Environmental Degradation Due to Deforestation in the Sundarban Forest of Bangladesh

Mohamamd Ali[a]*, Mirza Md Tasnim Mukarram[b], Ashfakul Islam[c]

Abstract—Accelerated consignment of deforestation in the largest single-track mangrove formation in the world, Sundarbans located at the southwest of Bangladesh is now in the urge of extinction. Anthropogenic activities coupled with natural hazards is leading to severe degradation of its ecosystem and intensifying coastal erosion at an alarming rate. This mangrove forest not only provides shelter and livelihood to living beings by its various complex ecosystem but also acts as a buffer against extreme natural calamities. Though multi-spatial & multi-scale approaches have been taken by various governmental and non-governmental organizations the condition of the mangrove forest is still degrading severely due to lack of mass awareness & existing feeble policies. This paper shows the present consequences of Sundarbans mangrove forest due to augmented amount of deforestation. The changes in ecosystem, biodiversity, livelihood, Carbon Dioxide content, salinity in past few years have been showed by collection of data from field survey, key informants including governmental and non-governmental organizations. An approach has also been taken to show not only the degree at which this mangrove forest is vulnerable at present but also the possible future scenarios have been showed based on data analysis which will might be helpful for other researchers and planners.

Index Terms—Sundarban forest, Management, Conservation, Deterioration, Deforestaion, Climate Change, Livelihoods

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1 INTRODUCTION

LARGE amount of deforestation in Bangladesh has put the Sundarbans mangrove forest, a UNESCO World Heritage site under constant threat [1].Unfortunately geographically flat terrain of Bangladesh along with its low lying feature makes it quite vulnerable to various natural hazards like tsunamis, earthquakes, cyclones, sea level rise and so on[2].Deforestation in the Sundarbans has now become one of the most major concern for Bangladesh not only for being the largest mangrove forest in the world but also for being a land sea interface that protects the coastal areas from natural hazards. According to FAO(2010) deforestation means: land spanning more than 0.5 hectares with trees higher than 10% or trees able to reach these thresholds in situ for reporting area under Forest Resources Assessment(FRA).Exaggerated amount of deforestation in the mangrove forest is forcefully destroying this highly productive ecological communities that provides the important ecosystems function[3].It has also been seen that anthropogenic activities has become a strong catalyst in destroying the ecological balance of this asset. The livelihood of nearly 4 million people depends on Sundarbans where considerable employment and income opportunities for approximately half million population comes from the non-timber forest products and various plantations [4]. This mangrove forest has the ability to protect the coastal areas from extreme natural calamities, provides livelihood to a heavy number of human population, maintains enriched diverse ecosystem, retains terrestrial sediments, recycles nutrients, supports clear offshore waters, serves as important and vital source of carbon sink, provides home to approximately 840 species of wild animals and 334 plant species, consists of rich diversity of aquatic and terrestrial flora and fauna [5].Hence it is extremely important to conserve this mangrove forest for the betterment of both the humans and the nature. This study seeks to identify the various simple and complex consequences which are existing at present and also attempts has been taken to predict some future consequences of deforestation

Figure: 1 (Map of Bangladesh) that might be seen in the Sundarbans. The predictions have been made based on historical and present data obtained from government, nongovernment organizations and field survey.

