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Effectiveness of co-management in reducing forest dependency and improving socioeconomics of forest dependent people in Bangladesh

SURIYA YEASMIN, KAZI NAZRUL ISLAM♥, MOHAMMED JASHIMUDDIN, MOHAMMAD MAHFUZUR RAHMAN, ANIRBAN CHOWDHURY JIKU
Institute of Forestry and Environmental Sciences, University of Chittagong. Chattogram 4331, Bangladesh. Tel.: +880-312606144,
♥email: nazrul.forestry@cu.ac.bd

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Abstract. *Yeasmin S, Islam KN, Jashimuddin M, Rahman MM, Jiku AC. 2022. Effectiveness of co-management in reducing forest dependency and improving socioeconomics of forest dependent people in Bangladesh. Asian J For 6: 56-64.* Co-management of forest protected areas (PA) has started its journey in Bangladesh, intending to conserve forest resources by creating alternative income-generating activities for forest-dependent people. This study was designed to assess the effectiveness of co-management initiatives in improving socio-economic status and reducing peoples' forest dependency at Dudpukuria-Dhopachari Wildlife Sanctuary (DDWS), Bangladesh. A total of 142 respondents consisting of 71 co-management project-supported people (treatment) and 71 local people (control) with similar socio-economic conditions without any project support, were surveyed randomly through a semi-structured questionnaire. The Difference in Differences (DiD) method was applied to assess the effectiveness of this program. Results revealed that there was an insignificant difference between co-management participants and non-participants in the case of total income. Both parties also observed a similar trend for total forest resource extraction. However, the monthly income of co-management participants from secondary occupations increased by USD 16.46. In contrast, the monthly fuel wood extraction of the co-management participants was reduced, equivalent to USD 2.21. The studied socio-economic parameters were more or less similar for both parties. We conclude that the co-management interventions in DDWS resulted from insignificant differences in terms of socio-economic conditions and forest dependency of local forest-dependent communities.

Keywords: Co-management, the difference in differences, forest dependency, protected area, socioeconomics

INTRODUCTION

Forests and people are two interconnected and crucial terms in forest resources management. Globally, about 1.6 billion people depend directly or indirectly on forest resources for their livelihood (United Nations 2011). In addition, poor people living in the vicinity of forested areas have multiple dependencies on forest resources – food, water, land, medicine, energy, timber, etc. for their subsistence. Due to the excessive extraction of forest resources and anthropogenic disturbances, tropical forests in developing and underdeveloped countries are being degraded and deforested daily. An estimated 420 million ha of forests have been lost worldwide through deforestation since 1990. During 2015-2020, the annual rate of deforestation was estimated at 10 million ha, seen from 12 million ha in 2010-2015 (FAO 2020).

Bangladesh, a developing country in South Asia, is facing various difficulties regarding forest resource conservation and management. Forested areas of the country are geographically distributed in the remote and underdeveloped parts of the country. People living in the vicinity of these government-owned forests are poor and ultra-poor. They encroach on forest land to make settlements and practice agriculture. In addition, they collect fuel wood, pole, timber, and other non-wood forest products from forests to meet their daily needs (Mukul et al., 2016; Ullah et al., 2020). Such detrimental activities accelerate forest degradation and deforestation in the country (Islam et al. 2019a; Abdullah et al. 2019; Ahmed et al. 2020). The Government of Bangladesh has taken some initiatives to conserve the reserve forests – rich in diverse native endangered flora and fauna. Some intact and less disturbed forest patches supporting rich biodiversity were declared protected areas (PA) as a part of conservation initiatives amid rapid forest cover loss (Feeroz 2013).

