A Social-Ecological System Approach for Forest Resource Management of the Himchari National Park in Bangladesh

by

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ABSTRACT

Deforestation is a common phenomenon in Bangladesh, leaving the country under a great threat of losing its natural habitat. The increasing rate of natural habitat loss has raised questions regarding the country's forest resource management practices. These practices were originally adopted to protect the forest ecosystem and secure the livelihood of the people dependent on forest resources. Despite the support from development partners like United States Agency for International Development (USAID), the country is still struggling to protect its forest resources from human encroachment. One of the major problems is the lack of inconclusiveness in current approaches. Most initiatives are not evidence-based and are project-based for only a certain period of time. This has failed to ensure sustainable outcomes. This study looks at Bangladesh's Himchari National Park forest management system to generate evidence regarding deforestation from 1991-2018 and highlight existing gaps. To identify and analyze the gaps, the study uses a social-ecological system (SES) lens. Results reveal deforestation across different time periods, articulates the overall governance structure regarding forest resource management and provides an overview of the major gaps within the system. The study also offers a set of recommendations for improving the existing management system and policy implications.

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CHAPTER 1

INTRODUCTION

Forest resources are considered to be the most critically vital habitats due to their biological diversity and ecological functions (Secretariat of the Convention on Biological Diversity, 2001). They play a significant role not only in providing environmental protection but also contribute economic benefits in the form of raw materials such as timber for industry and construction (Ghebrezg, et al., 2016). However, forest resources in Bangladesh are greatly threatened with extinction as scientists have identified an alarming rate of deforestation since the beginning of the 21st century (Booth, 2012). The Bangladesh Government has identified increasing population as one of the root causes of this deforestation with the rate of deforestation increasing as the population expands (Kamal, 2005). The lack of proper information on deforestation and forest resource management on the ground has made the situation even more dire.

Forest resource management is a branch of forestry that integrates ecology and biology, measurement, and policy and administration (Chazdon, et al., 2016). This can be defined as a practical application of the scientific, technical and economic principles of forest resources (Adekunle & Oluwalana, 2019). This includes management for aesthetics, fish, recreation, timber, water, soil, wilderness, wildlife, wood products, genetic resources, and other resource values (Ministry of Forests and Range, 2008). In a broad manner, forest resource management builds the capacity of forests to satisfy the social, political and economic needs of the landscape and living beings. A lack of management or poor management results in the threat of extinction of forest resources in the form of deforestation or forest degradation (WWF, 2020).

The shift towards ecologically sustainable forest resource management calls for reliable and updated spatial information using satellite data and remote sensing analysis to achieve sustainable outcomes (Dutt, et al., 2009). The role of satellite-based remote sensing analysis has increased significantly in forest resource management. Within the context of diminishing financial resources and saving time, a demand for analyzing forest cover change using remote sensing technologies is increasingly evident (White, et al., 2016). Acquiring appropriate forestry inventories is of vital importance for better planning and management of forest resources as well. Thus, the use of remotely sensed data can be seen as a prerequisite for achieving sustainable outcomes in forest resource management.

It is important to recognize that forest resource management occurs at the intersection of natural and social systems (Virapongse, et al., 2016). Despite this, conventional methods consisting of top-down approaches continue to dominate forest resource management further resulting in dynamic challenges. Solving these dynamic and complex challenges effectively entails a comprehensive novel governance approach including a cultural shift and integration of social and ecological sciences or a transdisciplinary approach. This approach is gaining momentum in addressing environmental issues and improving forest resource management (President's Council of Advisors on Science and Technology, 2011). Transdisciplinary approaches construct a conceptual bridge among different theoretical disciplines to address complex and dynamic real-world challenges (Tress, et al., 2004). In the field of forest resource management, the Social-Ecological System (SES) approach can nurture relevant transdisciplinary theoretical concepts and integrate different viewpoints within real-world contexts (Virapongse, et al., 2016). This paper explores the rich opportunities presented by using an SES approach to address environmental problems

generated by current forest resource management practices in Bangladesh and ensure sustainable outcomes.

This study couples the SES approach with remote sensing analysis to extract forest cover change information from 1991-2018 and illustrate the results of human-environment-institution interaction. The study analyzes land use land cover change (LULCC) for both core and buffer areas of the Himchari National Park (HNP) forest. The primary difference of governance between these two areas is that human encroachment and resource extraction are prohibited by law in the core area, whereas limited felling of trees and collection of forest resources is allowed in buffer areas. The goal is to understand the implications of different management approaches on the rate of deforestation.

The SES lens allows for insights into the actions and interactions of different actors and institutions within the study area. Forest villagers living in core and buffer areas are considered key stakeholders of the resource management system. Therefore, the study analyzes the socioeconomic condition of these stakeholders using a household survey. The purpose of this analysis is to understand the livelihood differences between the two groups. The study explores motivational factor(s) for why people live in a particular area. Finally, the study seeks to find a correlation between forest resource extraction by local stakeholders and deforestation. However, it is very difficult to know how much deforestation is directly caused by stakeholders' use of forest resources.

It should be noted that institutional performance along with regulatory norms, practice, and culture form the basis for forest resource management. Thus, governance relies on existing institutional structures and interaction among the actors, resource uses, and institutional mechanisms (Shahidullah, et al., 2015). This entire interaction can be conceptualized as

the SES framework (Faggin, et al., 2017). The main problem with Bangladesh's forest resource management exists outside of the forest area but can be explained through the SES framework lens. Therefore, it is imperative to consider a cross-sectoral approach for sustainable forest resource management. The study uses expert and stakeholder opinion to analyze the reasons behind deforestation, identify gaps in the existing governance structure, and provide a set of recommendations to improve the situation.

Study outcomes are threefold. First, it contextualizes the broad spectrum of SES to address deforestation and manage forest resources for HNP. Second, it produces comprehensive knowledge of Bangladesh's forest resource management and identifies the gaps in policy formulation and implementation that may shape the behavior of the relevant actors. Third, it identifies key research needs for ensuring adaptive sustainable governance and management of forest ecosystems that account for changing social and resource conditions.

CHAPTER 2

OBJECTIVES OF THE STUDY

The study comprises of the following objectives;

- Analyze the change in forest cover in the Core (Himchari National Park) and Buffer (surrounding areas) areas over the period 1991-2018
- Explore the interactions between actors, institutions and resource uses (Social-Ecological System) that shape the Himchari National Park management

CHAPTER 3

CURRENT CONTEXT OF FOREST RESOURCES MANAGEMENT IN BANGLADESH

Bangladesh is a very rich country in terms of forest resources and biodiversity and its forests have been under planned management for over a hundred years. Management started around 1894 during British rule (Biswas & Choudhury, 2007). The strategy at that time was focused primarily on revenue collection from forest resources. Currently, however, the country is undergoing a fundamental shift in the definition and operation of forest resources management. It seeks not only to increase the production of timber but also ensure clean air and water, provide a healthy habitat for wildlife, and promote nature-based tourism. This approach engages people in the entire process so that they have a stake in protecting forest land as a means for improving their standard of living (Bhuiyan, 2013). Following the adoption of this new system, the Bangladesh government developed a participatory management program and formulated several sectoral and cross-sectoral policies. In addition, development partners and Non-Governmental Organizations (NGOs) have undertaken numerous projects to support the forest sector with a view to making the approach sustainable (Biswas & Choudhury, 2007; Syed, 2017). Moreover, the government has identified critical forest as a "reserve forest". Reserve forests are areas of a forest set aside and preserved by the government as a wilderness and national park which enjoys judicial and/or constitutional protection (Schuck, et al., 2002). Despite this protection, most of Bangladesh's forested areas are still facing immense demographic pressure. This includes exponentially increasing use and dependence on forest goods and

services by the fast-growing population and poor enforcement of forest regulations, resulting in deforestation and forest degradation across Bangladesh (Bhuiyan, 2013).

According to the Forest Sector Master Plan (2016) prepared by the Bangladesh Forest Department, natural hill forests encompassed 128,630 hectares in 1990 but declined to 79,160 hectares by 2015. “Sal” forests, a forest type dominated by a single plant species, commonly known as the Sal tree (Shorea robusta) covered 23,650 hectares in 1990. It is now down to 17,490 hectares. Natural bamboo forests constituted 89,790 hectares in 1990, declining to 15,000 hectares in 2015 (Daily Sun, 2016; Booth, 2012).

Forests are being cut for everything from housing settlements to border posts to shrimp farms (Islam, 2013). While it is true that increasing population has made the scenario alarming, the role of bad governance also plays a major role in deforestation. Policy formulation, lack of finance, and poor monitoring capacity are major concerns in the country’s forest resource management. Therefore, the problem requires a more comprehensive approach that considers both socio-economic and ecological perspectives as well as policies regulating forests.

The depletion of forest land is more evident in the hilly regions of the country. This area has been experiencing exploitation over the past four decades due to excessive clearing of hill forest cover. This has resulted in the loss of species richness, increased water flow variability, accelerated hill slope erosion, greater flooding intensity, and a gradual decrease in the extent of hill area. Hill forest degradation and depletion has directly impacted those living within and in close vicinity of these areas as their livelihoods are heavily dependent on forest resources (Biswas, et al., 2012). The country, as a result, is losing its mountain

cultural heritage and suffering from disproportionate poverty and inequity. This study focuses on these regions due to environmental and socio-economic impacts.

The study area presents a huge potential for forest resource-based tourism as it is located near the largest sea beach, which is currently the largest tourism industry in the country. To support tourism, however, requires immediate action as the area is now under threat from human encroachment (Hossen, et al., 2019). The study seeks to address the problem by examining how the country is managing the forest resources of HNP and surrounding forest areas and exploring opportunities that ensure sustainable outcomes of forest resource management.

CHAPTER 4

SOCIAL-ECOLOGICAL SYSTEM (SES): ANALYTICAL FRAMEWORK

To understand how the social-ecological interactions within the specific context of HNP's forest resource management, the study has adopted an approach from SES literature (Faggin, Behagel, & Arts, 2017; Folke, 2006). The SES approach is used to highlight the interactions among the actors, resource uses, and institutions that are directly or indirectly related to resource management. This approach acknowledges that the emergence of technical approaches, rules, norms, and values within a particular context shape resource management initiatives. In its simplest form, the SES approach represents "… a complex system of interaction across resources, resource units, actors and governance sub-systems within specific social-ecological context" (Faggin, et al., 2017). Each sub-system also contains a set of variables that define the particular context (McGinnis & Ostrom, 2014). The general assumption in that the development of the SES model reflects the interaction between resource units and governance systems, which influences the behavior of actors who participate in the forest resource management initiative (Hinkel, et al., 2014).

There are already some significant insights in the literature that highlight sustainable forest resource management practices through an SES analysis. Faggin, Behagel, & Arts (2017) highlighted that the SES of Caatinga forest biome in Brazil has shaped the translation of sustainable forest resource management. The authors articulate the role of local and national actors in shaping these practices (Faggin, et al., 2017). There is also evidence of small-scale fisheries management in the Mexican state of Baja California Sur (BCS) where researchers have used the SES framework to assess spatial variation for determining the potential of achieving sustainability. They argue that SES analysis offers a guideline for

assessing the sustainability dimensions of resource use and management (Leslie, et al., 2015). Michael Cox (2014) applied an SES framework in his study of the Taos Valley Irrigation System in Northern Mexico. He combines the concepts of multi-level governance and social interconnected network analysis to detect the driving factors that maintain community-operated watercourses needed for farming communities (Cox, 2014). Moreover, a group of researchers investigated the SES of rangeland restoration in Iceland, observing statekholder behavior to gauge the effectiveness of resource management policies (Petursdottir, et al., 2013).

Based on the literature, the study adopted the following SES framework (Figure-1) for HNP management.

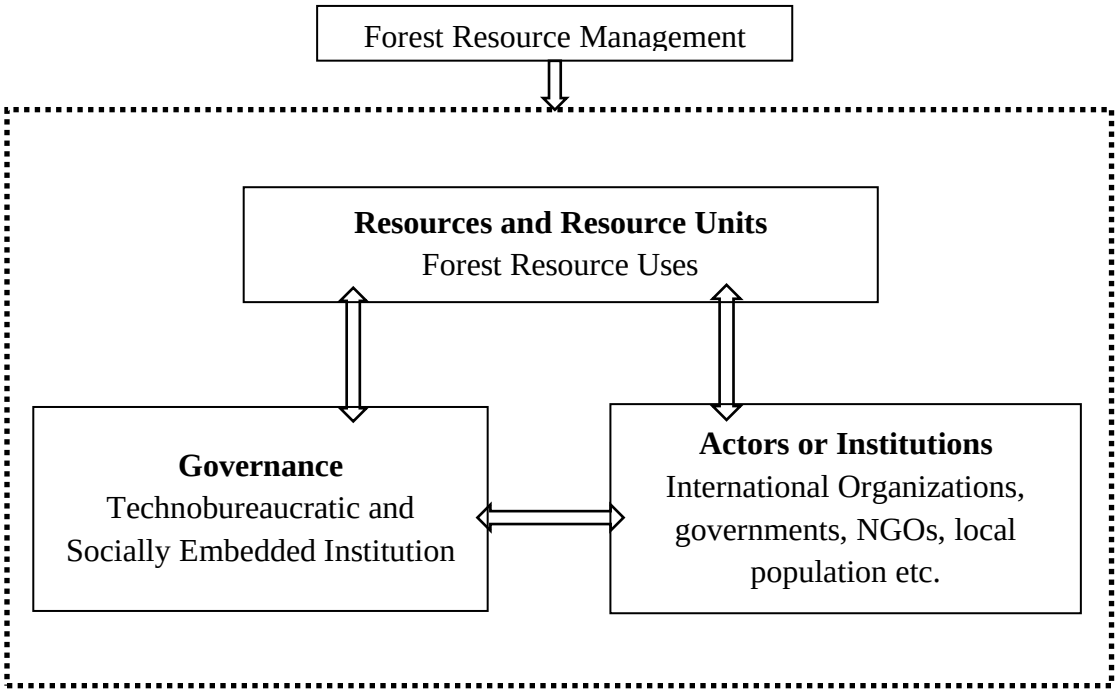

Figure-1: SES Framework for Himchari National Park Management

Based on this model, the study analyzes the following aspects for each subsystem: (1) the nature of available resources that characterize the study area and how these are being used, (2) the behavior of different actors and institutions towards the resource units, and (3) the existing governance system. The governance system was subdivided into two broad institutions—techno-bureaucratic and socially embedded. Techno-bureaucratic institutions refer to the formal regulations usually imposed by the overseeing authority (e.g. government, development partners etc.). Socially embedded institutions are related to the norms and values within the particular context (Faggin, et al., 2017).

