Determinants of household fuelwood collection from mangrove plantations in coastal Bangladesh

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ARTICLE INFO

ABSTRACT

The Government of Bangladesh has been establishing mangrove plantations since 1960. This study analyzes results from a household survey across eight coastal villages to investigate how local rural communities utilize these resources. The predominant direct use by households is the extraction of combustible fuel. Econometric results suggest that determinants of the household decision to collect fuelwood include respondent occupation and village. Farmers are less likely to extract mangrove fuels due to the availability of substitutes such as agricultural residues, and are also less likely obtain non-mangrove fuelwood via market purchase. Collection quantities are positively correlated with degree of impoverishment, with poorer households significantly less likely to access non-mangrove fuelwood markets. These results are robust to selection bias, spatial lag dependence, and spatial error dependence, and have important policy implications for beneficiary selection for future mangrove plantations.

1. Introduction

Since 1960, the Government of Bangladesh has established coastal mangrove plantations for the purposes of shoreline stabilization and storm surge protection. The Bangladesh Forest Department undertakes and monitors plantation activities, which are a significant component of the country's adaptation response to climate change. Although felling of whole trees is prohibited, the extraction of non-main stem material (e.g., limbs, pneumatophores, and leaves) by local communities is allowed and is the predominant direct use of mangrove plantations (Chow, 2015).

Woody combustion fuel (hereafter, fuelwood) is in some of the developing world the largest output generated from forests, benefitting more of the rural poor than any other forest product (Arnold et al., 2003). Studies of fuelwood collection typically explore several factors which affect household production possibilities and demand preferences. Research from Asia (e.g., Cooke, 1998; Heltberg et al., 2000; Kohlin and Parks, 2001; Sills et al., 2003; Gundimeda and Kohlin, 2008) generally indicate that the impact of household wealth on fuelwood production is highly location-specific, and may vary even within the same region. They often find that landholding and livestock ownership, as proxies for wealth and capital, respectively, can be positively correlated with total fuelwood collection, and market expenditures, particularly in remote areas where combustible fuels are scarce (e.g.,

Amacher et al., 1993; Amacher et al., 1996, 1999; Chen et al., 2006). In places such as coastal Bangladesh where fishing is a major economic activity, landholding and livestock are not universally applicable metrics. Therefore, evaluation of the determinants of fuelwood collection requires localized investigation, since predictions of household behavior are difficult to extrapolate from one area to another.

This study investigates how household characteristics affect fuelwood collection from mangrove plantations in coastal Bangladesh. Empirical analysis of fuelwood scarcity has generally overlooked the very poor, who often have less access to substitutes for fuels collected from village commons (Cooke et al., 2008). Most research also ignores the landless, which this study addresses by focusing on coastal villages where households are engaged in land-intensive activities such as farming as well as non-land-intensive activities such as fishing.

The rest of the paper is organized as follows. Section 2 describes the study area, survey methodology, and summary statistics. Section 3 introduces the theoretical model which motivates the reduced form empirical model described in Section 4. Section 5 presents and interprets results from the empirical model along with robustness checks and Section 6 concludes the paper with a discussion of policy implications.

2. Study area, methodology, and summary statistics

Bangladesh (20.6–26.6°N, 88–92.6°E) has a coastal zone where 75%

Table 1
Breakdown of administrative units included in study.

Division	District	Upazilla	Village	Sample size (households)
Barisal	Barguna	Patharghata	Padma	49
		Taltoli	Sokina	50
	Patuakhali	Kalapara	Momripara	30
	Bhola	Char Fasson	Babugonj	36
Chittagong	Chittagong	Sitakunda	Mirzanagar	40
			Saidpur	39
		Mirsarai	Gazaria	45
	Noakhali	Hatiya	Aladigram/Kalirchar	50

of the population lives in rural communities reliant upon agro-ecosystems and natural resources (Iftekhar, 2006). Deltaic sedimentation creates new coastal formations—*chars*—where the Bangladesh Forest Department has established mangrove plantations within the districts of Patuakhali, Barisal, Bhola, Noakhali and Chittagong (Saenger and Siddiqi, 1993).

This study analyzes data on demographics, livelihoods, geospatial location, and fuelwood collection behavior from households within eight villages spanning seven upazillas (subdistricts) (Table 1): Aladigram/Kalirchar, Babugonj, Gazaria, Padma, Momripara, Mirzanagar, Sokina, and Saidpur. Aladigram and Kalirchar are officially two villages but are situated contiguously, hence this study treats them as a single village. Surveys of 340 households—approximately 10% of all households within the selected villages—were conducted in 2012 as described by Chow (2015). Each respondent, typically a representative head of household, was selected if they were willing to complete the full survey, if they were an income earner, and, if the household collected mangrove materials, personally participated in collection. The sample was otherwise random. After surveys in two villages, Padma and Sokina, were complete, the questionnaire was modified to collect additional information on other fuels: purchased fuelwood, homestead trees, livestock dung, and other agricultural residues (e.g., grass and rice straw).

