

Human-elephant conflicts in the Teknaf Wildlife Sanctuary in Bangladesh

Hossain MS¹, Shawn MH¹, Røskaft E², Kvinta P³, Rahman M¹, Chakma N⁴ and Sarker AHMR^{1*}

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***Corresponding author:** AHM Raihan S, Institute of Forestry and Environmental Sciences, University of Chittagong, Chattogram 4331, Bangladesh

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¹Institute of Forestry and Environmental Sciences, University of Chittagong, Bangladesh

²Department of Biology, Norwegian University of Science and Technology, Norway

³573 Cameron Street SE, Atlanta, Georgia 30312, United States

⁴Department of Pali, University of Chittagong, Bangladesh

Abstract

Human conflict with Asian elephants (*Elephas maximus*) is a critical challenge for the conservation of the species in Bangladesh. Thus, the primary aim of this study was to check the conflict status between humans and wild elephants within the Teknaf Wildlife Sanctuary (TWS). Fifty-two respondents were randomly interviewed from both the local Bengali and Rohingya communities across the TWS using a semi-structured questionnaire. Our analyses show that wild elephants sometimes move into Rohingya camps and surrounding villages. Bengali residents reported higher incidence of encountering wild elephants than did Rohingya people. A majority of respondents were frightened upon seeing wild elephants, and they reported that elephant attacks caused human injury and death in their communities. Our analysis showed further that most elephant attacks took place during winter between evening and midnight. To deter wild elephants from their villages and camps, more than two-thirds of respondents used traditional deterrence techniques like fires, rock throwing, and group shouting, whereas one-third of respondents employed modern technology like Elephant Response Teams (ERTs), torch/flashlight, hand mikes, and watchtowers with solar-powered flashlights. One-fifth of respondents expressed satisfaction with the effectiveness of modern deterrence techniques. To minimize human-elephant conflict, respondents suggested introducing a variety of interventions. These include forming more ERTs, training residents on modern deterrence techniques, and raising awareness through environmental education programs. Respondents further suggested restoring traditional elephant migration corridors, developing core elephant habitat containing the animal's preferred food species, creating buffer zones with human-preferred plant species so as to reduce dependency on nearby forests (and to avoid wild elephants), and installing solar fencing and bio-fencing to deter elephants from settlements.

Keywords: Teknaf wildlife sanctuary; Attitude; Rohingya; Wild elephants

Introduction

Conflicts between humans and wildlife have become an increasingly important issue for conservationists over the past 30 years [1]. Most of these conflicts involve crop raiding by wild animals like the Asian elephant (*Elephas maximus*). Moreover, the utilization of natural resources between humans and wildlife can affect the natural ecosystem and may cause the suppression or even local extinction of wildlife populations [2]. Human-wildlife conflicts, especially with wild elephants, present a very important challenge for the conservation of protected areas [3]. Inevitably, there seems to be intense conflict and maximum damage involving villages are on the edge of the park boundary [4,5]. Disturbances by wild elephants are strongly seasonal, corresponding with paddy harvesting times [6]. Farms adjacent to the park boundary are likely to be raided, especially during harvest seasons (June-August and October-December) in southeastern Bangladesh, when paddy is at the optimal stage of growth [7]. Wild elephant's damage exposed crops and injure or kill people [3,8]. The presence of untamed elephants causes people to fear for their lives [9] and encourages them to avoid their fields at night [10], thus increasing the intensity of crop-raiding by elephants

[5]. However, relationships between humans and protected areas are often problematic and remain a serious barrier to successful conservation [11]. These relationships are multifaceted and poorly understood [12]. Available studies have focused on the loss of access to traditional natural resource extraction and on the damage to crops and livestock inflicted by wildlife as root causes of conflicts between humans and wild animals [13]. However, the character of conflict between people and protected areas varies locally and is consistent with the social values and economic status of the area people. Therefore, it is important to arrange protected area programs consistent with local needs. However, in the last five years, Bangladesh has been hosting about a million forcibly displaced Rohingya from Myanmar in several sprawling camps in Ukhia, Cox's Bazar, which has led to massive destruction of forest resources. Thus, this study aims to explore the conflict between Asian elephants and both local Bengali people and Rohingya refugees. The specific objectives were to:

- (i) explore the socio-economic condition of the people living across the study area,
- (ii) know the status and patterns of interactions between humans and wild elephants, and

- (iii) identify ways to mitigate conflicts between humans and wild elephants.