2 MATERIALS & METHODS

2.1 Study Area

The location of Sundarbans is in the south-west of Bangladesh between the river Baleshwar in the East and the Harinbanga in the West, which eventually falls to the Bay of Bengal the largest contiguous mangrove forest in the world. It lies between latitude 21° 27′ 30″ and 22° 30′ 00″ North and longitude 89° 02′ 00″ and 90° 00′ 00″ East and with a total area of 10,000 km2 in which 60% of the area lies in Bangladesh and the rest of it is in India. The land area, including exposed sandbars, occupies 414,259 ha (70%) with water bodies covering 187,413 ha (30%).
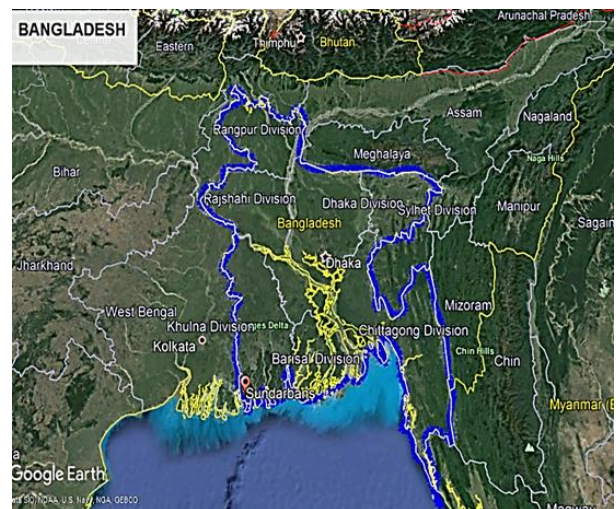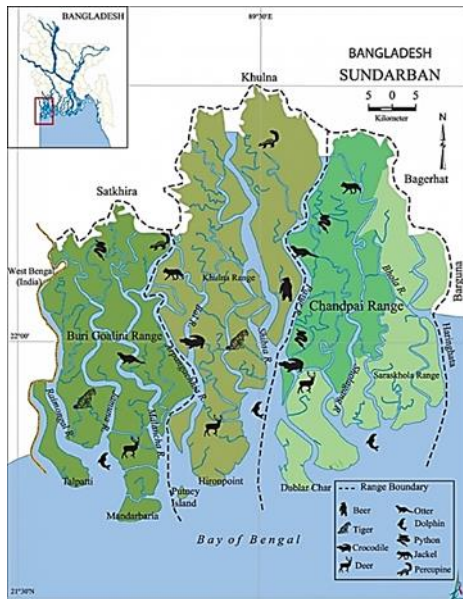

Figure: 1 (Map of Bangladesh)

Figure: 2 (Sundarban) Source: Banglapedia

2.2 Data Sources

This study is based on data obtained primarily from governmental & Nongovernmental organizations along with field level survey conducted in the locality of Sundarban and some residents living in city of Khulna.
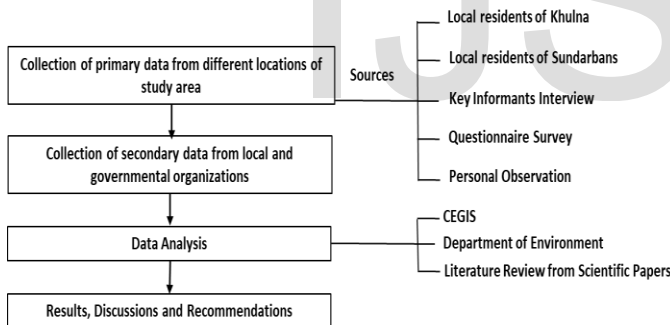

Figure: 3 Data Collection Method

2.3 Deterioration of Mangrove Forest

Sundarbans mangrove forest in Bangladesh is extremely rich due to presence of multiple natural resources like trees, birds, animals, water bodies, sink of carbon dioxide, honey, fuelwood, pulp, charcoal, thatch, fodder, wax, medicine and floras. Hence this renewable natural resource has both economic and ecological importance. But this mangrove forest is undergoing deterioration at a significant alarming rate. The overall mangrove ecosystem of the whole world is reducing at an astonishing rate due to both natural and manmade causes [6]. This Sundarban mangrove forest has now become the most threatened habitat in the world [7]. There are various reasons behind the depletion of Sundarbans of which unauthorized forest cutting and over exploitation of natural resources are the main. Overexploitation of Non-Timber Forest Products

(NTGPs) and wood, pollution from industrial and agricultural activities, oil spills from boats, power plants, ships polder constructions, sea level rise, cyclones, storm surges etc. has put Sundarbans under huge threat [8]. However, deforestation activities not only impact the natural biodiversity, residents and other infrastructure but also it badly effects the carbon fluxes in the soil and atmosphere thus alters the carbon cycle in the forest. Both educated and uneducated people are illegally using the resources which are economically important. Though there are some natural causes of deterioration of Sundarban but the gravity of degradation is extremely high due to the anthropogenic activities. Conservation and sustainable management efforts must be taken in order to protect this forest. The major reasons for the deterioration due to deforestation are mentioned below:

2.3.1 Illegal cutting down of trees

Significant number of logs of trees from the Sundarbans are cut down which unfortunately find their way out of the forest under the noses of the authorities. It has been seen that illegal trades have gained momentum where the corrupt officials and loggers' group together to clear out the precious trees from this forest. Though there are many programs under both governmental and nongovernmental organizations to promote the plantation of trees but an illicit trade is existing in this forest that is significantly reducing the number of trees [9].