However, such a declaration was not fruited due to a lack of departmental capacity, peoples' socio-economic status, and immense dependence on forest resources (Mollah et al. 2004; Roy and DeCosse 2006). Later on, forest-dependent people were involved in the management body in the name of PA co-management. Forest resources co-management was initiated in Bangladesh with direct supervision and financial support from United States Aid for International Development (USAID) in 2004. The main objective of such intervention was to conserve biodiversity and to halt or reduce forest cover loss along with livelihood improvement of forest-dependent people through Alternative Income Generating Activities (AIGAs) (Rahman et al. 2017a). USAID supported this community-based management approach in three phases in the name of three different projects. Initially, the Nishorgo Support Project (NSP) during 2004-2008, then the Integrated Protected Area Co-management (IPAC) project during

2008-2013, and Climate Resilient Ecosystem and Livelihood (CREL) project supported co-management activities during 2013-2018 (Islam et al. 2019a). Presently, there are 54 forest PAs in the country, out of which 21 PAs are under a co-management regime with 28 co-management organizations (BFD 2022).

Researchers and policymakers are trying to investigate the outcomes of such community-based approaches to forest resources management from different angles across the globe. In Nepal, community-managed forests successfully increased forest cover and biodiversity conservation (Thoms 2008; Anup et al. 2018; Shrestha et al. 2018). Siraj et al. (2018) found community-based forest management successful in addressing deforestation and livelihood improvement of forest-dependent people in Ethiopia. However, In Malawi, forest co-management creates no discriminable impact on forest-based household income (Mazunda and Shively 2015). In addition, the misuse of power by important actors for self-interest has been considered a major obstacle to the success of community-based forest management (Krott et al., 2014). Magessa et al. (2020) concluded that the participatory forest management policy failed to achieve governance objectives and meaningful devolution in Tanzania.

In Bangladesh, researchers are also trying to assess this people-oriented governance system in terms of biodiversity conservation, reducing deforestation, and upliftment of the socio-economic status of forest-dependent people. Islam et al. (2019a) revealed that forest cover loss was in progress in co-managed PAs in Cox's Bazar and Sylhet region. However, Chowdhury et al. (2020) found positive impacts of co-management on forest cover in the Chattogram region. Livelihood programs under the umbrella of co-management in Chunati Wildlife Sanctuary (CWS) contributed to the increasing income of forest-dependent people and reduced forest dependency (Rahman et al. 2017a,b). Jashimuddin et al. (2021) outlined some positive impressions of co-management in CWS regarding governance and biodiversity conservation. Rahman et al. (2016) reported that biodiversity indices had dropped in some PAs during the co-management regime. In addition, some exotic species become dominant in co-managed PAs (Nath et al. 2016; Rahman et al. 2017b; Islam et al. 2020). Islam et al. (2020) concluded that non-co-managed forests showed better biodiversity status and carbon sequestration capacity than co-managed PAs. In line with this finding, Islam et al. (2021) revealed that forest officials and co-management non-participants perceived poor co-management outcomes concerning the existence of native tree species, wildlife population, and agricultural activities inside the PAs of Bangladesh.

Dudpukuria-Dhopachori Wildlife Sanctuary (DDWS) has been one of the co-managed PAs since 2011 in the south-eastern hilly Bangladesh region. Some studies are on the socio-economic impacts of co-management in different PAs of Bangladesh. But how this management approach has impacted the income and social lifestyle of forest-dependent people in the vicinity of DDWS has not been investigated yet. This study thus has been designed to (i) investigate the impact of co-management on the income of forest-dependent people, (ii) examine the changes in the forest resource extraction of forest-dependent people, and (iii) compare the social status of co-management participants and non-participants based on present livelihood practices.

MATERIALS AND METHODS

Study area

Dudpukuria-Dhopachori Wildlife Sanctuary (DDWS) was declared a wildlife sanctuary on 9 May 2010 under the Bangladesh Wildlife Act 1974, later amended and renamed as Wildlife (Conservation and Security) Act 2012. It is situated at the junction of Rangunia and Chandanish Upazila (sub-district) of the Chattogram District and lies between 22º09' N to 22º22' N and 92º05' E to 92º10' E (Figure 1). The sanctuary is under the jurisdiction of Chattogram South Forest Division. With a total area of 4716.57 ha, DDWS comprises three beats under two ranges, namely Dudpukuria, Kamalachori fall under Khurushia Range, and Dhopachari beat under Dohazari Range. The beat is the lowest administrative unit of the Bangladesh Forest Department (BFD). Ecologically, DDWS is a part of Bangladesh's evergreen and semi-evergreen tropical forests. The monthly average temperature ranges from 11.4ºC to 33.7ºC, the monthly average rainfall is 252.7 mm, and the monthly average humidity is 76.6% (BBS 2022). Most of the sanctuary is covered by hills and hillocks (80%), and only 20% is plain land (Hossain et al., 2013; NN, 2018).