Materials and Methods

Study area

Teknaf Wildlife Sanctuary (IUCN category V) is situated about 48km south of Cox's Bazar district (21004/N, 92009/E), comprising approximately 116.15km² and covering 10 blocks (i.e., Raikhong, Saplapur, Shilkhali, Maddyannya, Dakhin-Nilla, Matabhanga, Rajachara, Ledha, Dumdumia and Teknaf) in three forest ranges (i.e., Whykong, Silkhali and Teknaf) of Cox's Bazar South Forest Division. The sanctuary is intended to manage and protect wildlife in addition to increasing the populations of important wildlife species, especially wild elephants. Although Cox's Bazar Forest Division was created between 1919 and 1920, the Teknaf peninsula was declared as Teknaf Elephant Game Reserve in 1983 under the Wildlife Preservation Act (1974). It is located near the political border between Bangladesh and Myanmar (Figure 1). The designation of game reserve could not provide adequate protection for the elephant habitats and was hence changed to wildlife sanctuary in 2010.



Figure 1: Map showing the study area.

Data collection and data analysis

The study was conducted in Rohingya camps and surrounding villages located close to the sanctuary in Ukhia sub-district of Cox's Bazar district. The Rohingya camps were established in 2017 and have been managed by the United Nations High Commissioner for Refugees (UNHCR). Prior to the data collection, we identified different spots across the study area where wild elephants attacked frequently. In total 14 places were selected for data collection across the study area. Five of these were located inside the Rohingya shelters, and the remaining nine were located outside the camps in villages including South Poliyapara, Balukhali, Rasidong, Nasari, Madhuchara, Hakaimpara, Kutupalong, Ulbaria, and Machkari. We interviewed Rohingya people (n=26) inside the camps and local

Bengali people (n=26) in the nine villages surrounding the camps. We performed a semi-structured questionnaire that included the respondent's socioeconomic status and their experience with wild elephants, such as how often they had witnessed the movement of elephants in their locality, the structure of the herd, times when they had feared an elephant attack, incidents of elephants chasing or attacking people, the period and time of attacks, the period and time of injury or death caused by attack, the location of these incidents, deterrence techniques used to protect life and property from elephants, supports received to deter elephants from settlements, and mitigation measures to address human-elephant conflict in the sanctuary. A total of 52 standardized, structured, and semi-structured questionnaires were administered equally in the camps and surrounding villages. The participants were selected

randomly, and completion of the questionnaires was facilitated using face-to-face communication tools. Only adults over the age of 18 years were interviewed. We mostly interviewed the heads of households, although in their absence we interviewed any willing family member. After collection of the field data, respondents were categorized on the basis of their gender (i.e. male and female), age (i.e. young (< than 31 years), middle age (31 to 50 years), or older (>50 years)), education (i.e. illiterate, <primary, primary, or above primary), occupation (i.e. day laborer, unemployed, NGO worker, businessman, housewife, farmer, CNG driver, road constructor, or carpenter), household size (i.e. small (up to 5 members) or large (>5 members)), and monthly income (i.e. poor (< BDT 5000), medium (BDT 5100 to 10000), or rich (> BDT 10000)). Data were analyzed using SPSS for windows version 24.0. Differences between perceptions were tested using χ^2 (chi-square) and ANOVA tests. The significance level was set at $p < 0.05$.

