The Asian Elephants and Associated Human-Elephant Conflict in South-Eastern Bangladesh

INTERNATIONAL UNION FOR CONSERVATION OF NATURE

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Research and Compilation

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PREFACE

The significance of the Asian elephants is now unequivocally established. The elephant is often popularly dubbed as a 'keystone', 'flagship', and 'umbrella' species as well as an important symbol of the planet's heritage. Notwithstanding the significance, this valuable mammal, the largest living land animal on the planet, has dwindled dramatically in the recent years primarily due to anthropogenic disturbances. The Asian elephants are found in 13 different countries in Asia. Currently, there are less than 50,000 elephants present in their natural habitat and near about 16,000 in captivity. The status of the Asian elephant is even more threatened in Bangladesh and the species has been enlisted by IUCN (2000) as 'Critically Endangered'. In the mid of the twenty first century, there were more than 500 elephants present in their natural habitats, but recent estimates suggest that the number is no higher than 220 in the wild.

Elephants used to extensively roam the hill forest areas in the South-east and North-east parts of the country. Increase in human population, expansion due to unplanned agriculture and settlement, various livelihood interventions are continuously destroying the forest as well as the core habitat and corridors of elephants. Asian Elephants are migratory mammals and tend to be territorial. When they migrate back to areas that have been claimed by human population, they disrupt and damage property, consume crops, cause injury and even mortally wound people in an attempt to recover their territory. Such confrontations are termed as 'Human Elephant Conflict' (HEC); they result not only in damage to human health and property, but also cause stress and death to the animals when they are in turn fended off and often attacked brutally by settlers protecting their land.

In this backdrop, IUCN Bangladesh has taken up a conservation initiative, with financial assistance from the US Fish and Wildlife Service (USFWS), to protect this valuable species under the auspices of a project titled "Action research for the conservation of Asian Elephants in Bangladesh". The conservation work was initiated in 2001 under the first Phase of the project in close collaboration with the Bangladesh Forest Department. The Project goal has been to protect Asian elephants in Bangladesh in their natural habitat and contribute towards the overall aim of conserving biological diversity and ecological integrity of the country. The project is now in its fourth phase, and works to better understand the issues resulting from HEC in Bangladesh at community and decision-making levels. It also aims to facilitate effective conservation and development

initiatives in some selected areas of the country by improving habitat conditions for the Asian elephants and to mitigate HEC. Some specific tasks undertaken during this phase include: GIS mapping of elephant habitats, corridors and routes in Chittagong, Chittagong Hill Tracts (CHT) and some parts of Cox's Bazar, and the publication of a book based on this study for wider dissemination.

The principal aim of this book is two-fold: (i) to provide selected information on status, biology, ecology and behavior of Asian Elephants based on a compilation of different secondary sources and literatures; and (ii) to prepare a series of GIS based maps on elephant routes, corridors, HEC areas, crop damage areas and elephant sighting areas drawing on the information collected from direct field surveys conducted by researchers of IUCN Bangladesh. We believe that the information presented in this book will be a useful source of reference for researchers, academics and various other stakeholders. We sincerely hope that this book will also aid policy and decision makers to act and think towards conserving this flagship species and combat the on-going conflicts.

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Dhaka
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ACRONYMS

°C	Degree Celsius
ANCF	Asian Nature Conservation Foundation
BBS	Bangladesh Bureau of Statistics
BDT	Bangladeshi Taka
CCF	Chief Conservator of Forests
CF	Conservator of Forests
CHT	Chittagong Hill Tracts
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
cm	Centimeter
DCCF	Deputy Chief Conservator of Forests
DCF	Deputy Conservator of Forests
DFO	Divisional Forest Officer
BFD	Bangladesh Forest Department
FGD	Focused Group Discussion
ft	Feet
GIS	Geographic Information System
GME	Geo-spatial Modeling Environment
GPS	Global Positioning System
ha	Hectare
HEC	Human Elephant Conflict
IUCN	International Union for Conservation of Nature and Natural Resources
km	Kilometer
m	Meter

mm	Millimeter
MoEF	Ministry of Environment and Forests
NTFP	Non Timber Forest Product
PA	Protected Area
PRA	Participatory Rural Appraisal
RAIN	Resource Awareness and Integration with Nature
RRA	Rapid Rural Appraisal
RS	Remote Sensing
USFWS	US Fish and Wildlife Service
VFA	Volatile Fatty Acids
WGS	World Geodetic System
WWF	World Wildlife Fund

CHAPTER ONE: INTRODUCTION

1.1. Asian Elephant: An overview

Asian elephants are forest dwelling elephant species, described as key stone species (Shoshani *et al*., 2004), flagship species (Phanthavong & Santiapillai, 1993; Nath & Sukumar, 1998; Perera, 2009), umbrella species (Miller *et al*., 1999; Whyte, 2004) and are often called the 'engineers' of the forest, as they play a significant role in maintaining the ecosystem they inhabit and can modify it both in positive and negative ways by their actions (Perera, 2009).

The word 'Elephant' comes from the Greek word "elephas" meaning ivory. This refers to their tusks. In scientific nomenclature, elephants belong to the order Proboscidae. This word is also Greek referring to another distinctive elephant anatomy, the trunk (Elephant Evolution, 2002-11; Rahman, 2008).

Under the order Proboscidae, there are two species of elephants, the Asian elephant (*Elephas maximus*) and the African elephant (*Loxodonta africana*). Both belong to the family Elephantidae. There are four subspecies of the Asian elephant: Indian elephant (*Elephas maximus indicus*), Sumatran elephant (*E. m. sumatrensis*), Sri Lankan elephant (*E. m. maximus*) and Borneo pygmy elephant (*E. m. borneensis*) (WWF, 2011).

Asian elephant is smaller than its African cousin. It can be distinguished by its much smaller ears and rounded back, in comparison to the saddle back of the African species (Santiapillai & Jackson, 1990). There are many other differences, examples include the tip of lip of the trunk is a single 'finger' in Asian species, compared with two in the African species (Khan, 1985), and a double domed forehead instead of a single dome (Santiapillai & Jackson, 1990). There are some anatomical differences as well between the two species distinguished by the number of ribs and vertebrae, and in the morphology of the cheek teeth (Seidensticker, 1984).

Asian elephants inhabit a variety of tropical forest habitats from humid evergreen lowland forest to dry semi-deciduous teak forests to cooler mountain forests reaching up to 10,000 feet above sea level. They are also frequent visitor to grasslands and farm areas. The ability to survive on variable diet enables them to live in disturbed and degraded forest lands. However, they require

ample space for movement and can exploit different food sources. This is why the Asian elephant is recognized as an 'umbrella' species, whose conservation could ensure the maintenance of biological diversity and ecological integrity of a large swath of land. The Asian elephant has become a "critically endangered" animal in Bangladesh (IUCN Bangladesh, 2000) due to habitat destruction, fragmentation (patchy nature of forest area) and loss of corridors (IUCN Bangladesh, 2004).

1.2. Present status of Asian elephants in the world

Populations of both elephant species continue to decline in the wild as they live under constant threat of habitat destruction and deforestation, as well as illegal poaching for ivory. Being the largest terrestrial mammal, elephants do not have any natural predators, they are however, threatened by human encroachment and poaching. Because of low energy diet, elephants require large area for foraging and hence survival. Moreover, most of the elephant herds need to migrate seasonally in search of greener pastures. It also has a longer gestation period compared to other large mammals. These two attributes puts this umbrella species at risk of rapid population decline, in addition to the threats already mentioned. For example, the population of African elephants plummeted in the late 1970's to early 1980's due to ivory poaching; estimates showed that the population declined from 1,341,000 animals to a little over 700,000 in less than a decade (Douglas-Hamilton, 1989). Although in a lesser extent, but the illegal killing of elephants for ivory still remains a grave threat (Douglas-Hamilton, 2009).

Loss of habitat is another major threat to the survival of elephants in the wild. As human population continues to grow at an alarming rate, wild animals are forced to survive in increasingly smaller areas compare to their former range. The corridors and routes that once offered a passage way for wildlife to travel from one area to another are now subjected to human habitation and intrusion. Like any other large mammal, this fragmentation alone threatens the ultimate survival of this mega species and is thus a grave concern. Forests are being cut down, wild areas are being converted to human settlements and crop lands to ensure greater benefits solely for humans in terms of food and space. Therefore, it should come as no surprise that human-elephant conflicts (HEC) are on the rise. In Sri Lanka alone, HEC claims the lives of 150 elephants and 100 people per annum. Similarly, a number of countries in Africa are experiencing similar HEC, resulting in deaths of both humans and elephants. In most cases, elephant victims are financially compensated for their loss; however, there is no price that can ever make up for the ultimate loss of life, be it human or elephant (Blanc *et al.*, 2007; Stephenson, 2007).

In global context, Asian elephant is currently listed as an "endangered species" (IUCN, 2011) and classified under Appendix I in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES/WWF, 2004). This species once inhabited the regions around Tigris-Euphrates in western Asia, Iran, areas south of the Himalayas; occurring throughout south and southeast Asia including the islands of Sri Lanka, Sumatra and Borneo, and into the mainland China, northwards at least as far as the Changkiang (Yangtze river) (CITES/WWF, 2004; IUCN/SSC, 2008). At present, elephants have disappeared entirely from western Asia, Iran, and most of China. The present populations of Asian elephants are thought to be restricted to primarily mountainous areas in the following countries: a) Indian sub-continent: India, Nepal, Bhutan and Bangladesh, b) Continental Southeast Asia: China, Myanmar, Thailand, Cambodia, Laos, Vietnam, and Malaysia, c) Island Asia: Andaman Islands (India), Sri Lanka, Sumatra (Indonesia), and Borneo (Malaysia & Indonesia) (Sukumar, 2003).

Habitat loss and fragmentation continues to be the primary reason for the decline of Asian

elephants. About 20% of the world's human population lives in or near the present range of the Asian elephant. With human numbers increasing at a rate of approximately three percent per annum in most countries, theoretically there could be a doubling of the human population in 23 years (ERI, 2008). The elephant's forest habitat has been reduced to a fraction of its former range.

The World Wildlife Fund (WWF) estimates that there may be only 10 Asian elephant population groups left, each with more than 1,000 animals spread across the countries mentioned (Stephenson, 2007). The extensive forests in India, where elephants roamed widely, now cover less than 20% of the country and barely half of that remains as suitable habitats for elephants. In central India, elephant population has been seriously fragmented (ERI, 2008). Thailand has cleared almost all its lowland forest areas, creating a huge void of wildlife habitat in the heart of the country. On the Indonesian island of Sumatra, vast areas of forest are being cleared to accommodate millions of people resettled from the crowded islands of Java, Bali, and Madura. Indo-China's forests were seriously damaged during 30 years of Vietnam war. In Sri Lanka, the vast Mahaweli River Valley Project for settlement, crops, and irrigation cuts a wide swath through the heart of elephant country. Myanmar, Cambodia, and Laos still have considerable forest cover, but they are also suffering from unmanaged and unsustainable logging (Hedges, 2006).

1.3. Present status of elephants in Bangladesh

The past and present distribution of elephants in Bangladesh directly corresponds to the extent of forested areas, including moist deciduous, mixed or semi-evergreen forest types. The ability to survive in marginal ecosystems enables elephants to inhabit areas that have been degraded as a result of human settlement in Bangladesh. Highest number of elephants can be found in the Chittagong Hill Tracts (CHT) region located in the south-eastern part of Bangladesh – an extensive hilly region bordered to the north and east by Tripura and Mizoram states of India respectively, to the south by the Arakan state of Myanmar, and to the west by the Chittagong district. In addition, elephants inhabit areas in Mymensingh, Sylhet, Chittagong and Cox's Bazar Forest Division (Santiapillai & Jackson, 1990). However, the elephants of Mymensingh and Sylhet forest divisions are primarily trans-boundary migrating herds moving seasonally from Meghalaya and Assam states of India in search of food.

Due to fragmentation of habitat, elephant ranges in Bangladesh became confined to small patches occupied by a single or few small herds. Some corridors have been totally abandoned due to degradation of forest cover, extension of human settlements, intensification of agricultural practice, unsustainable slash and burn practice, unplanned road construction, establishment of monoculture forests, etc. Estimations of elephant population in Bangladesh varied from author to author and elephants were categorized as resident, non-resident and captive in the respective studies (Table 1.1).

Table 1.1 : Different records of elephant populations in Bangladesh

Year	Elephant population				Reference
	Resident	Migratory	Captive	Total	
1978	-	-	-	150	Ranjitsingh, 1978
1978	-	-	-	250	Olivier, 1978
1985	-	60	-	200	Khan, 1985
1982	-	-	-	348	Gittins & Akanda, 1982
1983	-	-	50	-	Jackson, 1983
1996	151-170	42-54			Chakraborty, 1996
2000	195-239	-	-	-	Kemf & Santiapillai, 2000
2001	174-201	19-23	-	196-234	IUCN Bangladesh, 2004
2004	151-344	-	-	-	Feeroz *et al.*, 2004
2004	196-227	83-100	94 (Male: female=38:56)	278-327	IUCN Bangladesh, 2004

1.4. Human-elephant conflicts in Bangladesh

History of conflict between humans and elephants dates back to early civilization primarily over territorial possession. Likewise, in Bangladesh elephants come into conflict with humans because of inadequate space as they compete for the same habitat. This creates antagonistic feelings towards elephant conservation among people living in close proximity to elephant ranges. When elephants invade crops and settlements, humans defend their property by driving them away with fire, blank gun shots and crude bombs. As a result of this violence, both elephants and people are killed and injured. Due to persistent conflict, sometimes over generations, in many areas elephants have become a menace to people living within or near their habitat range (Kemf & Santiapillai, 2000).

One of the major causes of conflict in the study areas is agricultural crop damage. Several reasons have been put forward to explain crop raiding by elephants. Sukumar & Gadgil (1988) and Santiapillai & Widodo (1993) argue that elephants, being large bodied animals, are forced to raid crops to meet their nutritional requirements when their habitat gets encroached. Animals raid crops, as crops provide an easy source of highly nutritious food (Sukumar *et al.*, 1987). During this study, it was also observed that the presence of settlements in the corridors inevitably diverted the usual pathways of elephants, increasing HEC. Elephants raid crops occasionally in Cox's Bazar, Chittagong, CHT North and South Forest Division (Khan, 1980; Islam *et al.*, 1999; Aziz *et al.*, 2005). Rahman (2008) found that elephants prefer seasonal crops such as Jack fruit, paddy, watermelon, cucumber, green chilies, sugarcane and pineapples, but they rarely attack teak, rubber, or tea gardens. Much of the crop-damage is caused by animals that move in from other areas. Khan (2004) stated that for the year 2002, crop damage by elephants was 51%, property damage 21%, and bamboo damage was 11% of the total financial loss due to elephant attack in Bangladesh. It was also found that 39 people were killed in 2002 as a result of HEC and the highest number of human casualities (21%) was in Mymensingh (Khan, 2004).

Conflicts between humans and elephants have become an important issue for conservationists during the last 30 years (Lee *et al*., 1986). Current population of Bangladesh has increased to more than 142 million, giving a crude density of 965 people per km². Bangladesh is a small country of about 14.8 million hectares of land area (BBS, 2008) of which 2.53 million hectares (17.49%) is under forest cover. This includes 0.27 million ha of homestead forests and 2.26 million ha of state-owned forest reserves and Protected areas (Alam, 2008). As a result, elephants and farmers, along with poor people, have become incompatible neighbors in many parts of the elephant range in Bangladesh (Sarker & Røskaft, 2010). They cannot live together without conflict where agriculture is the dominant form of land use.

The main threats to wild elephants are human settlements, lack of vegetation cover and food source (Fowler & Mikota, 2006). According to IUCN Bangladesh (2004), HEC has claimed more than BDT 29 million as financial losses in twelve major elephant ranges areas of Bangladesh from 1997-2002 and it was also noticed from this study that 162 settlers and 22 elephants were killed during this period. Only within a year (2001-2002), the number of elephant death was reported to be as high as 14.

In the technical report-3 of IUCN Bangladesh, Khan (2004) stated that, as a result of HEC from 1997-2002, Mymensingh Forest Division and its adjoining areas suffered and experienced the highest financial losses (BDT 64,95,100) followed by CHT North Forest Division (BDT 55,99,800). The lowest total financial loss was observed in Sylhet Forest Division (BDT 3,14,400).

IUCN Bangladesh (2008) stated that, according to local people, there were no elephants in Sherpur area before 1990s. Elephant attacks started after 1990s. Severity of the attacks was found to be directly linked to the crop calendar, especially with the timing of paddy harvest; frequent raids were reported between March-April and August-December which corresponds with paddy ripening time. It was found that elephants rarely attacked houses that have electricity supply. Moreover, isolated houses were more frequently attacked resulting people to avoid making houses in isolated areas.

1.5. Context of the study

In the hilly areas of Bangladesh, elephants were once a common sight. Unfortunately, over the last few decades the number of elephants has considerably reduced. Human settlement in the forest areas, absence of tree cover inside the forest, reduction of food availability are considered as the leading causes of decline of the number of elephants in the forests of Bangladesh. Since food availability and habitat of elephants are decreasing day by day due to human activities, as reflect action there are conflicts rising between forest dwellers and elephants. And now human casualty and crop damage by elephant become a frequent news particularly in the hilly forest areas of the country. Similarly, death of elephants from this conflict is evenly common. Conservation of the Asian elephant is very crucial since it can contribute to maintain biodiversity and ecological integrity on a large-scale. The presence of this species in forested areas indicates that the forest is rich in biodiversity and has a healthy ecosystem. But in Bangladesh, the need for conservation of Asian elephant is not receiving enough attention neither at policy nor at implementation levels, even though the conservation of this species is nationally and internationally very important. Given this backdrop, IUCN Bangladesh has been working to conserve this majestic animal in Bangladesh since 2001 under a project titled, "Action Research for Conservation of Asian elephants in Bangladesh" with financial assistance from the US Fish and Wildlife Services. We realized that practical interaction with the local communities and associated local administrations can ensure

the sustenance of the species as well as the reduction in HEC. Since the inception of the project, IUCN Bangladesh has successfully completed three phases and is now at the final stage of the fourth phase. At this stage, the activity was concentrated to improve the understanding of HEC issues at local community and decision-making levels to facilitate effective conservation and development initiatives in some selected areas in south-eastern Bangladesh. In doing so, we have developed GIS based detailed maps on elephant's routes, corridors and HEC areas. We hope our findings will be used to facilitate appropriate interventions to protect, restore and improve elephant corridors and routes in the study areas for long term elephant conservation in Bangladesh.

1.6. Scope and organization of the book

This book has been prepared to provide identification and mapping of elephant routes, corridors, core habitats and buffer areas, HEC areas in terms of crop damage and human casualties in Chittagong, Cox's Bazar and CHT. Some basic information on population status and ecology of elephants has also been presented. In addition, this book provided some recommendations for the long term conservation of elephants in Bangladesh.

The first chapter gives an overview on Asian elephant that includes their present status in Bangladesh and the world, HEC issues and also the background of this work. The following chapter gives details of the three study sites. Chapter three enumerates ecological aspects of elephants. Chapter four describes the elephant routes, corridors, HEC areas, crop damage areas and core elephant habitat areas. Chapter five presents the present scenario of HEC in Bangladesh and the final chapter illustrates the conclusion with some recommendations to conserve this flagship species.

CHAPTER TWO: STUDY AREA

In terms of focus of this research, the study areas mainly encompass present day elephant ranges in the south-east country, which includes Chittagong, CHT (Rangamati, Khagrachari & Bandarban) and some parts of Cox's Bazar. Project sites selected in Chittagong included the upazila of Rangunia (Sukhbilash), Potia, Chandanaish and Bashkhali; in CHT, Mohalchari; Longadu (Pablakhali) and Kaukhali and in Cox's Bazar, Ramu (Baghkhali) and Chunati (Fashiakhali).

2.1. Chittagong

Chittagong district, with an area of 5,229 km^2, is bounded by Feni district and Tripura (Indian state) on the north, Cox's Bazar district on the south, Bandarban, Rangamati and Khagrachari district on the east and Noakhali district and the Bay of Bengal on the west (Harun, 2003). The city of Chittagong is located between 22°14′ and 22°24′30" north latitude and between 91°46′and 91°53′ east longitude (Osmany, 2003). It is quite different from other districts of Bangladesh for its unique ecosystems characterized by hills, rivers, the sea, forests and valleys. The temperature ranges from 13.5°C to 32.5°C and total annual rainfall is 2,687 mm. Main Rivers are Karnafuli, Halda and Sangu (Osmany, 2003).

The population in the city area is 2,579,107, and the density is 15,351/km^2. Main occupation in the Chittagong district is agriculture (Harun, 2003).

In both north and south Chittagong forest divisions, vegetation cover is sparse, scattered and fragmented. Monoculture practices such as, tea and rubber gardens are common in the north but not in the southern forest division. Human settlements are proliferating in the forest area that leads to hinder elephant movement along the corridors. Agricultural practices are common and HEC is frequent (Chowdhuri, 2004).

2.2. Chittagong Hill Tracts (CHT)

The CHT consists of three districts, namely, Rangamati, Khagrachari and Bandarban with an area of 13,180 km^2. The area is located between 21.25° and 23.45° north latitude and between 91.45° and 92.50° east longitude. Geographically, CHT is a part of Tripura Hill and Arakan Yoma branching off

from the Himalayan range and continuing to the south through Assam and Tripura of India to Arakan of Myanmar.

The topography of the region is featured by hills, ravines, and cliffs, originally covered by dense bamboo, trees and creeper jungles, but presently deforested in many places. The hills run from south in a north westernly direction in the region. The relief ranges from 1,000-2,000 ft above sea level in the north to 1,500-2,900 ft in the south. The Karnafuli is the largest river in the region. The region comprises of six main valleys formed by the Chengi, Kassalong, Maini, Matamuhuri, Rankhyong, and Sangu rivers and their tributaries. The climate of this region is tropical monsoon and rainfall ranges from 2159 to 3048 mm a year. Mean annual rainfall is nearly 2540 mm in the north and east and 2540 mm to 3810 in the south and west. Temperature ranges from 10.2°C to 35.1°C over the year (Rafi & Chowdhury, 2001).

There are 13 different ethnic groups inhibiting CHT (Irfanullah & Motaleb, 2011; Khan, 2001). This is a unique part of the country, both in terms of landscape and its people (Rafi & Chowdhury, 2001). Khan (2001) stated that the region's population has increased drastically over the last 30 years. The Governmental census recorded that CHT's population was only 0.385 million in 1961, 0.508 million in 1974 and 0.746 million in 1981; the current population is 1.28 million, which implies that the population has doubled in 20 years and tripled over the last 30 years (Rafi & Chowdhury , 2001).

The vegetation in this area is characterized by evergreen and semi-evergreen dominated by tall trees belonging to families dipterocarpaceae, euphorbiaceae, lauraceae, leguminacae and rubiaceae (Osmany, 2003; Roy *et al*., 2000). The *teak* patches are planted forests and not indigenous to CHT which is a valuable tree but ecologically unsound (Roy *et al*., 2000). The tribal people have been traditionally practicing social forestry by using the forest resources for domestic purpose. They exploited the forest resources, but did so sustainably such that the ecosystem can renew itself (Rafi & Chowdhury, 2001). According to an estimate only 3.2% of the area (104,304.6 acres) of CHT is suitable for all purpose agriculture (Roy, 1992). Traditionally shifting cultivation is practiced on the hill slopes by the ethnic communities (Osmany, 2003).

Farming is the main income generating activity for the majority of tribal groups (Rafi & Chowdhury, 2001). Orchards and pineapple gardens are widely popular throughout the region both for family consumption and for commercial sale. Trees like jackfruit, mango, lemon, etc. are usually grown in orchards. Although fishing is not a main source of livelihood for any of the ethnic groups but is done where there is scope for it (Rafi, 2001). Hunting is a primary source of livelihood among some ethnic groups, especially, Bawm groups and they regularly practice it. Many tribal groups also raise cattle (e.g., pig, cow etc.) and poultry. The poultry is always kept protected from wild animals (Rafi, 2001).

2.3. Cox's Bazar

Cox's Bazar district has an area of 2492 km^2 (Siddiqi, 2003), is located 150 km south of Chittagong bounded by Chittagong district on the north, Bandarban district, Arakan (Myanmar) and the Naf river on the east and the Bay of Bengal on the west (Siddiqi, 2003). The climate of Bangladesh is mostly determined by its location in the tropical monsoon region: high temperature, heavy rainfall, often excessive humidity, and distinct seasonal variations. The reversal of wind circulation between summer and winter is another important feature of the country's climate (Ahmed, 2003).

The estimated population of Cox's Bazar district is 14,19,260. The density of population is 570 km^2. The main occupation is agriculture (25.64%). Other occupations include fishing, agricultural

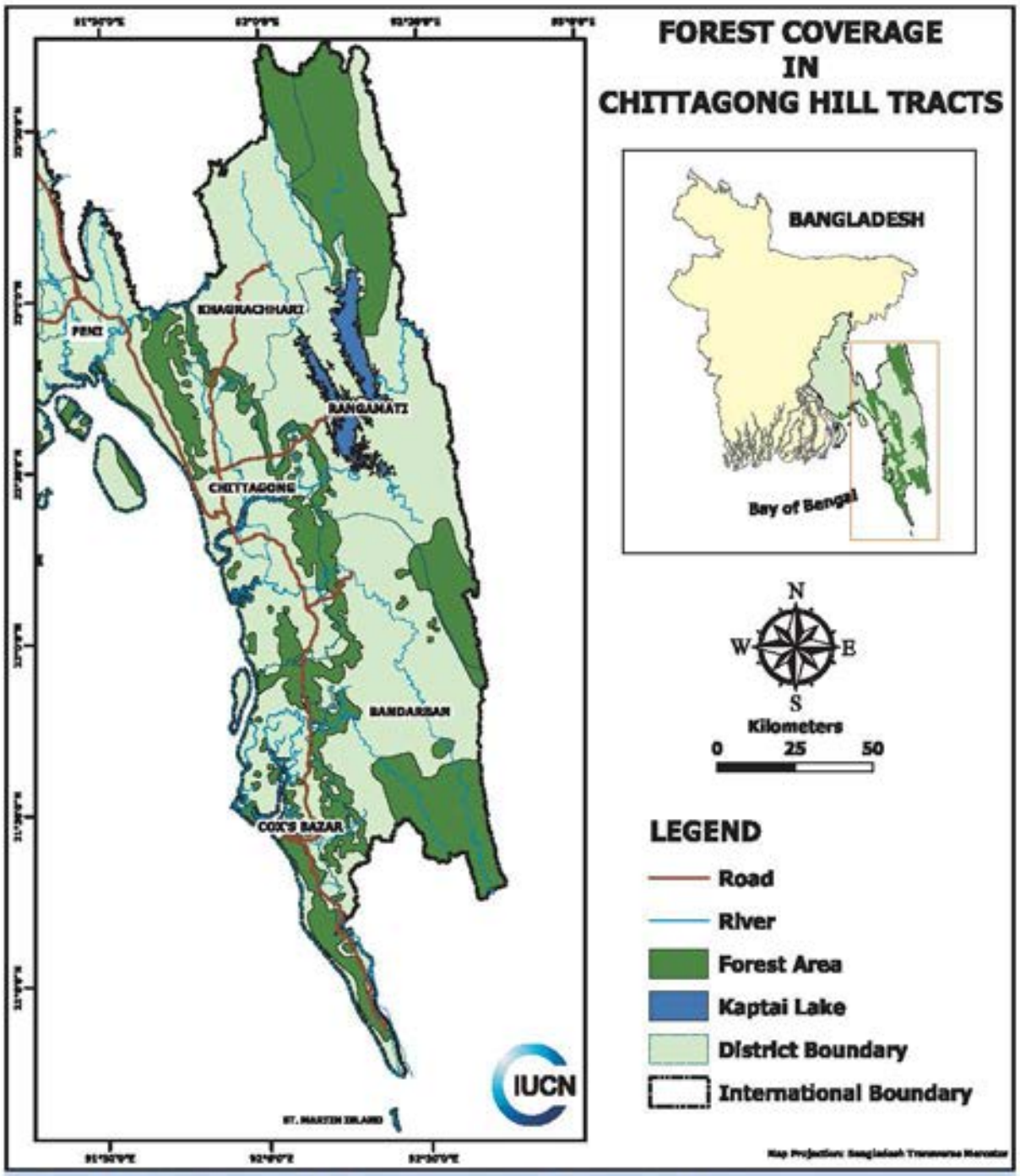


Figure 2.1: Map showing the forest coverage in the project area

laborer, wage laborer, service, commerce, transport etc. The main crops for cultivation in Cox's Bazar are paddy, potato, pulse, onion, garlic, ginger, betel leaf, betel nut, wheat, sugarcane, ground nut, tobacco, rubber, vegetables (Siddiqi, 2003).

Main forest areas are Phulchhari Range, Bhumaria- ghona Range, Meher- ghona Range, Baghkhali Range (Siddiqi, 2003). Vegetation covers at Teknaf, Shilkhali, Rongikhali forest block is sparse, which is considered a major threat to elephant population because most of the hill forests remain exposed due to the lack of trees (Chowdhuri, 2004). In Cox's Bazar south Forest Division, Teknaf forest block was declared as a Wildlife Sanctuary (previously game reserve) that is now in a degraded state in terms of forest canopy. The total reserve was 11,615 ha with semi evergreen

forests. In the north Forest Division forest cover is fragmented due to the construction of roads, highways and human settlement. In Fasiakhali forest block, the vegetation cover is good and it also provides shelter and food for elephants throughout the year. Monoculture rubber plantation was introduced near Bhomariaghona which has closed the elephant corridor for movement.

CHAPTER THREE: ECOLOGICAL ASPECTS OF ELEPHANTS

3.1. Home range and core habitat areas

Asian elephant lives in a wide variety of habitats, including savanna, scrub forest, and closed-canopy forest. They also inhabit grasslands, tropical evergreen forest, semi-evergreen forest, moist deciduous forest, dry deciduous forest and dry thorn forest, in addition to cultivated and secondary forests and scrublands. Previous studies have found that elephants prefer lowland forest habitats (Kinnaird *et al.*, 2003; Hedges *et al.*, 2005; Azad, 2006; Pradhan & Wegge, 2007) where nutritious foliage is abundant. Elephants have a strong preference for forests with high productivity located within valleys (Rood *et al.*, 2010). Landscape depressions are also natural waterways providing water sources and natural routes crossing through rugged terrain (Pan *et al.*, 2009; Shannon *et al.*, 2009). Forest dwelling elephants are seen from sea level to elevations of over 4,000m (Grimshaw *et al.*, 1995 and Choudhuri, 1999). According to the USFWS (2002), grassland forest-mosaics are considered optimal habitats and in such areas, as many as five elephants per 1 km^2 (0.38 square mile) have been recorded.

The size of the home ranges of Asian elephant vary considerably. For females it is between 34-800 km^2 and for males 200-235 km^2. However, home ranges of elephant can cover thousands of square kilometers (Sukumar, 2003). These variations in home ranges can be determined through habitat type, individual preference, tradition, inter family relationships and gender ratio. Grasslands are the preferred feeding habitat of elephants. However, for movement, resting, shade, breeding and other purposes Asian elephants need other types of habitats. The use of grasslands by elephants is determined by different factors such as, species composition, density of other herbivores, distance of grazing locations from the forest boarder and proximity of grazing locations to drinking sites (Ishwaran, 2001).

In Bangladesh, core habitat areas for elephants are located at CHT, Cox's Bazar and some parts of Chittagong forest divisions. Elephant distribution is governed by the allocation of human settlement, both past and present (Barnes *et al.*, 1991). In Cox's Bazar, it was observed that elephants take rest inside deep valleys with dense forest cover. They prefer bushy area for resting and grazing. Elephants require large amounts of water for drinking and cooling their body and to do so they tend to stay in proximity to water sources. They use hill stream water and mud found inside the forest to wallow in.