The study analyzes the management of the HNP using the SES model to find existing gaps, strengths, and potentiality that may lead towards sustainable forest resource management. It also analyzes forest cover change over time using remote sensing technologies to explain the link between deforestation and forest resource management within a social-ecological context.

CHAPTER 5

STUDY AREA PROFILE

The Himchari National Park (HNP) was selected as the study area. Located just south of the town of Cox's Bazar in Bangladesh, the HNP is comprised of lush tropical rain forest, grasslands, and trees. It also features a number of waterfalls, the biggest of which cascades down to a sandy beach. (Hossen & Hossain, 2018). In accordance with section 23 (II) of the Bangladesh Wildlife Preservation Act 1974, the Bangladesh Government designated about 1729 ha (4,271.15 acres) of Cox's Bazar as a National Park in 1980. The designation included three forest blocks—Bhangamura Reserve Forest (872 ha), part of the Chainda Reserve Forest (62 ha), and part of the Jhilongja Protected Forest (795 ha). These three blocks cover four forest 'beats' (local name for demarcated zones)—Kolatoli, Chainda, Jhilongja, and Link Road. The total landscape area of the forest is about 10,849 ha of which 1,729 ha are in the core zone, 5,247 ha in the buffer zone, and 3,873 ha are private land (Hossen, et al., 2019). A detailed map of the study area is illustrated in Figure-2.

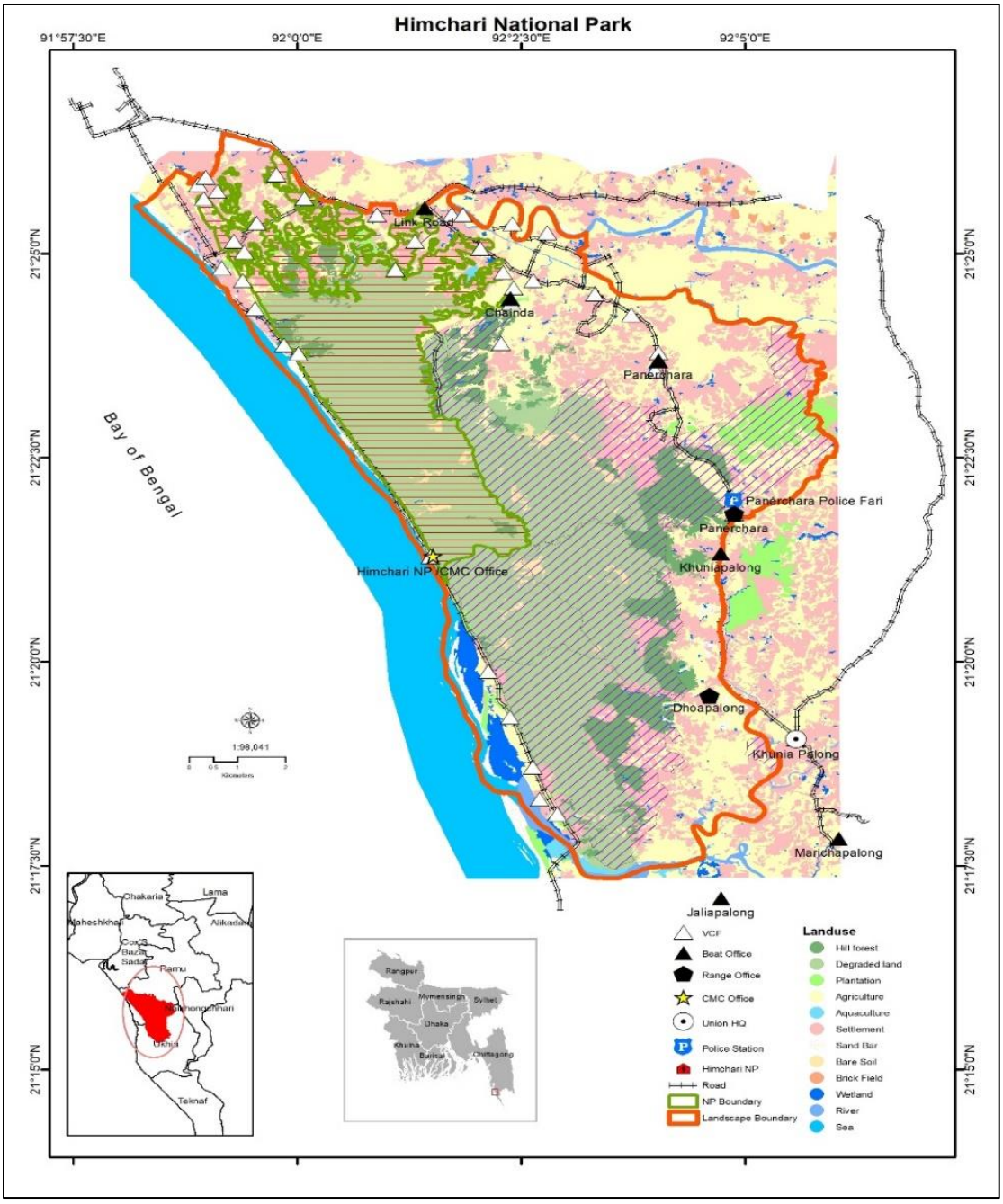

Figure 2. Himchari National Park

CHAPTER 6

MATERIALS AND METHODS

A case-study approach is used to showcase the association between forest resource management and SES. As forest resource management is a cross-sectoral issue and SES poses a complex and dynamic interaction, it requires a more holistic and comprehensive analysis. The use of an SES framework is appropriate for this case-study approach as it allows in-depth, multi-faceted explorations of complex issues in real-life settings (Crowe, et al., 2011). The following section briefly describes the methods used for each objective.

6.1. Forest Cover Change Analysis

Before constructing the association between SES and forest resource management, it is important to analyze the forest cover change of the study area. Forest extent and area of change are considered the primary data and baseline requirement for effective forest resource management (Potapov, et al., 2017). It is also needed to understand forest cover change and extent within the SES context. Therefore, the study considers both HNP core (core area) and buffer areas (surrounding areas) in analyzing forest cover and extent.

The core area is subject to government intervention aimed at stopping any kind of human-led activities to conserve the area and protect it from human encroachment. Buffer areas have similar characteristics, however, there is no government intervention. These areas are compared to demonstrate the local use of forest resources how it may impact afforestation or deforestation.

A supervised classification was performed on multi-temporal satellite imagery to map HNP forest cover in 1991, 2001, 2011 and 2018 (Table-1). Four major land use and land cover (LULC) classes were identified—settlement, water, forest and cropland (Table-2).

Table 1

Satellite Datasets Used for the Study

Data	**Acquisition Year**	**Bands/Color**	**Spatial Resolution**
USGS Landsat 5 Surface Reflectance Tier 1	1991	Multi-spectral	30 m
USGS Landsat 5 Surface Reflectance Tier 1	2001	Multi-spectral	30 m
USGS Landsat 5 Surface Reflectance Tier 1	2011	Multi-spectral	30 m
USGS Landsat 8 Surface Reflectance Tier 1	2018	Multi-spectral	30 m

Source: USGS

To model and predict LULC, a Classification and Regression Tree (CART) classifier was deployed in the open platform, Google Earth Engine (GEE). The study used images from Landsat 5 Thematic Mapper (TM) for 1991-2013, and Landsat 8 Operational Land Imager (OLI) for 2013-2018. The analysis used Surface Reflectance images with a spatial resolution of 30m. Scenes and images were geometrically, atmospherically, and radiometrically corrected and calibrated using GEE. Clouds and cloud shadows were masked with the *CFmask* function available in GEE.

A total of 300 random sample points was used for training and data validation. Of these, 200 were randomly selected as training data with the remaining 100 used as validation points. Training and validation points were interpreted using freely available high-resolution satellite and aerial imagery from GEE. This enabled analysis of places that could not be visited in the field due to safety, cost and time constraints.

Table 2

Classes Delineated for Supervised Classification

Land use class name	Description
Settlement	Residential, commercial, industrial, transportation, roads, mixed urban
Water	River, open water body, ponds and sea
Forest	Mixed forest lands
Agriculture	Crop fields and fallow lands

Source: Author's assumption

Post-classification change detection techniques were performed in ArcGIS. An overlay procedure was used to obtain LULCC during the specified time period. A two-way cross-matrix was obtained, which was later used to describe the key changes in both core and buffer areas. Cross tabulation analysis was conducted to determine quantitative conversions from one LULC category to another and their corresponding areas over the study period on a pixel-to-pixel basis. Two maps, consisting of different combinations of ''from–to'' class changes, were prepared from four class maps (see Results and Discussion Section 7.1 for details).

To evaluate accuracy of the land cover classification, the confusion matrix based on the classification on each period was generated using 100 validation points from freely available high-resolution GEE satellite and aerial imagery. Organized in rows and columns, the matrix is a square array of values that express the number of pixels assigned to a particular category compared to the actual category of the classification. Producer's accuracy (the probability that a value in a class was classified correctly) was calculated using the total number of correctly classified pixels divided by the total number of pixels actually in that class. User's accuracy (the probability that a value predicted to be in a

certain class truly is in that class) was calculated using the number of correctly classified pixels divided by the total number of pixels predicted within that class. The overall accuracy and the Kappa coefficient were also calculated to improve the interpretation of the error matrix.

6.2. Social-Ecological System (SES) Analysis

Traditionally, Bangladesh's resource management used a top-down approach. As mentioned earlier, this centralized approach failed to achieve the objectives of sustainable resource management resulting in the search for an alternative approach. Failure is attributed to the lack of relevant information regarding local resource conditions and a wide range of growing stakeholders associated with resource use. In addition, the country has acknowledged the necessity of public engagement in the resource management decision-making process (Shahidullah, et al., 2015). Therefore, the study analyzed the existing institutional structure to develop a list of stakeholders and their interests associated with forest resource management.

The study explores the multifaceted interaction among actors, institutions, and resource uses to explain afforestation or deforestation in the HPN and the dynamics of forest resource management practices in the country. The study also constructs a theoretical SES framework relevant to HNP management and underlines the practical implication of the SES approach to ensure the sustainability.

The study adopted an SES framework that consists of the following three sub-systems which continuously interact with each other:

(1) Resources and Resource Units—the uses of forest resources and the ecosystem services provided by these uses;

(2) Actors or Institutions—international organizations, federal and state governments, NGOs, market actors, and local populations; and

(3) Governance—techno-bureaucratic and socially embedded institutions.

The SES analysis is qualitative in nature and based on data obtained from 60 household surveys (30 from both buffer and core areas) and 18 Key Informant Interviews (KIIs) with representatives of the National and Local Government; Non-Governmental Organizations (NGOs); experts from both academic and non-academic sectors; private companies; and international organizations. Household surveys were performed using a random sampling technique. It should be noted that both core and buffer areas show similar socio-economic characteristics. Therefore, random sampling allows an unbiased representation of the population in the study area. The primary objective of collecting household information is to get an overview about the socio-economic conditions of both core and buffer areas.

In addition to the general overview, the survey depicts the behavior and socio-economic condition of the resource users of both areas. The goal is to find out who the major forest resource users are, what their livelihood conditions are, and what their motivations are for living in these places. This data informs the discussion of the characteristics of the local people as one of the SES actors, perhaps the most important one.

For first stage KII interviews, a list of representatives of the national government, development partners, and experts in relevant fields based on the literature was prepared. Additional KII respondents were selected using the 'snowballing' qualitative method, where interviewees were asked to indicate other potential interviewees (a list is presented in Table-3). A total of 18 interviews were conducted. The idea was to interview as many different or diversified SES actors as possible to understand their actions on HNP

management and collect data regarding the synergy between the governance system and actors. Among the 18 interviews, 16 were conducted in the local language (Bengali). Interviewee quotes were translated into English.

Following data collection, the study examined each sub-system using the SES framework, portraying interactions among the sub-systems from a qualitative analysis perspective. The study focuses, in particular, on identifying the reasons behind the forest cover change and the association with the human intervention within the study area. It also explains what resources are in danger of extinction; who the users of these resources are; how the formulation of policies by government, NGOs and international organizations shape the behavior of those actors in terms of resource usage; and what motivates these organizations to adopt a policy or conduct development initiatives. This illustrates the overall governance structure regarding forest resource management of the study area.

Table 3

List and Profile of the Key Informant Interviewees

Interview No.	**Profile of the Interviewees**
Interview 1	Executive Director, Arannayk Foundation
Interview 2	Freelance Consultant (National Resource Management Specialist)
Interview 3	Natural Resources Management Specialist and Science & Environment Advisor, USAID
Interview 4	Forest Department, Ministry of Environment, Forest and Climate Change
Interview 5	GIS-RS and Forestry expert in the NRM governance sector of Bangladesh
Interview 6	Fellow, Bangladesh Center for Advanced Studies (BCAS)
Interview 7	Executive Director, Nature Conservation Management (NACOM)
Interview 8	Technical Advisor, Sundarbans Management Project, GIZ
Interview 9	Local Reporter and Member, CMC
Interview 10	GIS and Remote Sensing Specialist, FAO
Interview 11	President, VCF
Interview 12	President, VCF
Interview 13	Member, CPG
Interview 14	Member, VCF
Interview 15	Member, PF
Interview 16	Member, CPG
Interview 17	Forest Range Officer, Bangladesh Forest Department
Interview 18	Senior Assistant Chief, Ministry of Environment, Forest and Climate Change

CHAPTER 7

RESULTS AND DISCUSSION

7.1. Forest Cover Change

Final thematic maps from the supervised classification of the forest cover change for 1991, 2001, 2011 and 2018 are exhibited in Figure-3 (core) and -4 (buffer). These maps were used to calculate the area for each pixel in GEE. The total area for each land use category was calculated in square kilometers (km) then converted into Hectares (ha). Results are summarized by year and LULC in Table-4 (core) and -5 (buffer).