Results

Demographic and socio-economic analysis of the respondents

Among respondents ($n=52$), more than half were young (55.8%), illiterate (53.8%), and belonged to a small family (65.4%), and varied significantly between the types of respondents (i.e. Rohingya versus Bengali) for age ($\chi^2=10.21$, $df=2$, $p=0.006$), education ($\chi^2=8.10$, $df=3$, $p=0.006$), and household size ($\chi^2=8.50$, $df=1$, $p=0.004$). Among respondents, the proportion of day laborers (21.2%) and unemployed persons (21.2%) was slightly higher than other types of occupation such as housewives (17.3%), NGO workers (13.5%), farmers (11.5%), and others (5.8%), and varied significantly between the types of respondents ($\chi^2=20.10$, $df=6$, $p=0.003$). The proportion of middle-income levels (39.2%) among respondents was higher than that of the poor (35.3%) and the rich (25.5%), and the proportion varied significantly between the types of respondents ($\chi^2=9.51$, $df=2$, $p=0.009$). The illiteracy rate was higher among the Rohingya population (57.7%) than among the Bengali respondents (50%). Family size, meanwhile, was larger among the Bengali respondents (53.8%) than the Rohingya respondents (15.4%).

Table 1: The number of incidents (times) and the number of wild elephant's encountered from 2016 to 2019 across the study area and ANOVA-tests of differences between their residential status.

Year	Incident Numbers and Number of Elephants Encountered	Types of Respondents			Statistics		
		Rohingya (N=26)	Bengali (N=26)	Total (N=52)	F	df	p
		Mean (\pm SD)	Mean (\pm SD)	Mean (\pm SD)			
2019	Incidents	1.65 \pm 1.49	0.69 \pm 1.05	1.17 \pm 1.37	7.2	1	0.01
	Elephants encountered	2.69 \pm 3.52	2.27 \pm 8.37	2.48 \pm 6.36	0.06	1	0.813
2018	Incidents	2.42 \pm 2.71	3.42 \pm 6.31	2.92 \pm 4.84	0.55	1	0.462
	Elephants encountered	1.85 \pm 1.64	4.19 \pm 4.77	3.02 \pm 3.73	5.61	1	0.022
2017	Incidents	0.04 \pm 0.20	6.54 \pm 12.25	3.29 \pm 9.19	7.31	1	0.009
	Elephants encountered	0.00 \pm 0.00	5.73 \pm 7.39	2.87 \pm 5.93	15.64	1	0.0001
2016	Incidents	0.00 \pm 0.00	5.42 \pm 9.88	2.71 \pm 7.44	7.84	1	0.007
	Elephants encountered	0.00 \pm 0.00	2.85 \pm 4.28	1.42 \pm 3.32	11.51	1	0.001

How often was there movement of wild elephants in your locality?

Whenever respondents were asked how often wild elephants moved in their locality, 88.5% indicated 'sometimes', while the remaining 11.5% said 'more often', and their perceptions varied significantly between types of respondents ($n=52$, $\chi^2=6.78$, $df=1$, $p=0.009$). No respondent from either the Rohingya or Bengali communities commented "too often" to answer the question.

The structure of the herd of wild elephants that visited camps or human settlement zones

When asked about the structure of wild elephant herds visiting the Rohingya camps and adjoining areas, respondents ($n=52$) reported that the number of male elephants (2.81 \pm 3.14) is less than half that of female elephants (5.56 \pm 6.00). There are also some infants in the herds (0.65 \pm 1.25). The size of the herds visiting villages surrounding the Rohingya camp (13.5 \pm 12.84) is larger than the herds visiting the Rohingya camp (4.535 \pm 3.42) itself, and the structure of the herd significantly varied between camps and adjoining villages (Male: $F=10.76$, $df=1$, $p=0.002$; female: $F=12.68$, $df=1$, $p=0.001$; and infant: $F=9.73$, $df=1$, $p=0.003$).