3.2. Corridor and routes

Asian elephants are migratory species. They can move over considerable distances even within a short period of time (Sukumar, 1989a). In the wild, elephant herds follow well-defined seasonal migration routes. The survival of this species largely depends on corridors and routes because it allows elephants to safely migrate, access food sources and establish crucial genetic links between herds (Joshi & Singh, 2009). The eldest female guides the group to follow the traditional migration routes. The presence of traffic on the road, construction of steep retaining walls and the presence of human population along the corridor and routes can limit the migration of elephants (Johnsingh & Williams, 1999).

3.3. Food and feeding behavior

Elephants are classified as mega herbivores and consume up to 150 kg of plant matter per day, (McKay, 1973; Vancuylenberg, 1977) they also drink around 140 liters of water a day (Ciszek, 1999). The Asian elephants diet constitutes of a large variety of plant species. They typically prefer to eat grass, but also like roots, leaves, vines, shrubs, stems and barks (Sukumar, 1990). According to USFWS (2002), grass typically accounts for more than 50% of the Asian elephant's diet. However, Joshi & Singh (2008) contradicts that the consumption of tree species (74%) is much higher compared to grasses (14%) and shrubs (8%), but their diet is mainly dependent on the availability of seasonal food around the year and during migration. Table 3.1 shows the list of suitable species for elephant diet and the parts consumed.

Table 3.1 : List of plant species favored by elephants as their daily food in the wild (IUCN Bangladesh, 2004; Joshi & Singh, 2008)

Bengali name	English name	Scientific name	Family	Parts eaten by elephant
Khoir	Cutch tree	*Acacia catechu*	Mimosaceae	Leaves, twigs and bark
Bel	Wood apple	*Aegle marmelos*	Rutaceae	Leaves, twigs and fruit
Kala koroi	Black siris	*Albizia lebbeck*	Mimosaceae	Leaves and twigs
Sada koroi	White siris	*Albizia procera*	Mimosaceae	Leaves and twigs
Chapalish	Chaplash	*Artocarpus chama*	Moraceae	Fruits and leaves
Kanthhal	Jack friuit	*Artocarpus heterophyllys*	Moraceae	Leaves, bark and fruit
Deua	Monkey jack	*Artocarpus lacucha*	Moraceae	Fruit
Bansh	Bamboo	*Bambusa* sp.	Gramineae	Node, leaf, newly sprouting branch, matured branch, entire bamboo when young
Kanchan	Kanchan	*Bauhinia purpurea*	Caesalpiniaceae	Leaves, twigs and bark
Shimul	Red silk cotton tree	*Bombax ceiba*	Malvaceae	Bark

Bengali name	English name	Scientific name	Family	Parts eaten by elephant
Jambura	Pummelo	*Citrus grandis*	Citraceae	Fruit
Narikel	Coconut	*Cocos nucifera*	Palmae	Leaf and fruit
Bohal	Indian cherry	*Cordia dichotoma*	Boraginaceae	Twigs
Durba	Caugh grass	*Cynodon dactylon*	Gramineae	Leaves and roots
Chhon	Umbella plant	*Cyperus difformis*	Cyperaceae	Entire plant
Sissoo	Sissoo	*Dalbergia sissoo*	Fabaceae	Leaves, twigs and bark
Lathi bansh	Solid bamboo	*Dendrocalamus strictus*	Gramineae	Leaves and twigs
Kusha	Big cordgrass	*Desmostachya bipinnata*	Gramineae	Leaves and roots
Mate alu	Purple yam	*Dioscorea alata*	Dioscoreaceae	Root and leaves
Chamror	Ovate-leaved Ivory wood	*Ehretia laevis*	Boraginaceae	Leaves and twigs
Bot gach	Banyan tree	*Ficus benghalensis*	Moraceae	Leaves, twigs and bark
Dumur	Fig	*Ficus hispida*	Moraceae	Leaves, twigs, bark and fruit
Bolchi ful	Indian plum	*Flacourtia indica*	Flacourtiaceae	Twigs and bark
Antmura	Indian screw-fruit	*Helicteres isora*	Sterculiaceae	Leaves and twigs
Misti alu	Sweet potato	*Ipomoea batatas*	Convolvulaceae	Fruit and leaf
Jarul	Crepe myrtle	*Lagerstroemia speciosa*	Lythraceae	Leaves and twigs
Aam	Mango	*Mangifera indica*	Anacardiaceae	Fruit
Muli bansh	Muli bambo	*Melocanna baccifera*	Gramineae	Node, leaf, newly sprouting branch, matured branch, if immature, then the entire bamboo
Dakrom	Kaim	*Mitragyna parvifolia*	Rubiaceae	Bark
Kola	Banana	*Musa sp.*	Musaceae	Trunk, leaf, fruit, but not the root
Kash	Wild sugarcane	*Saccharum spontaneum*	Gramineae	Leaves, roots
Kusum	Kusum tree	*Schleichera oloeosa*	Sapindaceae	Leaves and twigs.
Sal	Sal	*Shorea robusta*	Dipterocarpeceae	Bark
Jam	Black berry	*Syzygium* sp.	Myrtaceae	Leaves, twigs and bark
Shegun	Teak	*Tectona grandis*	Verbenaceae	Bark and twigs
Fuljharu	Tiger grass	*Thysanolaena maxina*	Gramineae	Entire plant
Boroi	Jujube fruit	*Zizyphus mauritiana*	Rhamanaceae	Leaves and twigs

In the wild, a mature elephant would spend as many as 18 hours per day for feeding. Asian elephants eat in the morning, late afternoon and night. They take breaks from feeding during the hottest parts of the day. Obviously the food consumed in the wild is low in nutrients and high in fiber (John & Subramanian, 1991), which entiles them to spend so much time on feeding.

Asian elephants have a special digestive system for rapid throughput of coarse vegetation and are adapted to a lifetime of foraging. Effective foraging is attained through continuous movement including, seasonal migrations and daily movement through a variety of habitats. Foraging activity is accomplished with the coordinated movement of feet, tusks and their dexterous trunk to select individual items of fruit (Poole & Granli, 2009). Asian elephants use many creative methods to retrieve their food. To eat long grasses they pluck a bundle and stick it inside their mouths using their trunks. Short grasses are eaten by stomping and kicking up the ground and then grabbing the grass using their trunks. To eat shrubs they break off twigs with their trunks (Ciszek, 1999; Poole & Granli, 2009). According to McKay (1973), elephant grazing in the dry season is negatively impacted by the presence of other herbivores. Elephants feeding preferences and behavior are also known to change over time due to changes in its habitat (Ishwaran, 2001).

3.4. Movement pattern

Movement patterns of wild elephants may vary according to their age, sex, reproductive state and population of a group. Free-living Asian elephants move almost all day long and even at night (20 out of every 24 hours) and are actively engaged in foraging, exploring, socializing and searching for con-specifics (Poole & Granli, 2009). Generally elephants rise well before dawn and start their morning activities in the vicinity of the area where they spent the night (Joshi & Singh, 2008). In case of elephant, the energy spent on walking is recorded as the lowest among all land animals (Langman *et al.*, 1995). Its behavior is geared towards saving the energy (Wall *et al.*, 2006). Being an enormous animal, Asian elephants tend to move slowly but they are vigorous and are continuously active both physically and mentally. By nature, elephants are rarely found still; some portion of their body (i.e., legs, ears, eyes, trunk, or tail) is always in motion. Even a motionless wild elephant is often found continuously moving its trunk and scenting; positioning its ears and head to monitor the movement, location and behavior of other elephants and their activities in their complex social and ecological environment. These types of motions are good predictors and indicators of active thinking (Poole & Granli, 2009).

Availability of food, water, as well as climate and seasons determine the location of an elephant's their home range. Typically during the dry winter months (January-April) Asian elephants reside in river valleys. At the onset of monsoon, they begin their long migration towards upper slopes in some of the areas (Joshi & Singh, 2008). Their day to day movement and resting patterns tend to fluctuate during monsoon due to restricted mobility. During the first part of the wet season (May-August) they reside in tall grass forests. Over the second part (September-December) they move to open forests with short grass cover (Sukumar, 1989b). In summer, elephants move more as they have to travel longer in search of food and water, due to reduction of fodder species and shrinkage of natural water sources (Joshi & Singh, 2008). Sometimes, when habitat patches with fodder plants become small and scattered, they have to extend their range to satisfy dietary requirements. This invariably brings them into conflict with humans, which is the main constraint in conserving these elephants (Samansiri & Weerakoon, 2007). A study pointed out that most of the incidents of crop raiding were found to be in late evening or during night time (Nair, 1990).

In another study indicated that most of the raids by elephants were carried out either by a solitary individual (adult males) or small groups (Santiapillai & Suprahman, 1986).

Predictor variables such as, human presence and proximity to elephants resulted in reduced feeding and increased display in elephants while distance of settlements to elephants did not influence behavior of elephants. Protection and non-conversion of canopy habitats and maintaining minimum threshold distance of humans from elephants would foster normal movement activities of elephants and help promote human-elephant coexistence in such landscapes (Mavatur & Singh, 2010).

3.5. Communication

Asian elephants use infrasonic calls to communicate with each other (Payne *et al.*, 1986). The ability of elephants to distinguish strangers from a wide range of more regular associates through recognition of voices (McComb *et al.*, 2000) and scents (Bates *et al.*, 2007) may in part explain the extremely large and convoluted temporal lobes of the elephant's brain (Shoshani, 1992). Different types of communications used by elephant can be as follows:

Acoustic communication

Elephant acoustic communication includes a broad variety of sounds (with components ranging from 5 Hertz to over 9,000 Hertz (Poole *et al.*, in press). Calls include very low frequency rumbles and higher frequency trumpets, snorts, roars, screams, barks, cries, chirps, croaking and other idiosyncratic sounds (Poole *et al.*, 1988; Poole, 1994; Soltis *et al.*, 2005 a & b; Leong, *et al.*, 2003; Stoeger-Horwath *et al.*, 2007). Elephants use acoustic signals to communicate complex messages of agonistic, defensive, associative, parental, mating, and other social nature. They are able to combine different call types to construct more complex calls and are capable of imitating or learning new vocalizations (Poole *et al.*, 2005).

Via acoustic signals elephants can recognize the individual voices of other elephants at distances of up to 2 km (McComb *et al.*, 2003). Detection of the calls of con-specifics has been estimated to vary from 2.2 km during daytime to 9.9 km at night (or over an area of 15-300 km^2) depending upon atmospheric conditions (Garstang, 1994). Extensive studies have confirmed that elephants produce low frequency sounds to interact in thick vegetation and among separated groups, and to coordinate their movements (Payne *et al.*, 1986; Poole *et al.*, 1988; Langbauer *et al.*, 1991; Garstang *et al.*, 1995; Larom *et al.*, 1997; McComb *et al.*, 2000). Elephants are the first terrestrial mammals reported to produce infrasonic sound (Payne, 1998). Infrasonic calls produced by elephants can travel 1-5 km or even more (ANCF, 2007).

Chemical communication

Chemical communication relates to signaling between opposite sexes for mating. Olfactory communication is achieved by pheromones (ANCF, 2007). Chemical signals including saliva, mucus secretions from the eyes, fluids from the genital tracts, temporal glands, ears and inter-digital glands, also play an essential role in elephant social and reproductive communication (Rasmussen et al., 1996; Rasmussen & Schmidt, 1998; Rasmussen & Krishnamurthy, 2000 and Rasmussen & Wittemyer, 2002).

Tactile communication

Tactile communication happens through sight and touch mainly during breeding period. When elephants meet, they vocalize, rub their bodies, press each other's foreheads, intertwine trunks or put trunks in each other's mouths (ANCF, 2007).

3.6. Social organization

Asian elephants can be categorized into families, bond groups and clans (McKay, 1973; Kurt, 1974; Sukumar, 2003 and Vidya & Sukumar, 2005).

i. The size of the basic family unit can range from four to twelve individuals. The social structure of female Asian elephants consists of related adults and their offspring. These groups are led by the eldest female, called the matriarch. A dominant hierarchical system determines the social status of each individual in the group. This system is based on age and physiological status (Schulte, 2000). The cohesiveness of families varies depending upon factors, such as, habitat type, season, relatedness, personality traits, tradition, deaths of influential members and the strength of the matriarch's leadership (Moss & Lee, in press).

ii. Over the course of hours or days, family groupings may temporarily separate and reunite or they may mingle with other social groups to form larger social units or aggregations. Such groupings may be predicated on close social bonds, home range and season (Douglas- Hamilton, 1972; Moss, 1983; Sukumar, 2003; Wittemyer *et al*., 2005; Archie *et al*., 2005 and Moss & Lee, in press). A bond group is two or more family units who associate with one another at high frequency relative to their associations with other family units in the population and whose members display associative behavior towards one another (Moss, 1983).

iii. Though rare in the Asian elephant, family units have been reported to meet and greet other units. Sometimes units come together to form clans (Schulte, 2000). A clan can consist of anywhere from twenty to two-hundred individuals (Sukumar, 1989b). However, inside these clans, each family unit is still held together very closely by the matriarch (Schulte, 2000).

Within this social arena, the lives of adult female and male elephants differ radically (Poole, 1994). Female elephants remain with their families for life, while male elephants leave their natal families around puberty, at which point they enter the socio-sexual world of adult males. Members of a family and bond group may be distinguished by long-term association patterns, greeting behavior, coordinated movement, resource acquisition, offspring care, decision-making, strong associative and protective behavior toward one another as well as cooperative anti-predator behavior (Douglas-Hamilton, 1972; Lee, 1987; Moss, 1988; Poole, 1998; Payne, 2003). In areas where water, minerals or high quality food are limited, or unevenly distributed, agonistic behavior in elephants is more common (Poole, 1994). The close and lasting social relationships formed by female elephants are remarkable in the context of their fluid social system (Archie *et al*., 2005).

3.7. Social learning

Social learning and behavioral innovation are essential elements of individual development and are the very fabric of elephant society, tradition and culture (Lee & Moss, 1999; Poole & Moss, 2008). Many of the techniques used by wild elephants to locate, select and extract food must be learned, either through experience or by watching others (McComb *et al.*, 2003) and social learning plays a critical role in a calves' acquisition of foraging knowledge and techniques of manipulating food items (Lee & Moss, 1999; Hart *et al.*, 2001). Successful mounting and intromission requires considerable skill and experience which may, in part, be gained by watching the behavior of older, more experienced males. Interaction with other elephants and the transmission of social and ecological knowledge is key to an elephant's survival (McComb *et al.*, 2003) and the motivation it demands isnecessary for an elephant to thrive.

3.8. Ecological importance

Asian elephants often physically transform the forest as they move through it, contributing to the ecological functioning of the forest. They create light gaps by knocking down trees; they keep the undergrowth clear by trampling vegetation and speed decomposition by shattering rotting logs (RAIN, 2010). Elephants can provide water for other species by digging water holes in dry riverbeds. The depressions (created by their footprints and their bodies) trap rainfall. Their paths also act as firebreaks and rain water channel (RAIN, 2010). Elephants act as seed dispersers via their fecal matter (Chapman *et al.*, 1992). They disperse seeds and fertilize the soil with their dung, compact it with their feet and cultivate it with their tusks. By digging for essential minerals they change stream flow, creating wet forest clearings (RAIN, 2010). Dispersing rice seeds through defecation elephants sometimes introduce new types of rice far from the villages they raid (Alexandre, 1978). An elephants' journey through the high grass provides food for birds by disturbing small reptiles, amphibians or insects (RAIN, 2010; IUCN Bangladesh, 2004).

CHAPTER FOUR: ELEPHANT CORRIDORS

4.1. Route and corridor mapping of Asian elephants

By definition, routes are usually pathways used by elephants to migrate for food and habitat, while corridors are strips of land that connect two or more of those habitats. Field observations revealed that most of the routes and corridors of elephants have been obstructed or shattered because of development activities such as human settlement, conversion of forest cover into crop fields, construction of roads. In most cases, it was observed that the habitats, especially natural forest areas, have been destroyed solely to favor people's benefits ultimately putting the largest land mammal in peril. Fortunately or unfortunately, elephants cherish their forefather's routes and corridors from time immemorial.

Habitat destruction, burgeoning human population, lack of awareness and lack of good scientific information are the major threats and challenges to the long term survival of the remaining elephant population in Bangladesh. Given the importance of this keystone species it is imperative to preserve this species and its habitat with ultmost sincerely. It is also very important to know and denoted their habitat, routes of migration and corridors they use to facilitate this conservation.

Geographic Information System (GIS) technology is an effective tool for managing, analyzing and visualizing wildlife data in order to target areas where conservation practices are needed. Global Positioning System (GPS), GIS together with Remote Sensing (RS, which includes both satellite images and aerial photographs) allow conservationists to apply geo-information technique to design effective natural resources management systems and to set precedence for the conservation of endangered/vulnerable species and their habitat. In this study, we used GPS, GIS and RS technology to define the routes, corridors, HEC sites and sighting locations of elephants. We believe that our findings will be useful for decision makers to tackle HEC effectively for the long term conservation of elephants in Bangladesh. This chapter portrays the generated route and corridor maps along with detailed description of the study sites including topographical features of the habitats and expansion of human settlement as well as agricultural land.

4.2. GIS mapping methodology

At first reconnaisance survey was conducted in elephant-ranges areas that were suggested by peer group members (FD officials, wildlife biologists, professors, academicians, researchers, etc.) involved in this project. Based on their consulatation and suggestions, nine sites were selected for detailed GIS mapping. GPS data on elephant routes, corridors, HEC areas, elephant sighting locations (e.g., location of crop damage) in Chittagong, CHT and Cox's Bazar were collected during field visits using Garmin E-Trex (GPS device). Strip transect method was used, the average length of which was about 5 km (ranges 3.5-7 km) and a total of 40 transects in nine sites were studied. Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA) were conducted to verify and validate GPS data collected on stated parameters. The GPS data were verified via local level participatory discussions, local people of the HEC affected areas were involved to identify the routes and corridors in their respective Unions (smallest administrative rural geographic unit). Collected GPS data were overlaid on online Google Earth image and showed to local people to identify during RRA and PRA. This visualization facilitated to identify routes and corridors of elephants to the participants during participatory sessions as they can relates them to the local infrastructure even their own settlements. This process not only ensured proper validation and greater improvement of routes and corridor identification but also revealed many unknown facts of elephant migration to the local participants, which helped them to become aware of the importance of conservation.

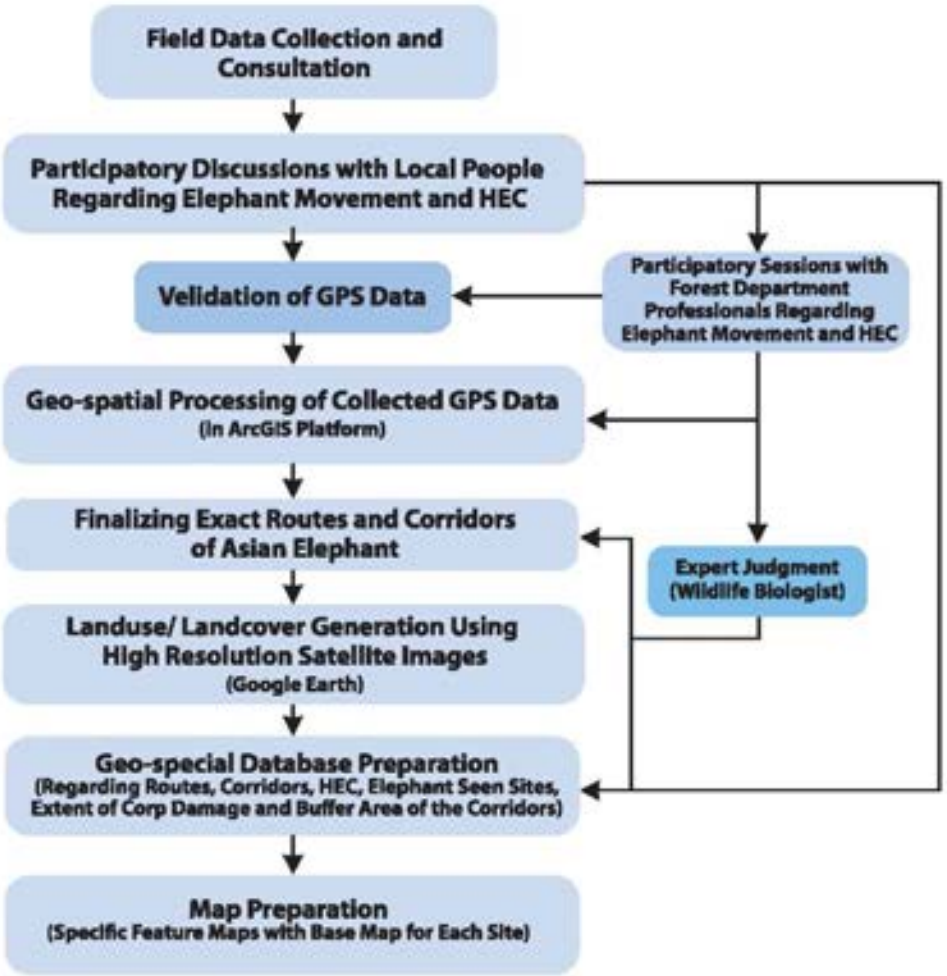


Figure 4.1: Flow diagram of the GIS mapping procedure.

The HEC sites were identified by regular field visits and then verified by consultation with local people and local FD officials. Advanced GIS and integrated spatial analysis were executed using Geo-spatial Modeling Environment (GME) extension tool in ArcGIS to finalize the routes and corridors.

Expert suggestions were incorporated to finalize the routes and corridors used by elephants in the study areas. Detailed land use/ land cover maps for the selected sites were generated utilizing high resolution (Spatial Resolution: ~ 0.5m) satellite images which were obtained from Google Earth platform (Google Earth Version 5.0.11).

The generated GIS layers were set into geographic coordinates (latitude/longitude) on the World Geodetic System of 1984 (WGS84) datum to maintain data uniformity and integrity with Google Earth. The attribute data were then incorporated into generated GIS data layers to develop a geo-spatial database on routes, types of corridors, HEC (i.e., number of human casualties and injury), elephant sighting locations, buffer areas of corridors, etc. Final layouts of the specific site maps along with their associated features were then accomplished in ArcGIS platform.

To measure the buffer area for elephant corridors, 0.25 km area in both sides of elephant routes (total 0.5 km) is considered. Frequent and irregular elephant movements were obtained through direct field observations, key informant interviews and focused group discussions.

4.3. Routes and corridors in the study areas

It was found that elephant movement becomes more frequent during crop harvesting seasons compared to other times of the year. Routes and corridors mapped during this study and the detailed outcome of our observations in different study sites are illustrated below in the following sections (Map 4.1- 4.62) and a summery is also provided in the Table 4.1.

4.3.1. Baghkhali

Baghkhali forest range is situated under three administrative districts namely Bandarban, Chittagong and Cox's Bazar. It covers Docchari, Naikongchhari, Kachhapia, Garjania & Kauarkhop Unions of the above three districts. Map 4.1 to 4.7 shows different features of this area including a base map. During the field visit eleven elephant movement sites were found in Baghkhali (Map 4.5). Among these regions nine seasonal movements and two rare ones were observed. Elephant movement was observed to be frequent in nine sites, but was limited in the remaining two due to human settlements and other anthropogenic activities. HEC was found in ten locations (Map 4.6), at these locations about seven people were found injured and two people had died in the last ten years (2000-2010). It was also revealed that HEC was mainly due to the establishment of human settlement and agricultural practice along elephant migration and movement routes in all except three areas. Formerly three routes for elephant movement along with the forest patches were detected (Map 4.2). These routes originate from within the deep forest. In this area nine active corridors (Map 4.3) of different dimensions were found, of which four major active corridors are as follows:

- Dochhari-Kachhapia 1, located between 21°26'5''N 92°13'47.3''E and 21°24'41''N, 92°12'21.01''E, and runs through agricultural and human settlement areas. Its total length was 3.85 km and estimated buffer area was 78.06 ha. Two HEC sites were found.

- Dochhari-Kachhapia 2, located between 21°26′48.538′′N 92° 13′47.3′′E and 21°26′19.498′′N 92°10′44.77′′E, and runs through agricultural and human settlement areas. Its total length was 5.081 km and estimated buffer area was 103.91 ha. Two HEC sites were found in this corridor.

- Nikhongchhari-Shandung 1, located between 21°23′35.214′′N 92°11′27.915′′E and 21°25′0.365′′N 92°10′56.386′′E and runs through agricultural land. Its total length was 1.42 km and estimated buffer area was 32.05 ha.

- Nikhongchhari-Shandung 2, located between 21°23′48.459′′N 92°10′35.643′′ E and 21°23′56.786′′N 92°11′21.277′′E, runs through agricultural land. Its total length was 1.30 km and estimated buffer area was 30.21 ha.

There was no abandoned corridor in this area. The total estimated buffer area of those corridors was 280.29 ha (The length of buffer area is highest 103.91 and lowest 4.21 ha) (Map 4.4). From the findings it was evident that this area was suitable for elephant mobility and yet they were quite undisturbed.

4.3.2. Bashkhali

Bashkhali is located in Kakhara and Lakhyarchar union of Cox's Bazar and Gajalia union of Bandarban Hill district. Map 4.8 to 4.14 shows different features of this area including a base map. Six sites were found where elephants move frequently over the seasons (Map 4.12). Six HEC sites are found (Map 4.13) in this area where One human death and about six injuries by Asian elephants were recorded. Seven active corridors (Map 4.10) were found, four of which were major. These are as follows:

- Gajalia-Kakhara 1, located between 21° 46′41.64′′ N 92° 8′3.953′′ E and 21° 46′36.227′′N 92°7′30.033′′E, runs through agricultural land. Its total length was 0.947 km and estimated buffer area was 22.54 ha. One HEC site was found. due to HEC amount of crop damage was found to be high.

- Gajalia-Kakhara 2, located between 21° 46′47.053′′ N 92°6′20.026′′ E and 21°46′57.879′′N 92° 6′1.623′′E, runs through agricultural land. Its total length was 0.606 km and estimated buffer area was 15.41 ha. Two HEC sites were found. Crop damage was found due to HEC.

- Gajalia-Kakhara 3, located between 21° 47′17.365′′ N 92° 5′ 44.301′′ E and 21°47′22.417′′ N 92°5′38.888′′E, runs through Forest and Agriculture land. Its total length was 0.144 km and estimated buffer area was 9.79 ha. One HEC site was found.

- Kakhara-Aziznagar, located between 21° 47′42.986′′N 92°5′18.68′′E and 21°47′49.121′′N 92°5′12.185′′E, runs through Forest and Agriculture land. Its total length was 0.258 km and estimated buffer area was 8.57 ha.

The total buffer area in the corridor was about 149.45 ha (highest 22.54 ha and lowest 4.64 ha) (Map 4.11). There were no abandoned corridors at this site. From Focused Group Discussions (FGD) and one-to-one discussions it was found that crop raiding tendency by the Asian elephant in this area is high and the relationship between humans and elephants is worse compared to other study sites.

4.3.3. Chandanaish

Chandanaish is under three unions namely, Kachuai, Kharana, Kanchanabad of Chittagong district. Map 4.15 to 4.21 shows different features of this area including a base map. Eight sites were found where elephant moves frequently on a seasonal basis (Map 4.19). Five people have been killed as a result of elephant attack at this site in between 2000-2010. Map 4.20 clear illustrates the fact that all the human settlement in the areas is located along elephant migration routes resulting high number of HEC. Nine active corridors (Map 4.17) were identified of which three major corridors are as follows:

- Kanchanabad-Chandanaish, located between 22°14′0.638′′N 92°3′1.625′′E and 22°13′45.035′′N 92°2′29.378′′E, and runs through agriculture land and forest land. Its total length was 1.2 km and estimated buffer area was 25.48 ha. One HEC site with crop damage is found.

- Kachuai-Kharana, located between 22°15′32.177′′N 92°2′31.112′′E and 22°15′32.177′′N 92°2′19.323′′E, and runs through agriculture land. Its total length was 0.35 km and estimated buffer area was 10.65 ha.

- Haidgaon-Shrimai, located between 22°17′17.238′′N 92°2′15.162′′E and 22°17′15.157′′N 92°2′4.76′′E, and runs through agriculture land and forest land. Its total length was 0.325 km and estimated buffer area was 9.41 ha.

All the corridors combined had an area of 55.86 ha (highest 25.48 ha and lowest 4.20 ha) of buffer area (Map 4.18).

4.3.4. Fashiakhali

This site is under Lama Union of Bandarban hill district and Fashiakhali and Dulahazara of Cox's Bazar district. Map 4.22 to 4.28 shows different features of this area including a base map. Six frequent and seasonal , and one rare movement sites (Map 4.26) were identified during field observation and participatory sessions. Map 4.27 shows eight HEC sites in this area. All the HEC takes place along migration routes of the elephants except for one. New settlement and cultivated land are causing HEC in this area. Six injuries and two human deaths were recorded at this site by elephant attacks in last ten years (2000-2010). Ten active corridors (Map 4.24) occupying a total of 145.34 ha (highest 51.08 ha and lowest 5.79 ha) of buffer area was identified for free movement of elephants. Among these ten, four major corridors are as follows:

- Lama-Fashiakhali 1, located between 21°42′48.846′′N 92°14′14.425′′E and 21°42′26.065′′N 92°14′9.511′′E, runs through agriculture and settlement land. Its total length was 0.77 km and estimated buffer area was 17.64 ha.

- Lama-Kakhara, located between 21°43′33.513′′N 92°14′1.471′′E and 21°43′40.66′′N 92°13′18.144′′E, and runs through agriculture land and settlement land. Its total length was 1.33 km and estimated buffer area was 29.44 ha.

- Lama-Fashiakhali 2, located between 21°43′36.648′′N 92°9′32.574′′E and 21°43′35.473′′N 92 9′ 12.474′′E, and runs through agriculture land and river land. Its total length was 0.67km and estimated buffer area was 16.61 ha.

- Lama-Fashiakhali 3, located between 21°46′12.529′′N 92°12′44.197′′E and 21°45′36.348′′N 92°12′25.883′′E, and runs through river, road and Agriculture field land. Its total length was 1.376 km and estimated buffer area was 51.08 ha.

4.3.5. Kaukhali

Kaukhali occupies three unions, two (Ghagra and Kalampati Union) under Rangamati district and Rajanagar Union under Chittagong district. Map 4.29 to 4.35 shows different features of this area including a base map. Eight seasonal elephant movement sites (Map 4.33) were identified and about seven human injuries were recorded in the seven HEC sites (Map 4.34). Six active corridors were identified (Map 4.31) occuping about a total of 67.21 ha (highest 18.97 ha and lowest 3.88 ha) of buffer area (Map 4.32). Among these six corridors four major corridors are as follows:

- Sapchhari-Ghagra 1, located between 22°38′46.412′′N 92°4′23.882′′E and 22°38′37.756′′N 92°4′14.241′′E, and runs through agriculture land. Its total length was 0.405 km and estimated buffer area was 10.98 ha.

- Sapchhari-Ghagra 2, located between 22°38′15.08′′N 92°3′16.639′′E and 22°38′21.106′′N 92°2′50.369′′E, and runs through agriculture land. Its total length was 0.77km and estimated buffer area was 18.97 ha. One HEC site was found mainly due to crop damage by elephants.

- Ghagra-Kalampati 1, located between 22°36′33.855′′N 92°2′20.453′′E and 22°36′29.276′′N 92°1′57.828′′E, and runs through agriculture land and settlement area. Its total length was 0.664 km and estimated buffer area was 16.37 ha. One HEC site was found with extensive Crop damage.

- Ghagra-Kalampati 2, located between 22°36′19.394′′N 92°1′16.373′′E and 22°36′23.974′′N 92°1′1.431′′E, and runs through agriculture land and forest land. Its total length was 0.470 km and estimated buffer area was 12.32 ha.

In the last twenty years, number of new human settlements and agricultural areas are established through conversion of forest land which increased the number of HEC. This was reported from the FGD's and one-to-one discussions conducted with local communities.