Table 4

Areas (in Ha) of Land Uses Resulted from the Classification in Core Area

Land use	**Areas in Hectares (Ha)**			
	1991	**2001**	**2011**	**2018**
Settlement	203.6	289.9	426.1	961.8
Water	269.8	369.4	276.5	184.8
Forest	1502.7	1287.2	1162.7	721.6
Agriculture	46.6	76.4	157.6	154.6

Source: Author's calculation

Table 5

Areas (in Ha) of Land Uses Resulted from the Classification in Buffer Area

Land use	Areas in Hectares (Ha)			
	1991	**2001**	**2011**	**2018**
Settlement	270.3	255.3	689.7	1467
Water	581.1	275	186.9	139.3
Forest	3275.4	3553.6	3050.5	2139.8
Agriculture	146.9	189.7	346.4	527.7

Source: Author's calculation

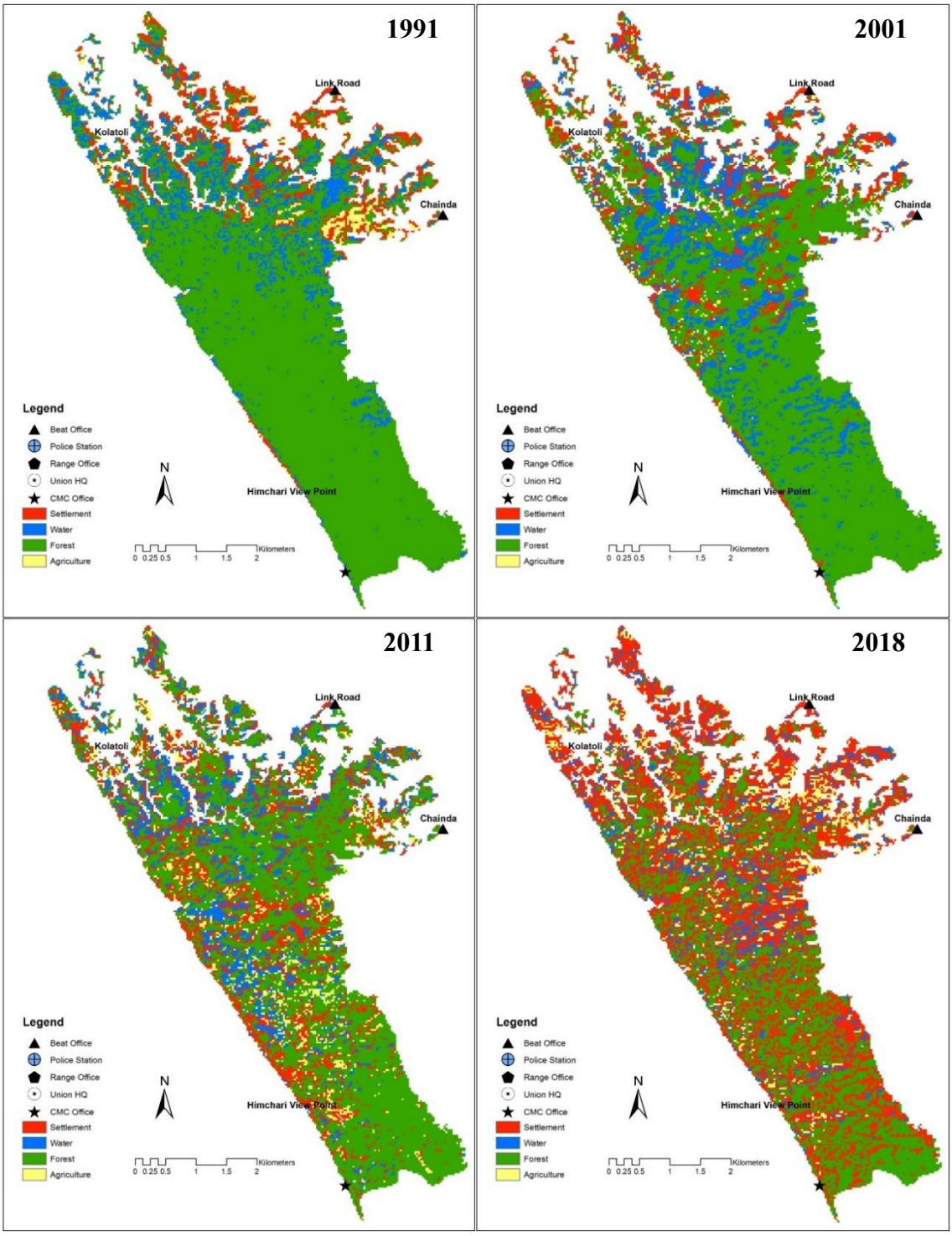

Figure 3. Land Cover Classification of the Core area

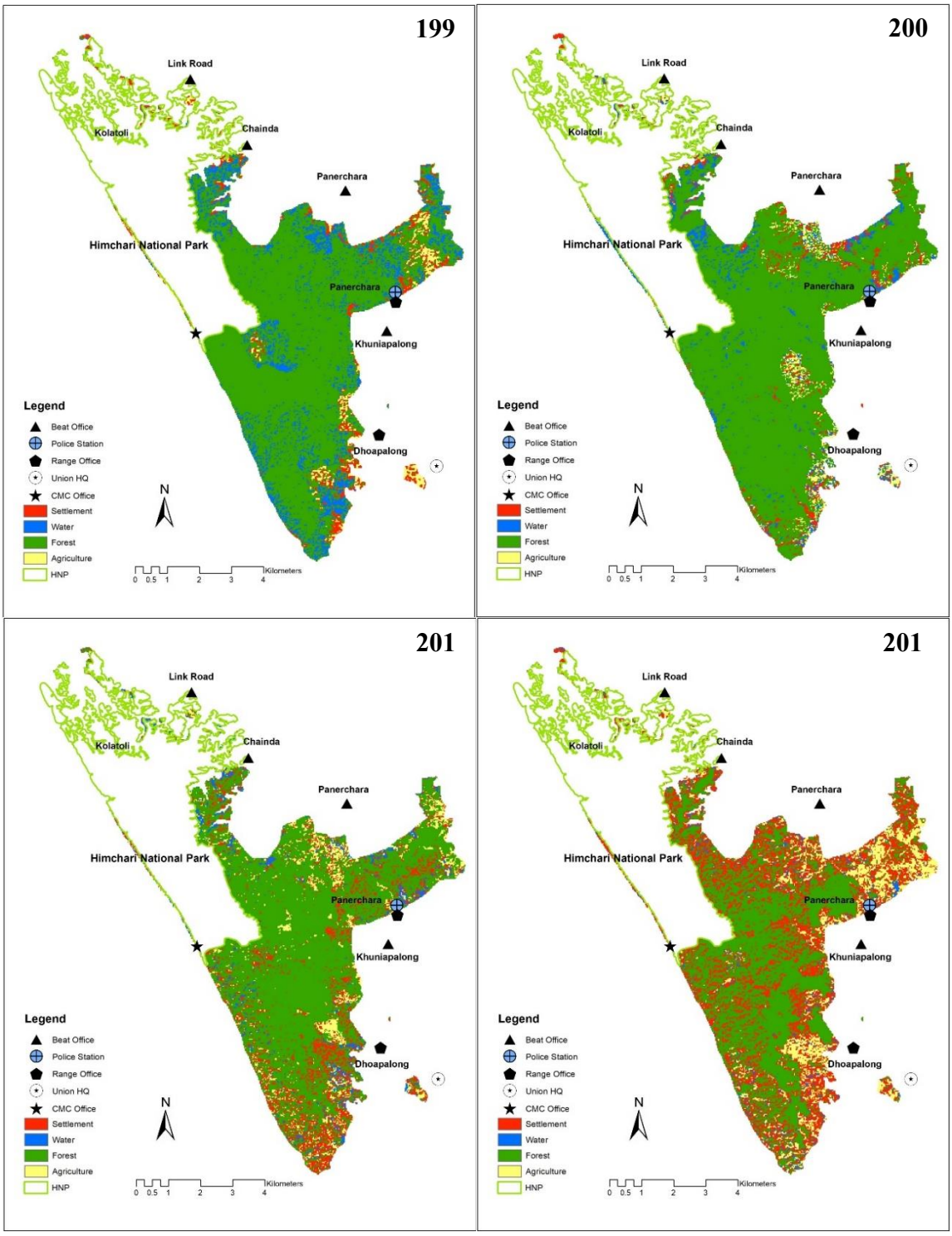

Figure 4. Land Cover Classification of the Buffer area

The resulting area for each core area class in 1991 highlights that “forest” comprised the largest share with 74.29% (1502.7 ha). Agriculture had the lowest share with 2.3% (46.6 ha). Water and Settlement had shares of 13.34% (269.8 ha) and 10.04% (203.6 ha), respectively. Forest was the dominant land use in the buffer area as well in 1991 at 76.64% (3275.4 ha). Water, Settlement and Agriculture uses were 13.6% (581.1 ha), 6.32% (270.3 ha) and 3.44% (146.9 ha), respectively.

The study found that forest area was reduced to 63.63% (1287.2 ha) in 2001 in the core area, a 14.34% decrease from 1991. The other three classes, on the other hand, increased in total share which explains the reduction in forest area. The shares of water, settlement and agriculture were 18.26% (369.4 ha), 14.33% (289.9 ha) and 3.78% (76.4 ha), respectively in the core area. It is noteworthy that although agricultural land had the lowest share, it increased about 63.95% between 1991 and 2001.

In the buffer area, the share of forest area increased to 83.15% (3553.6 ha), an 8.49% increase from 1991. There was also an increase in agricultural land (29.14%) during that period, up 4.4% (189.7 ha) from 1991. Interestingly, and despite the increasing trend of agriculture in the buffer area, the share of water land use was significantly reduced to 6.43% (275 ha) in 2001, showing a decrease of 52.68%. Settlement areas also decreased to 5.97% (255.3 ha). The buffer area experienced less growth during 1991-2001, which is very unusual for a country like Bangladesh where rapid urbanization has been taking place since 1991. However, it should be noted that Bangladesh suffered a devastating flood in 1998 that submerged two-thirds of the country (Ninno, et al., 2000). This flooding incident may have forced poorer populations to move from the buffer areas into the hilly forest area,

which is part of the core area. This may explain the increase in settlements in the core area and a decrease in the buffer area.

After 2001, both areas experienced a reduction in forest area and an increase in settlements. It is notable that the country had tremendous population growth between 2001-2011 from 130.5 million to 158 million (Banglapedia, 2015). This growth had significant impacts nationwide, including the study area. In 2011, core area settlement increased to 46.98% from 21.06% (426.1 ha) in 2001. Settlement area also increased to 16.14% (689.7 ha) share of total land use. This was a significant increase (170.15%) from 2001. The share of agricultural land also increased by about 106.28% and 82.6% in 2011 in core and buffer areas, respectively. Both areas experienced a reduction in forest land with decreases around 9.67% (core) and 14.16% (buffer) in 2011.

A drastic change is observed during the period of 2011-2018 in both core and buffer areas. By 2018, settlement areas increased approximately 125.72% in the core area and 112.7% in buffer areas. Importantly, settlement became the dominant land use in the core area, attributing to 47.55% (961.8 ha) of total land use. Forest area had a share of 35.67% (721.6 ha). This represents a significant reduction (37.94%) in forest land cover. There was also a significant decrease (29.85%) in forest land in buffer areas, encompassing only 50.07% of total land use in 2018. Water areas decreased during 2011-2018 by about 33.16% (core) and 25.47% (buffer) areas. Although the decreasing rate is higher in the core area, water use was 9.14% of total land use compared to 3.26% in buffer area. In terms of agricultural land, the core area faced a slight decrease (1.9%) in total share; whereas, there was a significant increase (52.34%) in agriculture during 2011-2018 in the buffer area.

During this period, Cox's Bazar gained the attention of large number of tourists. The long sea beach became a top tourist destination and a significant number of hotels were built in response to the increasing demand. The tourism industry was booming economically and offered local employment opportunity. However, the pattern of infrastructure development and tourism was mostly unplanned (Ethirajan, 2012). This led to economic growth but at the cost of biodiversity in the area. This haphazard development explains the increasing trend of settlement area and decreasing rate of forest land cover.

The study documents the overall LULCC for the area. Observations in both core and buffer areas are summarized and depicted in Figure-5 and -6, respectively.