Incidents of wild elephant encounters

Bengali residents reported a higher incidence of encountering wild elephants than Rohingya people during the period 2016-2018 (Table 1), which significantly differed between the respondents' type for 2019, 2017 and 2016 (Table 1). Over this time period (i.e., 2016-2019), the incidence was highly reported in 2017 but less reported in 2019 (Table 1). Most surprisingly, the Rohingya were more likely to encounter wild elephants in 2019 than the Bengalis did, although adequate measures had been taken to ensure their protection from elephant attack by the UNHCR (Table 1). The number of reported wild elephant encounters varied significantly between the respondent types for the period 2016-2018 (Table 1). Respondents mentioned the highest number of wild elephants was encountered in 2018, then in 2017. The number of encountered wild elephants was comparatively less in 2019 than in 2018 (Table 1).

Evidence of elephant's attack

Respondents presented more evidence of elephant attacks in 2018 and 2019 than in 2016. Among the respondents, the Rohingya said there was more evidence of elephant attacks in 2018 and 2019 than the Bengali people did. On the other hand, in 2017 Bengalis cited more evidence of elephant attacks than Rohingya did (Table

2). Respondents were also asked if they feared a wild elephant attack. More than half (57.7%) said they were "sometimes" scared to see wild elephants, and about one-third (28.8%) said they were always scared. Only a small number of respondents (13.5%) said they were not afraid of elephant attacks. Respondents' perceptions of this question varied significantly by type across the study area ($n=52$, $\chi^2=9.2$, $df=2$, $p=0.01$).

Table 2: Evidence of elephant's attack mentioned by the respondents in their locality and ANOVA-tests of differences between their residential status.

Years	Residential status			Statistics		
	Rohingya (N=26)	Local (N=26)	Total (N=52)	F	df	p
	Mean (\pm SD)	Mean (\pm SD)	Mean (\pm SD)			
2019	1.04 \pm 0.87	0.35 \pm 0.85	0.69 \pm 0.92	8.45	1	0.005
2018	0.96 \pm 0.96	0.46 \pm 0.81	0.71 \pm 0.91	4.12	1	0.048
2017	0.04 \pm 0.20	0.35 \pm 0.69	0.19 \pm 0.52	4.79	1	0.033

Seasons of wild elephant's attack

About half of the respondents reported that from 2017-2019 wild elephants mostly attacked their farms, adjoining houses, and home gardens in winter (i.e., November-February), whereas one-

third of respondents mentioned summer (i.e., March-May) (Table 3). Only Bengali respondents reported that wild elephants attacked their farms and home gardens during 'monsoon' season (i.e., Jun-Oct).

Table 3: Percentage of respondents mentioned the seasons of wild elephant's attack from 2017-2019 across the study area, and χ^2 tests of independence between the residential status of respondents.

Seasons of Wild Elephant's Attack		Residential Status			Statistics		
		Rohingya (N=26)	Local (N=26)	Total (N=52)	χ^2	df	p
2019	Winter	82.5	20	51.25	8.67	2	0.013
	Summer	16.5	60	38.25			
	Monsoon	0	20	10			
2018	Winter	100	14.28	57.14	19.4	1	1E-04
	Summer	0	85.68	42.84			
2017	Winter	100	0	50	7	2	0.03
	Summer	0	66.68	33.34			
	Monsoon	0	33.32	16.67			

Incident time of attack

The majority of respondents (57.3%) reported that wild elephants attack from evening to midnight. The remainder of respondents (42.3%) said elephants attack from midnight to early morning across the study area ($n=52$, $\chi^2=52.97$, $df=1$, $p=0.02$).

Evidence of human death or injury caused by wild elephant attack

More than half of the respondents ($N=52$, 53.8%) claimed that their relatives or neighbors were injured or killed in wild elephant attacks. Over the last three years, 15 people have died (i.e., 2019: 12, 2018: 2 and 2017: 1) and 10 have been injured (i.e., 2019: 9 and 2017: 1) in wild elephant attacks across the study area. Rohingya people experienced more casualties (66.7%) than Bengali people (33.3%, $F=4.13$, $df=1$, $p=0.27$). Most incidents occurred inside the forest (92.6%), while the remaining were outside the forest. These

perceptions varied insignificantly between the types of respondents ($\chi^2=0.622$, $df=1$, $p=0.434$).