4.3.6. Mohalchhari

Mohalchhari is under the Mohalchhari union of Khagrachari District. Map 4.36 to 4.42 shows different features of this area including a base map. Six elephant sites were found in Mohalchhari (Map 4.40). Four HEC sites were found in this area (Map 4.41) and about four people were injured over the last ten years (2000- 2010). Seven active corridors (Map 4.38) were found with no abandoned corridors. The total corridor buffer area was 44.27 ha (ranges 20.55- 4.37 ha) (Map 4.39). Among seven, four major corridors are as follows:

- Kalapahar-Mohalchhori 1, located between 22°56′29.282′′N 92°0′50.216′′E and 22°56′26.556′′N 92°0′56.661′′E and runs through forest and agriculture land. Its total length was 0.216 km and estimated buffer area was 7.14 ha.

- Kalapahar-Mohalchhori 2, located between 22°56′5.9′′N 92°17′0.072′′E and 22°56′0.116′′N 92°1′8.661′′E, and runs through forest and agriculture land. Its total length was 0.189 km and estimated buffer area was 20.55 ha.

- Kalapahar-Mohalchhori 3, located between 22°55′55.241′′N 92°1′10.577′′E and 22°55′44.583′′N 92°1′13.599′′E, and runs through forest and agriculture land. Its total length was 0.346 km and estimated buffer area was 20.55 ha.

- Kalapahar-Mohalchhori 4, located between 22°55′43.756′′N 92°1′1.619′′E and 22°55′45.657′′N 92°0′53.687′′E, and runs through forest and agriculture land. Its total length was 0.237 km and estimated buffer was area 7.84 ha.

4.3.7. Pablakhali

This site consisted of Sarbatoli and Baghachatar Union of Rangamati district. Map 4.43 to 4.47 shows different features of this area including a base map. Six seasonal elephant movement sites were identified during field observation (Map 4.45). Five injuries were noted at five sites from elephant attack in between 2001 to 2010 (Map 4.46). The area is covered in continuous natural forest and that's why there was no fragmentation among the forest patches. So, no active corridor was found in the visited locations of this site and accordingly no map was generated on corridor and buffer area.

4.3.8. Potia

The study site Potia is under three unions of Chittagong district, namely, Haidgaon, Ward No. 1 and Potia. Map 4.48 to 4.54 shows different features of this area including a base map. Three sites were found where elephants move frequently additionally two rare sites were also identified (Map 4.52). It was recorded that one human death and about two injuries by the Asian elephant had occurred in three different places of this site in between 2000 to 2010 (Map 4.53). One active corridor (Map 4.50) Haidgaon- Kehshahar was found which is located between 22°18′13.968′′N 92°1′18.993′′E and 22°18′12.571′′N 92°1′6.361′′E, and runs through agriculture land. Its total length was 0.408 km and estimated buffer area was 10.88 ha. This corridor comprised of one HEC site mainly for crop damage.

The elephant herd usually travel from Potia to Sukhbilash through a continuous hilly route connecting two areas. The HEC situation was almost similar to Bashkhali. Elephant raids increased during paddy harvesting season in this area.

4.3.9. Sukhbilash

This site is under the Padua Union of Chittagong district. Map 4.55 to 4.61 shows different features of this area including a base map. Elephant movement was frequent and five seasonal elephant movement sites and one infrequent site (Map 4.59) were identified during field observation. Seven HEC sites were recorded (Map 4.60). Seven injuries due to HEC were found over the last ten years (2000-2010). Four active corridors and one abandoned corridor were identified for free

movement of elephants (Map 4.57). The corridors are as follows:

- Bangalhalia-Padua 1, located between 22°22′39.571′′N 92°6′32.573′′Eand 22°21′59.688′′N 92°6′20.685′′E and runs through forest, settlement and agriculture land. Its total length was 2.225 km and estimated buffer area 38.42 ha. Two HEC sites were found where crop damage was found to be high.

- Bangalhalia-Padua 2, located between 22°21′49.526′′N 92°6′12.632′′E and 22°21′0.822′′N 92°5′56.141′′E and runs through forest, settlement and agriculture land. Its total length was 1.90 km and estimated buffer area was 64.47 ha. Two HEC sites were found mainly for crop damage.

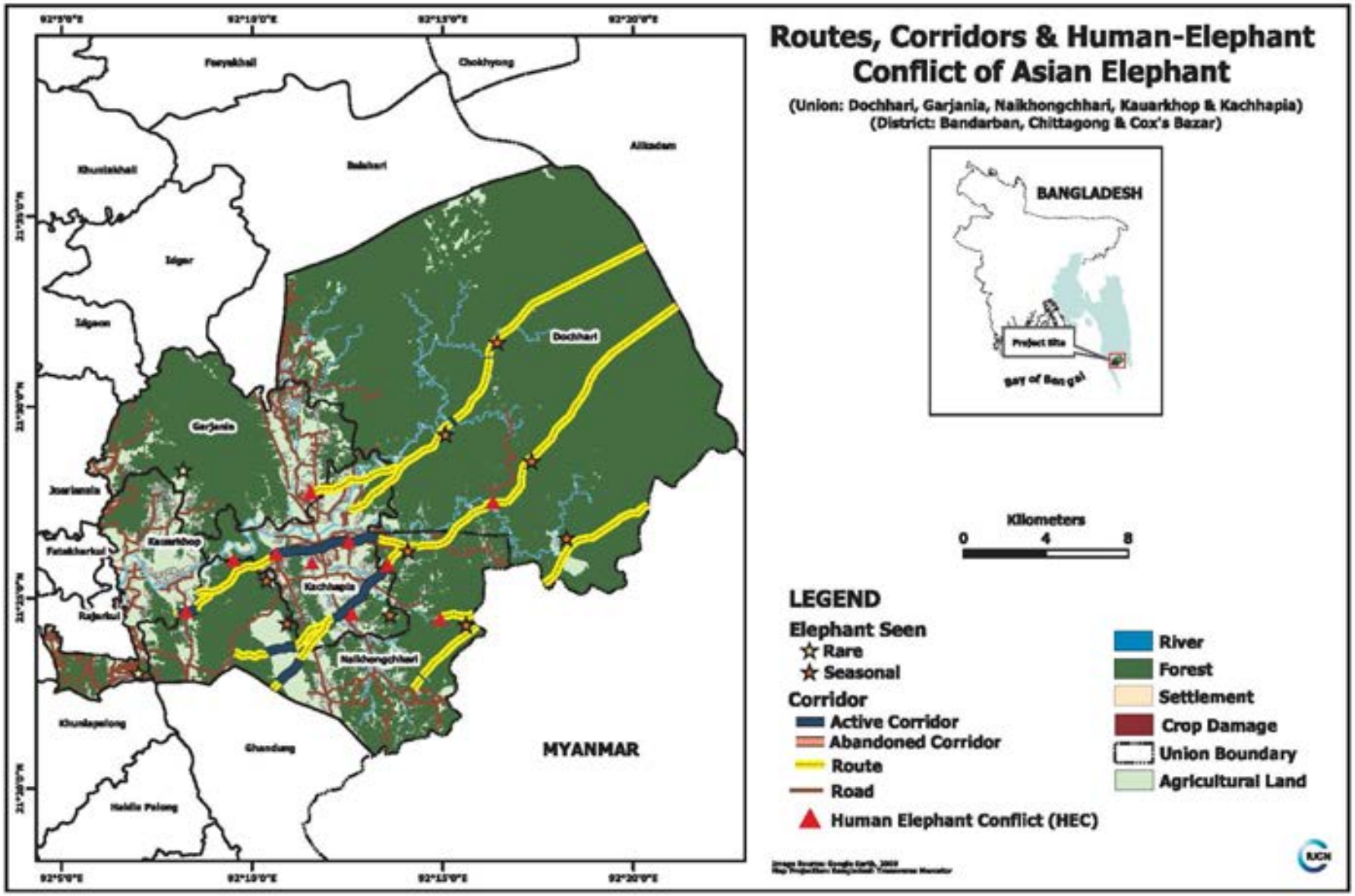
- Bangalhalia-Padua 3, located between 22°21′35.336′′N 92°6′31.039′E′ and 22°20′53.536′′N 92°6′0.935′′E and runs through forest, settlement and agriculture land . Its total length was 1.772 km and estimated buffer area 64.47 ha. One HEC site was found where crop damage was high.

- Rajbila-Padua, located between 22°21′16.929′′N 92°7′4.787′′E and 22°20′41.456′′N 92°6′ 7.071′′E and runs through settlement and agriculture land. Its total length was 2.119 km and estimated buffer area 44.14 ha. One HEC site was found where crop damage was high.

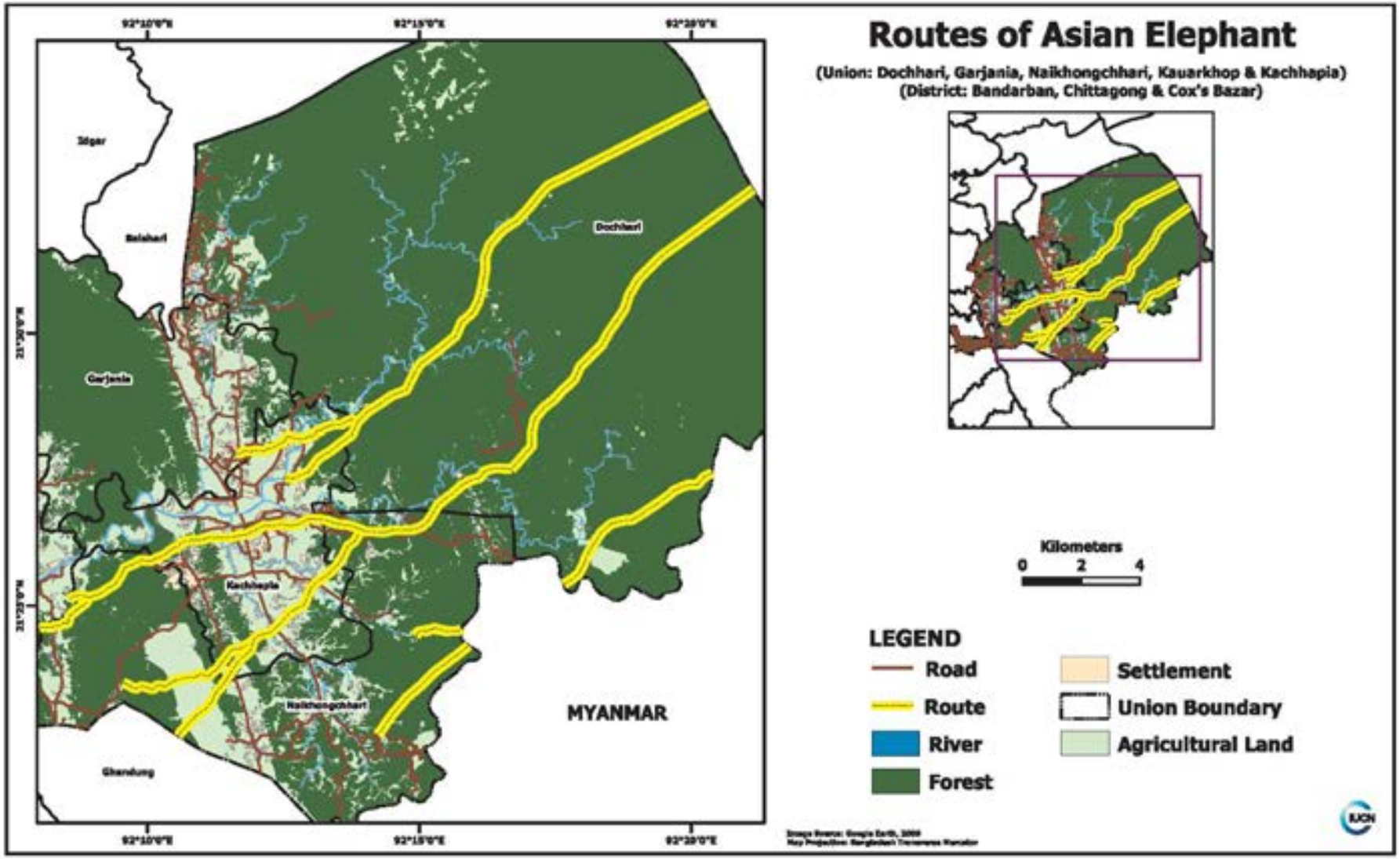
The corridors occupied 147.03 ha (ranges 64.47- 38.42 ha) of buffer area (Map 4.58). In this area it was observed that human settlement and agricultural crop field was along the routes of elephant that increased the conflict between humans and elephants.

Table 4.1: Summary of Asian elephant sighting locations, HEC sites and corridors in the study areas

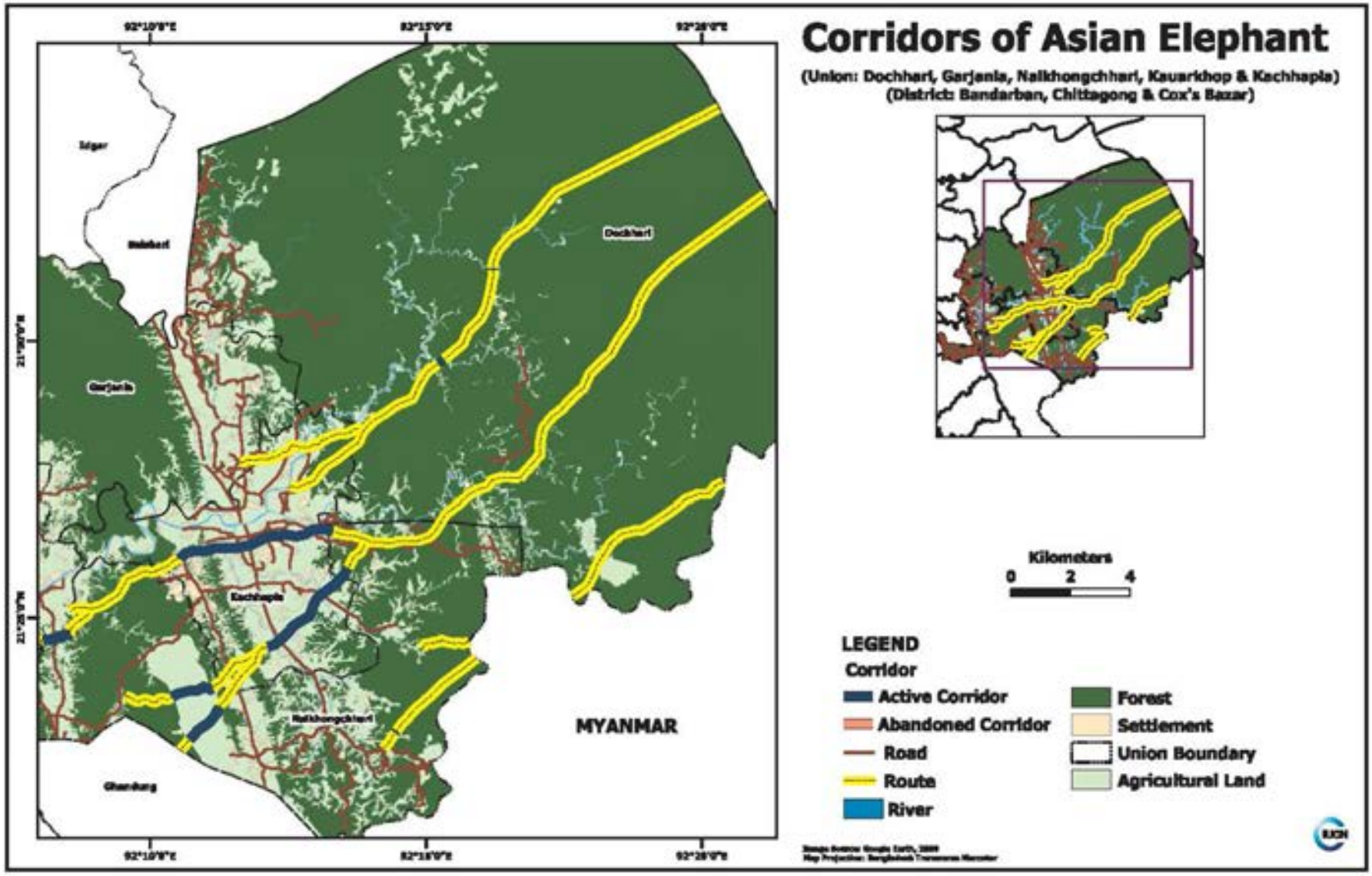
Sl. No	Sites	Elephant sighting			HEC			Corridor		
		Seasonal	Rare	Total	Injured human	Human died	Total sites	Active corridors	Abandoned corridor	Corridor buffer area (ha)
1	Baghkhali	9	2	11	7	4	11	9	0	280.29
2	Bashkhali	6	0	6	6	1	6	7	0	149.45
3	Chandanaish	9	0	9	0	5	5	9	0	55.86
4	Fashiakhali	6	1	7	6	2	8	10	0	145.34
5	Kaukhali	8	0	8	7	0	7	6	0	67.21
6	Mohalchhari	6	0	6	4	0	4	7	0	44.27
7	Sukhbilash	5	1	6	7	0	7	4	1	147.03
8	Potia	3	2	5	2	1	3	1	0	10.88
9	Pablakhali	6	0	6	5	0	5	0	0	0



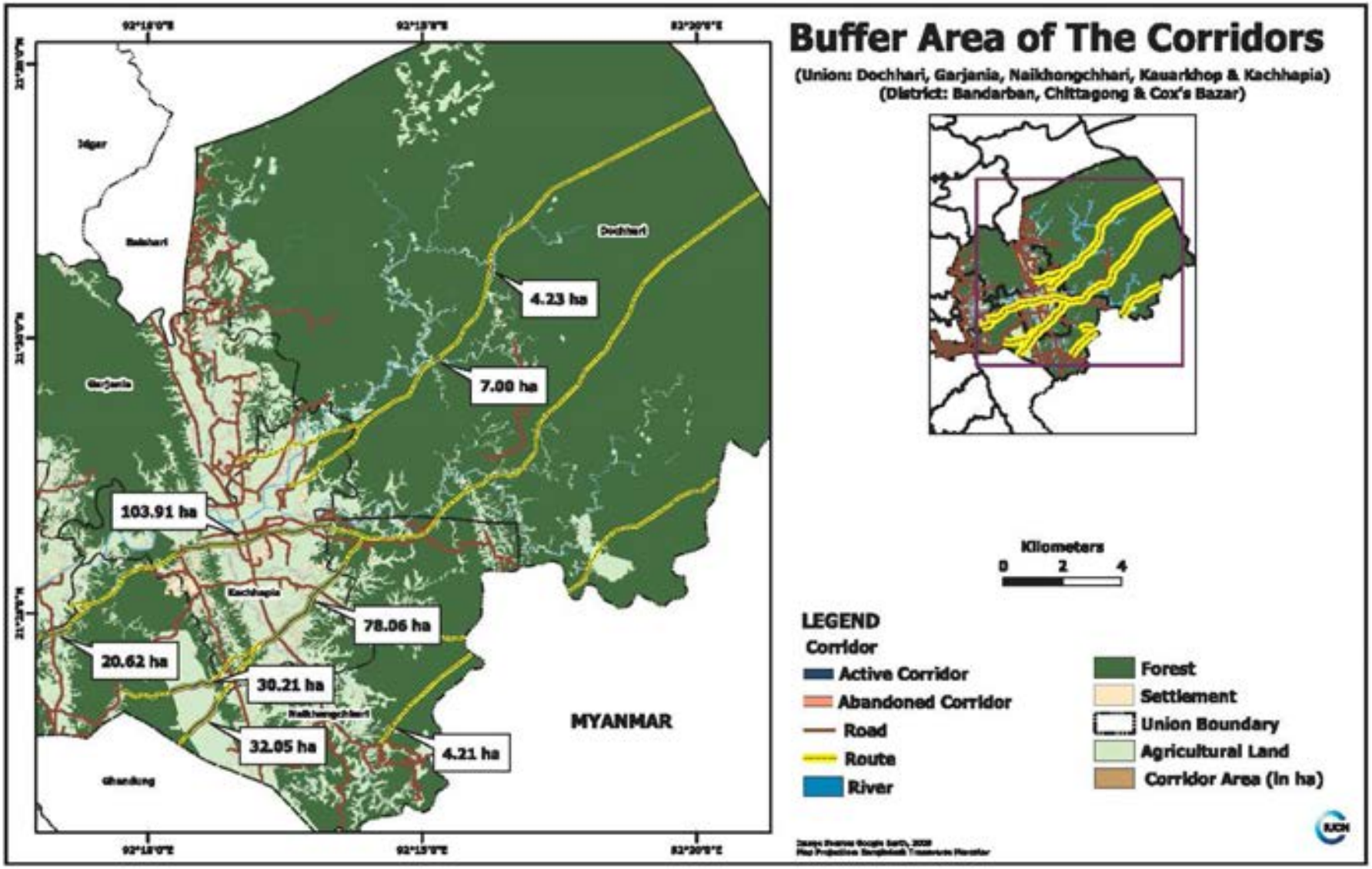
Map 4.1. Base map of Baghkhali



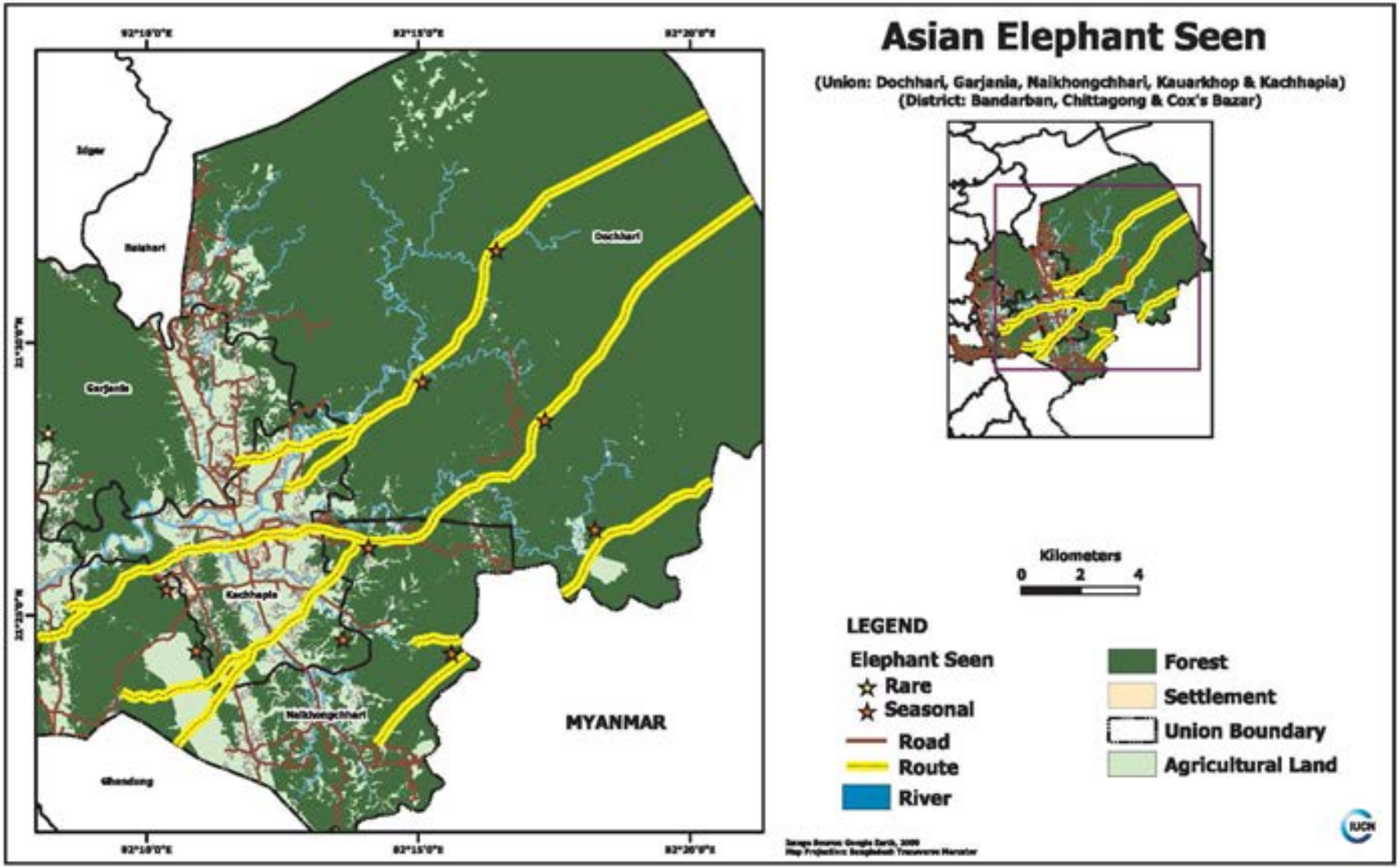
Map 4.2. Routes of Asian elephant at Baghkhali



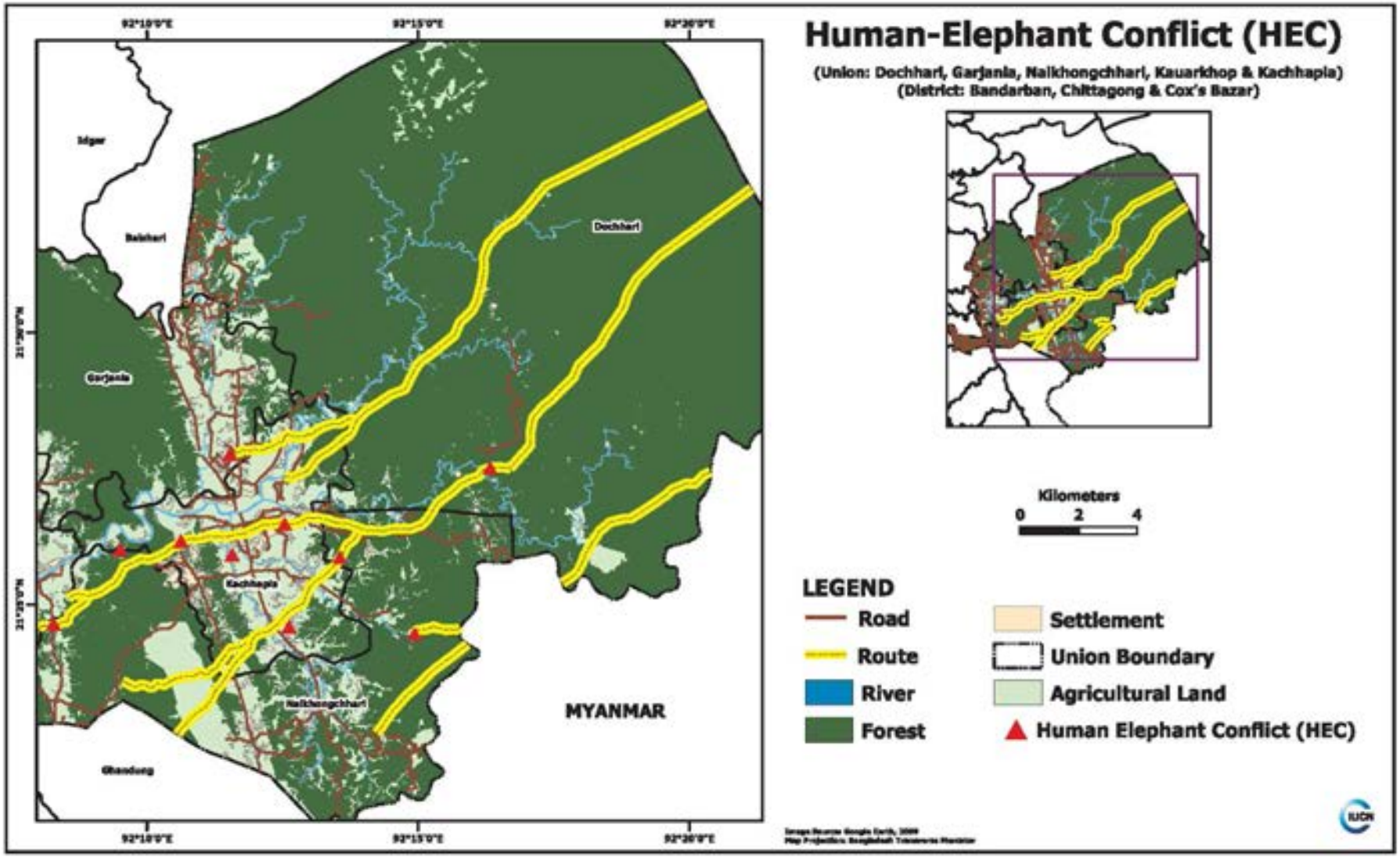
Map 4.3. Corridors of Asian elephant at Baghkhali



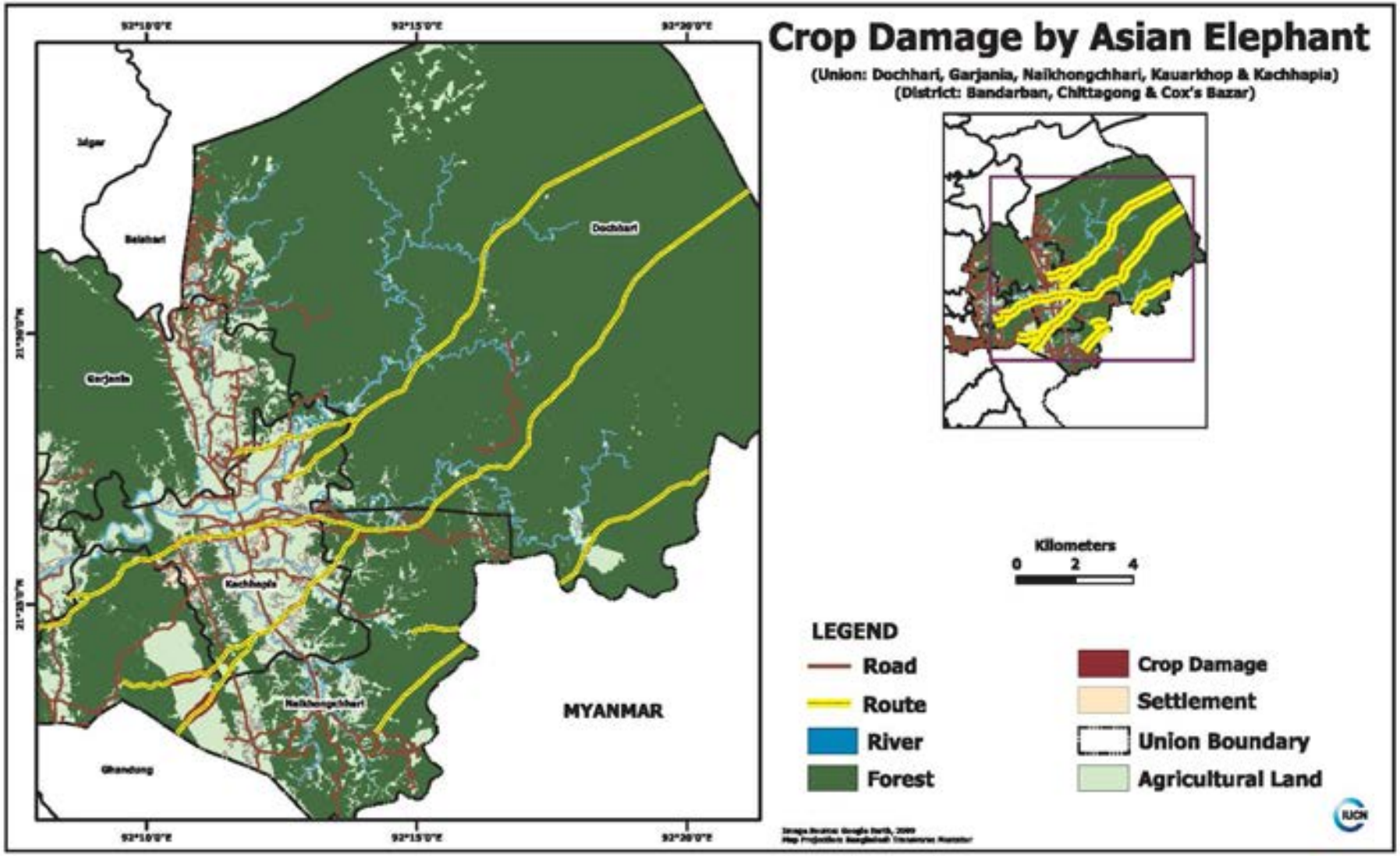
Map 4.4. Buffer area of corridors at Baghkhali