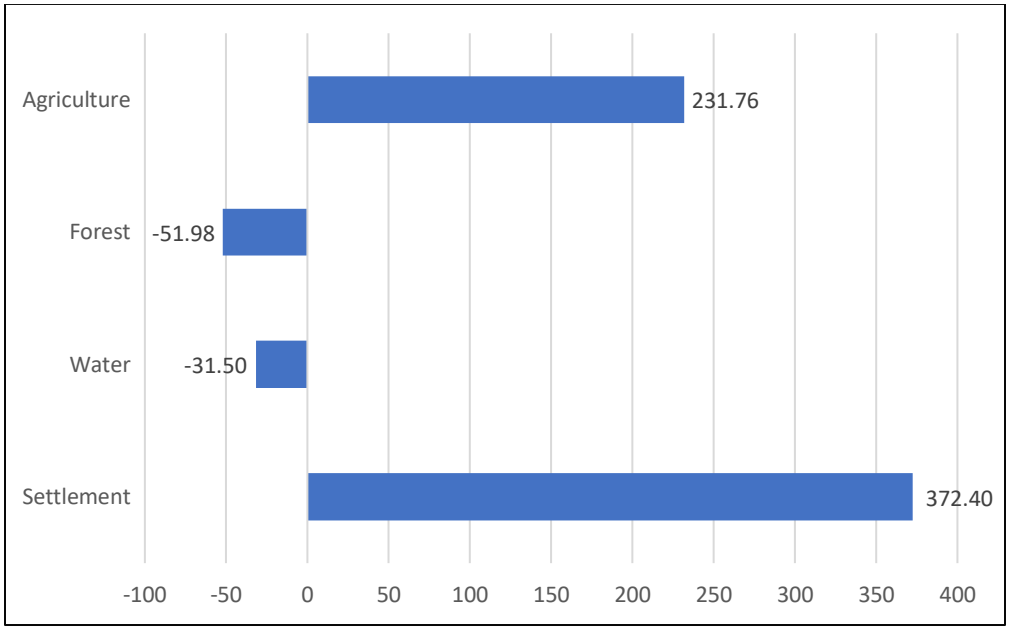

Figure 5. Estimated Change (%) in Land Cover Area between 1991 and 2018 in Core Area

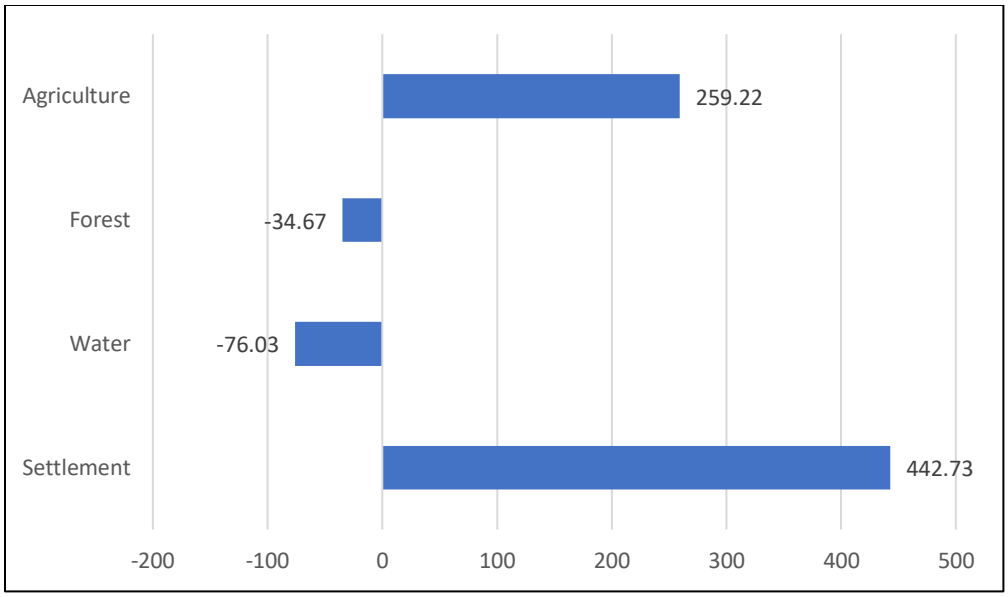

Figure 6. Estimated Change (%) in Land Cover Area between 1991 and 2018 in Buffer Area

The study revealed that settlement areas increased more than 370% and 440% between 1991-2018 in core and buffer areas, respectively. In contrast, there was more than 51% (core) and 34% (buffer) reduction in forest cover during the same time period. These values signify dramatic LULCC and incredible pressure that settlements exert on forest land cover. Development of the tourism industry and expansion of existing urban fabrics through rapid construction of residential, commercial, and industrial units and road networks have led to the destruction of the forest land in both core and buffer areas. The enormous progress in the economy may be associated with the rapid growth of the population which could be the primary cause of deforestation in both areas.

Despite the booming tourist industry and new job opportunities in the 2000s, agriculture increased more than 230% and 259% in core and buffer area, respectively, during 1991-

2018. This can be explained by the significant number of ethnic populations and marginalized groups whose livelihoods depend primarily on agriculture. However, the haphazard and unplanned growth has made the situation dire and caused the deforestation.

7.2. Post Classification Analysis

Post-classification comparison of changes was carried out using GIS. Maps were produced for understanding the spatial patterns of change between 1991 and 2018. The overlay of these LULC maps was used to produce the change maps for both core and buffer areas exhibited in Figure-7 and -8, respectively.

Following this, a change matrix or 'from-to' information for 1991-2018 for both core and buffer areas was developed using post-classification comparison based on earlier classification results. Results are summarized in Table-6 (core) and -7 (buffer).

It can be observed from the tables that around 32% of forest land in the core area and 45% in the buffer area remain unchanged over the years. It is also clearly evident that the majority of the forest areas have been converted into settlement areas. In the core area, 43.75% of forest lands have been destroyed due to the construction of residential, commercial, and industrial units and road networks. In buffer areas, the change is 31.22%.

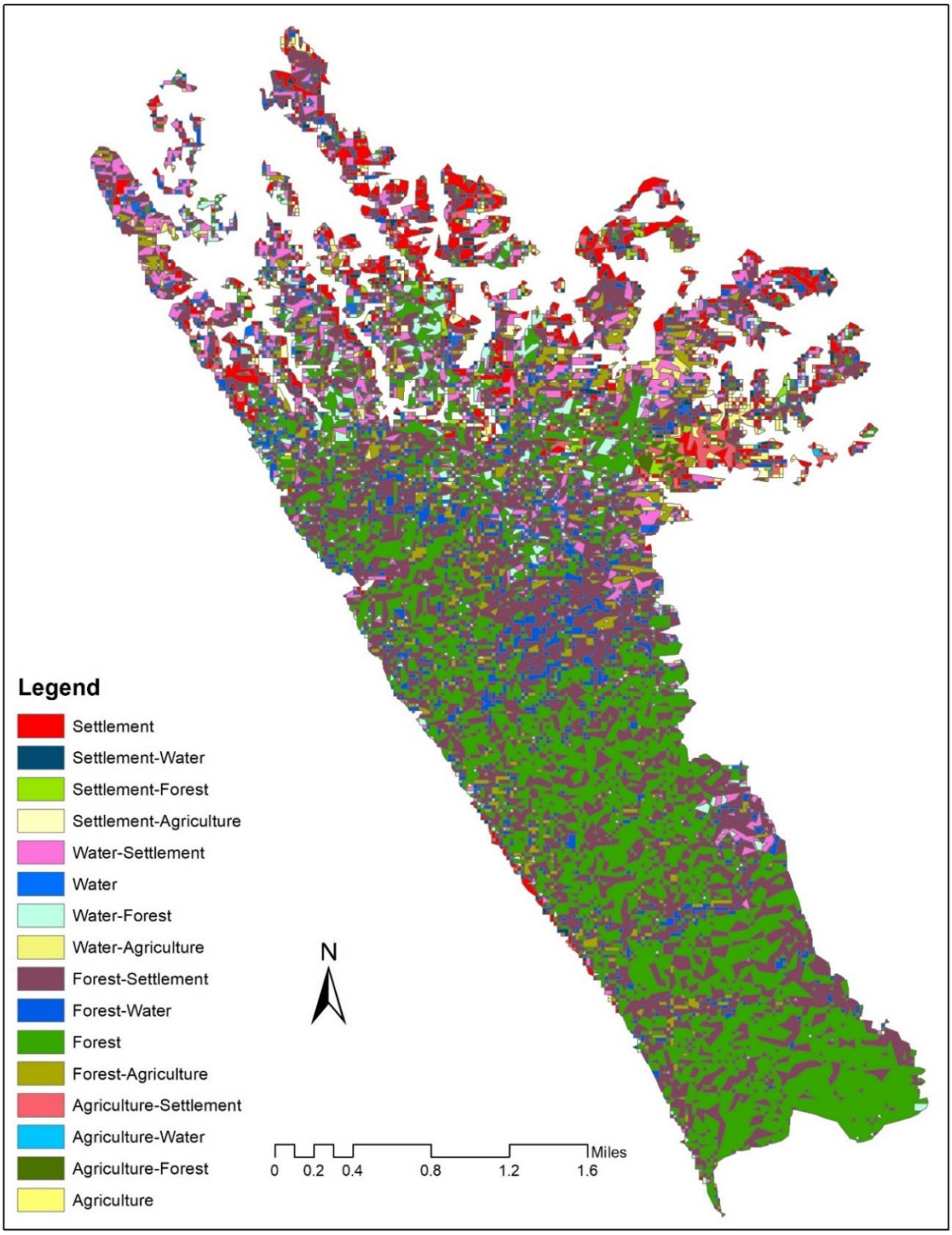

Figure 7. Major Land Use Conversion in Core Area from 1991 to 2018

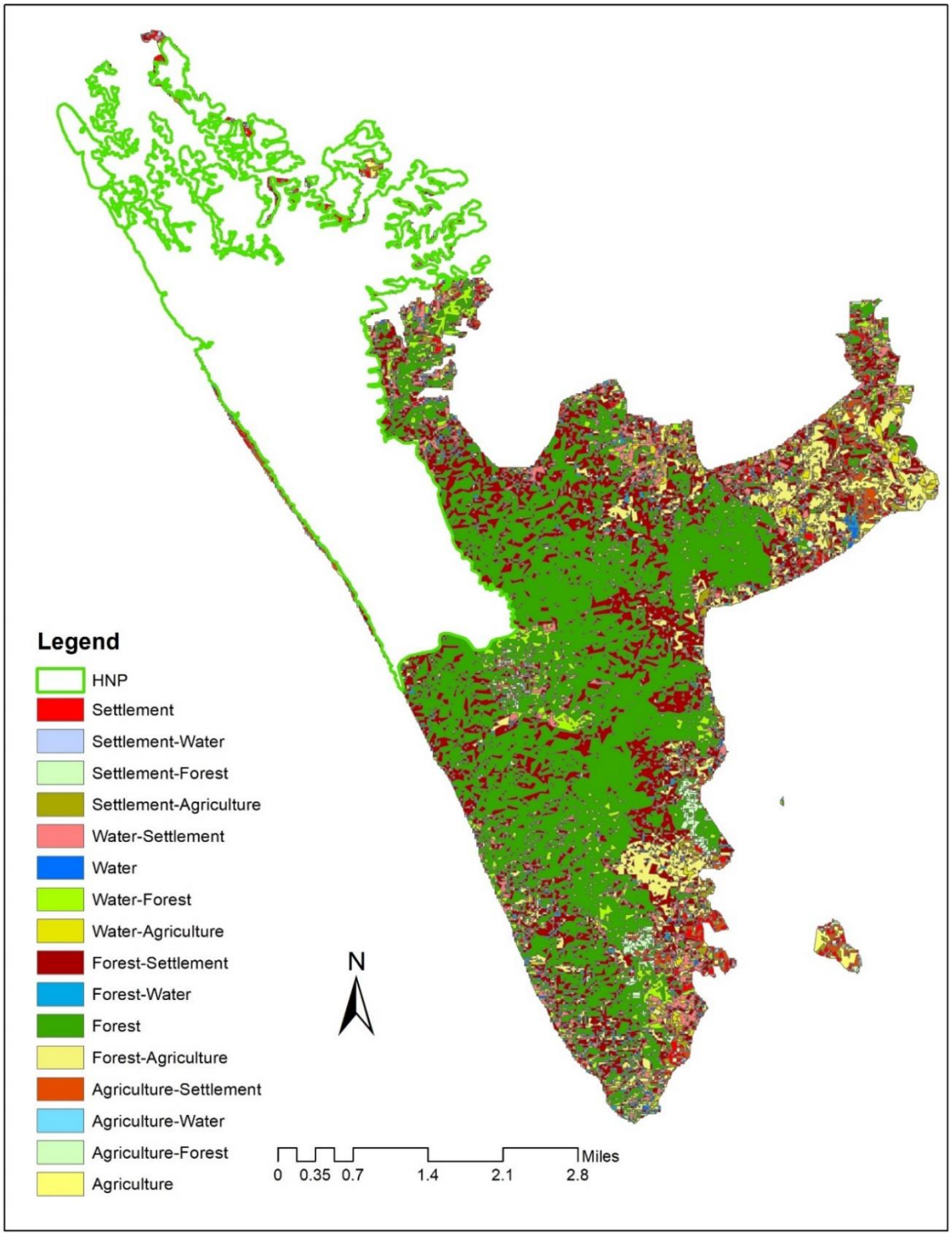

Figure 8. Major Land Use Conversion in Buffer Area from 1991 to 2018

Table 6

Land Cover (in ha) Transition Matrix in Core Area from 1991 to 2018

		2018				
		Settlement	Water	Forest	Agriculture	Total
1991	Settlement	132.510	21.892	17.066	27.476	198.944
	Water	137.062	28.837	67.030	15.678	248.606
	Forest	663.445	117.131	640.432	95.363	1516.371
	Agriculture	24.213	2.486	7.405	10.200	44.304
	Total	957.229	170.345	731.933	148.717	**2008.225**

Source: Author's calculation

Table 7

Land Cover (in ha) Transition Matrix in Buffer Area from 1991 to 2018

		2018				
		Settlement	Water	Forest	Agriculture	Total
1991	Settlement	131.342	19.425	32.613	74.023	257.402
	Water	214.591	26.235	205.363	82.568	528.757
	Forest	1046.939	77.733	1912.640	316.563	3353.875
	Agriculture	59.511	4.105	23.177	56.068	142.861
	Total	1452.383	127.498	2173.792	529.223	**4282.896**

Source: Author's calculation

7.3. Classification Accuracy Assessment

A confusion matrix was prepared for each year (1991, 2001, 2011 and 2018) classification to determine user's accuracy, producer's accuracy and overall accuracy of the supervised classification. The study also calculated Kappa statistics based on the confusion matrix.

The calculated value of the confusion matrix and accuracy assessments are summarized in Table-8, -9, -10 and -11.

Overall accuracy for the supervised classification is 85%, 83.5%, 81.2% and 83% respectively for 1991, 2001, 2011 and 2018 for both core and buffer areas. These indicate errors about 15%, 17.5%, 18.8% and 17% respectively. The value of Kappa coefficient for classification is 0.77, 0.75, 0.64 and 0.75 respectively for 1991, 2001, 2011 and 2018 which indicate values closer to +1. A value close to +1 indicates that the classification is significantly better than random.

As mentioned earlier, user's and producer's accuracy are typically not the same. For example, it can be observed from Table-9 that the producer's accuracy for forest land use is 97.2% while the user's accuracy is 92.6%. This means that even though 97.2% of the reference forest areas were correctly identified as "Forest", only 92.6% of the areas identified as "Forest" in the classification were actually forest area.