Deterrence techniques used to protect life and properties from wild elephants

Both modern and traditional techniques are used to protect human life and property from wild elephant attacks. More than two-thirds of respondents reported that they used traditional techniques like fires, throwing rocks, and shouting in a group to drive wild elephants out of their settlement zones. On the other hand, about one-third of respondents relied on modern technology such as ERTs, torch/flashlights, hand mikes, and watch towers with solar panel-powered flashlights. The proportion of respondents using modern technology was significantly higher in the Rohingya camps than in the surrounding villages (Table 4). Whenever respondents were asked about the effectiveness of deterrence methods, one-fifth expressed satisfaction with modern technologies, and their

proportion varied significantly with respondents' residential status (Table 4). On the other hand, the effectiveness of traditional deterrence techniques varied insignificantly by respondent types (Table 4).

Table 4: Proportion of people who responded concerning actions taken and their effectiveness for deterring wildlife from entering areas included in the study, and χ^2 tests of independence between the residential status of respondents.

Techniques/Effectiveness	Residential Status			Statistics		
	Rohingya (N = 26)	Local (N = 26)	Total (N = 52)	χ^2	df	p
Modern (i.e., ERT, Torch/flashlight, hand mike, watch tower)	46.2	15.4	30.8	5.78	1	0.016
Effectiveness of modern techniques	30.8	3.8	17.3	6.58	1	0.01
Traditional (i.e., Fire, throwing rock, shouting)	65.4	69.2	67.3	0.09	1	0.768
Effectiveness of traditional techniques	26.9	19.2	23.1	0.43	1	0.51

Supports received to deter wild elephants from the human settlement zones

Respondents were asked if they had received any assistance from public or private sectors to chase wild elephants from their locality. More than two-thirds of respondents answered 'no' (Table

5). Twice as many Rohingya answered yes to this question than Bengalis (Table 5). More than 25% of respondents said they had been provided torch lights, hand mikes, and ERT uniforms from the Forest Department and the IUCN. Also, 29% of respondents said that the Forest Department and IUCN cooperated in constructing watch towers (Table 5).

Table 5: Proportion of respondents on received supports to deter wild elephants from their locality, and χ^2 tests of independence between the residential status of respondents.

Variables		Residential Status			Statistics		
		Rohingya (N=26)	Local (N=26)	Total (N=52)	χ^2	df	p
Received supports	No	34.6	67.3	68.3	25.3	1	0.01
	Yes	65.4	32.7	31.7			
Support materials	Provide torch light, hand mike, dress for ERT	19.2	30.8	25	16.3	1	0
	Construction of watch tower	23.1	34.6	28.8			

Mitigation measures to overcome human-elephant conflicts

Respondents were asked what kind of action could be taken to reduce the level of human-elephant conflict. One-fourth suggested

that more ERTs be set up to drive wild elephants out of their locality (Table 6). More than one-fifth felt that environmental education programs were needed to create awareness in the Rohingya camps and surrounding villages about the conservation importance of forests and wild elephants.

Table 6: Measures prescribed by the respondents to mitigate the magnitude of human-elephant conflict, and χ^2 tests of independence between the residential status of respondents.