About 5,000 people live across the Dudpukuria landscape portion, and another 12,000 people live across the Dhopachari landscape (NN 2018). People are engaged in multiple income sources to earn their total livelihood. They cultivate rice, vegetables, and fruits; some work as day laborers and some run small businesses. The poor and ultra-poor people depend on forest resources for their daily needs. Therefore, they encroached on forest lands to grow agricultural products and extracted trees, fuel wood, bamboo, saplings, etc. (NN 2018).

Sampling framework

A bottom-up approach is followed for governing the co-managed PAs. Administrative activities of co-management are centered at Forest Range Office; each range has all governance components led by the Co-management Executive Committee (CMEC), previously known as the Co-management Committee (CMC). At the bottom of the co-management governance, there are several Village Conservation Forums (VCF) consisting of forest-dependent people living in the villages in the vicinity of the PA. Co-management intervention in DDWS was enacted in 2011 by institutionalizing two CMCs, One in Khurushia Range and another in Dohazari Range, by USAID-funded IPAC and CREL projects. A sum of 36 VCFs were formed under two CMCs to facilitate co-management governance in DDWS. Out of 36 VCFs, 21 were under the jurisdiction of the Khurushia Range, while 15 were under Dohazari Range. VCF beneficiaries were aided with different AIGA

supports, e.g., fruits and medicinal plants, seedlings, vegetable seeds, fish, poultry, handicraft assistance, etc., throughout the project duration. We randomly selected eight VCFs – four from each range. A total of 71 VCF members from these eight VCFs were randomly selected as treatment respondents for the questionnaire survey.

We employed the Difference in Differences (DiD) method to estimate the net change in the respondents' income and forest resource uses due to co-management intervention. A DiD estimation is a well-known econometric tool for investigating causal relationships of a certain intervention; when implemented does not have equal impacts on everybody at the same time in a similar way (Bertrand et al. 2004; Lechner 2011). Hence, it needs data from two parties, one involved in the intervention named as treatment, and the other not involved named as the control. So, we interviewed another 71 people having no involvement with co-management intervention, which made the total sample size 142 (71 treatment, 71 control). However, we collected secondary information from the BFD and CODEC field staff (Community Development Center; a national NGO – associate partner of the co-management implementing body in DDWS). The survey questionnaire of the study focused on income sources, monthly income amount, forest resource uses, and monthly income from forest resource extraction both before and after initiation of co-management, as well as common socio-economic attributes like existing household appliances, energy, and drinking water sources, domestic waste management, sanitary latrine uses, etc.

Calculation of change in income status and forest resource extraction

As DiD method requires pre- and post-treatment information from control and treatment groups, we used a recall method for both groups to evoke them stating the pre-and post-treatment information on their livelihoods and forest resource uses. We classified income sources into two categories. Income sources that contributed a major share in respondents' livelihoods were termed primary occupations, and other supporting money-generating activities were listed as secondary occupations. Forest dependency was assessed by asking about the number of monthly visits to the forest, types, and quantity of resources collected and calculating the price per market value.

The attributes used in the DiD method, and their definitions, are explained in Table 1. We employed the following regression framework to assess the impact of co-management on a participant household by eliminating the time-varying impact on the group that was not caused by this intervention.

Let, the state of the household k under study be H_k , and the period during which the intervention occurs be P_t. Here, H_k= 1 if k is a participant of the livelihood support program and 0 (zero) if k is a non-participant or a controlled household. And again, if k = 1, then similarly, P_t= 1 at the end of the intervention period and 0 (zero) before the intervention.

Let $Y_{k,t}$ be the response variable of the household k at the end of the intervention program.