Table 2 lists key summary statistics by village. Years of formal education for this cohort is low across villages, the overall average

being about three years. Households number six people on average, with over a third having multiple income earners due to the presence of multiple generations of working age. A majority of respondents in each village partake in multiple income-generating activities. Nearly half of all respondents cultivate land that they either own or rent, and over a quarter work as hired farm labor at some point during the year. Over 40% of respondents engage in marine, coastal, or riparian fishing using their own equipment, but only 4% work as hired fishing labor.

Respondents usually do not keep records of their revenues and expenditures and are typically unaware of their total annual earnings. This study calculates incomes based on answers to questions related to wages, expenditures, revenues, and frequency of income-generating activities. Because of the numerous estimations and imperfect recollections involved in calculating the net revenues of any particular activity, the calculated incomes are prone to substantial error. Unadjusted, income estimations are negative for 110, or nearly a third, of respondents. Since households are unlikely to truly have negative incomes, at least for long periods of time, negative calculated incomes are converted to zero for the purposes of these analyses. This adjustment suggests that households with negative incomes operate at a subsistence level and generate little surplus, a reasonable assumption for rural households in Bangladesh. However, because no similar adjustment is implemented for possibly overestimated incomes, the following averages are likely overestimates. Considering the adjusted data, average respondent income is Tk.302,000 per year (USD3887 per year), though this varies substantially by village. Average household income, calculated based on respondents' estimates of their proportional contribution, is Tk.464,000 per year (USD5972 per year).

An alternate measure of wealth is the number of rooms in the family home, under the presumption that the wealthier the household, the greater the number of rooms. Ordinary least squares (OLS) regression between total household income and the number of rooms confirms that the two characteristics are linearly correlated (Table 3). However, the number of rooms is also correlated with household size, likely due to a greater need for living space for larger families. Larger families are also more likely to have multiple income earners, further confounding the relationship between household size, rooms, and household income. Household income, household size, the number of income earners, and the number of rooms are all correlated with each other.

Table 2
Summary statistics at village level. Standard deviations in parentheses.

	Aladigram/ Kalirchar	Babugonj	Gazaria	Mirzanagar	Momripara	Padma	Sokina	Saidpur	All
Total households (approx.)	500	300	149	280	500	650	293	NA	
Number of respondents	50	36	45	40	30	49	50	39	339
# Activities (respondent only)	2.32 (0.87)	1.89 (0.71)	1.62 (0.65)	1.58 (0.59)	1.63 (0.72)	2.22 (0.96)	1.96 (0.75)	1.67 (0.66)	1.9 (0.8)
% Respondents w/mult. jobs	84	69.4	53.3	52.5	53.3	77.6	70	56.4	65.6
% Fishers, any (own equipment)	40	75	6.7	60	33.3	34.7	76	10.3	42.1
% Boat fishers (own equipment)	26	63.9	0	50	33.3	26.5	70	5.1	34.1
% Shore fishers (own equipment)	14	13.9	6.7	10	3.3	8.2	6	5.1	8.5
% Fishers (hired labor)	8	2.8	0	2.5	0	10.2	12	0	5
% Farmers	42	33.3	84.4	0	73.3	26.5	32	87.2	46.2
% farm (hired labor)	30	27.8	28.9	22.5	16.7	26.5	26	35.9	27.1
Mean age of respondent	39.6 (10.43)	38.44 (11.75)	45.84 (14.34)	44.08 (12.75)	39.8 (16.52)	42.39 (15.44)	34.82 (9.52)	37.33 (10.85)	40.31 (13.09)
Mean years of education	1.26 (2.42)	2.89 (3.22)	1.8 (2.56)	2.23 (2.6)	3.3 (2.68)	4.22 (3.6)	3.98 (2.65)	4.05 (3.56)	2.96 (3.11)
Mean household size	6.4 (2.09)	5.14 (1.51)	5.53 (1.27)	7.05 (2.93)	4.87 (1.63)	5.18 (1.86)	4.98 (1.39)	5.51 (1.93)	5.61 (2)
Mean # rooms	2.62 (1.19)	2.5 (1.13)	3.44 (1.8)	3.58 (1.3)	2.5 (0.94)	2.34 (1.05)	2.06 (1.1)	3 (1.1)	2.75 (1.33)
Mean persons per room	2.79 (1.16)	2.53 (1.37)	1.89 (0.74)	2.07 (0.68)	2.21 (1.02)	2.56 (1.27)	3.13 (1.75)	2.07 (0.92)	2.44 (1.24)
Mean respondent income (1000Tk/yr)	214 (745)	85 (185)	80 (99)	1253 (2130)	70 (93)	310 (789)	229 (808)	169 (232)	302 (961)
mean household income (1000 Tk/yr)	242 (746)	100 (203)	126 (186)	2395 (4717)	75 (100)	379 (861)	235 (807)	208 (241)	464 (1834)
Mean fuelwood, collectors only (kg/yr/HH)	4303 (6519)	2076 (3579)	2067 (1484)	464 (430)	1592 (2361)	3687 (4169)	3847 (5059)	2143 (1523)	3007 (4397)
Mean fuelwood, all (kg/yr/HH)	40.44 (64)	19.61 (35.08)	12.86 (15.43)	0.348 (1.57)	13.27 (22.31)	26.33 (38.91)	30.78 (47.73)	10.99 (15.29)	20.52 (38.91)