes. For these purposes they use the residues of boro rice, aman rice, wheat, jute, pulses, oilseeds and maize. The households of new CA research sites utilize these residues more efficiently than the old CA research sites and they mostly use this for feeding of animals and fueling purposes. The old CA research sites are best in utilizing their crop residues than new CA research sites. Between two methods of threshing (hand beating and machine) machine method is more popular in all the regions. So, it is obvious that large number of HHs prefer to use machine for threshing. The major constraints are harvesting, carrying, labour deficit, economic loss, difficulties in use, land preparation and insect and pest infestation. All these problems exist more or less in all areas in high, medium and low

extent. However, highest number of HHs claimed that the opportunity to crop residue retention is the farm level training that should be given to the farmers by GOs, NGOs or extension agents whereas lowest number of HHs claimed that it would be the opportunity for them if the field can be processed accordingly.

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