Table 8

Confusion Matrix Used to Determine the Accuracy and Kappa Coefficient of the Classified Map of the Year 1991

Land use	Settlement	Water	Forest	Agriculture	**Total**
Settlement	114	12	73	36	235
Water	37	188	0	99	324
Forest	0	9	1226	0	1235
Agriculture	78	0	9	526	613
Total	229	209	1308	661	**2407**
User's accuracy	48.5%	58%	99.3%	85.8%	
Producer's accuracy	49.8%	90%	93.7%	79.6%	
Overall accuracy			85%		
Kappa Coefficient			0.77		

Source: Author's calculation

Table 9

Confusion Matrix Used to Determine the Accuracy and Kappa Coefficient of the Classified Map of the Year 2001

Land use	Settlement	Water	Forest	Agriculture	**Total**
Settlement	148	40	21	26	235
Water	64	252	0	8	324
Forest	0	92	1143	0	1235
Agriculture	29	105	12	467	613
Total	241	489	1176	501	**2407**
User's accuracy	63%	77.8%	92.6%	76.2%	
Producer's accuracy	61.4%	51.5%	97.2%	93.2%	
Overall accuracy			83.5%		
Kappa Coefficient			0.75		

Source: Author's calculation

Table 10

Confusion Matrix Used to Determine the Accuracy and Kappa Coefficient of the Classified Map of the Year 2011

Land use	Settlement	Water	Forest	Agriculture	**Total**
Settlement	10	4	0	23	37
Water	4	75	0	6	85
Forest	63	0	574	8	645
Agriculture	14	44	9	95	162
Total	91	123	583	132	**929**
User's accuracy	27%	88.2%	89%	58.6%	
Producer's accuracy	11%	61%	98.5%	72%	
Overall accuracy			81.2%		
Kappa Coefficient			0.64		

Source: Author's calculation

Table 11

Confusion Matrix Used to Determine the Accuracy and Kappa Coefficient of the Classified Map of the Year 2018

Land use	Settlement	Water	Forest	Agriculture	**Total**
Settlement	92	46	1	30	169
Water	69	133	0	22	224
Forest	1	0	469	0	470
Agriculture	9	0	1	167	177
Total	171	179	471	219	**1040**
User's accuracy	54.4%	59.4%	99.8%	94.4%	
Producer's accuracy	53.8%	74.3%	99.6%	76.3%	
Overall accuracy			83%		
Kappa Coefficient			0.75		

Source: Author's calculation

7.4 Socio-Economic Settings: Core Area vs. Buffer Area

The summary statistics of a few selected variables of the study has been presented in the following Table-12.

Table 12

Summary Statistics of the Few Socioeconomic Variables

Socioeconomic Characteristics	Min value	Max value	Average value
Age of the household head	16	56	34.48
Number of household members	2	11	4.77
Years of formal education	0	12	0.45
Number of schools going children	0	3	0.47
Land amount (acre)	5	34	11.62
Household cash income (BDT)	15,000	70,000	37,483
Household cash expenditure (BDT)	13,000	65,000	34,467

Source: Author's Survey Data, 2018

From the table, it can be seen that the average household cash income and expenditure is BDT 37,483 and BDT 34,467 respectively. This indicates that the average savings for the households in the study area is around BDT 3,000. In the study area, the average number of household members is 4.77 which is almost similar to the national average (4.5). However, there are around 50% households that have more than the average number of members. It is no surprising to see that average year of formal education is 0.45 which means less than 1 year. The rate is almost similar for both buffer and core areas. In the village level (administrative name of local level), the country is suffering from a high illiteracy rate; particularly, more than half of population in Cox's Bazar district is illiterate (BBS, 2013). The study has observed the number of household members an influence in

terms of household income. Therefore, the study has constructed a diagram to showcase the relationship between household income and the number of household members in both buffer and core areas.

According to Figure-9, it is obvious that there is a positive relation between number of household members and household cash income, however, the relationship is not very strong. Following through, the study has considered analyzing the primary occupation of the household. The similar association between number of household members and household cash income has also been performed based on household primary occupation.

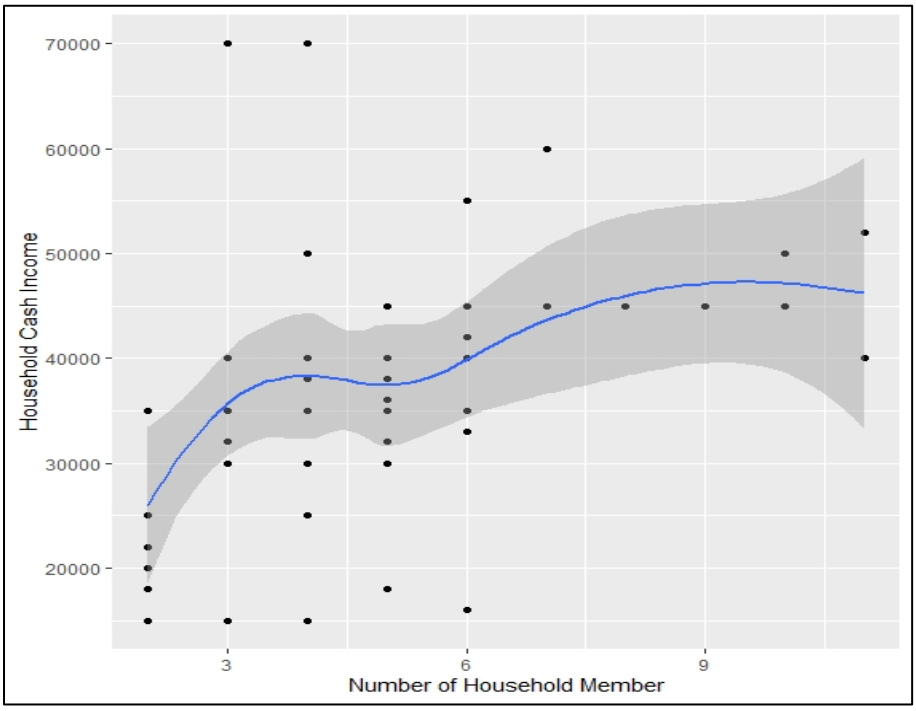

Figure 9. Scatterplot Diagram with Smoother Line to Show the Relation Between Number of Household Members and Household Cash Income

From Figure-10 and -11, it can be seen that for both buffer and core areas, major household primary occupation is ‘day laborer’ and around 50% of the survey respondents has claimed to be a day laborer. All the businessmen live in the buffer area. One of the major reasons for them living in the buffer area could be to enjoy the transport facilities and accessibilities to the outer world. On the other hand, all the farmers in the study area live in the core area. This is because of the opportunities of agricultural activities within the core area. Furthermore, most interestingly, similar number of households from both buffer and core areas are involved in forest related work. It is hard to tell how many people from each family is actually involved in the forest related works and how much resources they are extracting from the forest. However, there are several people who are part of the co-management initiatives introduced by Government of Bangladesh and supported by USAID.

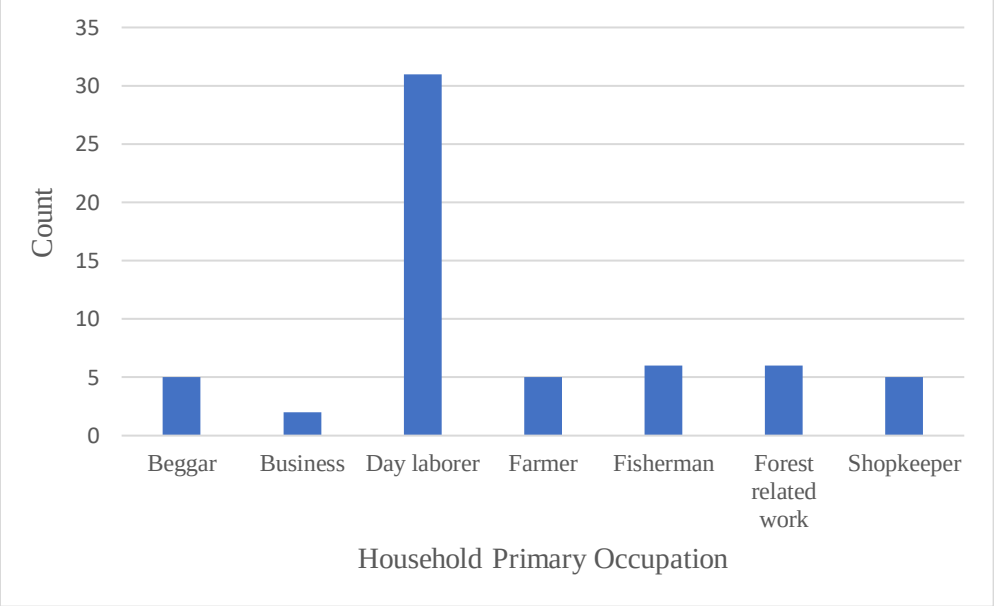

Figure 10. Histogram to Show the Frequency Distribution of Primary Occupation of the Households

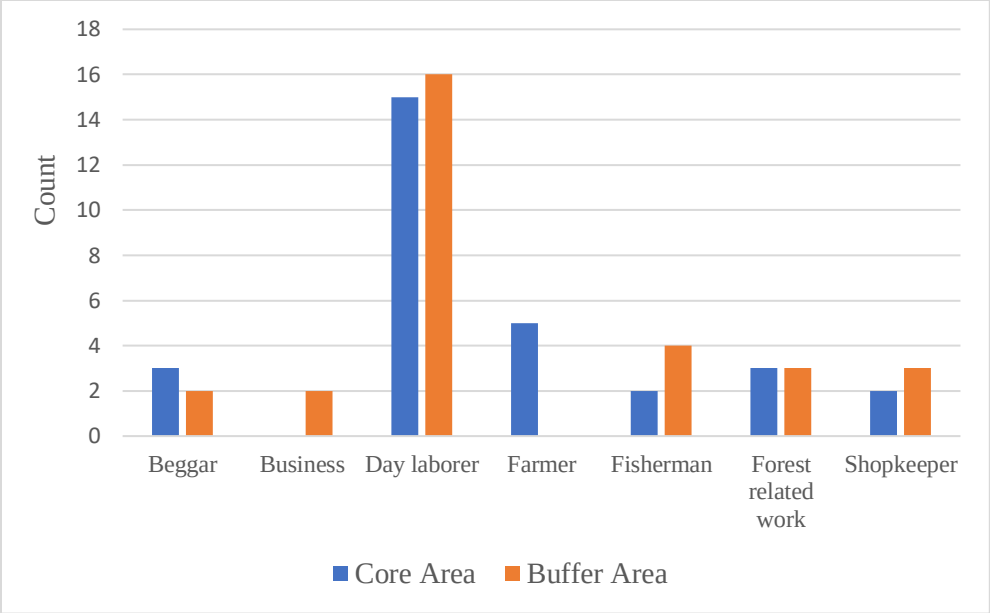

Figure 11. Histogram to Show the Frequency Distribution of Primary Occupation of the Households Based on Area Types

The study has also analyzed the dependency of the people on the forest products living in core and buffer area. The resulted outcome has been illustrated in Figure-12. It is evident from the figure that 93% of the survey respondents living in core area collects fuelwood from their nearby forest, whereas in buffer area, 66.67% survey respondents collect fuelwood. Others buy from the nearby markets. In terms of the bamboo collection particularly for the domestic purposes, more survey respondents living in the core area collect compare to the survey respondents in the buffer area. Besides, every survey respondent living in the core area, collects leaf from the forest. In contrast, only 26.67% of survey respondent in the buffer area collect leaf. Collection of fruits also indicates similar result. It is, therefore, evident that people living in the core area are more dependent on the

forest resources than the people living in the buffer area. It also shows that the enormous pressure on the forest area comes from the people living in the core area.

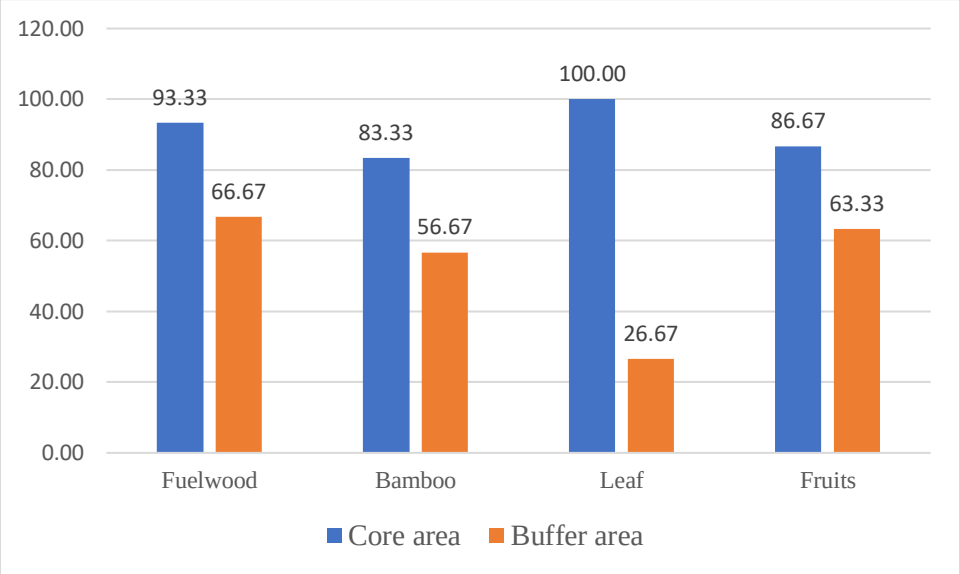

Figure 12. Collection of Forest Products by the Percentage of People Living in Core and Buffer Area

The people living in the core has better access to the forest resources which explains their reasons for the dependency. Based on the survey analysis, the average time for the survey respondents in core area to collect forest products is 17.23 minutes. On the contrary, the survey respondents living in the buffer area had to travel more than 19 minutes to get the forest products. As there is no physical boundary for core and buffer area, it is really difficult to assume from where they collect the forest resources. Based on the travel distance, the study is assuming that most survey respondents go to the core area to collect the forest resources.