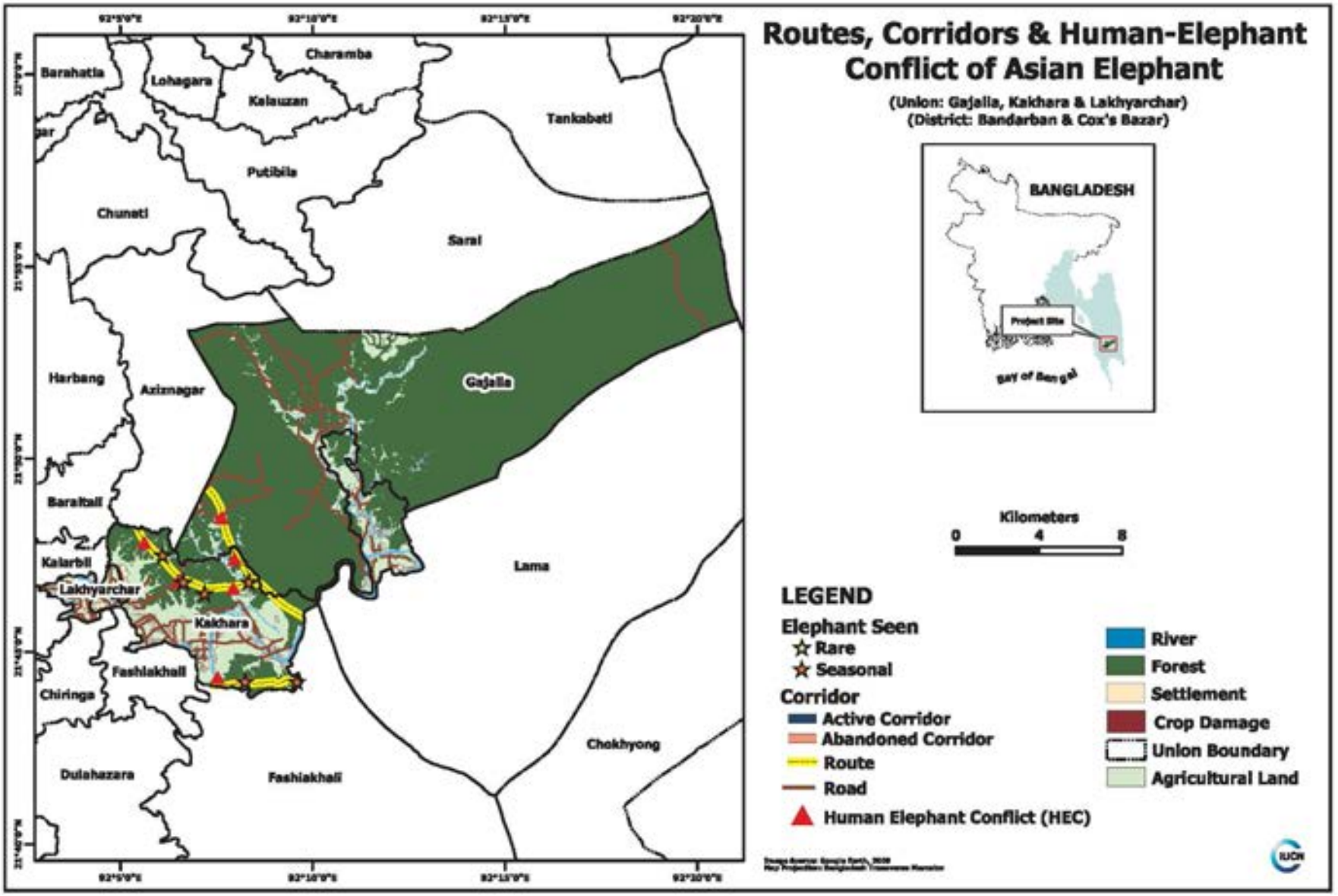
Map 4.5. Elephant seen at Baghkhali



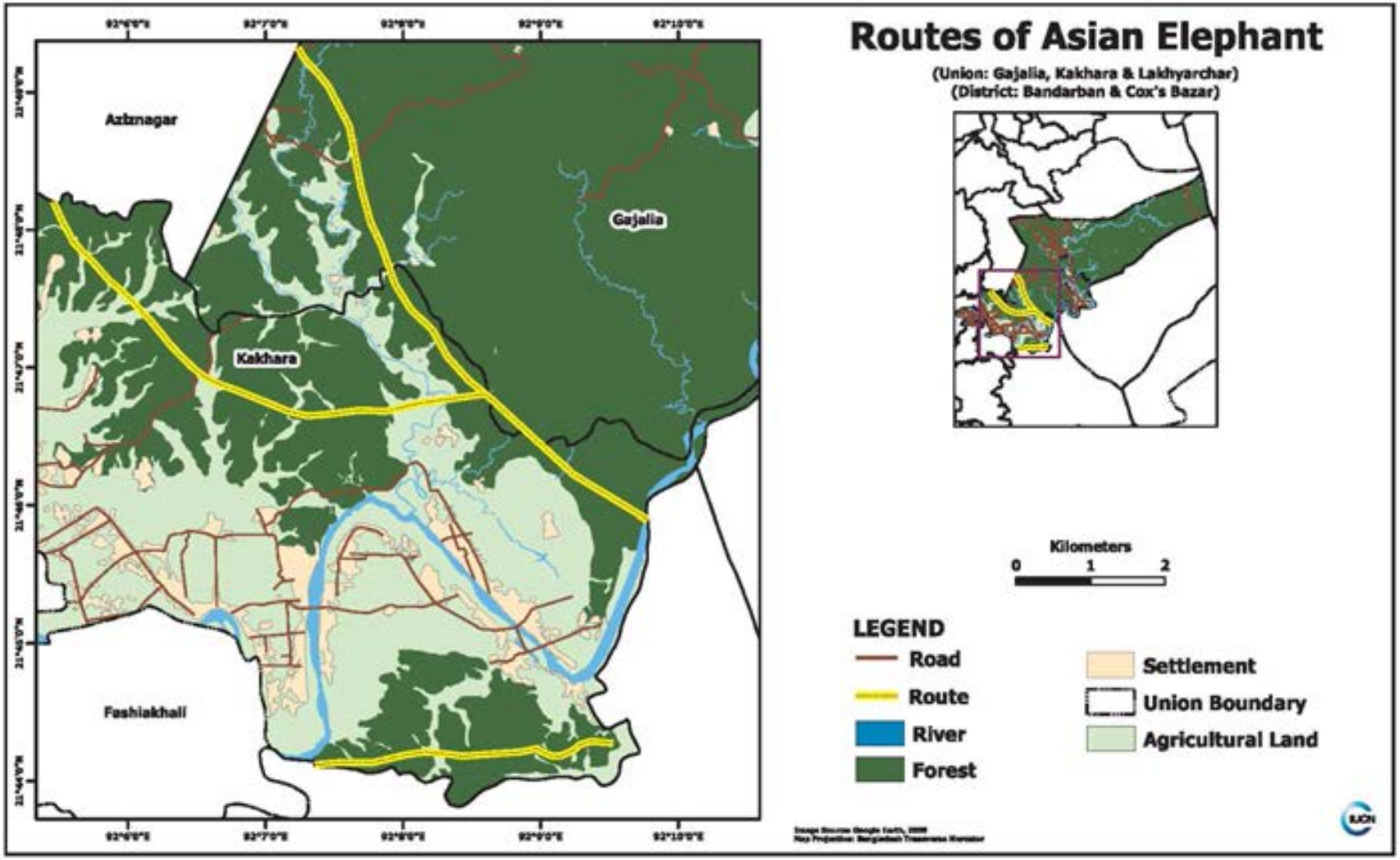
Map 4.6. Human elephant conflict at Baghkhali



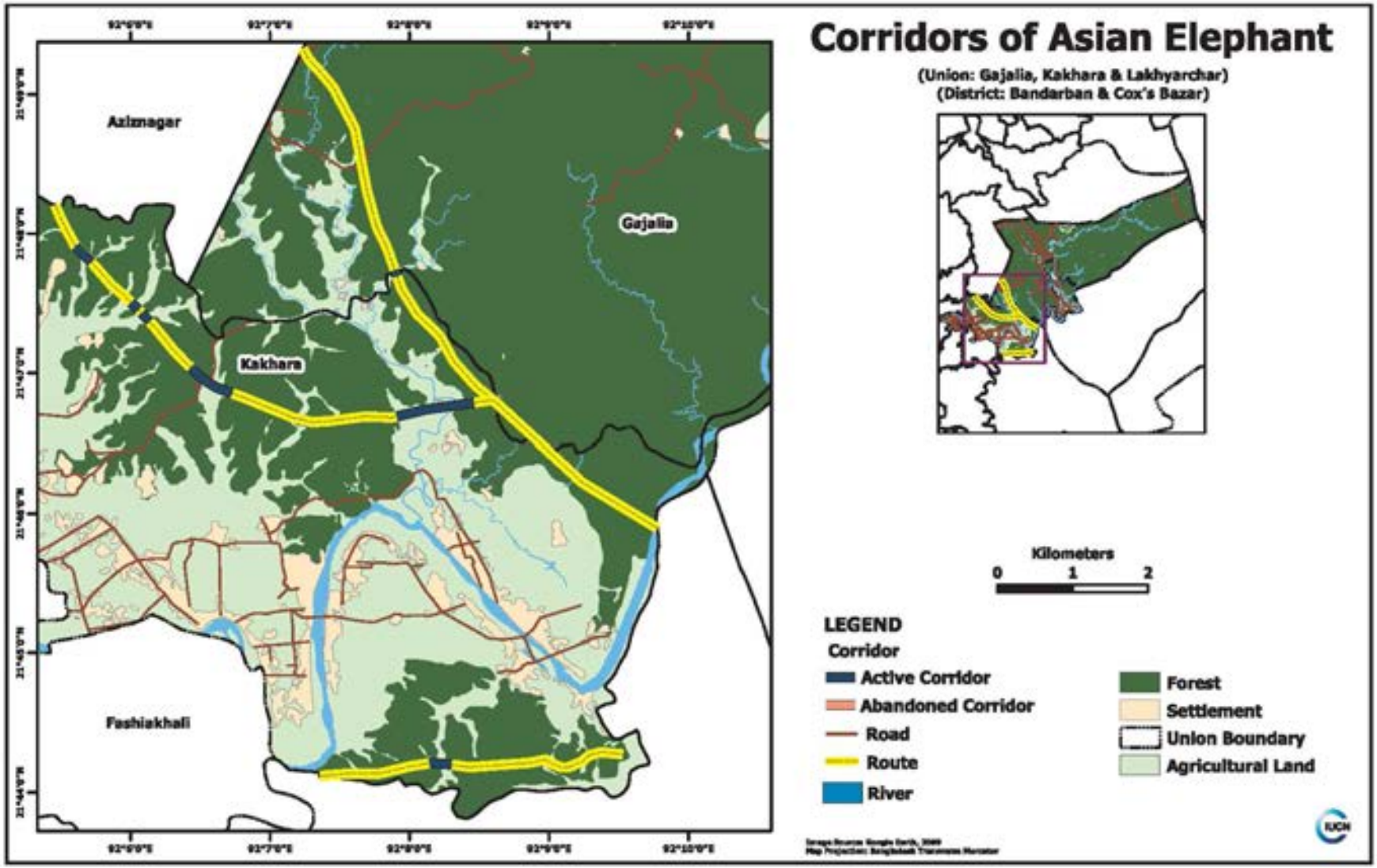
Map 4.7. Crop damage by elephant at Baghkhali



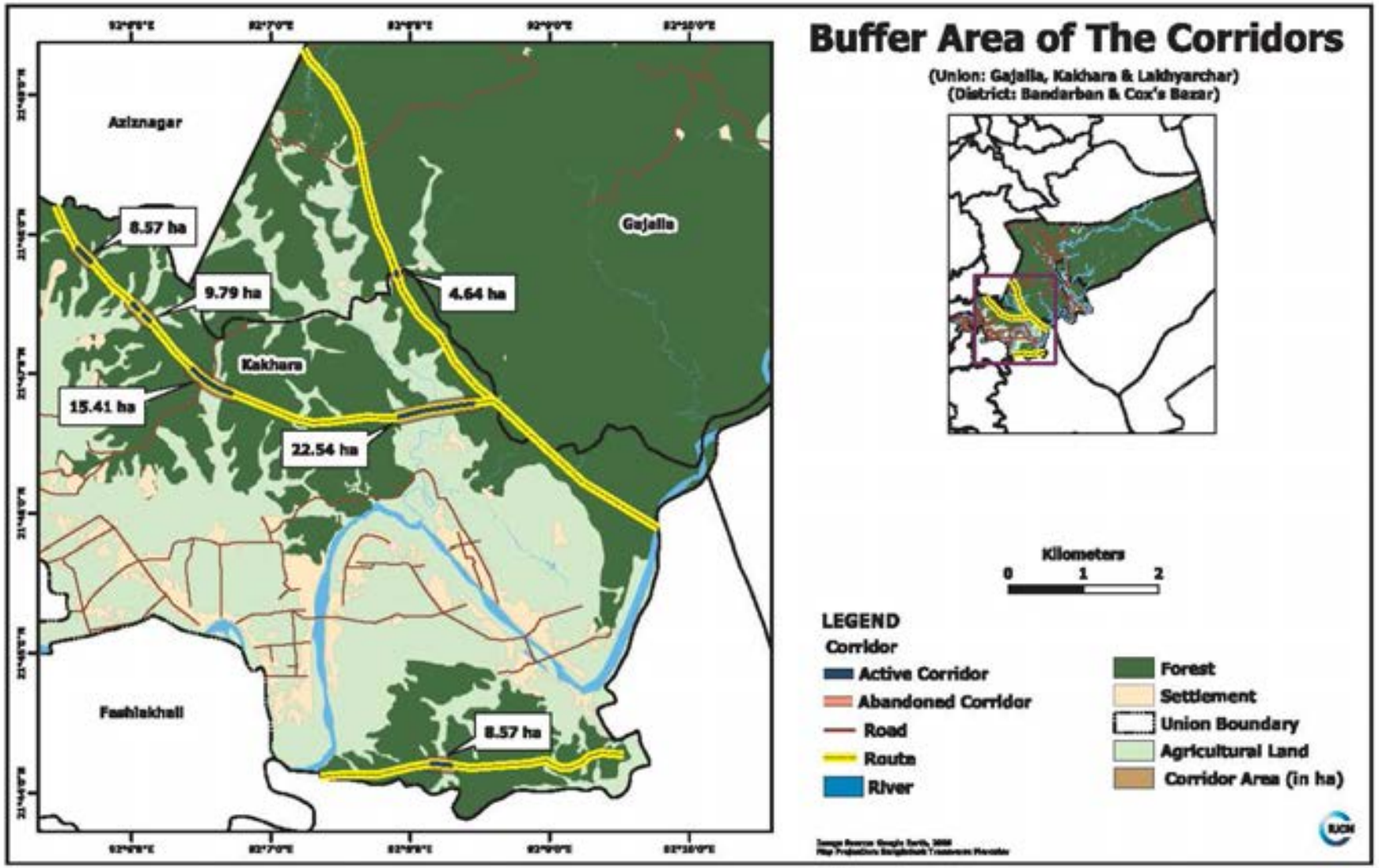
Map 4.8. Base map of Asian elephant at Bashkhali



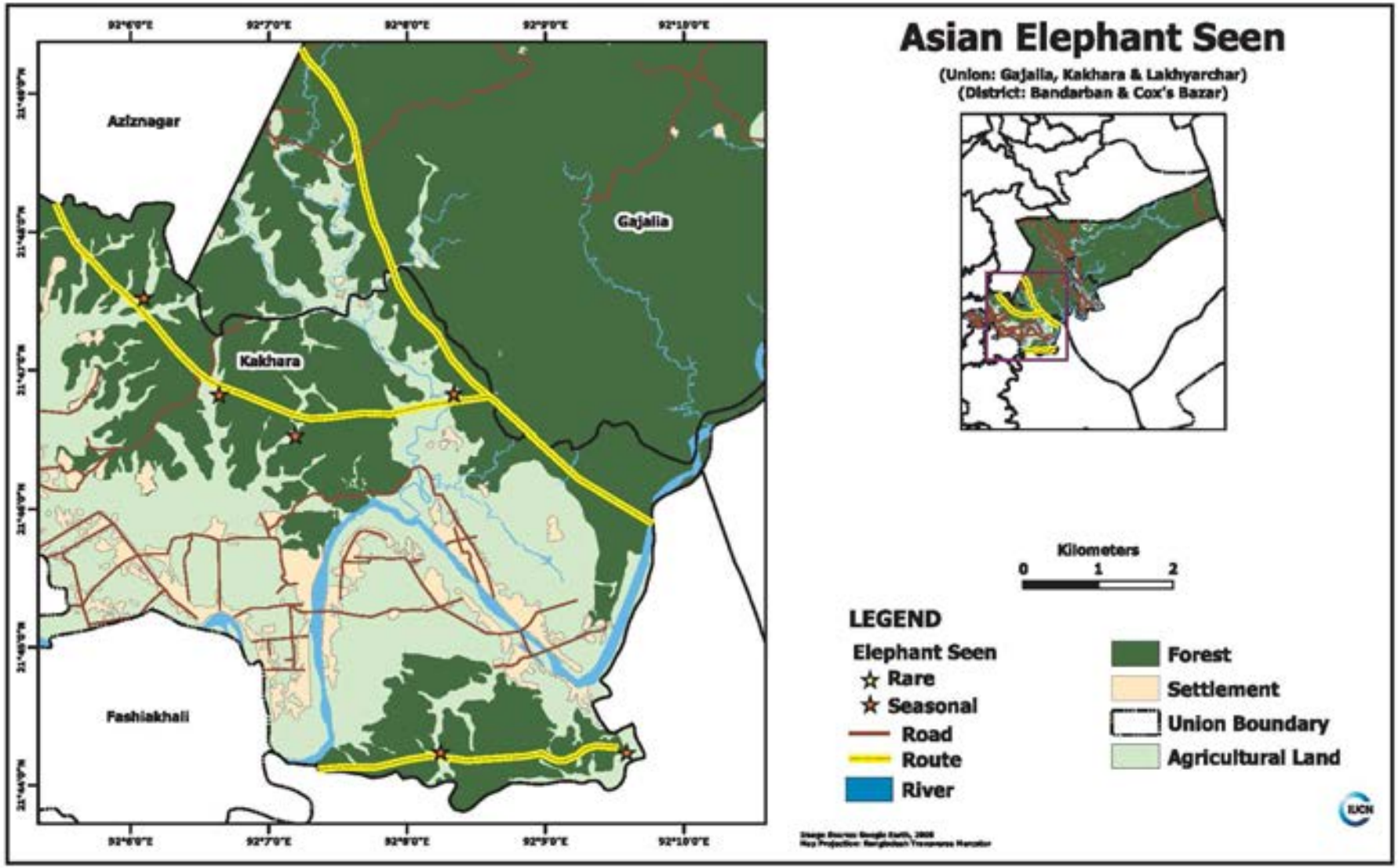
Map 4.9. Routes of Asian elephant at Bashkhali



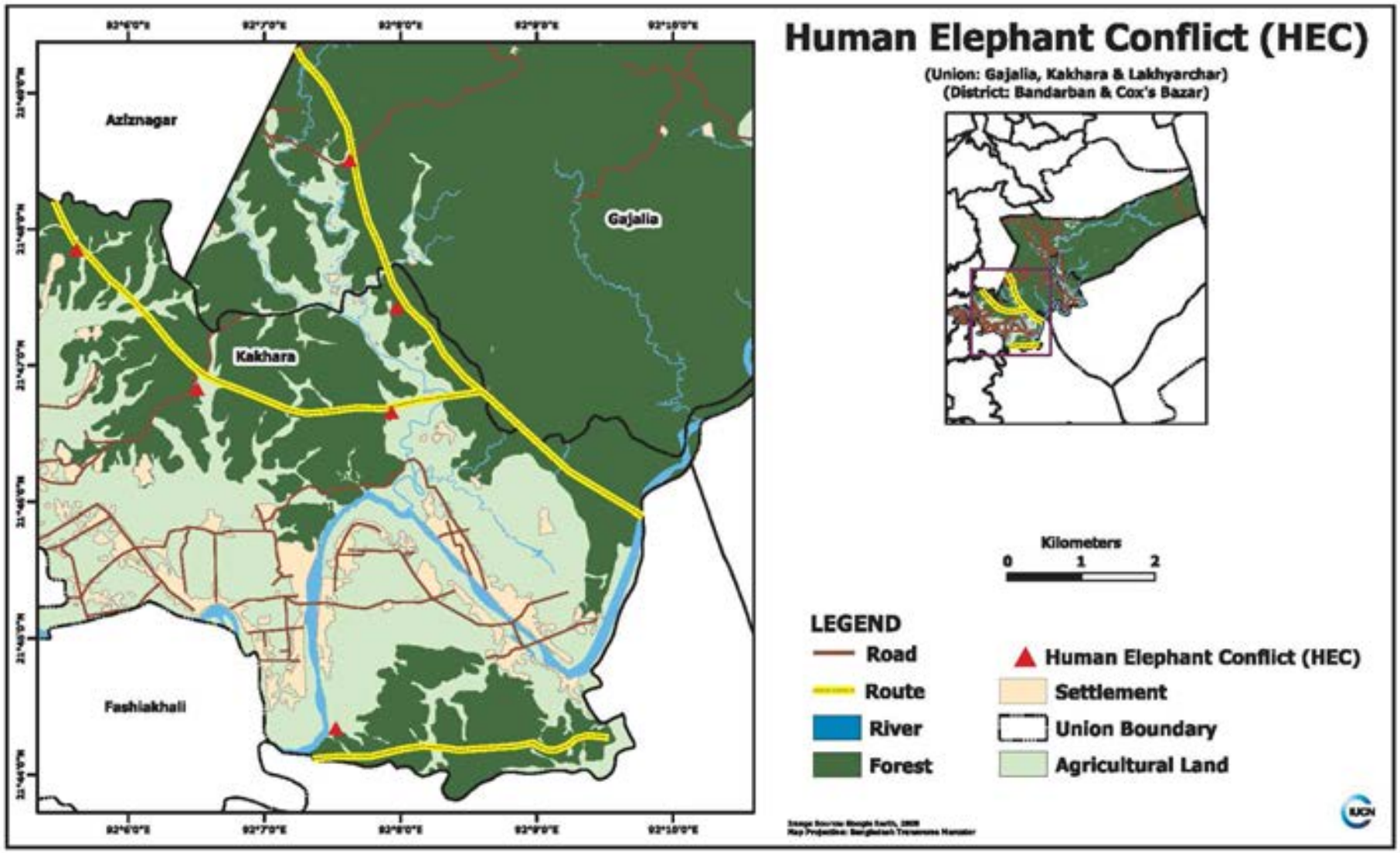
Map 4.10. Corridors of Asian elephant at Bashkhali



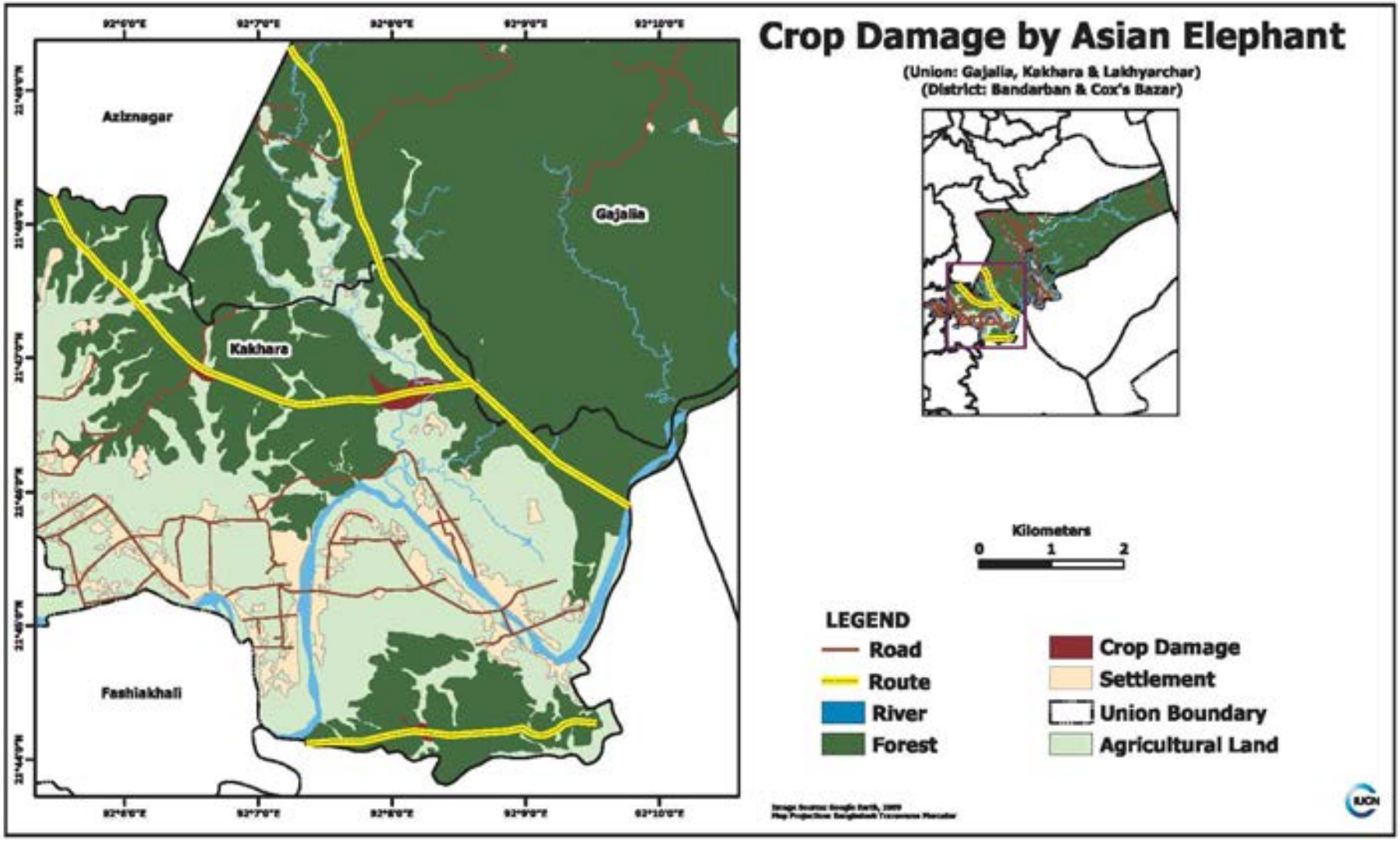
Map 4.11. Buffer area of corridor at Bashkhali



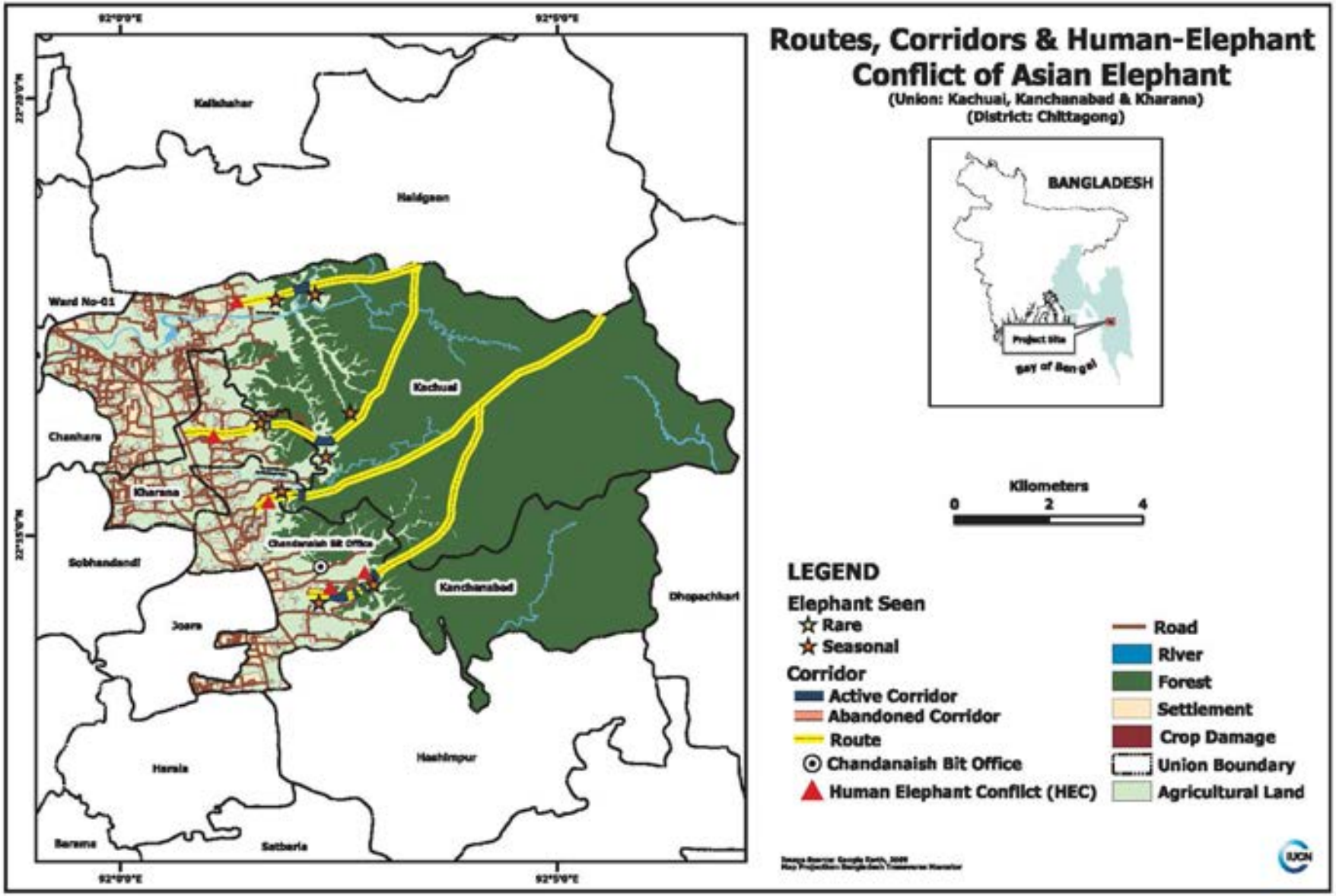
Map 4.12. Elephant seen at Bashkhali



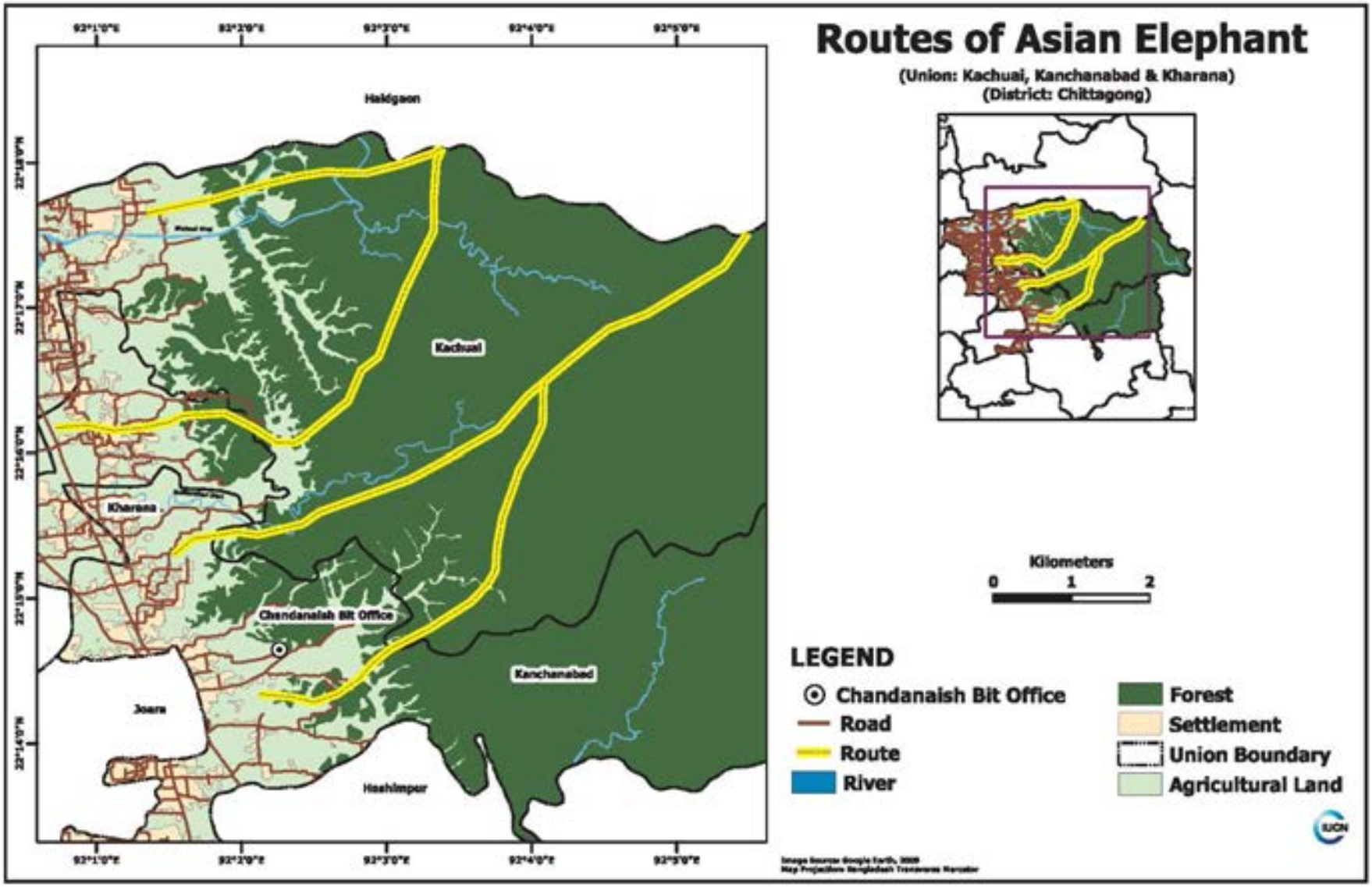
Map 4.13. Human elephant conflict at Bashkhali