2.3.2 Imbalance in agricultural expansion

Agricultural expansion is one of the major reasons for deforestation [10]. Severe damage of ecosystem is seen due to the agricultural expansions in Sundarbans. The water quality of the surrounding rivers is affected by the augmented number of nitrates that are being used in the lands. The habitats of wild life are also in danger because of haphazard expansion. Huge number of trees are being cut by the local farmers in order to plant salt tolerant paddy in unplanned way which is also deteriorating the forest area.

2.3.3 Cultivation of Shrimp

The demand of shrimp in the international market is extremely high as a result of which more and more areas in the forest are used for cultivation of shrimp. Since 1980's the area for shrimp culture has been increased by almost 10 folds. Survey data obtained from 264 higher income households from six villages in mongla shows that approximately 46% of the overall income comes from shrimp cultivation [11]. Saline water is allowed to enter into the land which is trapped later in order to cultivate the shrimp and this trapped water is increasing the salinity

2.3.4 Overburdened population and Urbanization

With the increasing population the demand of people increases which leads to shrinkage of forest. Deforestation occurs at great extent in order to meet the requirements like building of house, construction of roads & highways etc.

Overpopulation directly impacts the forests and thus causes deterioration.

2.3.5   Livestock Ranching

The Major disruptive effects on mangrove forest environment are occurring due to increasing livestock ranching. Almost 340 million tons of carbon dioxide is emitted into the atmosphere due to the deforestation that is caused by cattle ranching globally and it contributes to approximately 3.4% of current global emissions [12].

2.3.6   Lack of Public Awareness

The deterioration of mangrove forest is greatly linked with failure of proper management policies which includes: failure of institutions to effectively manage coastal mangrove resources and conflicting activities, poor planning and knowledge of coastal land use and implementation of development plans that does not include environmental protection principles, lack of skilled and well-trained officials. Thus, due to lack of proper management policies and poor knowledge of mangrove ecosystem is leading to destruction of the resources in this forest [13].

2.3.7   Climate Change

Sundarban provides shelter for almost 425 species of wild life which includes 42 species of mammals and 300 species of birds. Sundarban provides ecosystem services like: protection of human lives, shelter from cyclones, nursery for aquatic life, timber production, oxygen production, waste recycling, trapping sediments, carbon sink, supply of food and building materials [14]. All these valuable services are under threat due to the effect of climate change. As the coastal areas of Bangladesh are on the front line of climate change so storm surges, drainage congestion and sea level rise directly are directly threating the existence of Sundarbans [15]. As per IPCC around 20% of coastal ecosystem will be lost because of sea level rise by the year 2080 along with some regional variability [16].

2.3.8   Cultivation of Shrimp

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5   RESULTS AND DISCUSSIONS

As trees are cut down clearance of forest occurs which leads to erosion of soil [17]. The type of soil and magnitude of soil disturbance control the impact of deforestation on soil and release of soil carbon. The lifecycle of the vegetation is related to the carbon content of soil. Decomposition and release of carbon occurs in the environment when vegetation dies. Due to deforestation soil is exposed to sunlight which results in increase of soil temperature and rate of soil carbon oxidation. Hence Carbon dioxide content in the atmosphere increases due to this process. Operations like logging and tillage can also increase the rate of release of soil carbon at extreme rate [18].

Some very important and commercial species of Sundarbans are: Nypa fruticans (Golpata), Heretiera fomes (Sundari), Ceriops decanda (Goran), Excoecaria agallocha (Gewa), Sonneratia apetala (Keora), Xylocarpus mekongensis (Passur), Avicennia Officinalis (Baen). The growth and sustainability of the mentioned species mostly depends on salinity condition. Heretiera fomes (Sundari), the most demandable species of Sundarban survives only on low saline water but if sea level rises the salinity will increase which will eventually threat the existence of this asset.