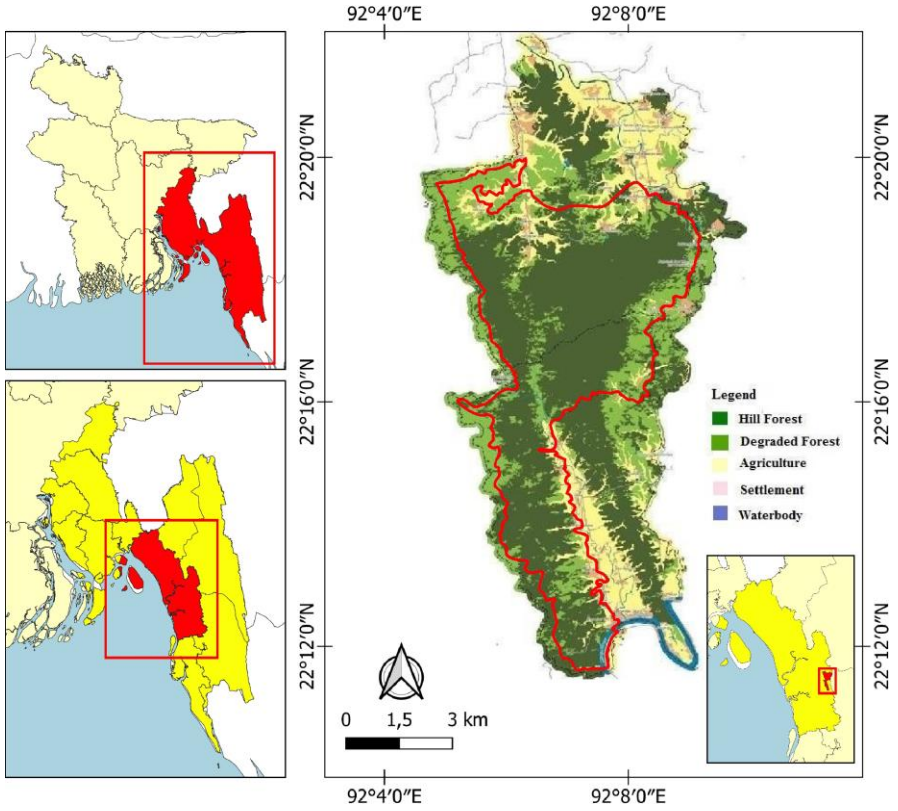

Figure 1. The landscape of Dudpukuria-Dophachari Wildlife Sanctuary, Bangladesh (Source: Winrock International)

Table 1. Derivations of the attributes of DiD method

Type of household	Period of measurement	Response variable
Treatment household	Pre-treatment[a]	$Y_{k,0}$
Control household	Pre-treatment	$Y_{c,0}$
Treatment household	Post-treatment[b]	$Y_{k,t}$
Control household	Post-treatment	$Y_{c,1}$
Difference in treatment household	Pre-treatment and post-treatment	$D_k = Y_{k,1} - Y_{k,0}$
Difference in control household	Pre-treatment and post-treatment	$D_c = Y_{c,1} - Y_{c,0}$
DiD between treatment and control household	Pre-treatment and post-treatment	$(Y_{k,1} - Y_{k,0}) - (Y_{c,1} - Y_{c,0})$

Note: [a]In 2011, as recalled by the respondents during the survey in 2017. [b]In 2017, during the survey

Thus, the regression takes the form of (1):

$$Y_{k,t} = \beta_0 + \beta_1 . H_k + \beta_2 . P_t + \beta_3 . (H_k * P_t) + e \quad (1)$$

Where ($H_k * P_t$) is the interaction term of intervention and period, β_0, β_1, β_2, and β_3 are the parameters to be estimated, and e is the normally distributed error term with mean zero and constant variance. Now, using equation (1), we get equations (2) through (5):

When *k* is a control household and *t* is before the intervention.

$$Y_{c,0} = \beta_0 \quad (2)$$

When *k* is a treatment household and *t* is before the intervention:

$$Y_{k,0} = \beta_0 + \beta_1 \quad (3)$$

When *k* is a control household and *t* is after the intervention:

$$Y_{c,1} = \beta_0 + \beta_2 \quad (4)$$

When *k* is a treatment household and *t* is after the intervention:

$$Y_{k,t} = \beta_0 + \beta_1 + \beta_2 + \beta_3 \quad (5)$$

Thus, the difference in difference in $Y_{k,t}$, or household *k* in an income-generating activity *i* can be measured by (6).