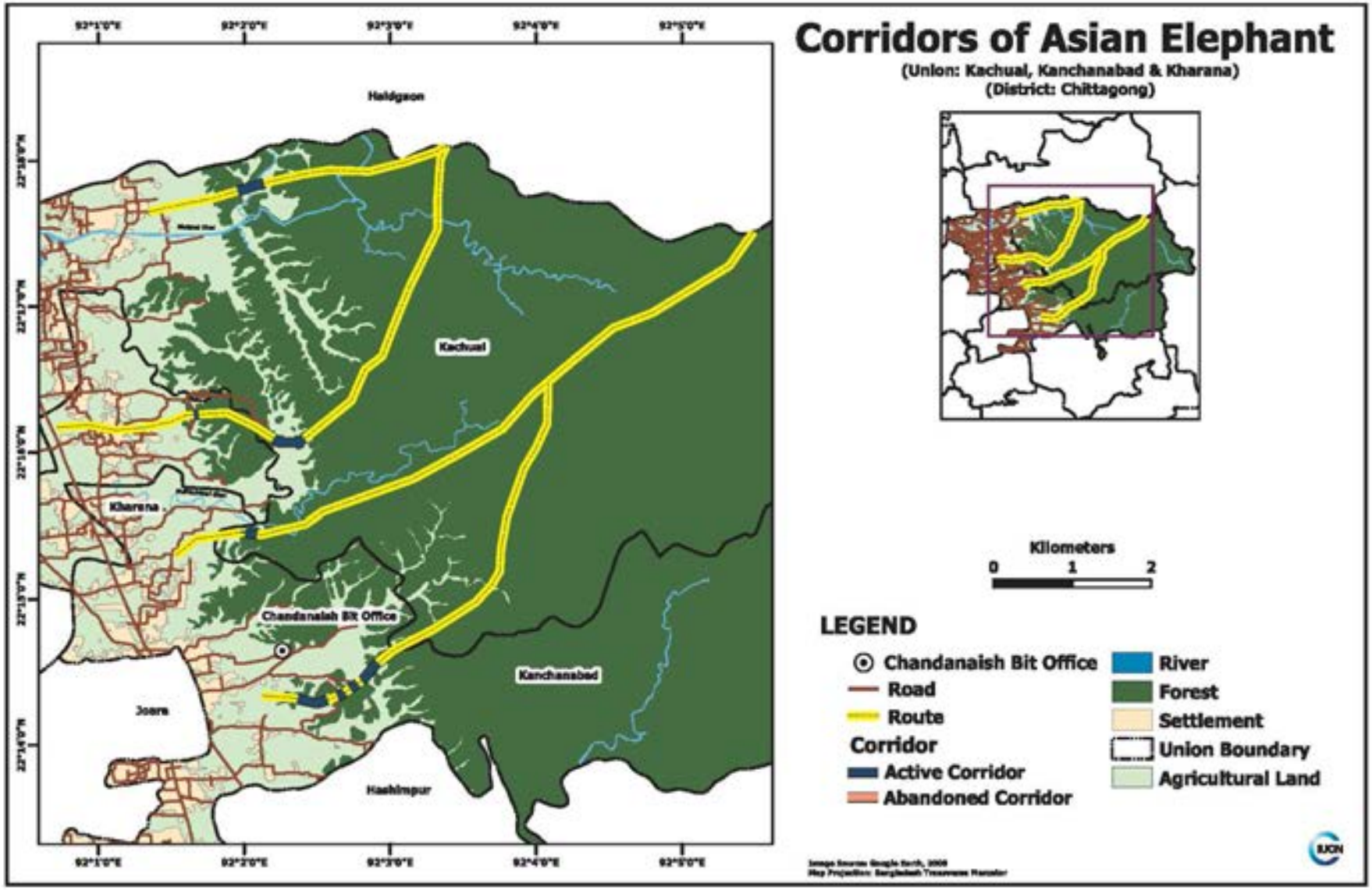
Map 4.14. Crop damage by elephant at Bashkhali



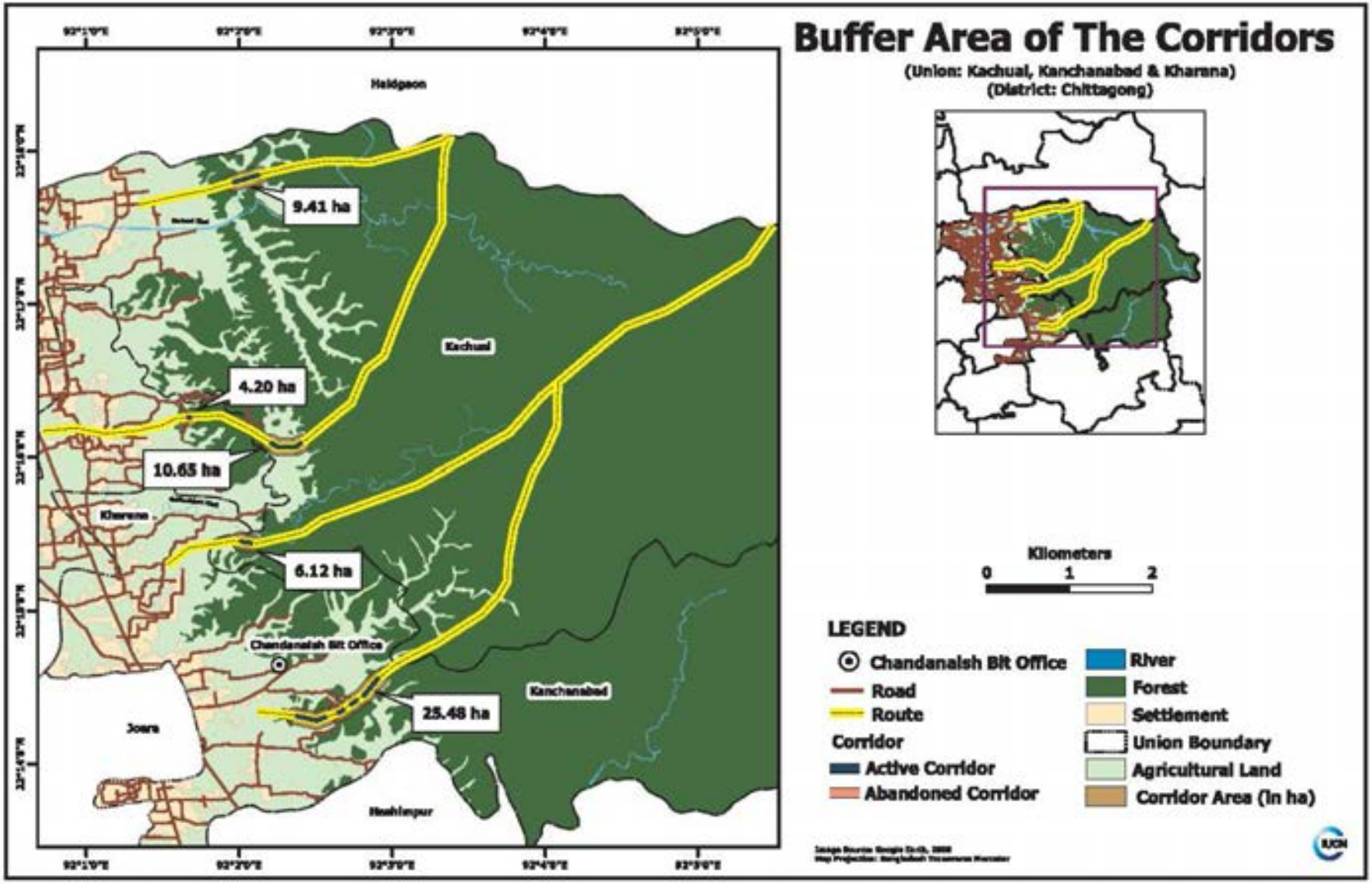
Map 4.15. Base map of Asian elephant at Chandanaish



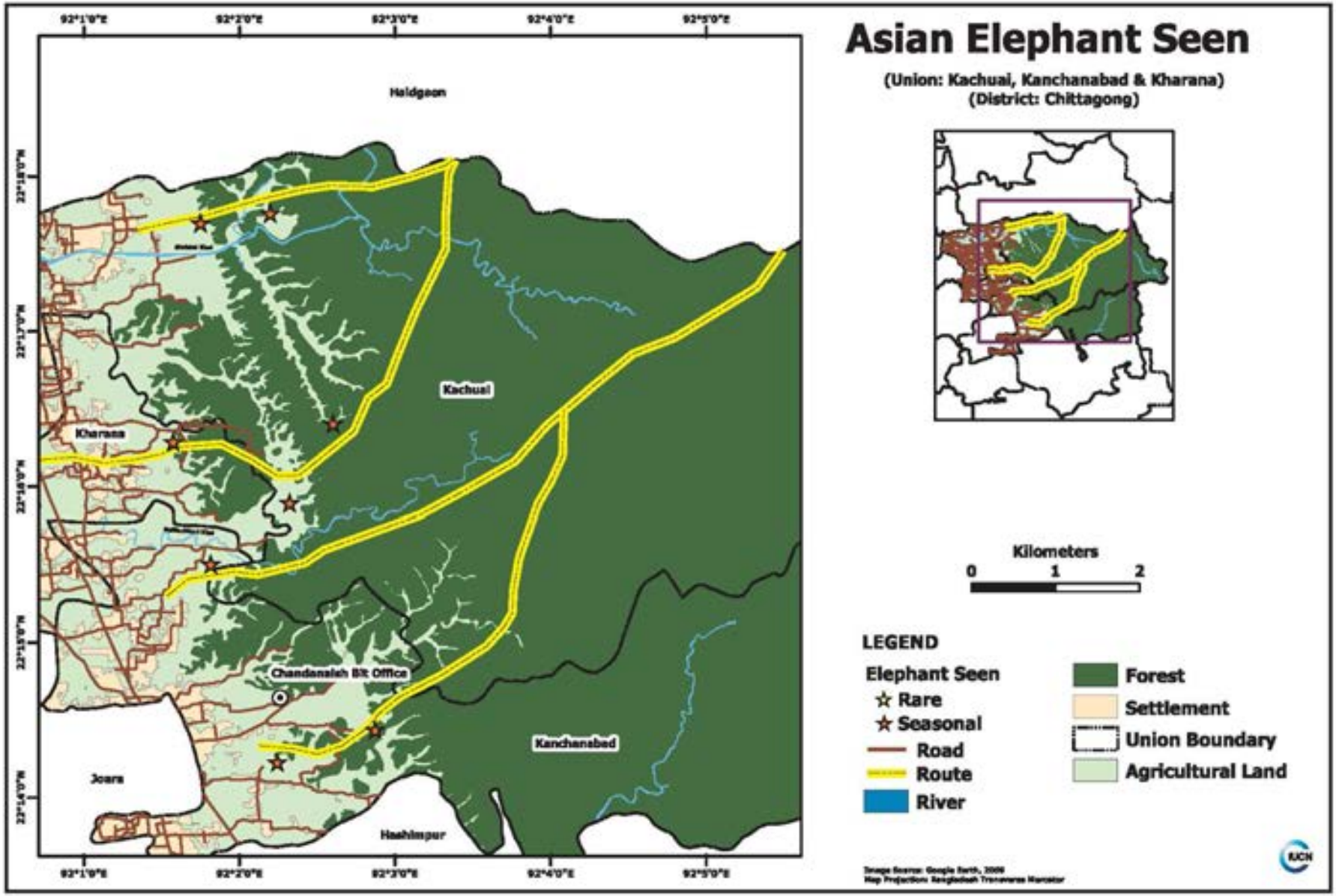
Map 4.16. Routes of Asian elephant at Chandanaish



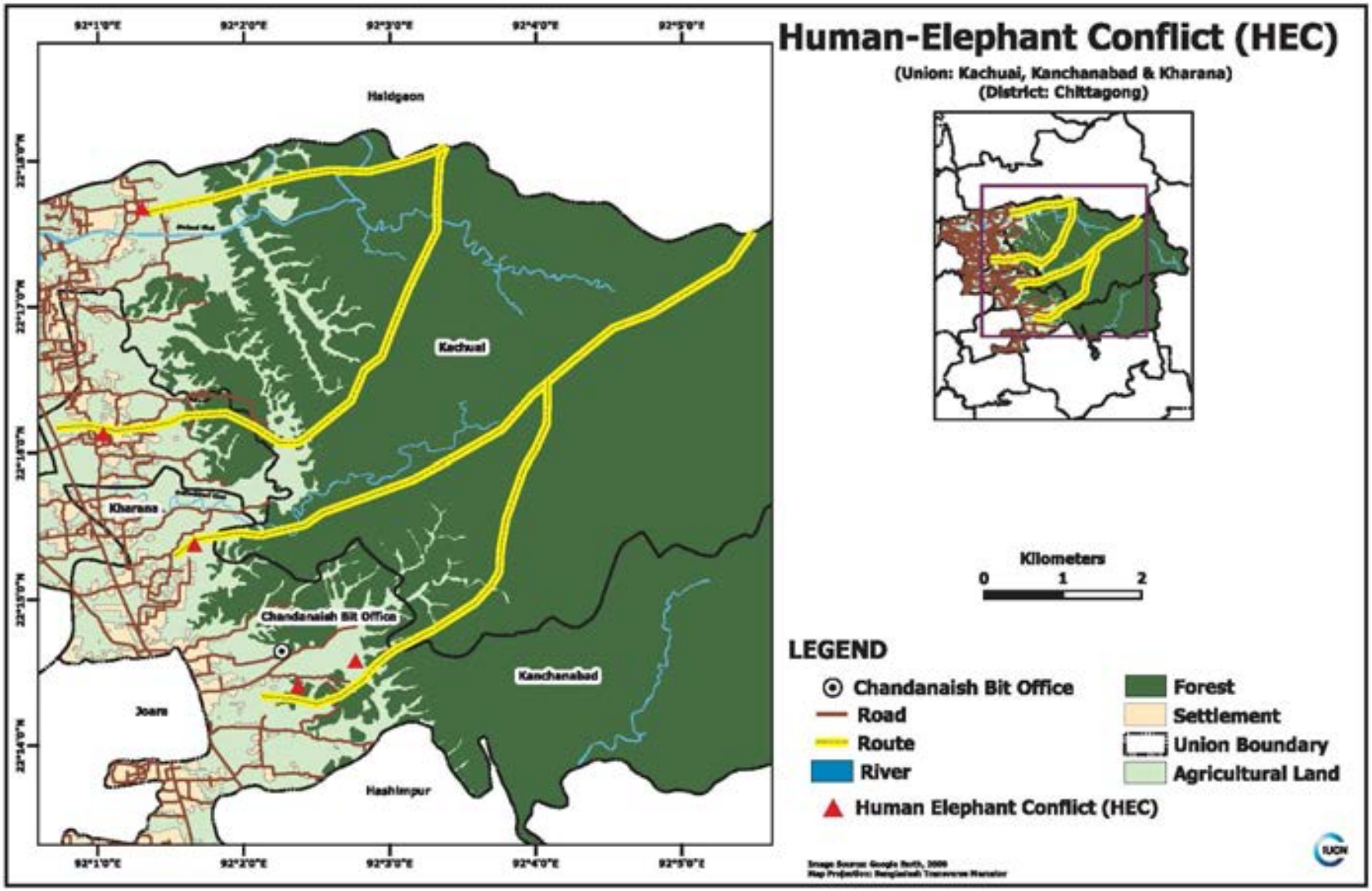
Map 4.17. Corridors of Asian elephant at Chandanaish



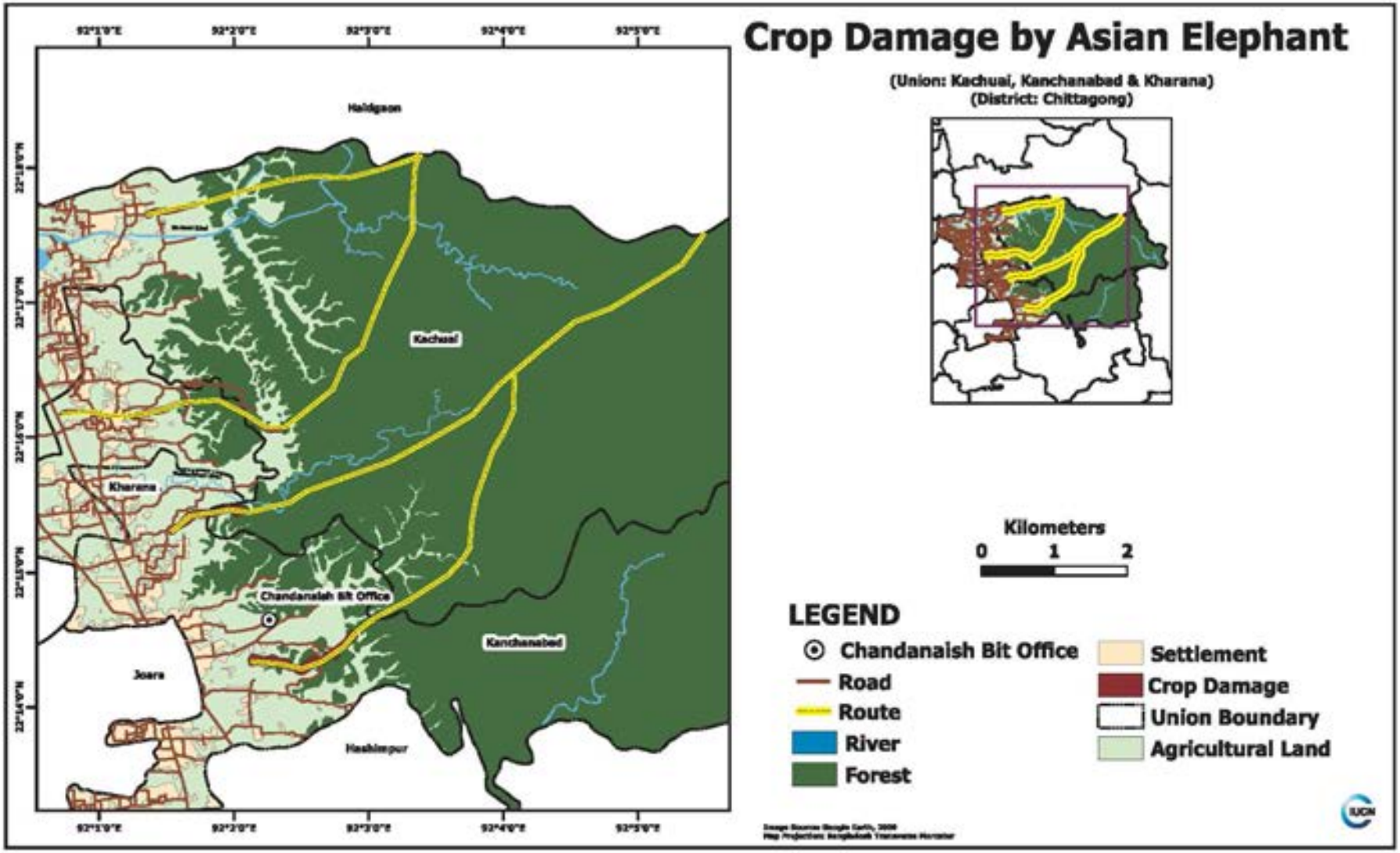
Map 4.18. Buffer area of corridor at Chandanaish



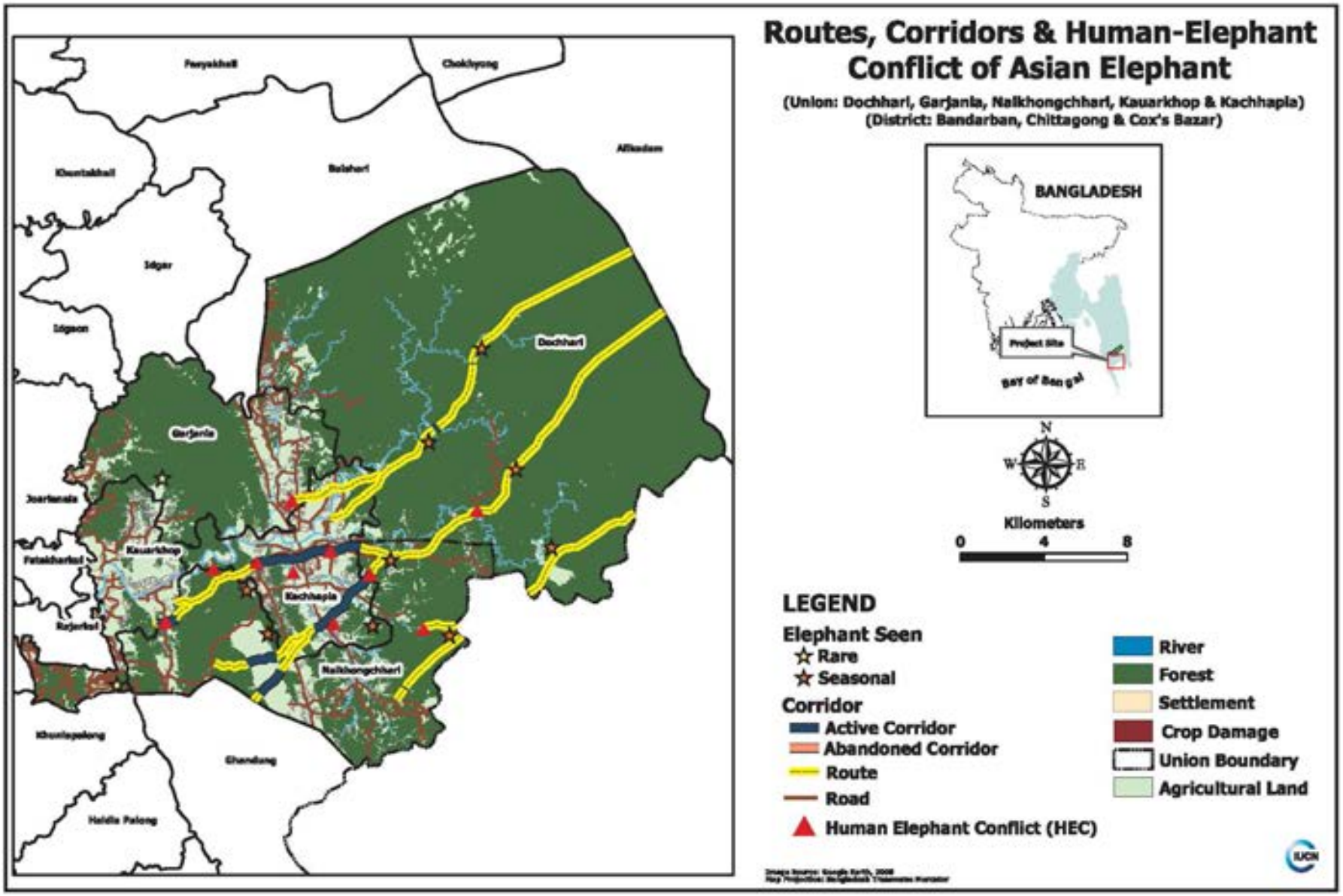
Map 4.19. Elephant seen at Chandanaish



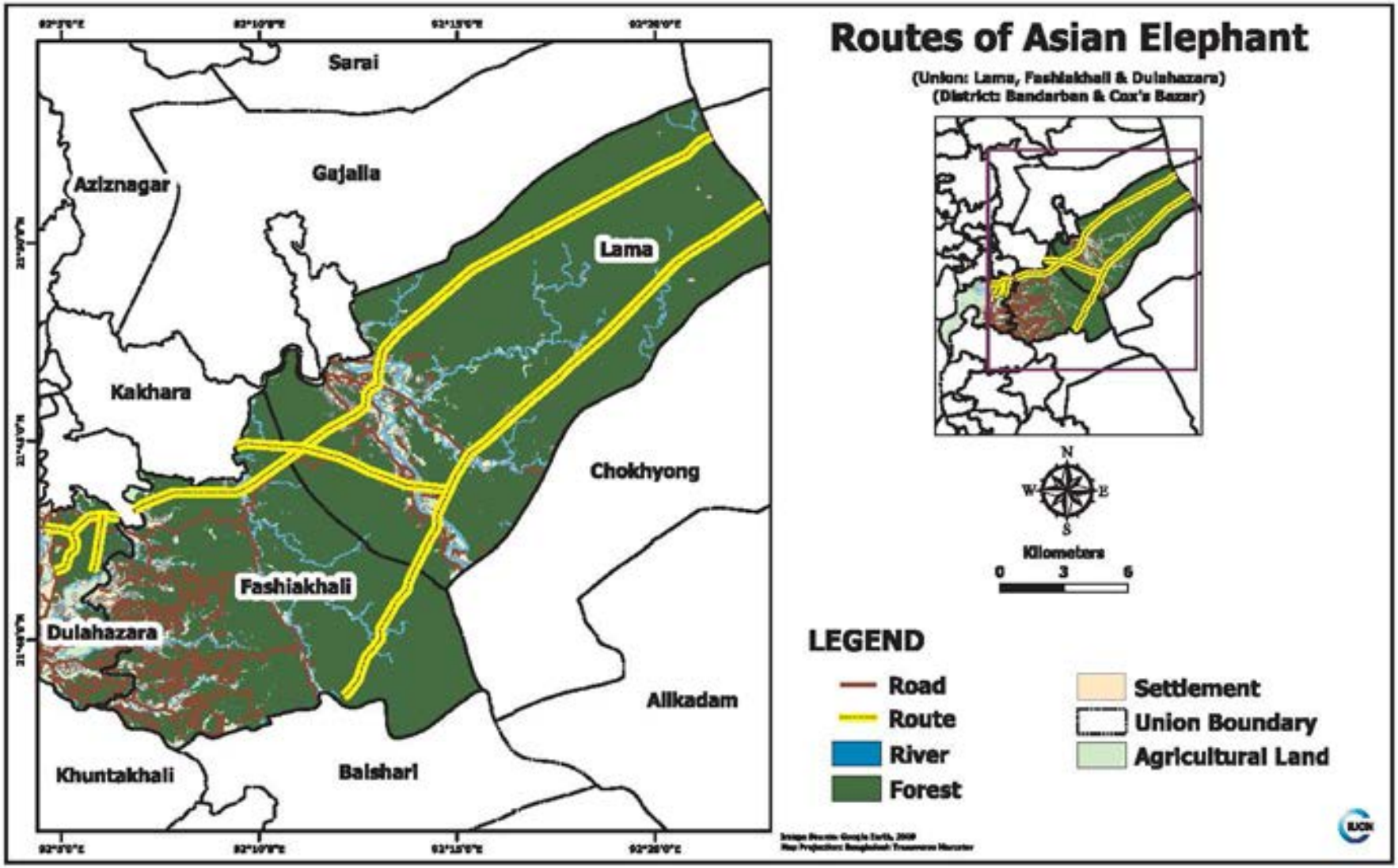
Map 4.20. Human elephant conflict at Chandanaish



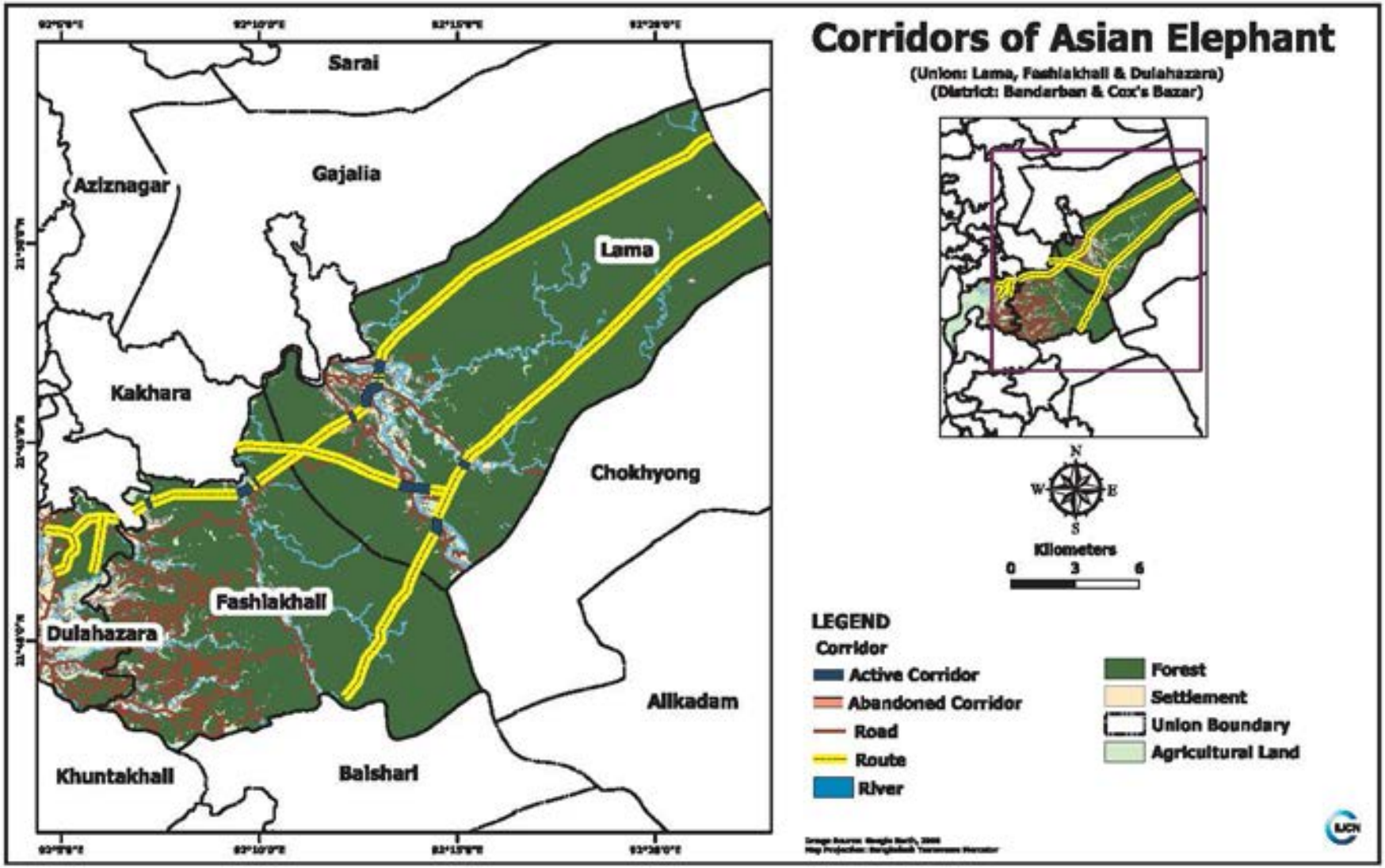
Map 4.21. Crop damage by elephant at Chandanaish