Prescribed Measures	Residential Status			Statistics		
	Rohingya (N=26)	Local (N=26)	Total (N=52)	χ^2	df	p
Create awareness through environmental education and extension programs among people and provide equipments to for guarding	34.6	11.5	23.1	15.64	6	0.01
Provide training on effective low-cost modern deterrence techniques through CCM based training centers	15.4	11.5	13.5			
Create more ERTs and watch towers with high powerful flashlights	34.6	15.4	25			
Create barriers by bio-fencing by non-palatable plant species	11.5	11.5	11.5			
Connecting traditional corridors and develop core area by elephant's food species	3.8	23.1	13.5			
Avoid wild elephants by creating buffer zones with human preferred plant species to fulfill their daily needs.	0	7.7	3.8			
Establish solar fencing to restrict the entry of wild elephants in the settlement zones	0	19.2	9.6			

Moreover, a significant portion of the respondents felt that measures need to be taken to provide training on modern deterrence techniques. Some respondents felt that traditional elephant corridors and core areas could be developed using elephants' preferred food species. Also, a number of respondents emphasized the need to create buffer zones with human-preferred plant species to meet their daily needs and to avoid wild elephants. Some respondents encouraged the installation of solar fences and bio-fencing (planting species elephants find unpalatable outside the buffer zones to prevent them from entering settlement areas). The prescribed mitigation measures varied significantly by residential status of respondents (Table 6).

Discussion

Countries that have received sudden and unexpected influxes of refugees have experienced catastrophic environmental imbalances, as well as social and economic pressures [14]. The use of natural resources by refugees can create competition with host communities. Although the Rohingyas are receiving aid and cooperation from the government and NGOs to address social and economic challenges, local people are not getting similar support. Studies have shown that the perimeter of refugee camps expand rapidly and replace surrounding forest land [15]. As a result, the health of surrounding forests-including protected sanctuaries-has been reduced. Environmental problems like human-elephant conflict can increase with the degradation of elephant habitat and the construction of obstacles (i.e., refugee camps) in migration corridors. In our study, we found that the rate of encountering wild elephants has increased in the Rohingya camp and in the surrounding villages due to environmental problems. While the Bangladesh Forest Department has focused on protecting the Rohingya refugees from elephant attacks, local Bengali residents have not received such help, and thus our research shows a higher incidence of elephant attacks in villages surrounding the camp than in the camp itself. The number of elephant attacks increased significantly with the arrival of the Rohingya refugees in 2017, but it has now dropped considerably. With the extreme destruction of elephant habitat, most wild elephants have moved away from the TWS to other places, like the Chunati Wildlife Sanctuary to the north. We found that elephant attacks occur most frequently during winter. This is no doubt due to the lack of food and water in the forest during winter. Thus, elephant herds stay in the forest near settlement zones during the day and enter those zones during at night to raid farms and home gardens. This results in the injuries and deaths of people trying to protect their farms and gardens. Our research also shows that most incidents took place inside the forest. This means that both local residents and refugees had entered the forest to extract resources for their livelihoods. Given this, policy makers should formulate appropriate policy solutions to reduce the dependency of local residents and refugees on the wildlife sanctuary. The cost of conflict between human and wildlife exposes people's unenthusiastic feelings towards the management of protected areas. The situation is worsened by the fact that people resent the protection of these crop raiders. When people reside

around protected areas, they complain that wild animals intrude on their agricultural fields [16]. On the other hand, sanctuary managers argue that people have encroached on the habitats of wildlife, a result of severe human population growth [17]. Local people are unable to protect their crops when they live close to protected areas. In Tanzania and Uganda, farmers reported that crop-raiding wildlife caused crop damage in their settlement zones [18].