The study also intends to find the factors that motivate people to live in a particular area. Following through, the study has conducted regression analysis to explain the monthly income. The study has assumed that the distribution of household income is the main

socioeconomic indicator in the study area. The purpose of doing the regression analysis is to observe the association between household income and different socioeconomic variables. At first, the study has considered household cash income as dependent variable to perform the regression analysis and number of household members as an independent variable. After that another independent variable has been added in the previous model to develop another model to check what explains the income better. Similarly, four models have been developed to explain the household income in the study area. The regression coefficient output has been presented in Table-13.

Table 13

Regression Coefficient Output Regarding the Association Between Household Income and Different Socioeconomic Variables

	Dependent Variable: Household Income			
Model	(1)	(2)	(3)	(4)
Number of HH Member	2185.823***	2800.796***	1841.063***	2019.540***
relevel(Area_Type, “Core area”)Buffer area		8221.114***	12068.660***	10189.970***
Amount of Land (ha)			1511.990***	1325.900***
Travel Time between household and forest resource collection				409.993***
Constant	27197.500***	20155.650***	5242.318***	-317.701
R-squared	0.162	0.271	0.470	0.596
Adjusted R-squared	0.147	0.246	0.442	0.567

The simple regression analysis resulted in a coefficient value of 2185.823. This means that an increase of one person in a household is associated with around BDT 2,186 higher household income. This is a positive association. The r-squared value 0.162 indicates that a 16.2% difference in the dependent variable can be explained by the independent variable. The study ran a second regression model, adding an independent variable—types of area. The analysis was releveled to the core area. It can be seen from the regression coefficient that households in the buffer area are associated with around BDT 8,221 higher income compare to households in the core area. The r-squared value 0.271 from the second model indicates that the 27.1% difference in the dependent variable can be explained by the independent variables. This association is statistically significant.

In the third model run, the independent variable "land amount" was added to further explain variation in household income distribution. The regression coefficient shows that a one unit increase in land amount is associated with around BDT 1,512 higher income, which is statistically significant. The r-squared value also increases (0.47). This indicates that 47% difference in the dependent variable can be explained by the independent variables.

Finally, "travel time to collect forest resources" was added to the fourth run as an independent variable which increased the r-squared value to 0.596. The regression coefficient shows that one unit increase in travel time is associated with around BDT 410 higher income. Adding this variable explains the household cash income variation well.

In addition, the study found Akaike information criterion (AIC) values of 1290.357; 1283.964, 1266.828 and 1252.506 for model runs 1-4, respectively. This indicates that the last model run (4) is the most effective. The study tried to explain income variation further

by using other independent variables, but regression outputs were not statistically significant.

It is clear from the above analysis that people living in the buffer area tend to have more household income than those living in the core area. In the fourth model, it is observed that household groups travel longer to obtain forest resources. This suggest that living far from the forest area may provide higher income opportunities. However, it does not explain the motivation for why people live in the core area. A possible answer was elicited from the KII interviews.

The majority of people living in the core area have less expenditures than those in buffer areas (Interview 11-16). This is largely because housing conditions are worse than in the buffer area and maintenance costs are minimum. In addition, a significant number of households do not expend housing costs in the core area as shelters are made available by the authority. To understand how this impacts decisions on where to live, the study analyzed expenditures similar to the household income analysis. The regression coefficient outputs are presented in Table-14.

Results are very similar to the household income regression analysis. Increasing numbers of household members is associated with higher expenditure. The households within the buffer area have higher expenditures compared with those in the core area. In the second model run, it was noted that household members in the core area are associated with more expenditures compared to those in the buffer area. Having more land is also associated with higher expenditures. All associations are statistically significant.

Table 14

Regression Coefficient Output Regarding the Association Between Household Expenditure and Different Socioeconomic Variables

	Dependent Variable: Household Expenditure		
Model	(1)	(2)	(3)
Number of HH Member	2046.545***	2675.862***	1847.663***
relevel(Area_Type, "Core area")Buffer area		8412.874***	11733.100***
Amount of Land (ha)			1304.768***
Constant	24711.470***	17505.290***	4635.864
R-squared	0.162	0.293	0.462
Adjusted R-squared	0.147	0.268	0.433

Both r-squared value and AIC also improved when adding independent variables to each successive model run. Similar to the income analysis, the study attempted to explain expenditure variation further by using other independent variables, but regression outputs were not statistically significant. Results clearly show that living in the buffer area is associated with higher expenditures compare to living in the core area. This may be one reason people live in the core area. This is consistent with insights from local interviewees.

7.5 Social-Ecological System (SES) Analysis

7.5.1. Forest Resources in Core and Buffer Areas

HNP is comprised of mixed tropical evergreen and semi-evergreen forests. Once known as a rich spot in biodiversity dominated by Dipterocarpus spp. mixed with bamboo, the study found substantial deforestation and forest degradation from 1991-2018. At present, the forest area is covered by 117 tree species. However, these are in great threat due to the cutting of seedlings and saplings by fuel collectors (Hossen & Hossain, 2018). This section identifies the factors associated with forest resource depletion in the study area through household surveys and interviews.

(A) *Lack of clarity for system boundaries*: HNP was declared a National Park in 1980. At present, there are three distinguished zones—core (national park), buffer, and impact. However, these designations are hypothetical based on interviews (Interviews 1, 2, 5 and 9). For example, Interviewee 5 states, "A group of us walked through the forest areas taking CS Khatiyan and RS Khatiyan on hand to check whether this is a forest land or not and then we verbally agreed to consider this part as core area and that part as buffer area". No efforts have been made to provide a physical demarcation of boundaries to prevent human encroachment for cultivation and settlement activities. Therefore, clear boundaries do not actually exist between core and buffer areas. Interviewees 1, 5 and 6 report that human exploitation and encroachment of forest land have worsened the situation and adversely affected ecological boundaries of the national park. "There is not much forest area left now to survive" (Interviewee 2).

(B) *Resource uses*: One of most important uses of forest resources in HNP is energy obtained through fuel wood collection. "Villagers tend to go to the forest almost every day

to collect fuel wood for their day-to-day life" (Interviewee 9). Based on the household survey, those living in the core are heavily dependent on fuel wood mostly for household fires. Livelihoods in the buffer area also depend on the firewood. However, they also sell firewood and charcoal in local markets to businesses (Interview 9). "They can easily sell forest products as they have easy access to the local markets" (Interviewee 9). They also collect bamboo and wood for commercial sawmills and domestic and commercial furniture making (Interviews 1, 9 and 10).

There is no way to track and quantify how much firewood is used for domestic and business purposes. Nevertheless, it is estimated that around 1,000 people enter the forest every day to collect fuel wood for daily purposes (Interviews 11-16). "There is another purpose for collecting fuel wood from the forest, charcoal for the hotels and restaurants, which has become a growing concern very recently" (Interviewee 10). "This is the most profitable business right now. Almost every big hotel, has their own supply chain and nobody knows their source" (Interviewee 10).

With the rise of the tourist industry, hotels and restaurants have flourished. Almost all restaurants have a barbecue grill, as it is popular in Bangladesh. This requires a substantial amount of charcoal. This has become a hidden but big industry in the Cox's Bazar area (Interviews 9, 10). Some restaurants have their own supply sources from a number of day laborers. The study found that while restaurants and business are set up informally and haphazardly, they represent a very organized setting. Still, it is very hard to tell which area (core or buffer) is being affected by the activities that support these businesses.

The villagers also collect sungrass and dry leaves for food for their domestic animals. The study determined that cattle grazing is a widespread practice, particularly in the core area.

The use of forest land as pasture for cattle is one of the most common livelihood strategies of local people (Interviews 1, 2, 5, 9, 11-17). “Most [of] the people living in the core area are farmers and almost every family among them has a cow or a goat” (Interviewee 17). Although the introduction of domestic animal grazing in protected areas is prohibited based on the Wildlife Act (2012), this common practice has been proven to be one of the reasons for forest destruction. Cattle grazing also prevents the forest from naturally regenerating.

The use of HNP forest resources is also linked with non-wood forest products including fibers and food (Interview 7). These are often used for direct consumption by local people and sometimes their cattle. This practice is very local in nature and does not fall under formal regulations. The study also does not find any link to commercial consumption of such kind of products. This practice does, however, put pressure on the forest resources in both core and buffer areas.

As highlighted earlier, the study area is mostly in hilly regions. During the monsoon season, landslides are a common phenomenon. “Almost every year, there is a landslide during the rainy season and sometimes, people die as well” (Interviewee 10). Destroying the forest degrades soil quality, which eventually increases the probability of landslides.

Another important use of forest resources is attributed to environmental benefits. During both dry and humid seasons, the forest area provides gentle breezes to its surrounding areas. In addition, the unique landscape attracts many people from around the country each year. These non-economic values are important as they do not degrade the forests.

(C) *Environmental Pollution*: The growing rate of air pollution in Bangladesh has a significant effect on forest resources (Interviewee 1). Since 1990, there has been a steady increase of pollution. For instance, PM2.5 levels rose from 65 to 101 micrometers per cubic

meter in 2016 (Shachi, 2018). The air is more polluted in the city area compared to areas like HNP. However, the study found that the increasing practice of brick fields in the buffer area in particular is causing air pollution in the HNP (Interviewee 9). “The presence of brick fields has made the air polluted in the Himchari. If the forest department and local police diminish the brick field structures in one place, the group made it again elsewhere in the forest” (Interviewee 9).

It is evident that air pollutants have an enormous impact in the long run by changing the climate via both wet deposition (comprises rain, hail and snow) and dry deposition (consists of gases, aerosols and dust) (Lorenz, et al., 2010). Experts also consider the development of brick fields as one of the aspects threatening the HNP and increased destruction of forest land (Interview 1, 2, 7 and 8). “Government should deal with brick field owners and ban any kind development near the forest. However, political willingness is very important in this case” (Interviewee 1).

(D) *Illegal tree felling*: The HNP is heavily affected by the illegal extraction of forest resources for commercial purposes which mostly includes illegal tree felling (Interview 1-18). The reason for the illegal tree felling is unknown. However, people suspect the development of brick fields has led to the activity (Interview 11-16). Another reason for illegal tree felling is the increasing demand for fuel collection for commercial purposes and a lack of cheap alternative resources (Interviewees 1 and 5).

(E) *Betel leaf cultivation*: The study does not find any existing literature on betel leaf cultivation in the HNP. However, key informant interviews (Interviews 1, 7 and 9-16) revealed the practice of betel leaf cultivation. “If you go to the very core area of the forest, there will still be some places where people are cultivating betel leaf” (Interviewee 9). The

practice is very prominent in the buffer area. Due to local police and forest guard patrols, the practice of betel leaf cultivation is shifting towards the core area where it is difficult to monitor (Interview 11-16). Local interviewees consider betel leaf cultivation as an emerging threat to forest resources.

(F) *Settlements*: Based on the LULCC over time, the study has already illustrated the encroachment of human settlements in both core and buffer areas. The percentage change in forest cover is larger in the core area. However, institutional infringement (e.g. mosques, madrasas, schools, etc.) is very prominent in the buffer area (Interviews 1, 2, 5 and 11-16). In addition, Rohingya populations have been encroaching on forest land since 1990s and this population is increasing (Chowdhury, 2019). This has created enormous pressure on forest land. There is also a tendency to regulate encroachment by destroying a forest area for designating land as Khas land. This has been done under the supervision of some of the elite groups in the study area (Interviews 4 and 11-18).

7.5.2. Actors and Institutions

The study identified relevant stakeholders or actors that are directly or indirectly associated with the HNP management. Based on the literature and key informant interviews, three broad categories of stakeholders were identified—government officials, local actors, and NGOs and development partners. The study explored the engagement of these stakeholders in HNP management activities.

(A) *Government officials*: One of the major actors under this category is the Ministry of Environment, Forest, and Climate Change. This ministry is responsible for formulating policies regarding forest resources. It is composed of a number of departments. The most relevant for forest resource management are the Forest Department (FD), Department of

Environment (DoE), and Bangladesh Forest Industries Development Corporation (BFIDC). Among these, FD deals with day-to-day activities regarding the protection, conservation and management of forest resources. The head of FD is known as the Chief Conservator of Forest. Under his supervision, there are four designated wings—Forest Management, Planning, Education, and Training and Social Forestry. The department is the focal department in planning, implementing, and monitoring policy initiatives proposed by the Ministry. It is also responsible for monitoring the activities of local officials.

HNP falls under the jurisdiction of Cox's Bazar South Forest Division, which is headed by a Divisional Forest Officer (DFO). The Range Officer (RO) of Cox's Bazar Range, however, oversees HNP management and has been identified as a key stakeholder. There are also four beats responsible for guarding the forest. Each beat office is managed by a local forester who is also responsible for protecting forest resources. There is no separate HNP Assistant Conservator of Forests (ACF) or Range Officer (Interviews 4, 17 and 18).

There are a number of other ministries as well who are indirectly related with forest sector management, e.g., Planning Ministry or Planning Commission, Ministry of Finance, Ministry of Public Administration, and Ministry of Land (Interviews 4 and 18). Under the Planning Commission, the General Economics Division (GED), Programming Division (PD), and Implementation Monitoring and Evaluation Division (IMED) are related with forest sector planning and management as well. GED is responsible for sectoral and five-year planning for the country. PD is authorized to prepare an Annual Development Program (ADP) that consists of different projects to achieve the goals of the five-year plan. IMED is responsible for monitoring and evaluating specific ADP projects. The study did not find any actions taken by this division for the management of HNP so far.

Under the Ministry of Finance, the Finance Department (FD) is responsible for preparing and allocating national funds for governmental interventions. The Economic Relations Division (ERD) conducts the administrative process to channel international funds. The study found a manpower shortage for managing HNP resources due to the lack of monetary provision. The Ministry of Public Administration is responsible for allocating appropriate government officials in a designated ministry. The study found a significant problem in this section of the governance structure.

FD does not have significant institutional memory due to inconsistent administration. Officials get transferred from one ministry to another every few years (Interview 4). There is also a tendency of misallocation of human resources, including not allocating the right person in the right department (Interviews 1, 2, 4 and 18). “Not having a right person in the right department has become a common phenomenon in Ministry of Environment, Forest and Climate Change now-a-days” (Interviewee 18). The FD also lacks technical expertise regarding forest resource management (Interviews 2 and 4). “The ministry should appoint someone who has knowledge about forest resources; most of the people have come from administration who don’t have any knowledge on forest management” (Interviewee 2). The Ministry of Land is indirectly involved, but there are always conflicts between forest and general public lands (Interviews 1 and 4). The study finds that this particular ministry often overlooks management of forest resources in Bangladesh, particularly for HNP. “Land ministry is very powerful at the local level and they are responsible for dealing with the khas land, which is a source of land dispute within the forest department” (Interviewee 6).