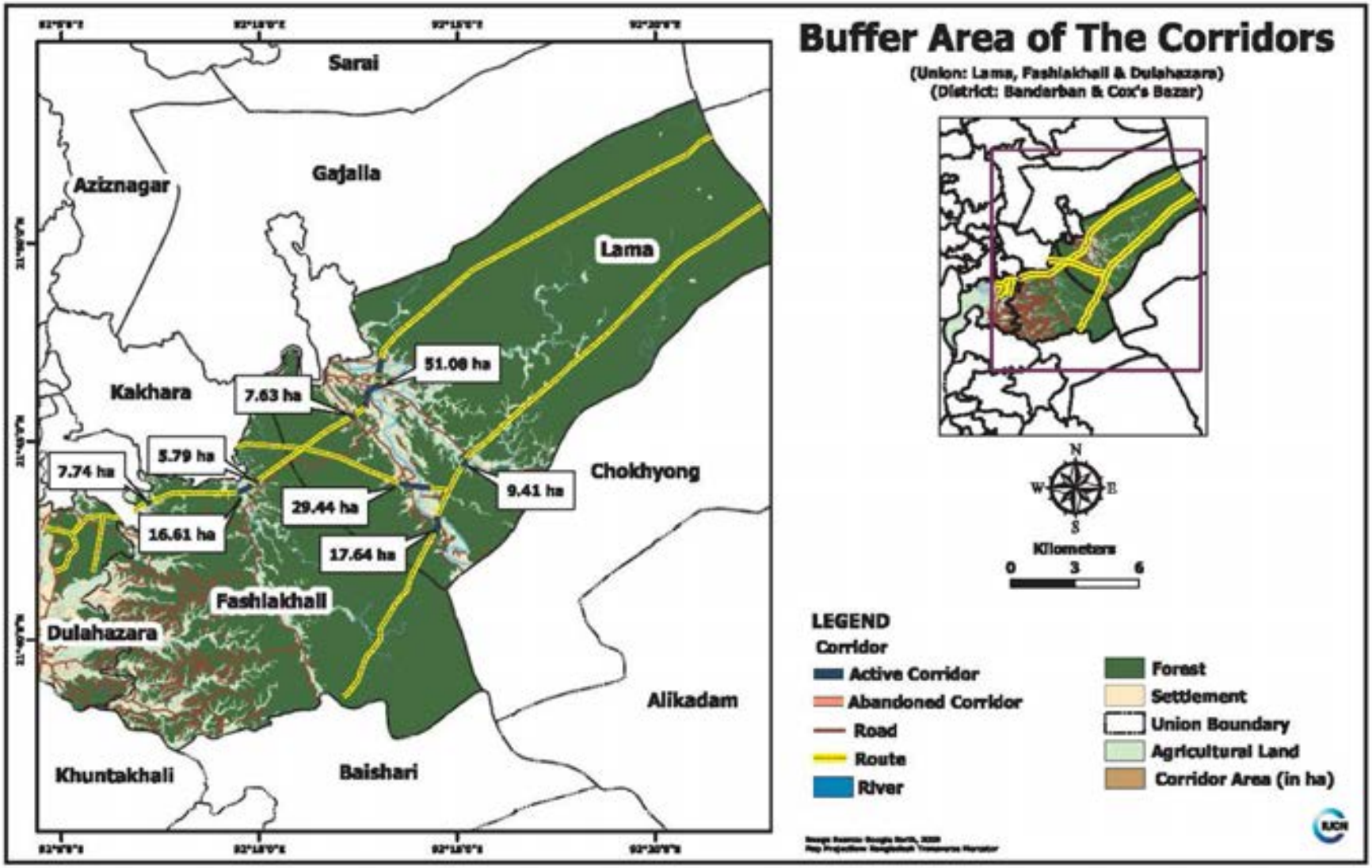
Map 4.22. Base map of Asian elephant at Fashiakhali



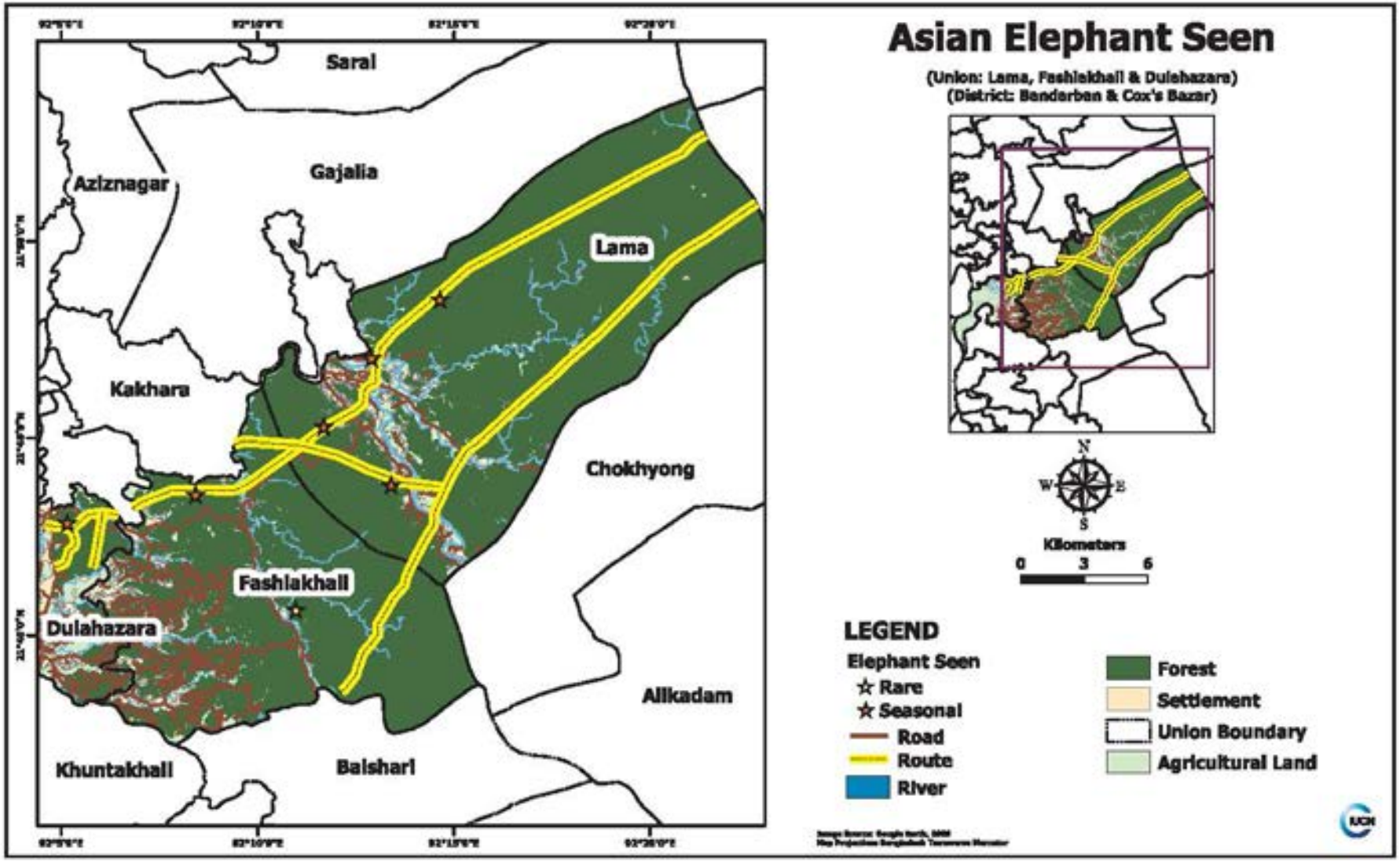
Map 4.23. Routes of Asian elephant at Fashiakhali



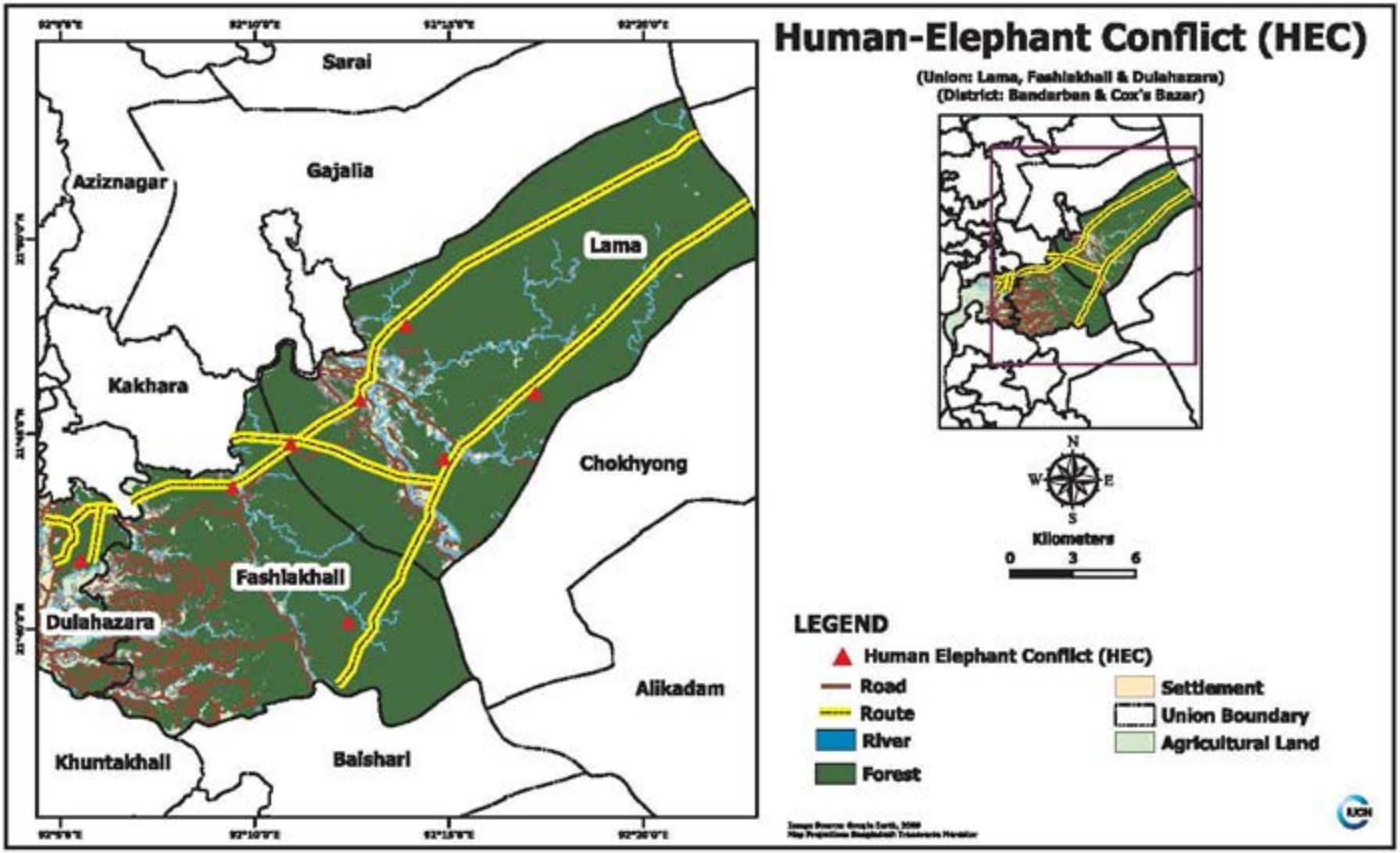
Map 4.24. Corridors of Asian elephant at Fashiakhali



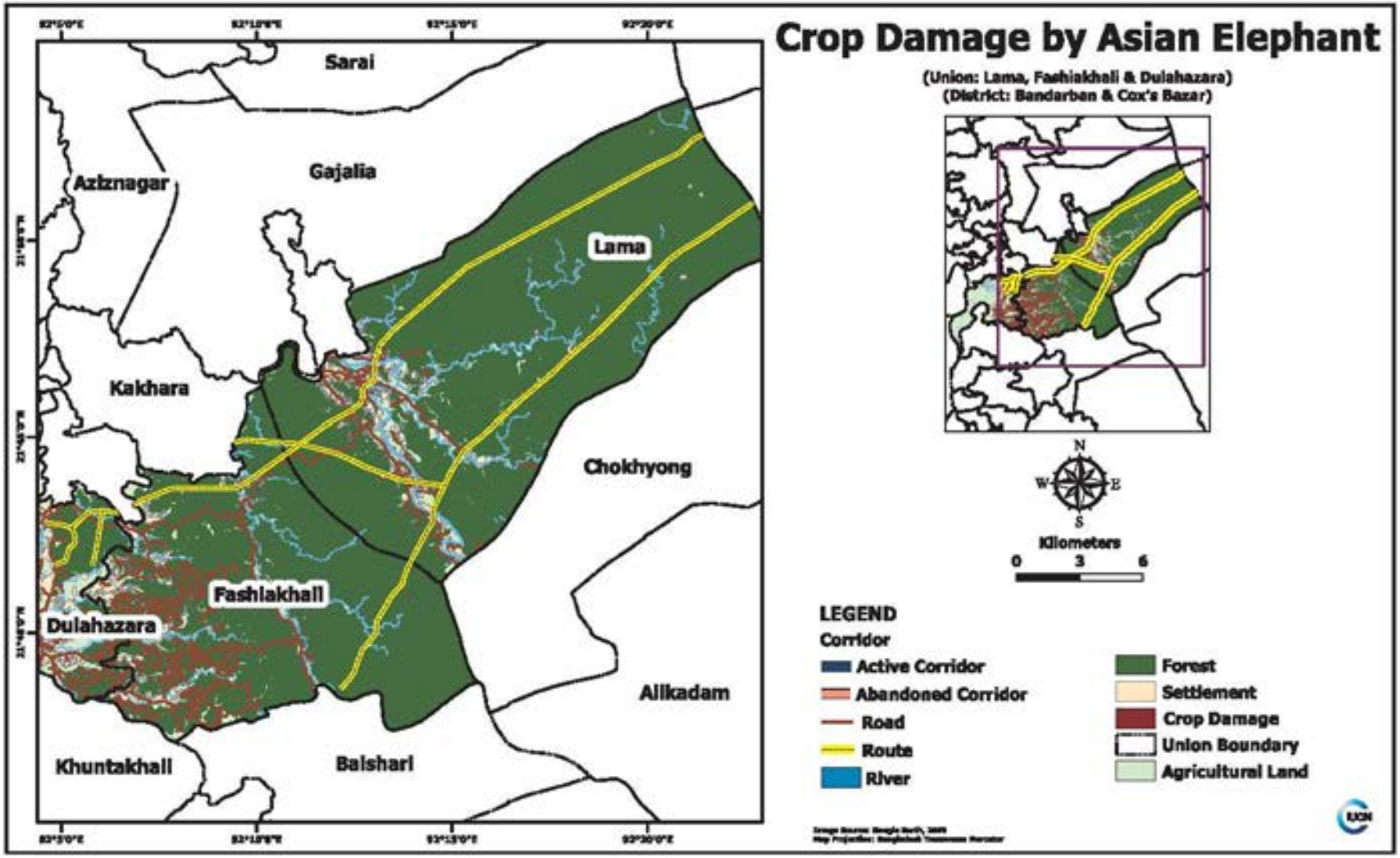
Map 4.25. Buffer area of corridor at Fashiakhali



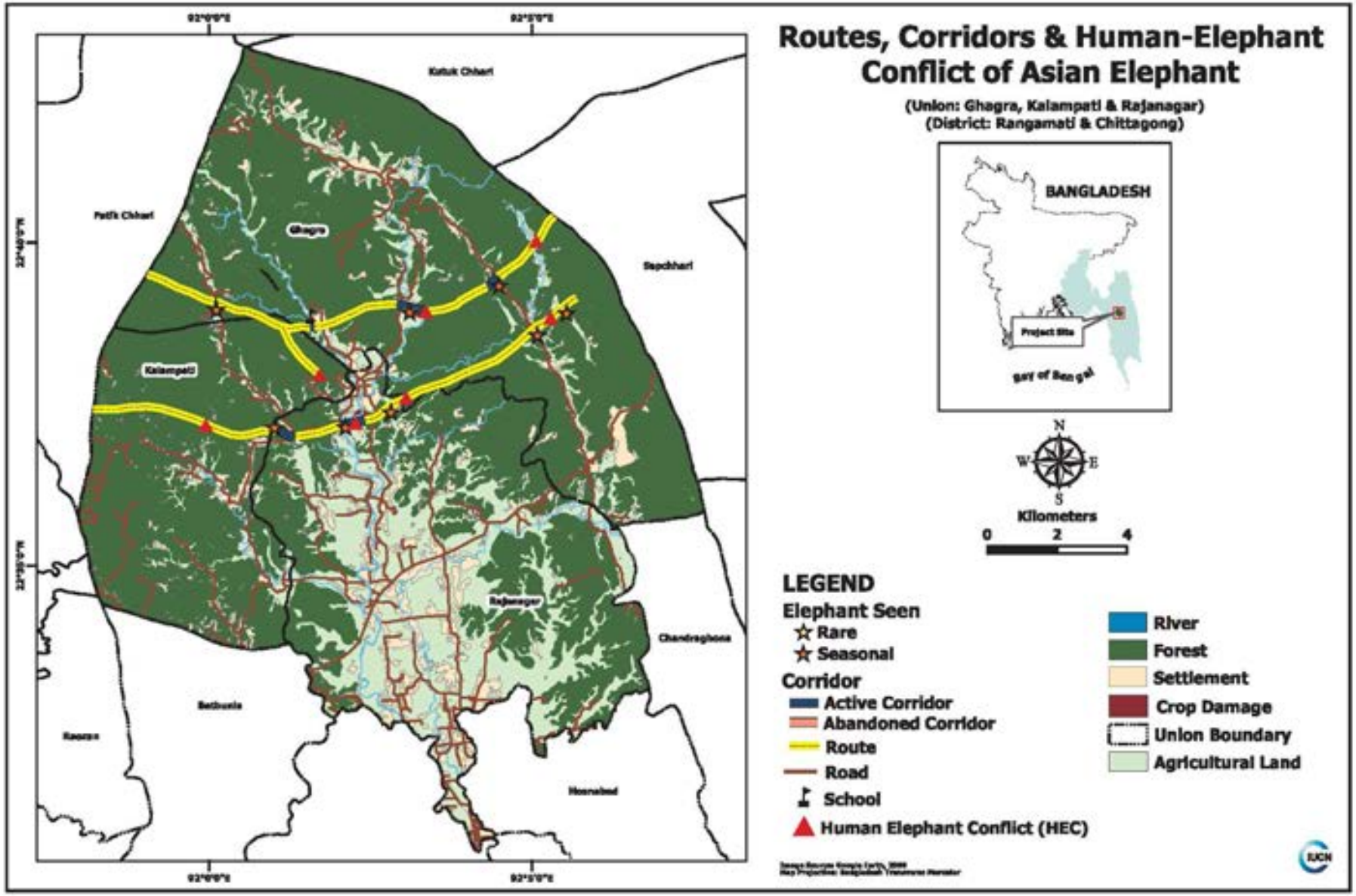
Map 4.26. Elephant seen at Fashiakhali



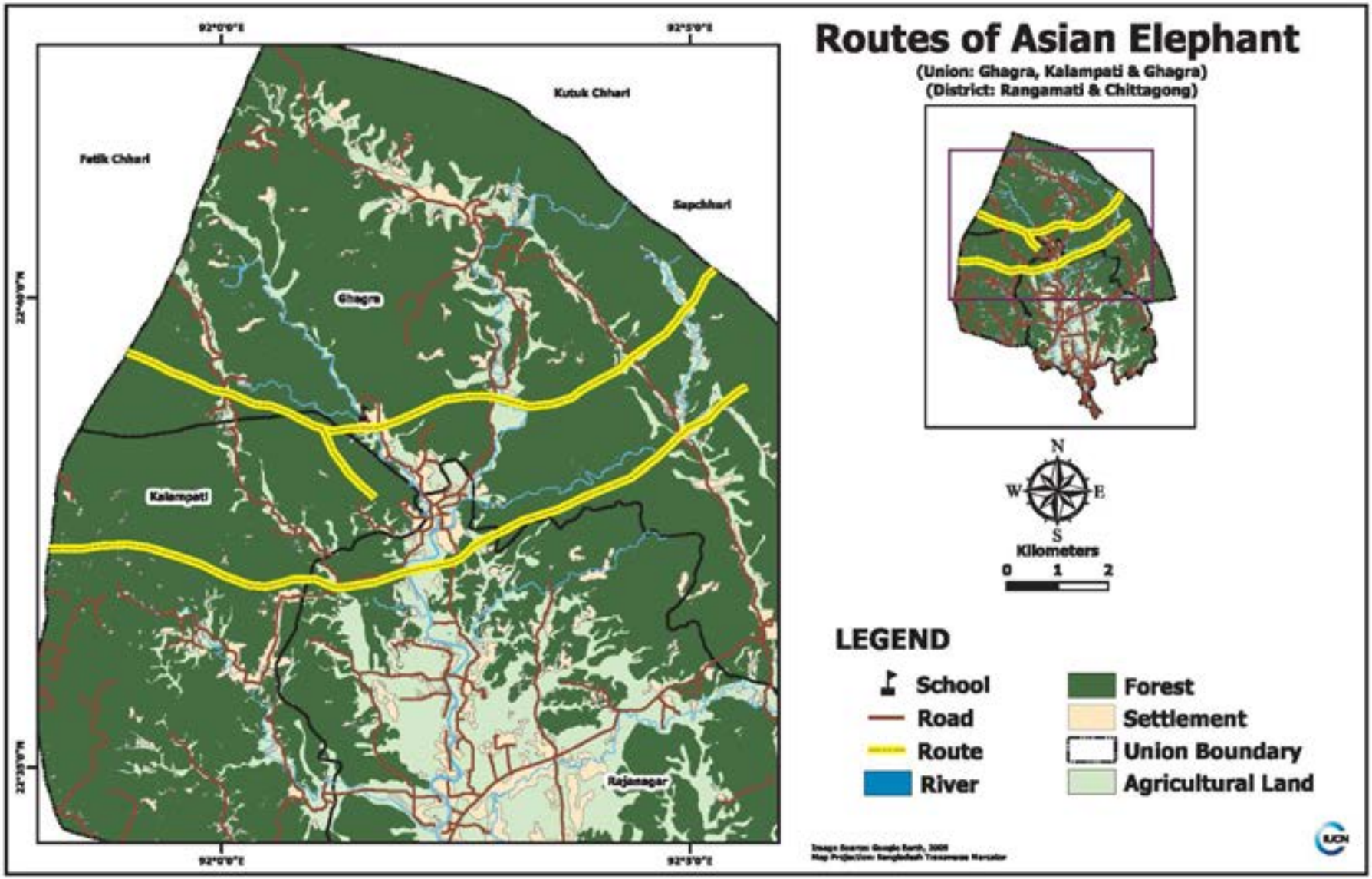
Map 4.27. Human elephant conflict at Fashiakhali



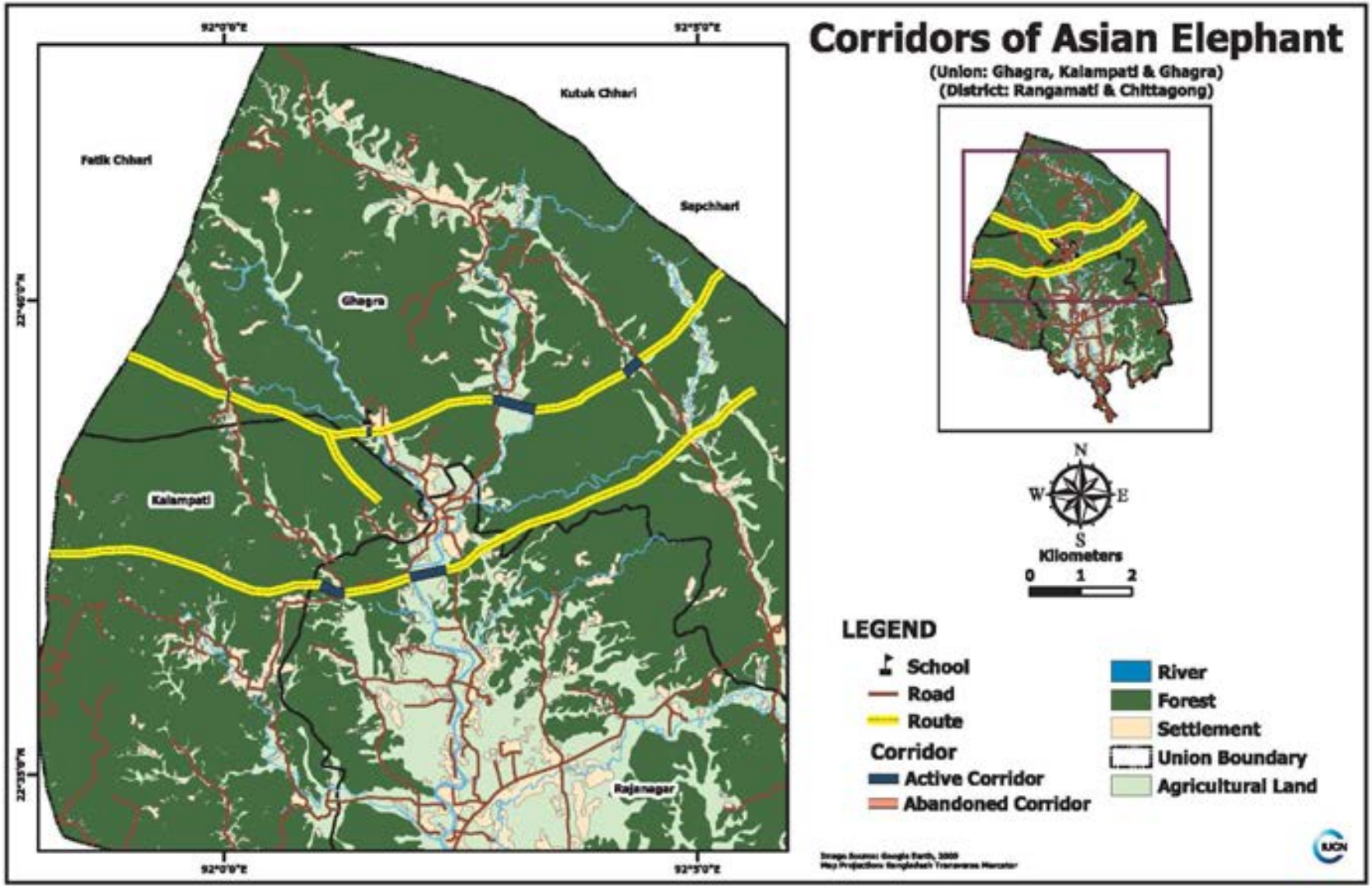
Map 4.28. Crop damage by elephant at Fashiakhali



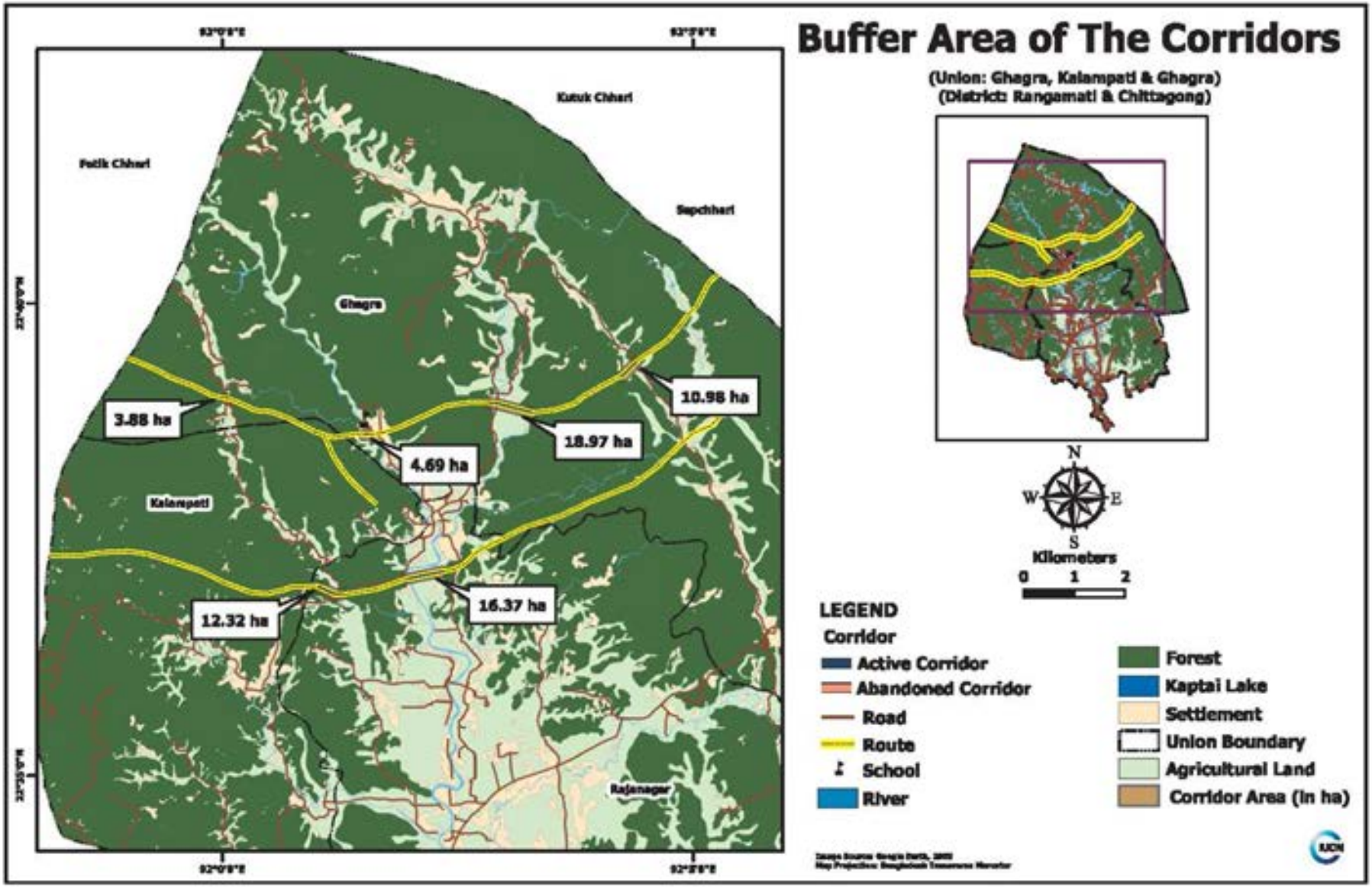
Map 4.29. Base map of Asian elephant at Kaukhali