Deforestation causes massive erosion throughout the tropics; heavy rainfall washes away soil and as a result the total yield of crops decline. After heavy rainfall on cleared forest lands, the runoff of the rain discharges soil into local rivers and thus a lot of problem is created by raising river beds which results in frequent floods [19]. The following table shows the inundated area of Sundarbans by different scale of sea level rise:

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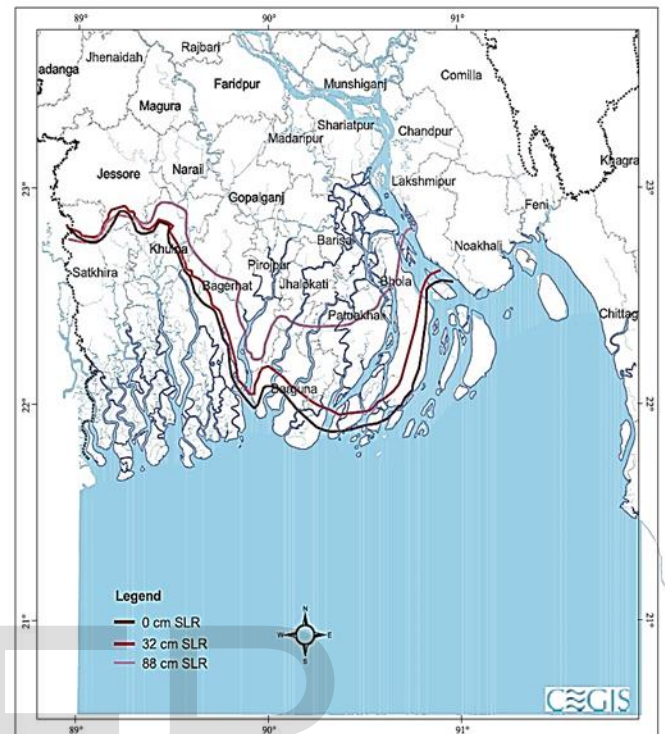
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Table 1: Different scenarios of Sundarbans under various sea level rise (Source: World Bank 2000)

Climate change event	Potential Impacts
Sea level rise	10 cm SLR will inundate 15% of the Sundarbans 25 cm SLR will inundate 40% of the Sundarbans 45 cm SLR will inundate 75% of the Sundarbans 60 cm SLR will inundate the whole Sundarbans 1-meter SLR will destroy the whole Sundarbans - Species like (Heretiera fomes), main economic species in the Sundarbans, would be replaced by less valuable (Ceriops decanda),(Goran) and Excoecaria agallocha (Gewa) . - Loss of Sundarbans and other coastal wetlands would reduce breeding ground for many estuarine fish, which could reduce their population. - Sea level rise would result in saline water moving further into the delta. This would reduce the habitat for fresh water fish, although it could increase the habitat for estuarine fish.

Suitable area for Sundari with respect to different stages of sea level rise:

Table 2: Information about suitable area (Sundari)

Year	Suitable area(ha)
2001(Base)	80489
2050(32cm SLR)	69571
2100(88 cm SLR)	43884

(Source: CEGIS, 2005)

Suitable area for Gewa with respect to different stages of sea level rise:

Table 3: Information about suitable area (Gewa)

Year	Suitable area(ha)
2001(Base)	590267
2050(32 cm SLR)	58992
2100(88 cm SLR)	55021

(Source: CEGIS, 2005)

The following map shows the inundation of coastal locations of Bangladesh under the various stages of sea level rise:

Figure 3: Inundation of coastal area under different sea level rise scenarios (source: CEGIS, 2005)

Deforestation alters land and so that many of animals do not survive. Removal of trees thins the forest canopy and thus sun rays are blocked during the day and holds in the heat at night. Such kind of disruption leads to extreme temperature swings that are harmful for the animals. Many wonderful species of animals have been lost, and many others remain endangered. Animals like Pantherra Tigris (The Royal Bengal Tiger) are losing their habitats and have become endangered and may even go extinct. Since each species of an ecosystem depends on other so loss of one species can have negative consequences for other species.

People living engulfing Sundarban are engaged in honey collection, wood cutting, fishing, collecting thatching materials, fuel wood collection etc. If deforestation keeps on increasing then it will influence climate change which may lead to sea level rise and eventually many residents will become homeless and jobless. For example: a lot of people earns their livelihood by collecting and selling honey from the Sundarbans but due to deforestation the quantity of honey collection is decreasing. The graph below shows the decrease in collection of honey from 2013-2017:
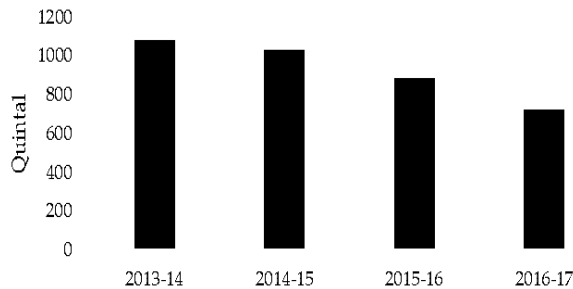
Figure 4: Honey collection from Sundarbans during 2013-2017

Trees are natural reservoir that accumulates and stores carbon containing chemical compounds for a particular period. Hence forest trees serve as carbon sinks and the phenomenon by which carbon dioxide is removed from the atmosphere by the tree is carbon sequestration. Mangrove trees are most efficient carbon sequestration [20]. Sundarban is a unique carbon sink for Bangladesh and it is gradually decreasing because of deforestation. Mangrove trees are the natural tanks that store Carbon dioxide.