Habitat degradation and fragmentation gradually increase the occurrence of human-elephant conflict, an important challenge for Bangladesh. Extensive harvesting of forest resources (i.e., large trees) brings wild elephants closer to humans because elephants forage on the secondary vegetation that grows after a disturbance [19]. Moreover, elephants have increased contact with humans due to changes in land use [20]. Isolated agricultural farms along park boundaries may expand the human-elephant interface and create a land-use pattern that favors elephant foraging [21]. As people have continued to transform more land and forest for settlement and also for establishing Rohingya camps, shrinking habitats have compressed wildlife populations to levels beyond their carrying capacity. When the carrying capacity is exceeded, the interaction between humans and wildlife intensifies [22], and this is strongly related to the size of the Protected Area (PA). There are a variety of mitigation techniques for reducing human-elephant conflict and providing residents with materials and knowledge regarding such techniques can lessen the conflict and create positive interaction between humans and wild elephants. The mitigation techniques employed by farmers in Bangladesh are similar to the short-term, active deterrent methods used to control human-elephant conflicts throughout Africa and Asia [4,23]. Creating fire, throwing rocks, and shouting are traditional mitigation techniques practiced over the study area. Use of traditional versus modern mitigation techniques is determined largely by various constraints such as lack of training, knowledge, or financial support. The use of torches is the most common deterrent method, and our field observations indicated that farmers probably use this mainly out of tradition rather than efficiency. The respondents also stated that guarding fields was especially beneficial in reducing human conflict with elephants, as it provided an early warning [17]. Farmers are unwilling to use guns, probably because the elephant is a protected species, and efforts to destroy it may lead to prosecution. Therefore, people living near PAs suggested that the Forest Department should assist in the deterrence of wild elephants. Some studies have explored viable options to deter crop raiding elephants [7,24]. Elephants are more likely to raid along boundaries rather than going deep into farming areas because the risk of detection is lowest in buffer areas between PAs and land cleared for cultivation [25]. Chilies (*Capsicum* spp.) have been proven effective in discouraging African elephants (*Loxodonta africana*) from raiding crops [26]. There are seasonal fluctuations in crop raiding that coincide with food availability and crop maturity [8]. The respondents stated that bio-fencing and solar fencing surrounding their fields could be especially beneficial in reducing human-elephants conflict. However, understanding

and perception of conservation mostly varies with the distances of human settlements from the park boundary and the level of education of forest villagers residing around the PA [5,27].

Human-elephant conflict is a complex and pervasive problem that occurs throughout the range of the Asian elephant in the south-east and north of Bangladesh. Habitat loss and fragmentation have broken many of the larger habitat areas into smaller patches that now support small, isolated elephant populations in the country. Such populations are often confined to small areas unsuitable for elephants and therefore come into increasing conflict with the surrounding villagers. Conflict between humans and wild elephants is amplified in such areas. Negative attitudes of forest villagers towards the conservation of wild elephants are increasing. Under current conditions, most local farmers would eliminate elephants from their environment if given the choice [28]. In addition to conflict with people, elephant populations in small, isolated areas are also more susceptible to extinction threats because they are exposed to catastrophic environmental and genetic stochastic effects [29]. Habitat fragmentation and habitat loss may affect their movement between habitats and populations and thereby prevent genetic connectivity. Such populations are susceptible to genetic degradation and are highly vulnerable. Moreover, the problem of reduced or inadequate habitat-and the resulting human-elephant conflicts-would make the management of small and isolated populations very difficult [30]. Therefore, to ensure the conservation of wild elephants, existing traditional corridors should be opened up to link the habitat areas used by elephants migrating between Bangladesh and India and between Bangladesh and Myanmar. Habitat integration at the international boundary requires interstate cooperation. To achieve this goal, conservation agencies at the national and international levels must advocate for this and work with different stakeholders involved in the formulation and implementation of relevant policies. Attitudes and perceptions about wildlife depend on designing optimal and effective management schemes and introducing suitable preventative measures [31,32].

The traditional methods of deterring wild elephants have failed or are disputed in many countries in Asia and Africa [7]. An alternative to these methods could come from the agricultural sector, which can be viewed both as a landscaping solution and as a major source of sustenance for the local community [25]. The tolerance of local communities towards conservation of wild elephants should be encouraged by reducing crop loss through effective low-tech deterrence techniques. Several low-tech methods have been proposed to prevent elephant damage in Asia and Africa. In East and South Africa, the wire netting of tree stems, in conjunction with the cultivation of honeybees, could potentially be used as one such mitigation measure to prevent tree loss [33]. This approach can be effective because elephants are sensitive to the sound and sting of bees [34]. The use of chili extracts has also shown particular promise. Capsicum-based products are non-toxic and environmentally friendly. Moreover, elephants sophisticated olfactory sense and their excellent memories make them especially