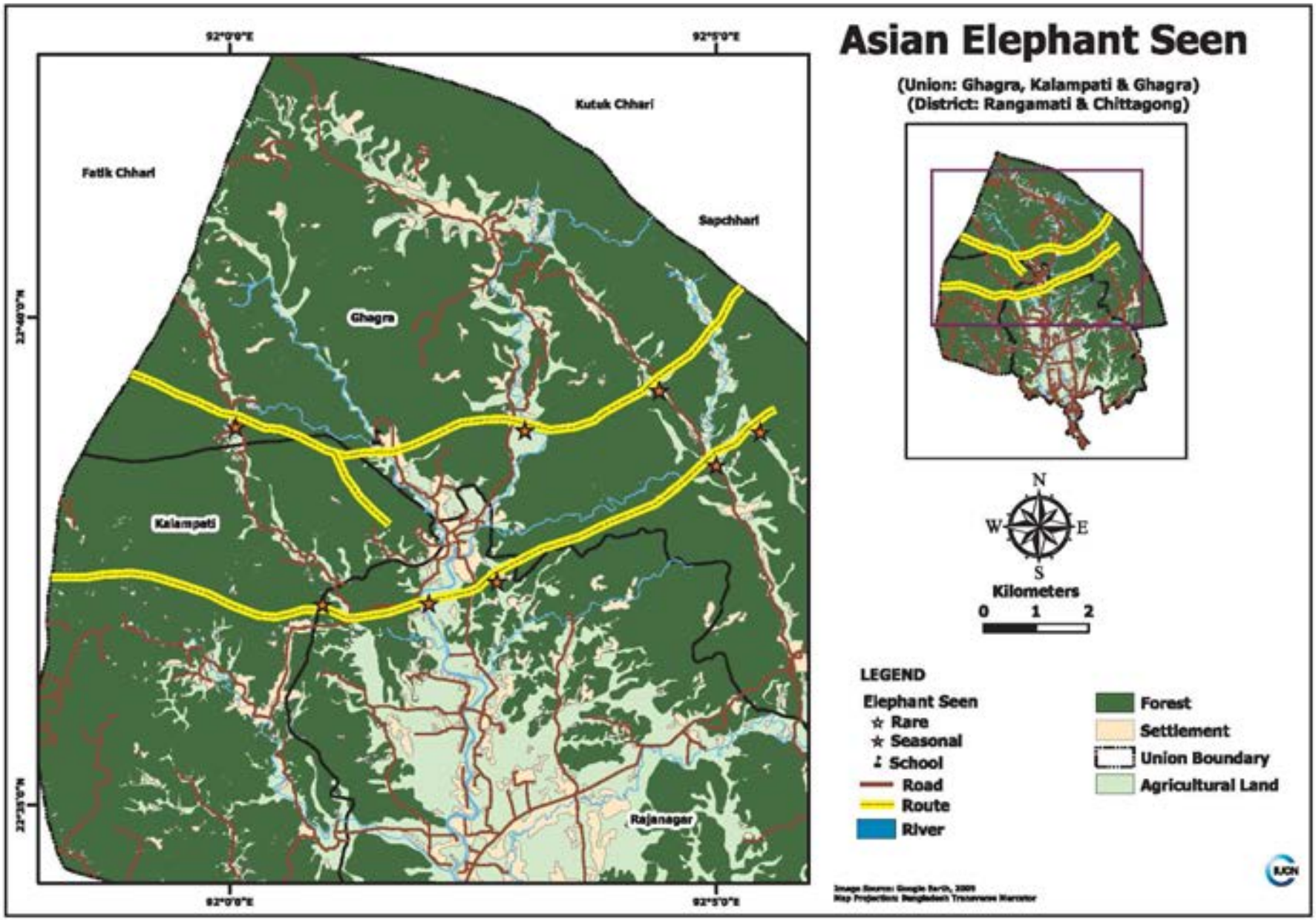
Map 4.30. Routes of Asian elephant at Kaukhali



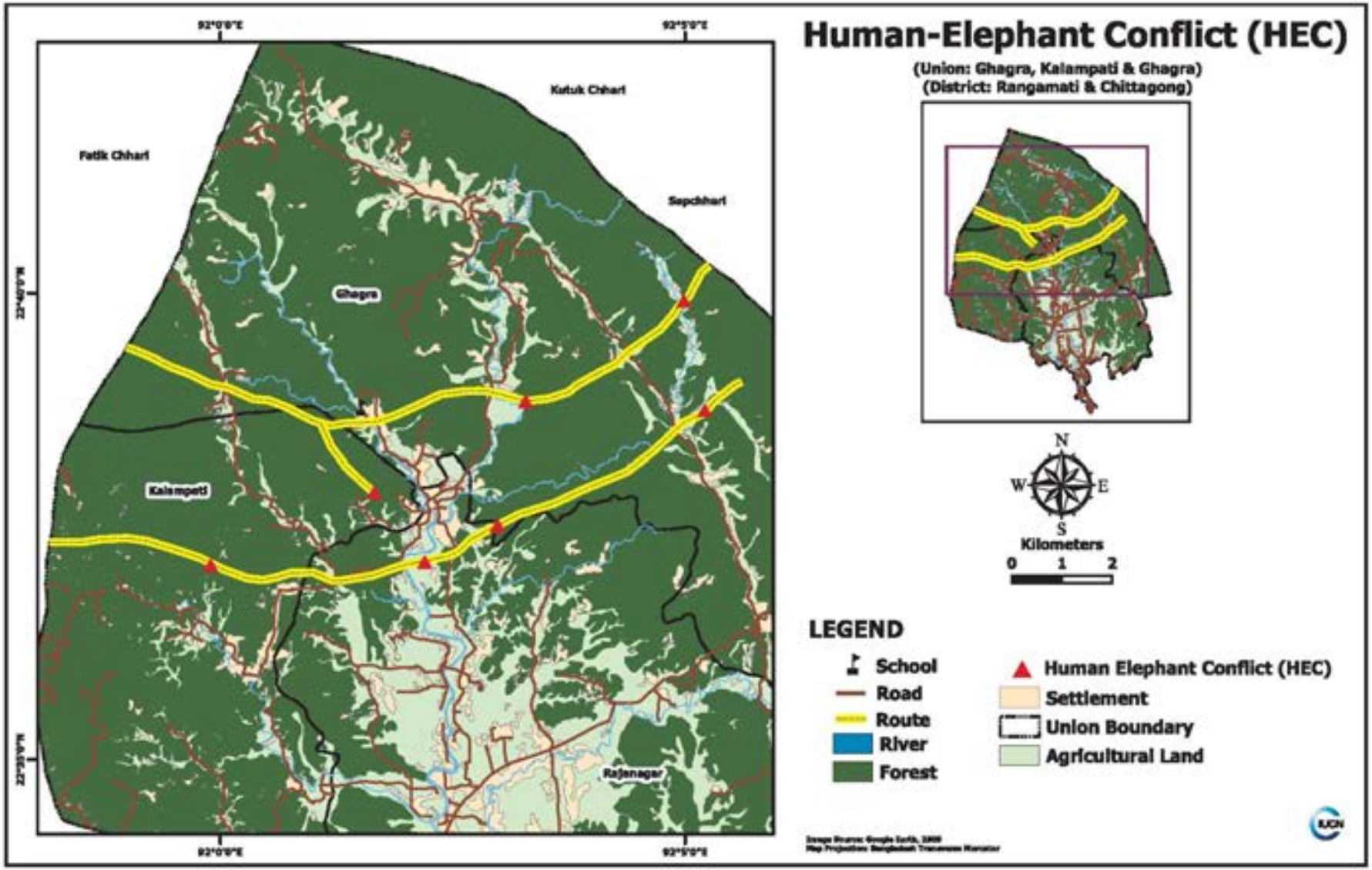
Map 4.31. Corridors of Asian elephant at Kaukhali



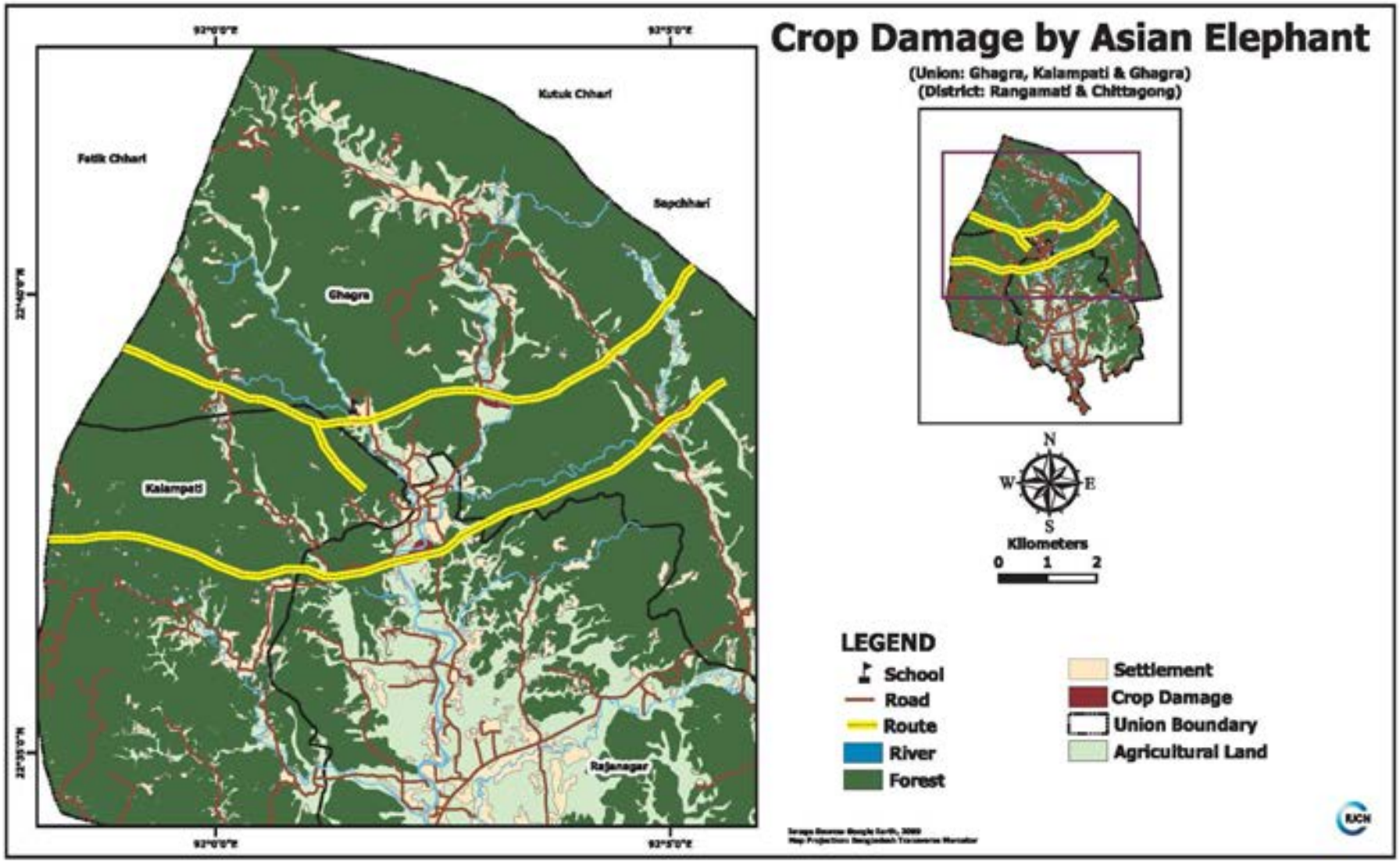
Map 4.32. Buffer area of corridor at Kaukhali



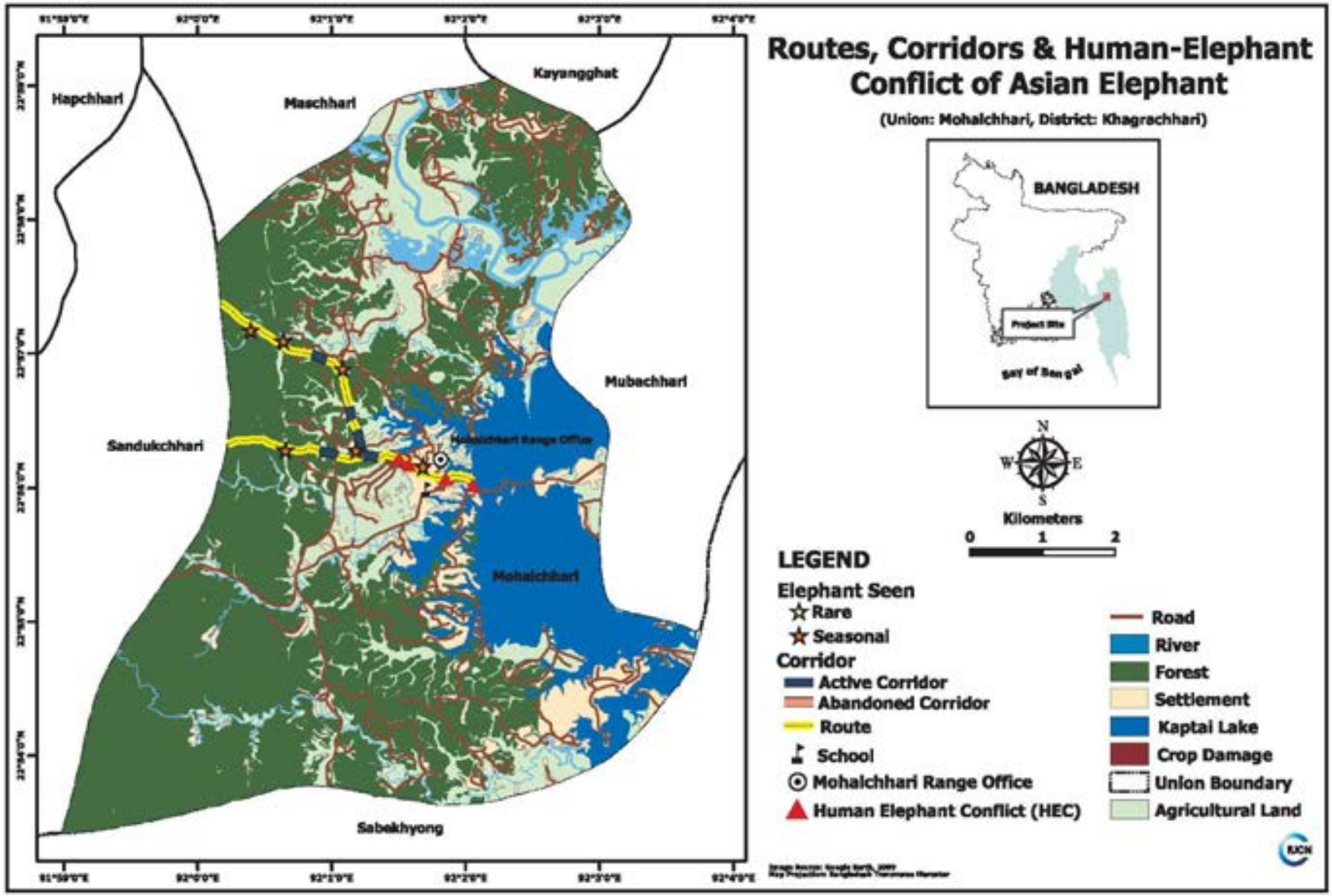
Map 4.33. Elephant seen at Kaukhali



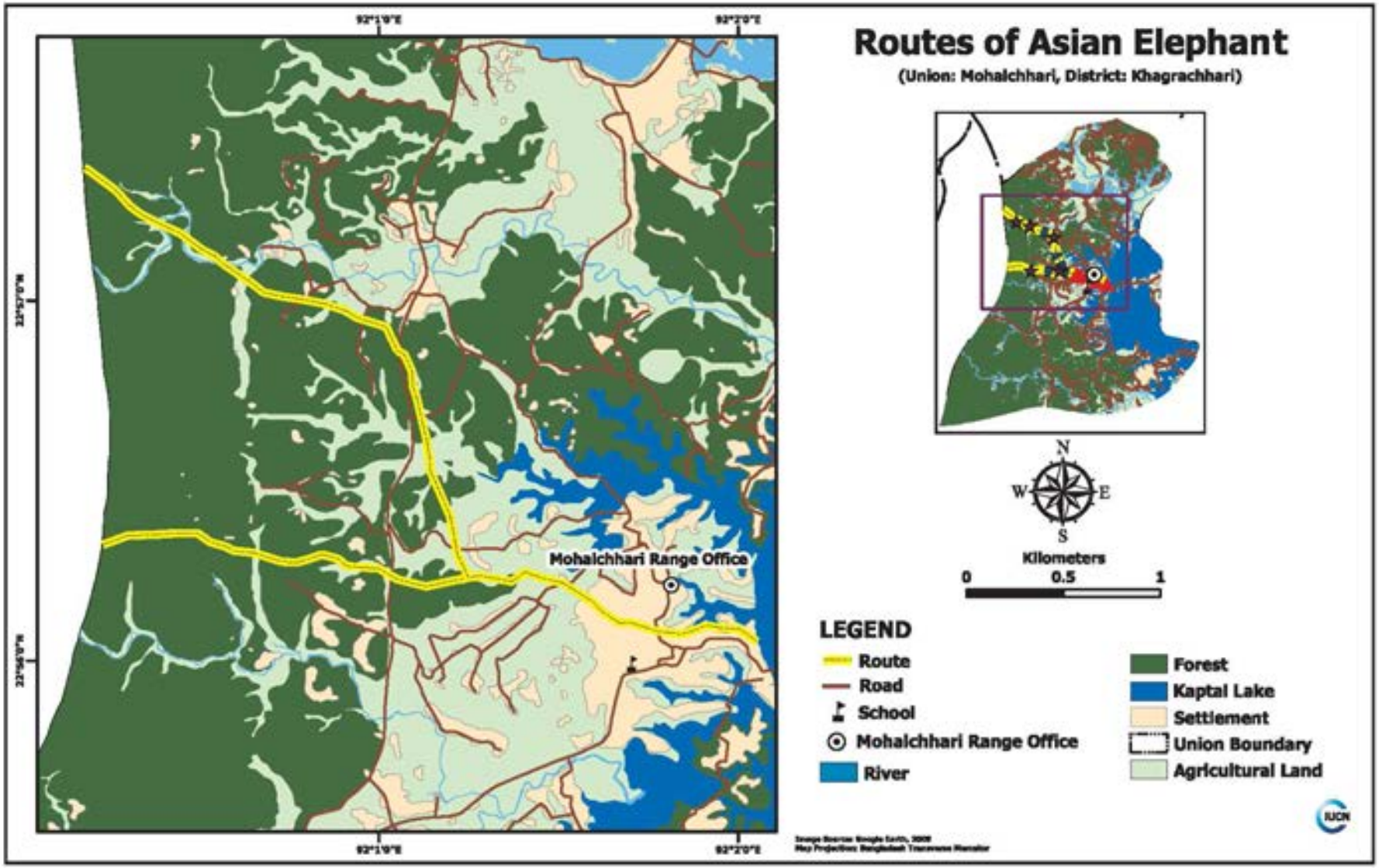
Map 4.34. Human elephant conflict at Kaukhali



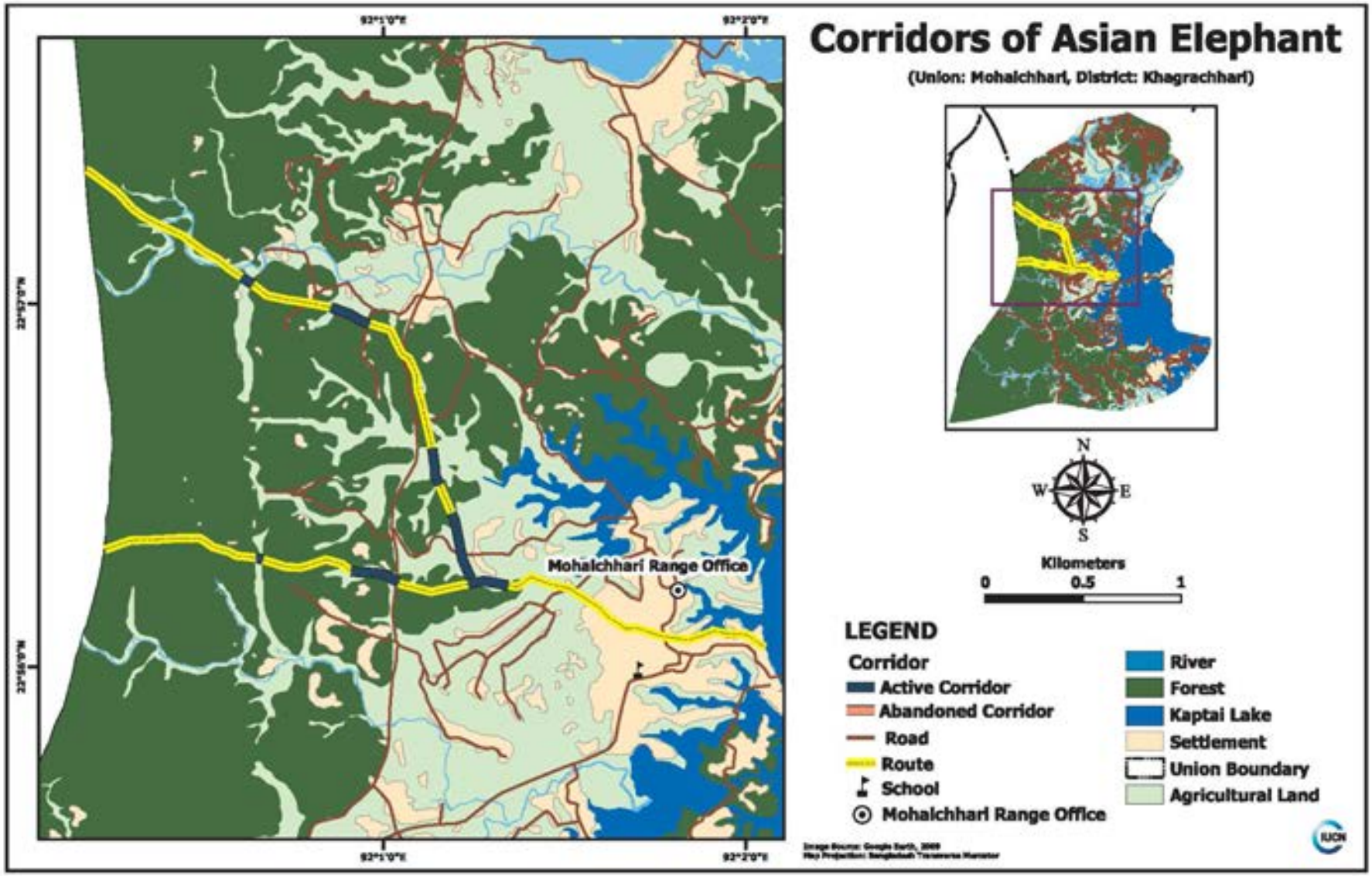
Map 4.35. Crop damage by elephant at Kaukhali



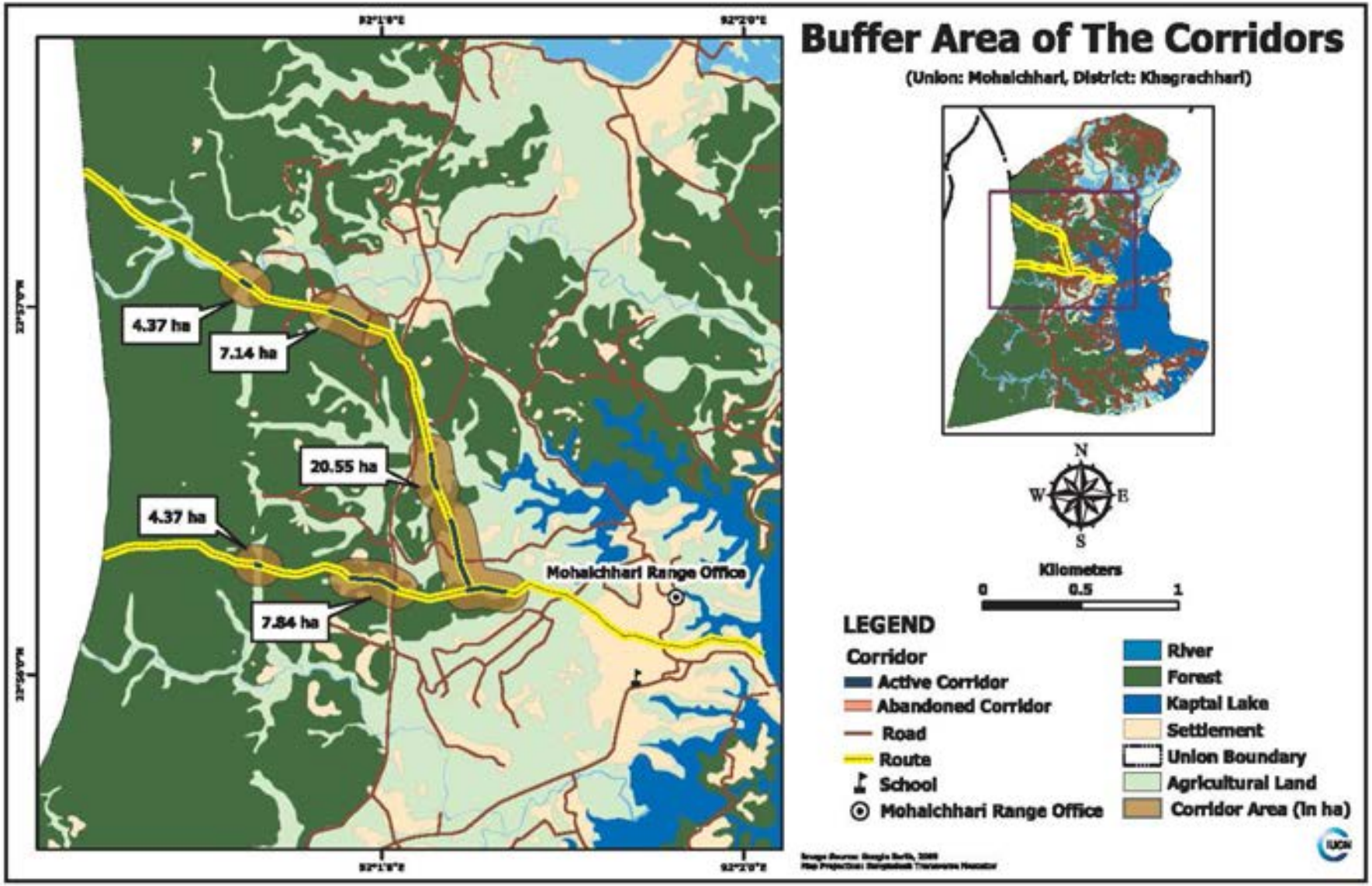
Map 4.36. Base map of Asian elephant at Mohalchhari



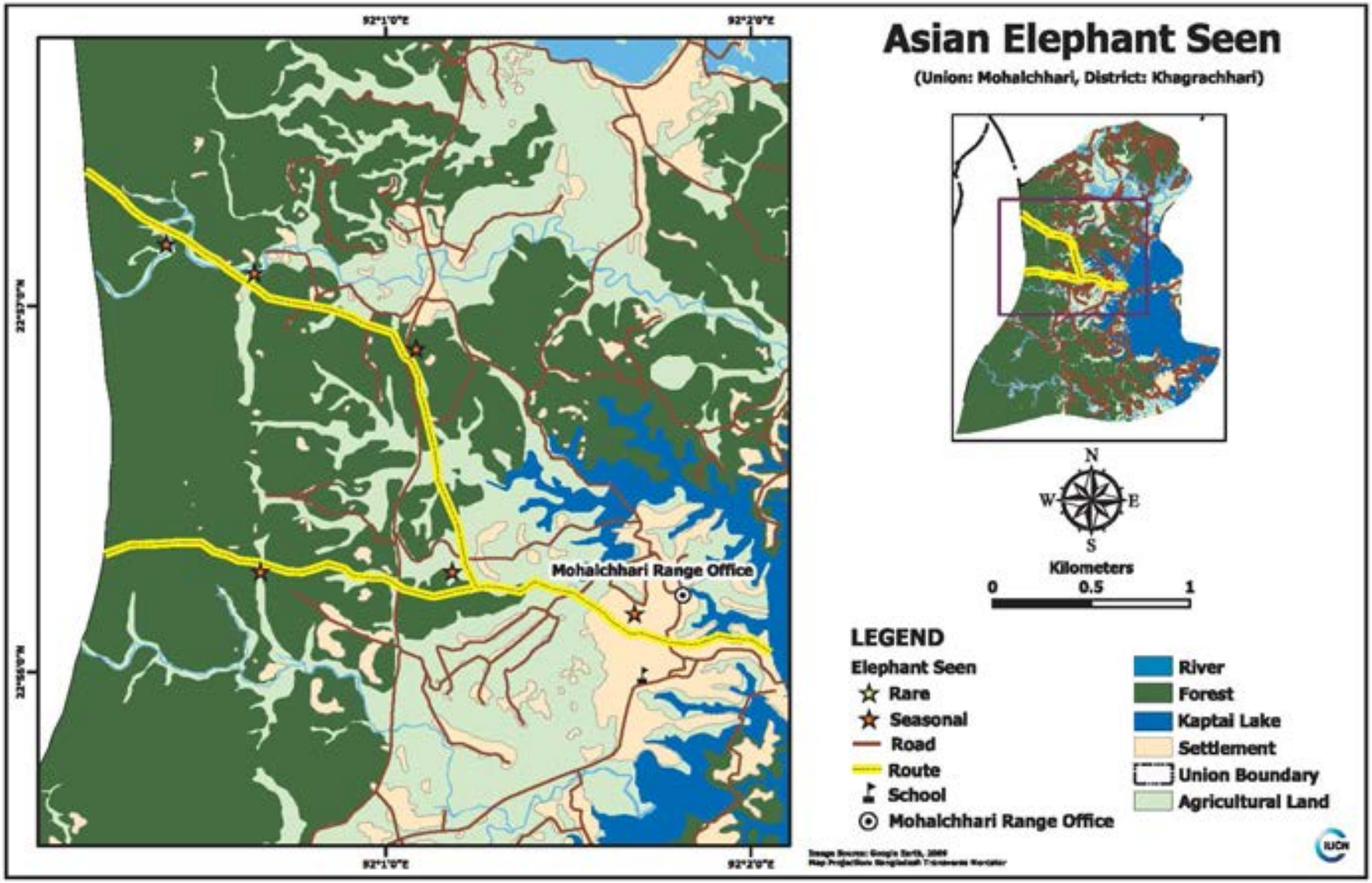
Map 4.37. Routes of Asian elephant at Mohalchhari



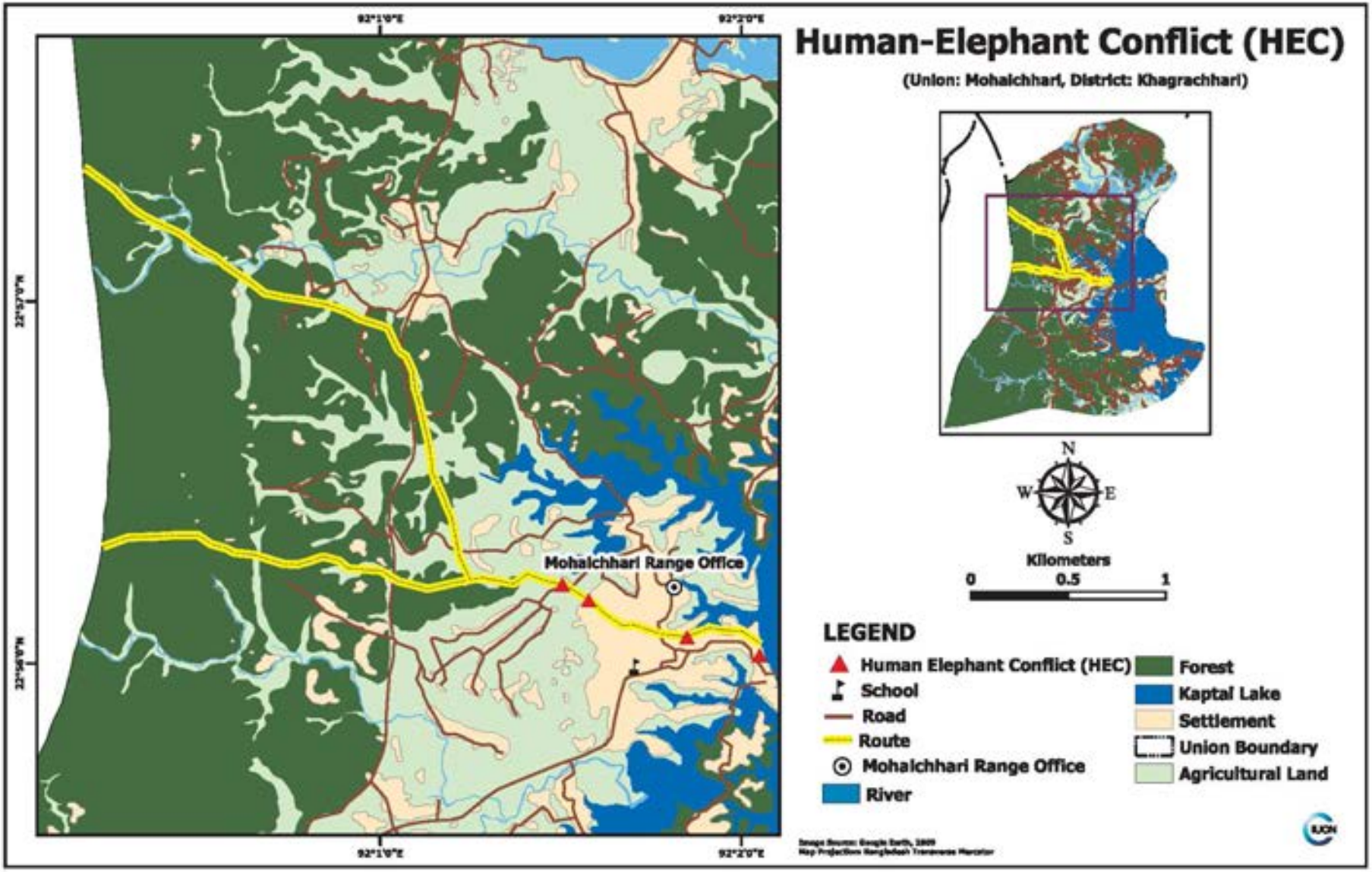
Map 4.38. Corridors of Asian elephant at Mohalchhari