The chart below shows the different stock of carbon in different mangroves of the world:

Table 4: Worldwide mangrove forests stock of carbon

Source	Site	Ecosystem carbon stocks (Mg C ha^{-1})
Mm Rahman 2015	Vegetation types, Sundarbans	159.5-360.0
Mm Rahman 2015	Salinity zones, Sundarbans	170.1-336.1
Donato et al.2011	Indian Sundarbans	212.5-312.5
Kauffman et al.2011	Mangrove in Yab, Micronesia	897.8
Kauffman et al.2011	Mangrove in Babeldoab, Republic of Palau	618.3
Murdiyarso et al.2010	Mangrove in Kalimatan, Indonesia	488
Adame et al.2013	Sian Ka'an biosphere reserve, Mexico	631.33
Jones et al.2014	Mangrove ecosystems in northwestern Madagascar	443.2

Carbon is absorbed by them for their own needs which is a boon. The greater the number of biomass are, the greater will be the amount of carbon dioxide pulled out from the atmosphere. Thus, rise of temperature and climate change will be

under control. The overall carbon stock of Sundarban mangroves in Bangladesh was evaluated and the approximate future status after a century was predicted based on changing trends in the past 30 years. For this analysis hybrid model of Markov chain and Cellular automata. Currently 36.24 Tg and 54.95 Tg Carbon resulting in total blue carbon stock of about 91.19 Tg C. As per the prediction 15.88 Tg C would be lost from Sundarban mangroves by the year 2115 [21].

Sundarban plays a significant role in the tourism sector of Bangladesh and has a good economic point of view. A lot of people across the world come to visit this mangrove forest every year because of its extremely diversified nature. Tourism has a very good contribution to the economy of the Sundarban. The following table and pie chart below shows the different elements of the economy of the Sundarbans during the year 2015-2016:

Table 5: Economic sectors of Sundarban

Sector	Amount of money in taka (Cr)
Tourism	414
Protection Service	3,881
Livelihood	1161
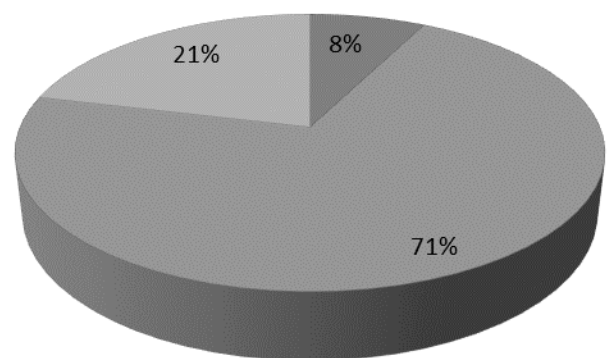
Figure 5: Pie chart of economic sectors of Sundarban

This figure was published in a study conducted by Chittagong University's Institute of Forestry and Environmental Sciences between 2015 and 2016 with technical and financial assistance from Winrock International, USAID and John D Rockefeller Foundation. Wildlife biologist AHM Raihan Sarker, environmental economist M Nur Nobi, and Geographic Information Science analyst Emran Hassan carried out the study]. Hence, it's a great matter of fact that the tourist loca-

tions are in endangered by the risk of sea level rise and as tourism brings stability to economy so it must be managed properly.