(B) *Local stakeholders*: The primary local stakeholders of HNP (apart from government employees) are forest villagers, ethnic community groups, forest settlers, fuel wood collectors, sungrass collectors, dry leaf collectors, betel leaf cultivators, bamboo collectors, medicinal plant collectors, livestock grazers, local elites, local political representatives, brick field owners, and forest grabbers. Local elites are businessmen. They are also one of the most influential stakeholders as they have economic advantages and sometimes political support. Local representatives or Upazila Nirbahi Officers (UNOs) are political figures and are accepted authorities by most people. Activities by government officials aimed at managing the HNP need to ensure UNO engagement and cooperation. The study finds a very cumbersome bureaucratic process in managing forest resources from formulating plans and policies to implementation. Thus, cooperation among elite groups, UNOs, and forest personnel is essential to ensure the success, safety and security of interventions and foresters.

(C) *NGOs and development partners*: There are a number of NGOs currently engaged in the study area. These include Arannayk Foundation, NACOM, CODEC, NONGOR, Marine Life Alliance, GONOSASTHO, Coast Trust, Grameen Bank, BRAC, ASA, Care, Pulse and Proshika. Among them, Arannayk Foundation and NACOM are the most heavily engaged with the forest resources management activities. USAID is the only development partner currently operating in the study area. USAID has conducted a number of significant initiatives in partnership with local NGOs.

(D) *Tourism operators and hotel owners*: As highlighted earlier, the Cox's Bazar area is a hot tourist spot in the country, attracting more tourists each year. The continued pressure of the haphazard development of hotels is expected to greatly threaten the forest ecosystem.

Therefore, the study identifies tourism operators and hotel owners as potential stakeholders in HNP management.

(E) *Bangladesh Armed Forces*: It is a common practice for the Bangladesh Armed Forces to build camps in the hilly HPN region for training and to deal with political unrest. With rapid urbanization and tourism development, there is a shortage of space for these temporary camps. As a result, they often use forest land to build their camps (Interviews 2, 4, 17 and 18). While the camps are temporary, the damage to forest land is permanent. "Every year they come to this area to set up a camp and every time they take a lease from forest land. Because of their settings, the land loses its habitat forever" (Interviewee 1).

7.5.3. Governance Structure for the HNP Management

The most widely known forest resources-related act in Bangladesh is the Forest Act of 1927. The last time this act was amended was in 2000. To regulate forest management on private land and negate the control of private landowners over their tenants, the Private Forest Act (1945), Private Forest Ordinance (1959), and State Acquisition Tenancy Act (1959) were introduced (Alam, 2009). These are the fundamental policies for forest management in Bangladesh. In addition, the country has adopted numerous policies and acts regarding forest resource management. Most notable among them are the Bangladesh Forestry Sector Master Plan (1995), National Biodiversity Strategy and Action Plan (2004), Social Forestry Rule (2004), Wildlife Act (2012), National Forest Policy (2016) and Protected Area Management Rules (2017) (Forest Department, 2020).

The present forest land management system in Bangladesh was developed in response to changing needs over time. Importantly, the Bangladesh Government has adopted co-management initiatives to engage people in the whole process to make them feel

responsible for the resources, realize their stake in the forest, and ensure better livelihood conditions of those depending upon the forest. The goal is to simultaneously eradicate poverty and ensure biodiversity protection.

With support from USAID, co-management initiatives were first introduced through the 2004 Nishorgo Support Project (NSP) in five protected areas and the 2008 Integrated Protected Area Co-Management (IPAC) project in 18 protected areas (Interviews 3, 4 and 18). Following these efforts, USAID launched the Climate-Resilient Ecosystems and Livelihoods (CREL) program (2013-2017) to expand these mechanisms and bridge the gap between policy makers and local people (Interviewee 3). Recently, the government formulated the Protected Area Management Rules (2017) adopting and highlighting co-management. Here, NSP, IPAC and CREL projects and Protected Area Management Rules make up the socially embedded institutions within this governance structure. This structure is guided by the techno-bureaucratic institutions. In the case of HNP management, socially embedded institutions play the most critical role. This study, therefore, analyzes the existing co-management system as it represents the whole governance structure for the management of both core and buffer areas. The analysis was conducted based on the Interviews 1, 3, 4, 8 and 18 and an unpublished document named Himchari National Park Management Plan (2015).

The Co-management Organization (CMO) consists of the following types of bodies with designated roles and responsibilities for forest resource management:

(A) *Co-Management Committee (CMC)*: The CMC is composed of 29 members. DFO and UNO are the advisors of the CMC. The respective Range Officer (RO) serves as the Member-Secretary. Within the committee, there are an elected chairperson, vice-

chairperson and treasurer. The committee includes the following members: UNO, Upazila Agriculture Officer, Upazila Fisheries Officer, Upazila Animal Resource Officer, Upazila Social Worker Officer, ACF, Range Officer, Beat Officer, 1 Member of the Police, 2 Members of Union Parishad, 2 Elite People, 10 Members from PF, 4 members from CPG, 2 members from the divisional forest office and a Member from a divisional minority group. The committee is responsible for facilitating effective conservation initiatives, ensuring participation of a wide array of stakeholders in forest resource management, checking the income and expenditure for the co-management organization, and supporting the implementation of relevant development activities.

(B) *Co-Management Council (CMC)*: The council consists of the following members: Upazila Agriculture Officer, Upazila Fisheries Officer, Upazila Animal Resource Officer, Upazila Social Worker Officer, ACF, Range Officer, Beat Officer, 1 Member of the Police, 2 Members of Union Parishad, 6 Members from PF, 2 members from CPG, member from divisional forest office and a Member from a divisional minority group. Similar to the committee, the respective Range Officer (RO) serves as the Member-Secretary. Within the council, one chairperson, two vice-chairpersons and one treasurer are elected. The Co-Management Committee is the executive body for the Co-Management Council. In addition to supporting the committee, the council is responsible for scrutinizing the activities of CPG, PF and VCF to ensure the financial functionality of CPG and PF and enable voluntary work.

(C) *Peoples Forum (PF)*: The Peoples Forum is formed by the election of representatives within Village Conservation Forum (VCF) members from all villages of the core and buffer areas. All key stakeholders are represented, including women, youth, low-income

households, and important resource user groups. Two representatives from each village VCF are part of the forum. An elected committee within the PF is comprised of one chairperson, one secretary, one treasurer and 8 members. One of the group's major responsibilities is to ensure the participation of the forest villagers in the management plan so that their (villagers) livelihoods remain protected. In addition, the PF performs a lead role in preparing annual work plans for sustainable forest resource management in both core and buffer areas. The forum is also responsible for raising awareness among the local villagers about the impacts of climate change.

(D) *Village Conservation Forum (VCF)*: The VCF represents a tier of grassroots community poor villagers in the co-management organization. The formation and function of the VCF is indicative of the democratic approach to co-management initiatives. There are 35 VCFs within the study area. The major responsibilities of these forums include critiquing and proposing resource management initiatives, raising awareness among the villagers about the protection of forest land, supporting initiatives regarding social forestry, and forming a Community Patrol Group.

(E) *Community Patrol Group (CPG)*: the CPG is formed from the members of the VCF. There is no specific guideline about the number of members. The group is advised by the CMC and DFO. Their major responsibilities are to patrol the forest land with the forest guards, support forest guards in recovering illegally captured forest land, and provide support to the local forest office as needed. The group is paid for their services.

CHAPTER 8

GAPS IN THE GOVERNANCE STRUCTURE

The Bangladesh Government, with the support from the World Bank, assessed forest resource management practices in Bangladesh in 2016. The HNP management system scored a 30% effectiveness rating (Bangladesh Forest Department, 2016). This poor score motivated the government to adopt the co-management initiative (Interviews 1, 4 and 18). The 2016 study found co-management as a potential approach to protecting forest resources in core and buffer areas, at least on paper. However, there are some significant gaps that may hinder the implementation of this initiative on ground. This section discusses existing gaps within the overall governance structure for forest resource management and co-management initiatives.

- The co-management initiative is still led by project activities. Although the government developed the Protected Area Management Rules (2017) for the co-management initiative, not much effort has been given to institutionalizing it. One of the major reasons for the lack of ownership is that USAID conducted the CREL project with involvement of local NGOs instead of the forest department (Interviews 4 and 18). "Forest department has all the capacity to run a project like this; besides, we are mandated to do so but we need technical and financial support which USAID could have provided us for that project" (Interviewee 4). The Forest department is the implementing agency of the forest ministry and is capable of implementing the policy on ground. However, USAID made the Forest Department an advisor. The department should have been directly engaged in the project (Interviews 4 and 18). Yet, the co-management system does not articulate a clear role for the forest ministry. Furthermore,

the purpose of the co-management organization was to bridge policymakers and local people. This indicates a lack of accountability within the management system.

- During the stakeholder analysis, the study identified potential stakeholders and explored their roles in forest resource management. It is clear that the co-management organization has failed to ensure coordination among these stakeholders. The system does not take into consideration the role that other government ministries can play in protecting forest resources as well. In particular, the system does not explain how infrastructure development work needed for sustainable tourism and effective management of the HNP should be coordinated. This requires involvement of personnel from relevant cross-cutting ministries.
- The co-management initiative has not articulated a plan for sustainable funding. The study revealed that money due the CPG for their services, after completion of the CREL project was not received (Interview 11-16). The Government, with the help of Ministry of Finance, is developing a separate budget to channel the money. However, this is a time-consuming process (Interview 18). Therefore, it is necessary to integrate the HNP management into the internal budgetary process. “Government should have separate budget stream to sustain the maintain system for Himchari” (Interviewee 2).
- The co-management system has certainly addressed the issue of inclusiveness, attempting to ensure the participation of women and ethnic minority groups. For minority groups, the study identified the presence of different ethnic groups including Rohingya, Tanchangya, etc. However, there is a provision for only one representative from ethnic minority groups in the formation of a committee. This does not represent the voice of the entire population, indicating a lack of true inclusiveness. Moreover, the

study found out that women are often overlooked as males dominate the committee structure and social acceptance (Interviews 9 and 11-16).

- The co-management system articulated roles and responsibilities for the CPG under the supervision of DFO and CMC. The study identified a potential threat to the lives of CPG members patrolling the forest due to the presence of forest grabbers (Interviews 11-16). Forest grabbers are sometimes heavily armed, but CPGs do not carry anything to defend themselves. There is no clear indication of who should be responsible for the security of the CPG. Thus, the management system fails to ensure their full safety. In addition, there should be opportunities for economic and social benefits to motivate the CPG in patrolling the forest area.

CHAPTER 9

CONCLUSION AND RECOMMENDATIONS

The study conducted supervised classification to analyze forest cover changes in both core and buffer areas of HNP forest land. Result showed deforestation and forest degradation in both areas. The study also found that encroachment of human settlement is increasing in both areas, indicating growing pressure from development. Following the deforestation analysis, the study applied an SES approach to identify the root causes of deforestation and degradation and determine how forest resources may be better managed for sustainable outcomes. As part of the SES, the study analyzed potential reasons behind resource loss, including engagement of relevant stakeholders and governance structures associated with forest management initiatives. The study also addressed potential gaps in the existing governance structure. Based on this work, a set of recommendations follow that may improve the existing management system for both core and buffer areas.

The primary focus of forest resource management, particularly for the core area, is to protect the existing natural habitat and safeguard the rehabilitation and restoration of the forest habitat in a natural way. At present, the HPN forest is degrading and losing its natural habitat. From the household survey analysis, it was observed that much of the pressure on the forest comes from those living in the core area. To reverse this situation, habitats can be restored using Assisted Natural Regeneration (ANR), which is a simple, low-cost and relatively suitable method for small areas (Shono, et al., 2007). For buffer areas, a social forestry approach that includes economically valuable and fast-growing tree species can be used so that the pressure of fuel collection can be more equitably distributed between core

and buffer areas. Selective felling should be conducted in the buffer areas to meet the demand for forest villagers.

As mentioned earlier, there are no physical boundaries demarcating core, buffer, and settlement areas. Without physical delineation, it is almost impossible to resolve conflict between conservation and development and ensure effective policy implication (Saito-Jensen & Jensen, 2010). The effectiveness of delineating physical boundaries for forest resource management has been observed in Nepal (Acharya, 2002), Mexico (Klooster, 2000), Tanzania (Wily, 2001) and Bolivia (Pacheco, 2004). In the case of HNP, non-disputed and completely encroached boundaries as well as demarcation between core and buffer areas of forest should be identified using GPS. Permanent signs and/or concrete pillars are needed to delineate physical boundaries around core and buffer areas. Appropriate labels should be installed for easy interpretation. A regular maintenance program should also be conducted by forest guards and CPGs with supervision from the CMC and local forest department.

At present, the HNP management system does not have a monitoring unit. An effective monitoring system associated with a governance structure offers sustainable forest resource management (Hickey & Innes, 2005). Therefore, regular monitoring should be established to analyze forest cover changes. Effective HNP management requires a separate monitoring unit headed by technical remote sensing experts. This monitoring team can be assisted by CPGs and forest guards to collect on-the-ground data. The unit should be responsible for checking changes in forest cover each year and reporting back to the forest ministry and CMC. The monitoring unit, in consultation with the FD, should develop a GIS/GPS-based system for systematic collection of patrolling data. This data can be

merged with remotely sensed data for a comprehensive overview of the HNP. Data should be collected separately for core and buffer areas to track afforestation or deforestation.