suitable for adverse conditioning [35]. Furthermore, chilies have value as elephant-resistant cash crops [36]. Therefore, chili cultivation and beehives could be used in the conflict zones in Bangladesh. The success of this approach may improve the political support for the conservation of Asian elephants in Bangladesh. However, more research is required to determine the effectiveness of this scheme. Lower-technology methods usually require a greater level of community involvement than higher-technology methods [23]. It is urgent to learn how communities want to approach human-wildlife conflict situations. This information is essential for formulating successful strategies to overcome the conflict [37]. Community-based Conflict Management (CCM) is an approach used to manage and mitigate conflict in a sustainable manner. It empowers communities to address their own conflict problems. CCM is a long-term cumulative approach involving local communities, traditional authorities, governments, and NGOs at a local level in conflict management. It requires proper coordination among the different stakeholders. In view of the remote and relatively poor circumstances of most communities suffering from conflict in Bangladesh, low-tech deterrents are considered most suitable for CCM, as they are generally robust, cheap, and easy to maintain. Education is necessary to achieve public support for nature conservation [38]. It is also important to promote the use of educational programs to expand adult literacy and explain the benefits of PAs as a component of conservation programming. Levels of education or specific knowledge about conservation are positively correlated with more positive attitudes towards nature conservation [6,39]. They also require little or no outside support. Convincing the community to take responsibility for the interventions is essential to the success of the CCM approach. In doing so, CCM can support the government's initiatives to conserve the Asian elephant in the country by building the capacity for the alleviation of human-elephant conflict and by evaluating the effectiveness and impact of conflict management tools. CCM can develop expertise at a local level. Unfortunately, such a platform is absent from the existing protected-area management system in Bangladesh. Thus, it is important to establish Community-based Conflict Management Training Centers (CCMTCs) at the local level [40].

These centers would organize training programs as part of building the capacity of local communities to ensure better management of conflict using low-cost deterrence techniques. CCMTCs can disseminate information on elephant conservation and conflict management by publishing maps, booklets, posters, training manuals, newsletters, and documentary video films, as well as by organizing workshops, meetings, and campaigns at local levels. These measures can create awareness among the different stakeholder groups and thereby encourage positive attitudes towards conservation. CCMTCs, with the collaboration of national NGOs (e.g., The Grameen Bank, BRAC), can organize training in alternative income-generating activities for the local people as a way of mitigating the effects of wildlife by reducing the villagers' dependence on crops for their livelihood. The expansion of free

education in areas adjacent to the parks and the incorporation of environmental education into the school curriculum can have positive impacts on the awareness of young people and on their specific knowledge about contemporary conservation issues. The introduction of environmental studies in primary and secondary schools may influence younger people to be supportive of nature conservation and wildlife in the near future. In this context, CCMTCS can introduce environmental education and extension programs in surrounding communities. These programs will serve to stimulate community development related to conservation and to increase knowledge about the park and conservation and about park-people linkages. Such activities will create the perception by the people that the protected area has value and can bring benefits to the local communities. The introduction of environmental studies in primary and secondary schools may influence younger people to be supportive of nature conservation and wildlife in the near future.

Conclusion

Human-elephant conflict is mainly associated with the crop raiding behavior and habitat destruction of elephants. In southeast Bangladesh, villages surrounding the Rohingya refugee camps are more vulnerable to crop damage by wild elephants than are the camps themselves. Due to the habitat degradation and fragmentation caused by the expanding Rohingya camps, along with the dependency on forest resources for the livelihood maintenance of refugees and local residents, it will be a great challenge to sustain wild elephants in the Teknaf Wildlife Sanctuary in the near future. To increase support for elephant conservation in the TWS, we must continue to search for pragmatic solutions to reduce the magnitude of existing human-elephant conflict.

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