Fourth assessment report of IPCC predicts that climate change will intensify extreme weather events such as cyclones and associated storm surges, especially along the Bay of Bengal. Almost every year Bangladesh is affected by cyclones. From 1877-1995 Bangladesh was hit by 154 cyclones in which 5 were severe cyclonic storms, 43 cyclonic storms and 68 tropical depressions. Cyclone sidr killed more than 3,000 people and affected over six million people during the year 2007.Approximately 0.9 million homes were damaged and 0.3 million homes were completely destroyed [22]. The coastal zones will be totally unprotected if there remains no tree and as a result the loss of lives will be increased which will destroy the economy significantly. Furthermore, phenomenon like land subsidence and erosion will also be increased due to deforestation

With the help of trees carbon dioxide and other greenhouse gases can be mitigated. But when the trees are being cut and burned or removed, they become the sources of carbon. Due to constant deforestation the ratio of greenhouse gases in the atmosphere has increased [23]. It is anticipated that around 20% of greenhouse gas emissions along with 1.5 billion tons of carbon is released every year by tropical deforestation [24].

Ocean acidification can cause severe damage to the aquatic ecosystem. Due to the deforestation the amount of carbon dioxide increases in the atmosphere which also influences the quantity of dissolved carbon dioxide. Since industrial revolution oceans have already become 30% more acidic thus putting ocean species and the aquatic life at an extreme risk [25]. There is a direct link between land use and water quality, deforestation leads to exposure of land surface which contributes to soil erosion and leaching of nutrition from soils into nearby catchment area. Siltation will decrease the depth of water which will eventually increase the temperature of water and increased water turbidity. These kinds of condition will prevent the entrance of light and ultimately the productivity of phytoplankton will be reduced. So, fish productivity and diversity will be in risk [26].

6 CASE STUDY ANALYSIS

We have conducted a survey on the resident of the sundarban and the adjacent area in order to know their opinion regarding the impact of deforestation and reasons in sundarban due to shortage of time we were able to reach only 150 people, the age of the people ranges from 18-60 years table shows the demographics of the participants. Number of male participants were more than the number of female participants. 64 percent of the participants were from sundarban and adjacent area where 36 percent were from city area.

Table 6: Participants' opinion regarding the impact of deforestation in Sundarban

	Very High	High	Moderate	Low	Very Low
Accelerates land erosion	57	46	31	9	7
Loss of species composition	83	59	1	3	3
Sea level rise	96	50	4	0	0
Loss of Habitat	70	54	13	8	5
Reduction of livelihood	88	49	7	5	1
Loss of carbon sink	58	47	22	13	10
Decrease in number of tourists	61	43	27	11	8
Increased natural hazards	79	52	7	9	3
Increased emission of greenhouse gas	26	38	45	27	14
Degradation of aquatic ecosystem	81	59	0	10	0

Out of 150 people 64.7 percent were educated while rest are uneducated. The majority of the people were observed healthy with the percentage of 74 and 26 percent were sick and only 14percent people were unemployed and rest are engaged with income related activities.
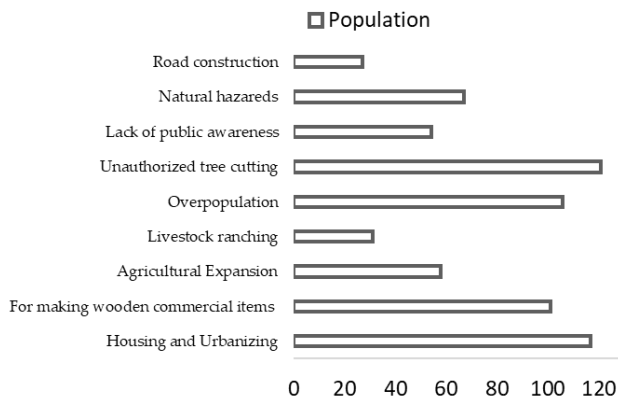
Figure 7: Participation beliefs for the most serious reason for deforestation.

Table 7: sample demographics

		Frequency	Percentage
Gender	Male	87	58
	Female	63	42
Place of residence	City	54	36
	Sundarban Area	96	64
Educational Level	Educated	53	35.3
	Uneducated	97	64.7
Average Annual household Income (Taka)	Unemployed	21	14
	<20,000	67	44.6
	20,000-50,000	33	22
	>50,000	29	19.3
Age (Yr.)	18-45	81	54
	>45	69	46
Health Status	Healthy	111	74
	Sick	39	26

4 CONCLUSION

Deforestation of sundarban can lead serious consequences like sea level rise, biodiversity loss, extinction of different species and it will directly affect the economy. To save this forest it is very important to identify the existing problems along with the reasons behind it. The study conducted provides some historical data that show the various degradation sectors and also shows people's perception on how and at what degree the Sundarban is getting destroyed. We recommend in this paper to provide researches with true data for analysis and promote in depth public participation for conserving this mangrove forest.

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