$$DiD = (Y_{k,1} - Y_{k,0}) - (Y_{c,1} - Y_{c,0}) = \beta_3 \quad (6)$$

Comparison of social status

Social status depends on different indicators. In our study, we focused on demographic information, information on property ownerships like land ownerships and types of households along other socio-economic parameters. Education is an important indicator of social status or social change. Therefore, information was collected on respondents' educational backgrounds and the presence of school-going children in respondents' households. We categorized the educational background of respondents into two classes; (a) primary level means if respondents at least have attended a primary school which ranged from class one to class five; (b) secondary level ranges education from class six to class ten. In addition, respondents were asked questions on other parameters like existing household appliances, sources of energy, sources of drinking water, cooking systems, etc. To highlight the difference in minimum hygiene and cleanliness practices between the two groups, we also collected information about the uses of sanitary latrines and ways of domestic waste management.

RESULTS AND DISCUSSION

Demographic attributes and income sources

Basic demographic attributes of treatment and control groups didn't show any significant differences. The mean family size ranged from 5.75 with SD ± 2.6 for treatment and 5.29 with SD ± 2.15 for the control group (Table 2). In addition, most of the people from both treatment (84.5%) and control (81.7%) groups had only primary level education, and a few respondents (treatment 15.5%, control 18.3%) had secondary level education. There were no significant differences in the presence of school-going children (Table 2). Most families from the treatment (86%) and control (83%) groups were found to send their children to school. Meanwhile, about three-quarters (74.65%) of the treatment group and 59.16% of the control group lived on encroached land, some of which managed to take the land as a lease or rent from big landowners (Table 2). However, about 15% of the respondent from both groups have their own land. Household conditions of both groups were also found to be similar. Almost all the people from the treatment and control groups (95.78%) lived in a hut, and only a few (3.22%) could afford brick-built houses with corrugated iron sheets (Table 2).

The income sources of the study area were not widely varied. Agricultural activities were prominent income-generating sectors. However, the study found respondents engaged in multiple income-generating activities, which were classified into two categories. Earning sources producing a major share of the livelihood were categorized as primary occupations, whereas other supporting income sources aside from a primary occupation were secondary. The most observed primary occupation was rice cultivation

(76.06%), followed by day labor (10.56%) and small business (5.63%). The remaining 4.93% of primary earning sources included masonry, driving, rubber cultivation, lemon cultivation, remittance, etc. (Table 3). On the other hand, vegetable cultivation was the most observed secondary occupation (79.45%). People grew seasonal vegetables like hyacinth bean, string bean, gourd, pumpkin, cucumber, ladies' finger, bitter gourd, chili, potato, and coriander around their homestead around the year. Other observed secondary occupations were day labor (6.85%), small business (6.85%), driving, and other minor services (6.85%) (Table 3).

Changes in monthly income status

Table 4 reports the income status change between treatment and control groups before and after co-management intervention. It showed no significant changes in total income status due to the intervention between the group involved in the project and those who were not. There was no significant change in the income from primary sources too. However, the treatment group had increased their income (USD 16.46) from secondary occupations. The main secondary occupation of the respondents was vegetable cultivation.

Changes in monthly forest resource extraction

Table 5 shows the change in monthly forest resource extraction (USD) by treatment and control groups. Local people depended on different kinds of forest resources for their daily necessities. DDWS produces several forest resources like timber, pole, fuel wood, medicinal plant, bamboo, cane, broom, various wild fruits, etc. No significant change was found in the total amount of monthly forest resource extraction (Table 5). The main three resources-fuel, wood, bamboo, and saplings, were particularly analyzed to see the extraction changes due to co-management intervention. The monthly fuel wood extraction of the treatment group was reduced by USD 2.21 (Table 5). However, there was no significant change in monthly bamboo and sapling extraction.