To protect existing landscape features of core and buffer areas, past allocation of forest land to individuals for private purposes due to wrongly recorded khas lands needs to be resolved (Interviews 1, 2, 4 and 18). This is the most complicated aspect in managing forest resources as one of the most vulnerable populations of the country lives in the forest area. To resolve this, the study emphasizes a long-term resource management plan that integrates HNP management with local and regional development processes and establishes a clear set of conservation objectives. The plan should include ecotourism development, alternative livelihood opportunities for the local forest community, capacity development of the co-management organization, and awareness raising among villagers regarding the conservation of forest resources, among others. Revenue generated from ecotourism should be shared with local communities for development initiatives. This also provides a continuous revenue generation opportunity for HNP management. However, further research is needed to examine alternative and diversified livelihood opportunities for those living in the study area.

The study realizes that to achieve sustainable forest resource management outcomes, the governance system needs to be adaptive within a changing SES context (Chaffin, Gosnell, & Cosens, 2014; Keskitalo, 2013; Schultz, Folke, Österblom, & Olsson, 2015). SESs are not static. Rather, they are dynamic in nature and can result from changing climatic patterns. Thus, agents within a governance structure must be adaptive. The study underscores the need for further research on the adaptive governance systems considering the impact of climate change on HNP. Agent-based modeling is recommended for

mathematically simulating the actions and interactions among the agents within a SES. This approach offers a future research scope in terms of adaptive SES for the HNP.

Coordination among the different ministries is a prerequisite for a successful resource management initiative (Interview 1, 3, 4, 8 and 18). Based on the stakeholder analysis, the study suggests considering a cluster of ministries that are directly and indirectly associated with forest resource management activities. For instance, an executive committee, headed by the Ministry of Environment, Forest, and Climate Change, can be established with representatives from the various ministries. This could include elected CMC members, members from civil society organizations, and members from Bangladesh Armed Force. Having a member from CMC, will ensure their ownership. To make it more transparent, the committee could also include members from relevant development partners. The executive committee should be tasked with resolving land disputes with a focus on the forest protection as well as ensuring local livelihood opportunities. The committee, in consultation with the Ministry of Public Administration, could also ensure the stability of forest management employees. Moreover, such coordination will ensure adoption of comprehensive policies and better policy implication platforms that may motivate actors to protect and conserve forest resources in both core and buffer areas.

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APPENDIX A

HOUSEHOLD SURVEY QUESTIONNAIRE

Forest Resource Management and Social-Ecological System: A Case Study on Himchari National Park in Bangladesh

Date:
Name of the Village:
Name of the Upazila:
Core or Buffer Area

- Core area
- Buffer area

Lat:
Long:

Section-1: Demographic Information

1.1 Are you the household head? Yes No	
1.2 What is the sex of the household head? Male Female Other Don't want to answer	
1.3 What is the age of the household head (in years)?	
1.4 What is the total number of persons in the household?	
1.5 How many of the household members are male?	
1.6 How many of the household members are female?	
1.7 How many years of formal education has the Household Head completed?	
1.8 How many household members have received formal education?	
1.9 At present, what is the total number of school going children in the household?	
1.10 Overall, what is the highest level of education attained in this household? Illiterate Literate but without formal education Primary school High school College degree Bachelor's degree	

□ Graduate degree (e.g. Master's, PhD.) □ Other □ Don't want to answer
1.11 What is the household head's primary occupation? □ Unemployed □ Private service holder □ Government service holder □ Salesman □ Fisherman □ Farmer □ Businessman □ Day laborer □ Rickshaw puller or CNG driver □ Bus driver □ Forest related work □ Student □ Retired □ Other (please specify) □ Don't want to answer
1.12 What are the primary occupations of all other household members? (select all that apply) □ Unemployed □ Private service holder □ Government service holder □ Salesman □ Fisherman □ Farmer □ Businessman □ Day laborer □ Rickshaw puller or CNG driver □ Bus driver □ Forest related work □ Student □ Retired □ Other (please specify) □ Don't want to answer

1.13 What is the total amount of land that your household owns, in local unit?	
1.14 What is the total amount of land that your household rented, in local unit?	

1.15 What is the total amount of land that your household cultivates, in local unit?	
1.16 For how many years has the household head lived in this village?	
1.17 (If not born here) What was the primary reason for moving in this village? □ Forced migration □ Marriage □ Looking for a job □ Family □ Education □ Business □ Other □ Don't know □ Don't want to answer	
1.18 How many members of the household ever migrated to another location?	
1.19 If yes to 1.18, what is the reason(s) for migration?	

Section-2: Household Income, Expenditure and Savings

2.1 What is the total annual cash income that the household received in the last year?	
2.2 What is the total annual non-cash income that the household received in the last year?	
2.3 What are the sources of cash income for the household in the last year? Select all that apply □ Sale of crops □ Sale of livestock □ Sale of livestock related products □ Sale of timber related products □ Day laborer □ Business income □ Wage or salary from professional job □ Rent received □ Pension or government support	

☐ NGO program money ☐ Other (please specify) ☐ Don't want to answer
2.4 What are the sources of non-cash income for the household in the last year? Select all that apply ☐ Fishing ☐ Forest products ☐ Timber and wood ☐ Other (please specify) ☐ Don't want to answer

2.5 What was the total annual expenditure of your household last year?	

2.6 What are the sources of the annual household expenditure in last year? Select all that apply ☐ Food ☐ Water ☐ Education ☐ Medical ☐ Clothes ☐ Household construction materials ☐ Household durables ☐ Leisure activities ☐ Livestock related cost ☐ Growing plant related cost ☐ Hiring farmers or laborer ☐ Transportation ☐ Firewood ☐ Charcoal ☐ Kerosene ☐ Other fuel related cost ☐ Other (please specify) ☐ Don't want to answer

2.7 What was the total annual savings of your household last year?	

Section-3: Household Asset Information

3.1 Please select the type(s) of land your household owns: ☐ Cropland farmed for personal uses ☐ Cropland farmed for commercial uses ☐ Home garden

- Private pasture
- Natural forest land
- Other (please specify)
- Don't want to answer

3.2 Please select the type(s) of land your household cultivates on:

- Private land
- Communally owned land
- Family owned land
- Sharecropped
- Open access land
- Own land
- Forest or government land
- Other (please specify)
- None (household does not cultivate)
- Don't want to answer

3.3 Which crops does your household grow?	

3.4 Which of the following livestock does your household own? Select all that apply

- Small livestock (chicken and/or duck)
- Medium livestock (sheep and/or goat)
- Large livestock (cow and/or buffalo)
- Don't want to answer

3.5 Does this household have electricity?

- Yes
- No

3.6 What is the source of electricity of this household?

- Connected to the national grid
- Generator
- Solar power
- Other (please specify)
- Don't want to answer

3.7 Please indicate if your household owns/owned any of the following assets: (Select all that apply)

- Television
- Radio
- Refrigerator
- Mobile phone
- Computer
- Electric/gas stove
- Motorbike
- Bicycle

- Boat
- Planting instrument(s)
- Household furniture(s) (be specific)
- Transport vehicle(s) (be specific)
- Solar panel
- Other(s) (please specify)
- Don't want to answer

Section-4: Shocks to Household Welfare

4.1 During the past year, how affected was your household by the following events?

	Very Negative	Somewhat Negative	Nothing Significant	Somewhat Positive	Very Positive	Not Applicable
Drought/low rainfall						
Heavy rainfall						
Floods/storms						
Crop/livestock disease						
Economic shocks						
Theft/burglary						
Other (please specify)						

4.2 Did your household experience the following shocks in the last year as a result of the selected event(s)? Select all that apply

- Loss of crops
- Loss of livestock
- Loss of employment
- Loss of land
- Loss of other assets (please specify)
- Other(s) (please specify)
- Don't want to answer

4.3 How did your household cope with those shock(s)? Select all that apply

- Collect more forest products
- Harvest more agricultural products
- Sell assets
- Spend cash savings
- Do extra casual work
- Assistance from NGO
- Assistance from Government
- Loan from bank
- Change of occupation
- Reduce food consumption
- Reduce household spending
- Did nothing in particular
- Don't want to answer

4.4 Has their any effect from the changing climate? If yes, then how?

Section-5: Health and Nutrition Information

5.1 What are the major food items that your household has consumed last week?

- Rice
- Puffed rice
- Diary
- Vegetable protein
- Animal protein (eggs, meat, poultry, fish)
- Other (please specify)

5.2 Which of the following food items are purchased and non-purchased?

	Purchased	Non-Purchased
Rice		
Puffed rice		
Diary		
Vegetable protein		
Animal protein (eggs, meat, poultry, fish)		
Other (please specify)		

5.3 How many of your household members did suffer last year from health diseases?	
5.4 How many of your household members did visit the health care center or hospital last year?	

5.5 What is the distance, travel mode and travel time between your household and nearest health care facility?

Distance in km	Travel mode	Travel time in minute

Section-6: Household Interactions with Forest and Forest Management Activities

6.1 What types of forest exist in your area?

- Reserve forest
- Community forest
- Private forest
- Don't know exactly

6.2 What is the major purpose of this forest?	

6.3 Which of the following forest products does your household collect or purchase for your household use in the last year? Select all that apply

	Collect	Purchased
Fuelwood		
Charcoal		
Timber		
Leaf or grass fodder		
Bamboo		
Medicinal plants		
Honey		
Oil palm		
Fruits		
Vegetables		
Others (please specify)		

6.4 What is/are the purpose(s) of using forest products?

- Food (fruits, vegetables)
- Cooking food
- Food for livestock
- Electricity
- Household furniture
- Commercial purpose
- Others (please specify)

6.5 What is the major season of using forest resources and why?	

6.6 What is the distance, travel mode and travel time between your household and forest resources?

Distance in km	Travel mode	Travel time in minute

6.7 Is there any on-going forest resource management activities near your household?

- Yes
- No
- Don't know

6.8 If yes to 6.7, what are the major activities going on? Who is/are responsible?

6.9 If yes to 6.7, does any one of your household members engage on the forest management activities?

- Yes
- No
- Don't want to answer

6.10 If yes to 6.9, what is/are the roles of you or your household members in the forest management activities?

6.11 If yes to 6.9, what is/are the benefit(s) does your household member or you or your household receive? Select all that apply

- Monetary benefit
- Social service
- Security from the natural shocks
- Nothing significant
- Don't want to answer

6.12 What is the impact of forest resource management activities to protect the natural forest and how do the activities effect on your village livelihoods?

Section-7: Quality of the House and Sanitation Facility Information

7.1 What type of material are the external walls predominantly made of? □ Earth/dirt □ Grass/fiber/straw □ Wood □ Bricks □ Concrete/cement □ Other (please specify)
7.2 What type of material is the roof? □ Earth/dirt □ Grass/fiber/straw □ Wood □ Bricks □ Concrete/cement □ Other (please specify)
7.3 What is the floor made of? □ Earth/dirt □ Grass/fiber/straw □ Wood □ Bricks □ Concrete/cement □ Other (please specify)
7.4 What kind of toilet facility do members of your household usually use? □ None □ Pit latrine □ Trench latrine □ Aqua privy □ Other (please specify)
7.5 Do you share this toilet facility with other household(s)? □ Yes □ No □ Don't want to answer
7.6 What is the main source of drinking water for members of your household? □ Ponds □ Well (shared) □ Well (private) □ Piped external □ Piped to the house □ Other (please specify) □ Don't want to answer

7.7 What is your household's primary source of fire for cooking in your dwelling?

- Firewood
- Kerosene/Oil
- Gas
- Electricity
- Biomass cook stove
- Solar energy
- Other (please specify)
- Don't want to answer

7.8 What is the distance, travel mode and travel time from your household to the following?

	Distance in km	Travel mode	Travel time in minute
Nearest market			
Brick burning field			
Nearest industry			
Nearest sawmill			
Tourism activity			

Please write down any comment/feedback regarding this survey on the box below:

Thank you for your responses. We will ensure the confidentiality of your response.

APPENDIX B

KEY INFORMANT INTERVIEW QUESTIONNAIRE

General Information

- How do you define forest resource management?
- How do you define social-ecological system regarding the forest resource?
- What is your role in forest resource management?
- What is your organization's role in forest resource management?

Resource and Resource Units

- What are the major resource units of the Himchari National Park?
- What is the significance (both local and national) of the resources of Himchari National Park?
- What do you think about the association between livelihoods of village people and forest resources?

Actors

- Who are the major actors in using the forest resources?
- Who are the major actors (other than you or your organization) for forest resource management?
- What are the roles and responsibilities of those major actors?
- How the roles and responsibilities may overlap to each other and how are those coordinated?

Governance

- What are the research activities that have been conducted so far?
- What are the outputs or outcomes of those research activities?

- What are the indicators of defining the outputs or outcomes of those research activities?
- What are the major policies or strategies regarding forest resource use and forest resource management?
- What are the outputs or outcomes of those policies and strategies?
- What are the indicators of defining the outputs or outcomes of those policies and strategies?
- What are the major international initiatives regarding forest resource management?
- What are the outputs or outcomes of those initiatives?
- What are the indicators of defining the outputs or outcomes of those initiatives?
- Is there any synergy between national policy and international initiatives?
- How the local people are effected by those policies and international initiatives?
- What is your opinion about the interaction between livelihood and forest resource management?

APPENDIX C

INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL

Template:IRB_T_Post-Review_Approved

Notification of Approval

To:	David Pijawka
Link:	STUDY00010157
P.I.:	David Pijawka
Title:	Forest Resource Management and Social-Ecological System: A Case Study on Himchari National Park in Bangladesh
Description:	This submission has been approved. You can access the correspondence letter using the following link: Correspondence_for_STUDY00010157.pdf(0.01) To review additional details, click the link above to access the project workspace.

EXEMPTION GRANTED

David Pijawka
CLAS-SS: Geographical Sciences and Urban Planning, School of
480/727-7319
pijawka@asu.edu

Dear David Pijawka:

On 5/16/2019 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Forest Resource Management and Social-Ecological System: A Case Study on Himchari National Park in Bangladesh
Investigator:	David Pijawka
IRB ID:	STUDY00010157
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Consent Form_KIIs.pdf, Category: Consent Form; • KII Questionnaire, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • HH Survey Questionnaire, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Outreach Email for KIIs.pdf, Category: Recruitment Materials; • Consent Form_HH Survey.pdf, Category: Consent Form; • Form-Social-Behavioral-Protocol_MUEP Thesis.docx, Category: IRB Protocol;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 5/16/2019.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Yousuf Mahid
Yousuf Mahid