Table 2. Demographic attributes of households surveyed

Variable	Treatment	Control
Family size (Mean number)	5.75 (± 2.6)	5.29 (± 2.15)
Educational status (% of respondents)	Primary level: 84.5 Secondary level: 15.5	Primary level: 81.7 Secondary level: 18.3
School-going children (% of households)	86	83
House types (% of households)	Hut: 95.78 Brick-built house: 3.22	Hut: 95.78 Brick-built house: 3.22
Land ownership (% of households)	Encroached: 74.65 Leased/rented: 8.45 Owned: 15.5	Encroached: 59.16 Leased/rented: 26.76 Owned: 14.08

Table 3. The occupation pattern of the respondents surveyed

Types of occupation	Percentage of respondents (%)			
Primary Occupation	Agricultural activities	Labor	Small business	Others
	78.88	10.56	5.63	4.93
Secondary Occupation	Vegetable cultivation	Labor	Small business	Others
	79.45	6.85	6.85	6.85

Table 4. Changes in the respondents' monthly income (USD*) in Dudpukuria-Dhopachari Wildlife Sanctuary, Bangladesh

Parameters	Total income	Income from primary occupations	Income from secondary occupations
$Y_{c,0}$	82.67	72.91	11.86
$Y_{k,0}$	122.61	103.76	15.73
$Y_{c,1}$	70.77	54.81	16.55
$Y_{k,1}$	122.47	85.56	36.88
D_c	11.9	-18.1	4.69
D_k	-0.14	-18.18	21.15
DiD	11.75 (1.01)	-0.08 (-0.01)	16.46 (2.47**)

Note: Values in parentheses are t-statistics, $D_c = Y_{c,1} - Y_{c,0}$; $D_k = Y_{k,1} - Y_{k,0}$; DiD = D_k - D_c; *USD = (1 USD = 82.98 BDT in 2017); **Significant at 5% level

Table 5. Change in value (USD per month) of extracted forest resources in Dudpukuria-Dhopachari Wildlife Sanctuary, Bangladesh

Parameters	Fuelwood	Bamboo	Sapling	Total
$Y_{c,0}$	5.38	3.93	2.85	12.23
$Y_{k,0}$	7.27	3.59	3.32	13.11
$Y_{c,1}$	4.64	3.01	2.83	10.55
$Y_{k,1}$	4.32	2.81	2.20	9.68
D_c	-0.74	-0.91	-0.02	-1.68
D_k	-2.95	-0.78	-1.12	-3.42
DiD	-2.21 (-1.90*)	0.14 (0.26)	-1.1 (-1.02)	-1.74 (-1.24)

Note: Values in parentheses are t-statistics. *Significant at 10% level

Table 6. AIGA supports provided by co-management intervention

Provided AIGA supports	Percentage (%)
Fruit and medicinal plant seedlings and vegetable seeds	61.97
Fruit and medicinal plant seedlings, vegetable seeds and fish	4.23
Fruit and medicinal plant seedlings and fish	2.82
Fruit and medicinal plant seedlings and handicrafts	2.82
Fruit seedlings and vegetable seeds	23.93
Only vegetable seeds	1.41
Only fish	1.41
Only handicrafts	1.41

Linking monthly income changes with co-management intervention

The co-management supported or treatment group of DDWS was aided by local fruit and medicinal plant seedlings such as *Mangifera indica* L., *Artocarpus heterophyllus* Lam., *Syzygium cumini* (L.) Skeels, *Litchi chinensis* Sonn., *Ocimum sanctum* L., *Phyllanthus emblica* L., etc., seasonal vegetable seeds, fish, poultry, and handicraft assistance. Table 6 represents the distribution pattern of AIGA supports provided to the co-management participants of DDWS. Participants were found to receive different combinations of more than one AIGA supporting item, whereas very few participants received only one item. Among the combinations, the maximum number of participants (61.97%) were supported with fruit and medicinal plant seedlings and vegetable seeds, followed by 23.93% of participants receiving fruit and medicinal plant seedlings. The remaining participants received different combinations of all other supports (Table 6). Among the AIGA supports, participants were found to generate money by cultivating and selling seasonal vegetables from the seeds provided. However, not all fruit and medicinal seedlings became suitable for harvesting within six years. Very few participants reported they could harvest some fruits. Fish farming and handicrafts assistance were found to be provided to a small extent that also could not generate any significant income.

Moreover, participants supported with poultry failed to produce any profit due to unknown poultry diseases and early death. Therefore, the study did not find any potential support to uplift the treatment group's total income over the control group. Hence, supported peoples' income status was seen partially improving when the income sources were categorized.

Comparison of socioeconomic condition

The present socio-economic condition of both the treatment and control groups was found to be almost similar. No significant differences were found among the studied attributes. All the parameters analyzed for both groups generated almost similar results. Figure 2 depicts the comparison of the presence of existing household appliances, energy sources, types of cooking systems, domestic waste management, and drinking water sources between the two groups. The treatment group was a bit ahead in owning television (treatment 18.3%, control 11.27%). The Control group was found to be in a better position in the case of energy sources. More people from the control group were using electricity, solar energy, and a mix of electricity and solar energy than the treatment group. People depending on kerosene and having no good source of energy were large in number from the treatment group (treatment 25.35%, control 18.3%). However, the percentages of people using the Improved Cooking System (ICS) were more in the treatment group than in the control group (treatment 16.9%, control 11.27%) (Figure 2). Lastly, the treatment group was also found to be in better condition in the case of sanitary latrine use; 93% of participants were found to use sanitary latrines, whereas the percentage of non-participants was 87.3%.

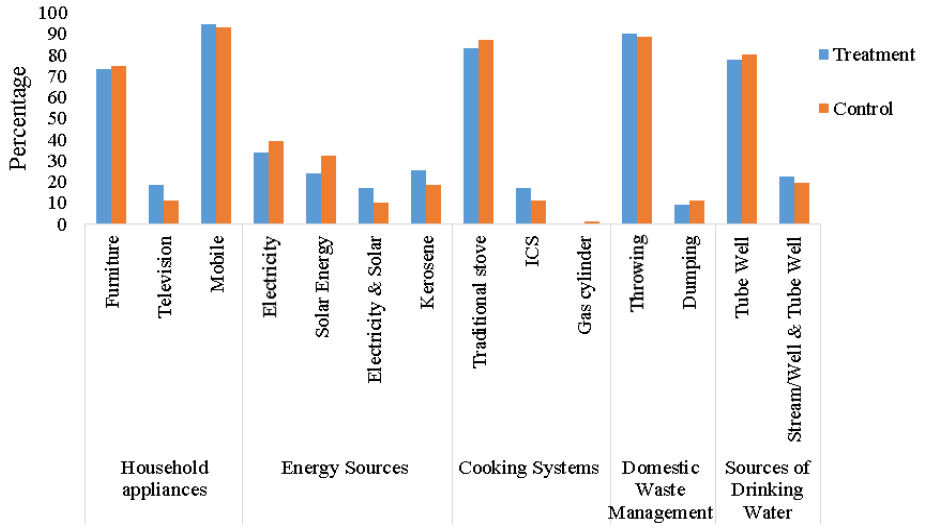

Figure 2. Comparison between treatment and control groups in terms of socio-economic parameters

Discussion

Changes in monthly income status

Co-management is a hard reality in some developing and underdeveloped countries in Asia and Africa (Islam et al., 2020). However, scientific findings regarding the outcomes of this community-based approach to forest resources management are not on the same line. This study unveiled that AIGAs support didn't significantly improve the income status of co-management supported groups. However, participants increased by USD 16.46 from their secondary occupation (Table 3). Participants could generate profit from seasonal vegetable cultivation among the AIGAs supported in the study area under a co-management scheme. There were also some individual stories of big success. One participant was found to make good profits from vegetable cultivation that surpassed income from his primary occupation. Several studies (Mukul and Quazi 2009; Sohel et al. 2009; Das 2013; Rahman et al. 2017a; Islam et al. 2019b) reported from different PAs of Bangladesh provided evidence that co-management brought positive changes to the income status of participants.

Changes in forest resource extraction

Though total forest resource extraction wasn't notably reduced, results found a reduction of USD 2.21 in monthly fuel wood extraction for the co-management participants group, which was a good sign of the change (Table 5). Similar to our study, Alam et al. (2014) found that the forest resource collection has decreased gradually in Teknaf Wildlife Sanctuary – an important co-managed forest PA of the country since 2004. Chen et al. (2012) stated positive improvement in family income and forest conservation through implementing community-based nature conservation initiatives in China. In addition, community-based conservation initiatives in Nepal contribute to livelihood improvement and forest resources conservation (Bijaya et al., 2016).

Socio-economic comparison

Estimates from demographic attributes were almost similar for both groups. The majority of both parties lived on encroached land and in low-cost-built houses and had poor educational backgrounds (Table 2). However, almost all the households from both treatment and control groups sent their children to school, which was a good indicator. Existing household appliances, sources of energy and drinking water, etc. parameters were examined to check participants' economic solvency. Types of the cooking systems were estimated assuming traditional stoves are more fuel wood oriented while ICS consume fewer fuels hence helping reduce fuel wood extraction. But the study did not find any sign that co-management provided or helped the participants regarding this issue. Some other NGOs, excluding studied co-management programs, were aided by some treatment and control owning ICS. Percentage uses of sanitary latrines and domestic waste management were measured to see if the intervention improved the hygiene status of the supported community. No studied parameters notably showed that co-management brought progressive changes in forest-dependent communities' lifestyles. In Ghana, a community-based conservation approach positively affected human capital but had minimal impact on the other capital, including household well-being and resilience (Akamani and Hall 2015). Using the Sustainable Livelihood Framework for a co-managed protected area in Madagascar, Ward et al. (2018) also found that co-management's perceived livelihood outcomes are negative and unevenly distributed.

Challenges

Several challenges might override the effectiveness of this intervention. One of the key factors could be people's livelihood dependence on agricultural practices. People of the study area mainly depend on traditional agricultural practices from the beginning of their settlement. Mukul et al. (2017) also reported that agricultural practices, illegal felling, encroachment, and removal of minor forest products are some of the major threats to co-managed PAs in Bangladesh. Phromma et al. (2019) indicated a similar issue for Phu Kao-Phu Phan Kham National Park, Thailand, that the protected area might control resource access to some extent but cannot resist agricultural expansion. Pulhin et al. (2007) and De Royer et al. (2018) also reported that co-management in the Philippines and Indonesia is still struggling due to the absence of social justice, unstable policy, bureaucratic procedures, weak institutional support, etc.

In conclusion, co-management intervention in DDWS brought partial as well as little changes in the income status and forest resource extraction behavior of forest-dependent people. Co-management-supported and non-supported peoples' lifestyles also showed no significant differences. Participants' livelihood experienced partial improvement mainly from vegetable cultivation though there were a few examples of other activities like planting fruit and medicinal plant species, fish farming, handicrafts, etc. In contrast, participants' forest resource extraction for fuel wood collection showed a small reduction.

This study specifies that provided supports were insufficient, and people became economically solvent enough to change and improve their lifestyle and gradually become less forest dependent. One reason could be that the provided AIGAs support did not create a wide range of non-forestry income variations. More non-forestry income-generating activities will increase participants' income resilience and free them from going to the forest, reducing forest disturbances significantly. The study suggests initiating more diversified non-forestry income-generating activities To increase households' income resilience. From field observation, the study suggests occupations like automated rickshaw pulling, CNG-run auto-rickshaw driving, running a small business, poultry rearing, handicraft making, etc., as some prospective options.

Another big challenge is continuity and success sustainability once any positive change starts occurring. Most of the time, these changes come from donor-funded projects. So, there is a big possibility of reverting to the previous state once the project ends. However, success stories could be continued if the governance of co-

management and the supported participants have a strong backup plan. Therefore, it is also necessary to prepare well-thought planning and guidelines for managing this sustainability after the project.

Limitations of the study

This study was conducted in only one co-managed protected area out of 21 in Bangladesh. Therefore, more precise results might be derived if the study considers a few more protected areas.

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