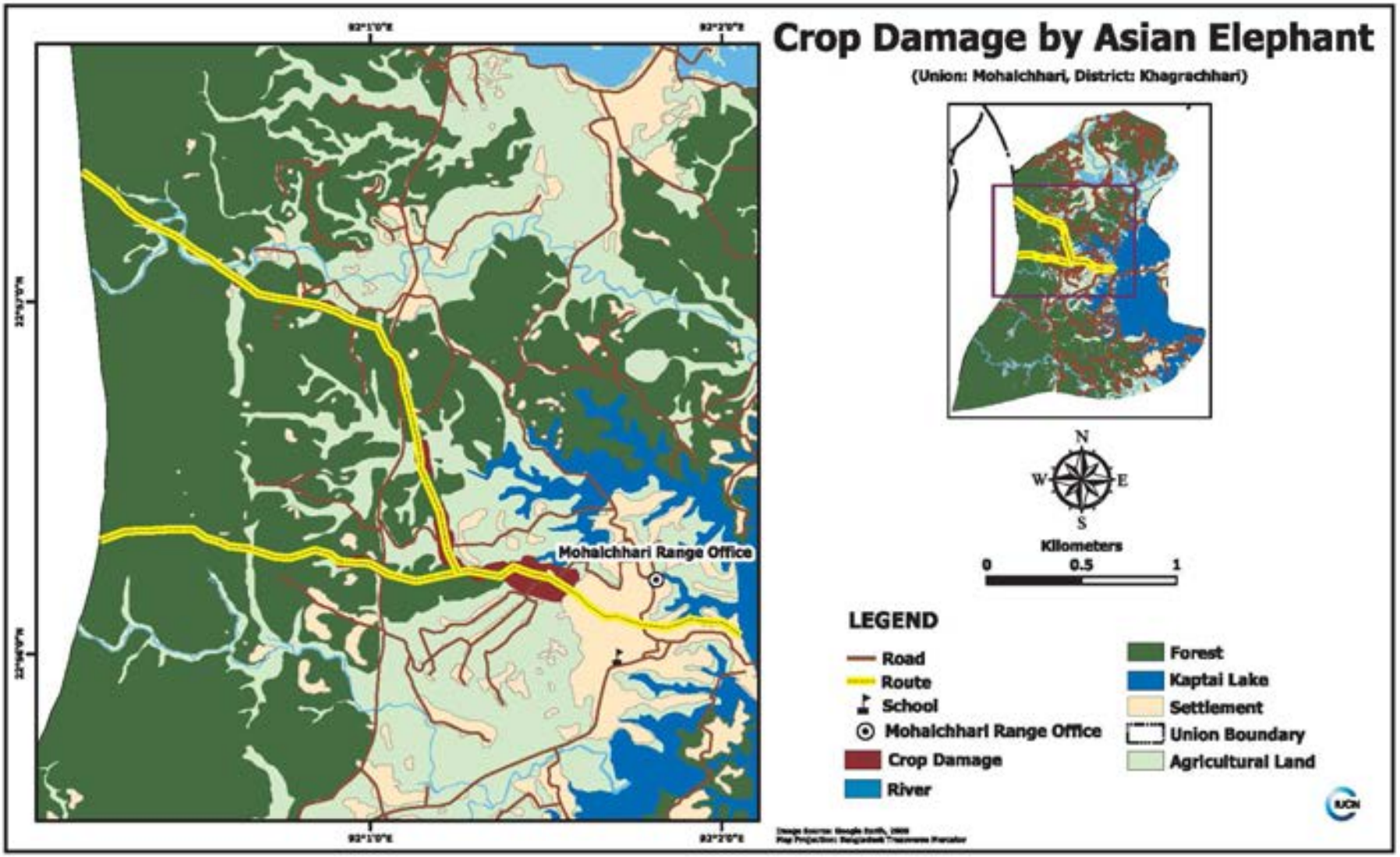
Map 4.39. Buffer area of corridor at Mohalchhari



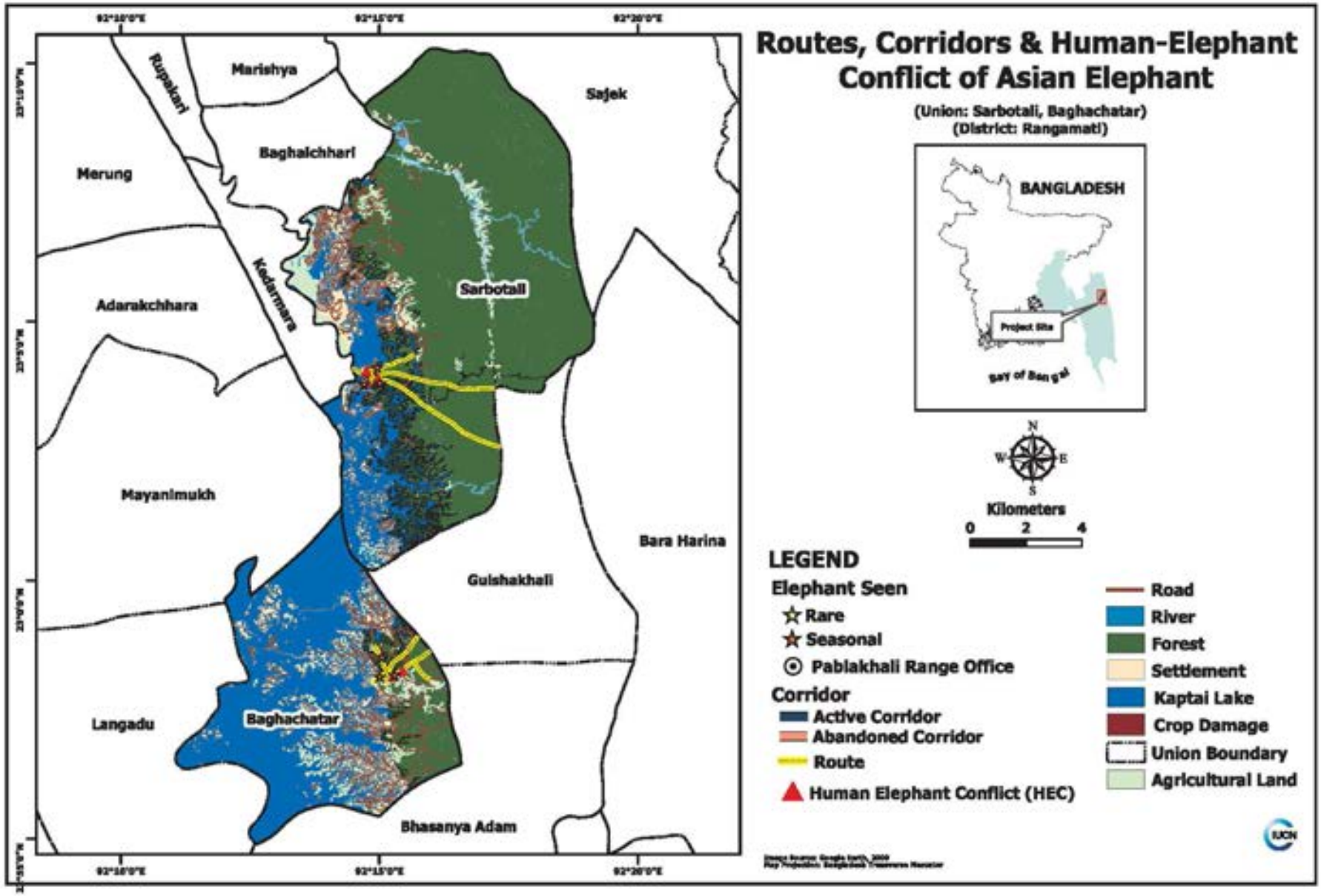
Map 4.40. Elephant seen at Mohalchhari



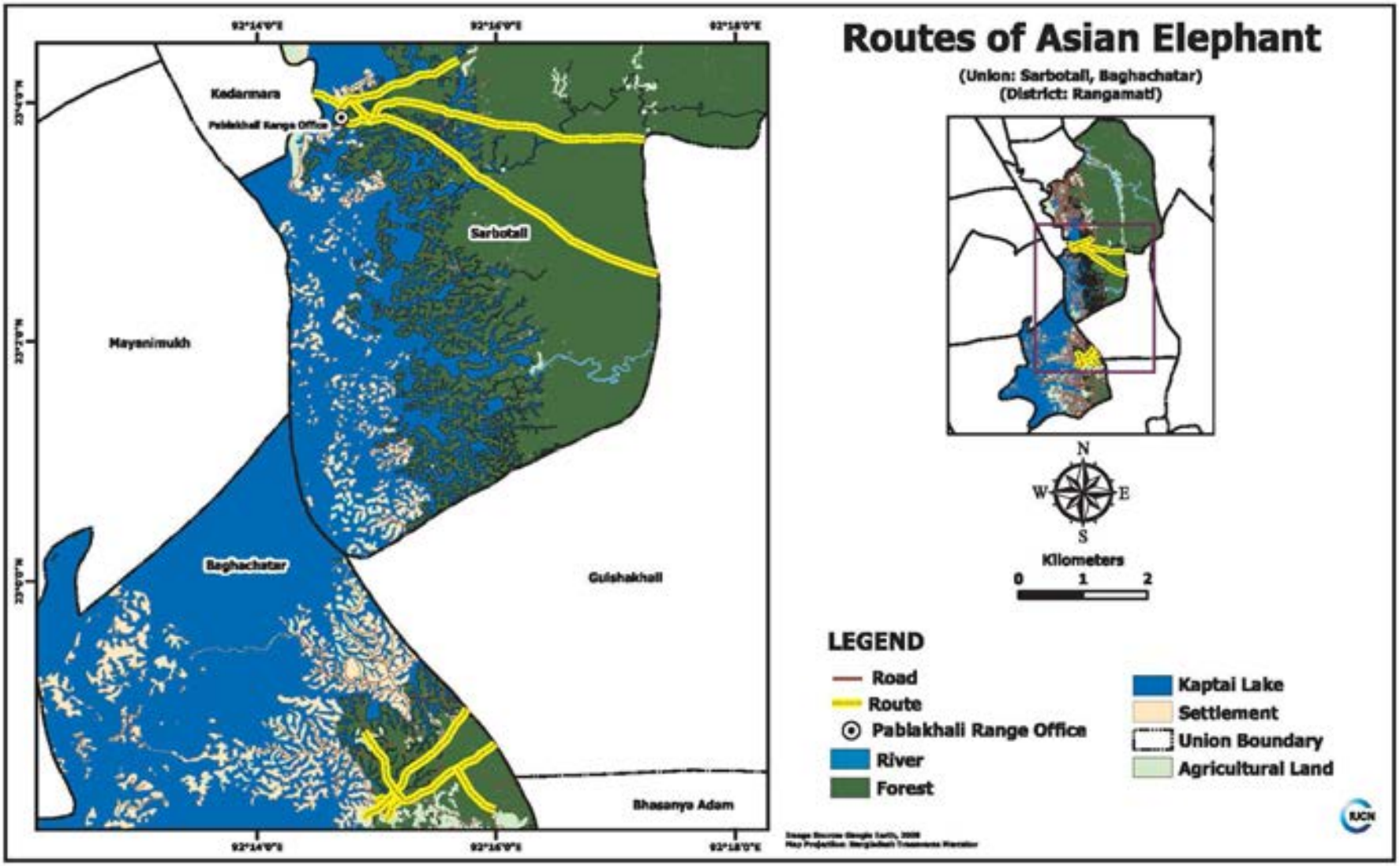
Map 4.41. Human elephant conflict at Mohalchhari



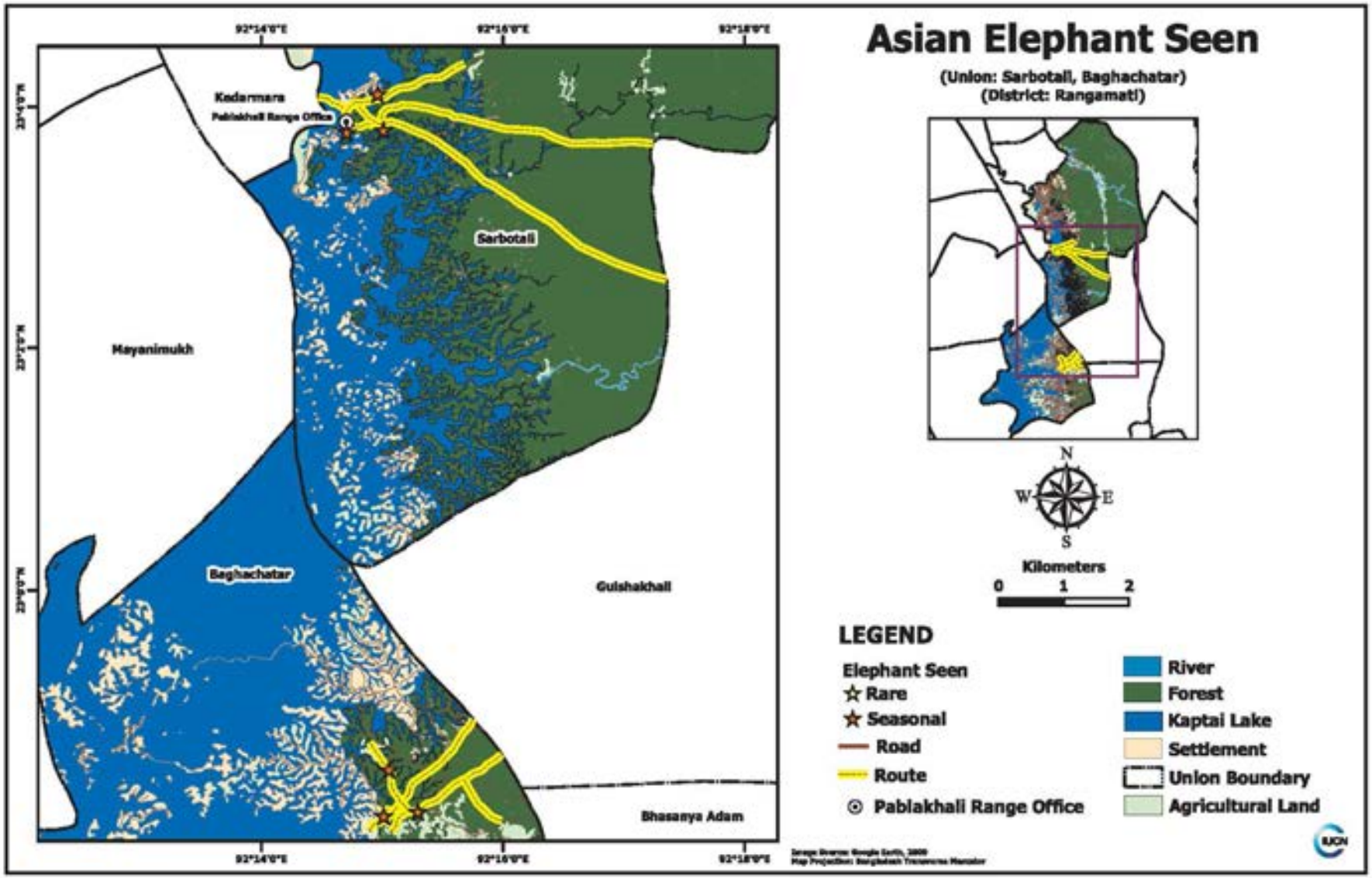
Map 4.42. Crop damage by elephant at Mohalchhari



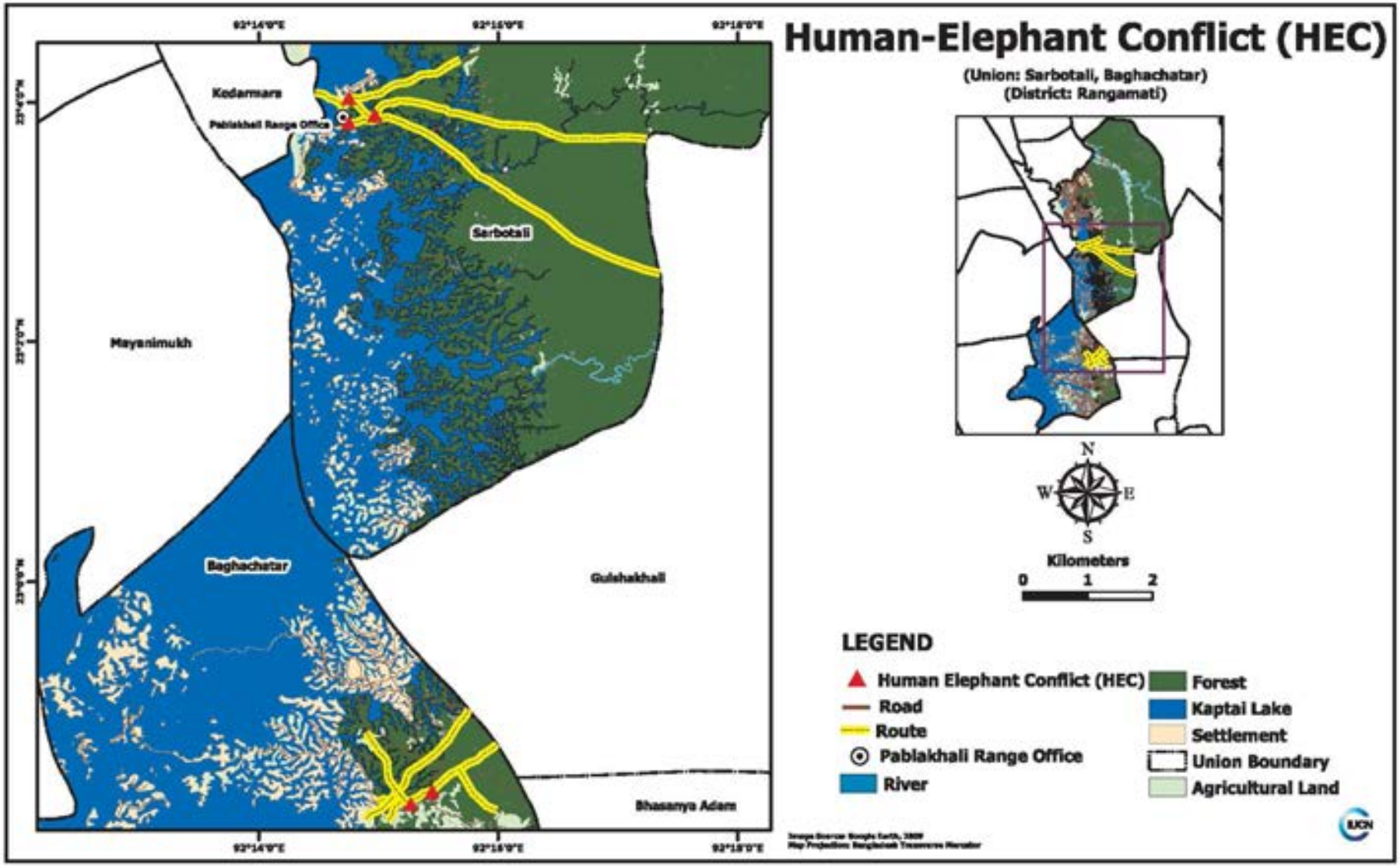
Map 4.43. Base map of Asian elephant at Pablakhali



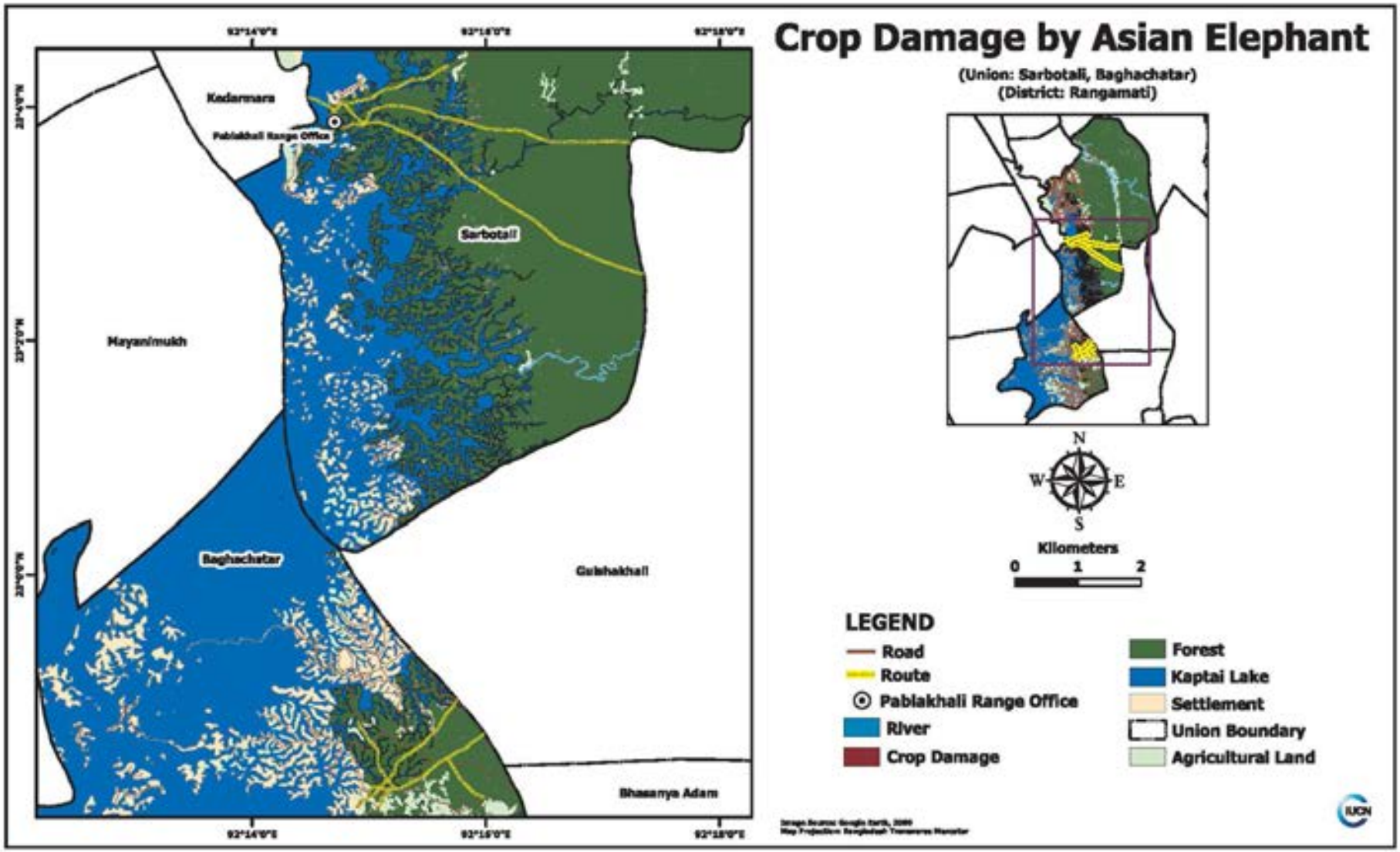
Map 4.44. Routes of Asian elephant at Pablakhali



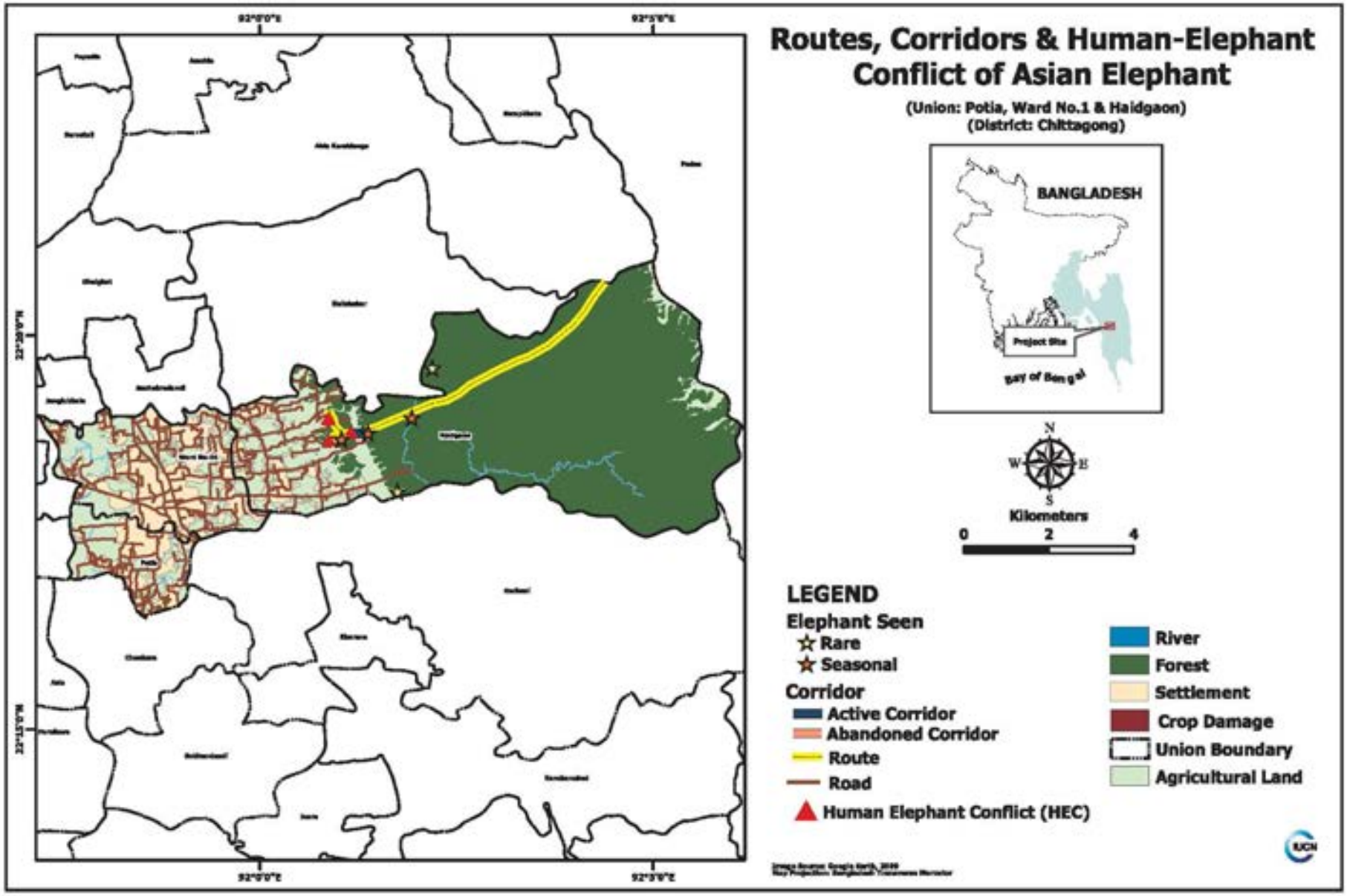
Map 4.45. Elephant seen at Pablakhali



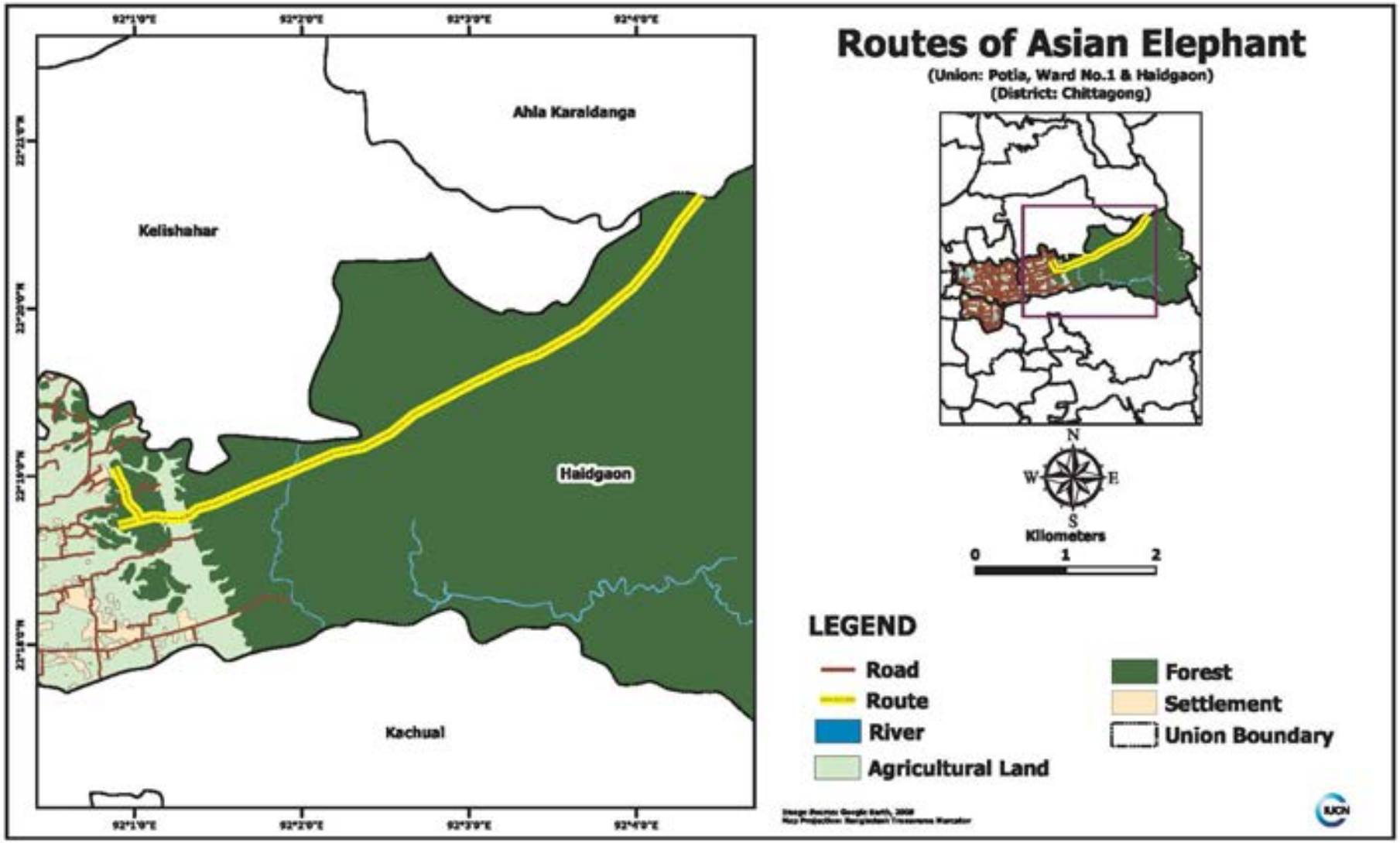
Map 4.46. Human elephant conflict at Pablakhali



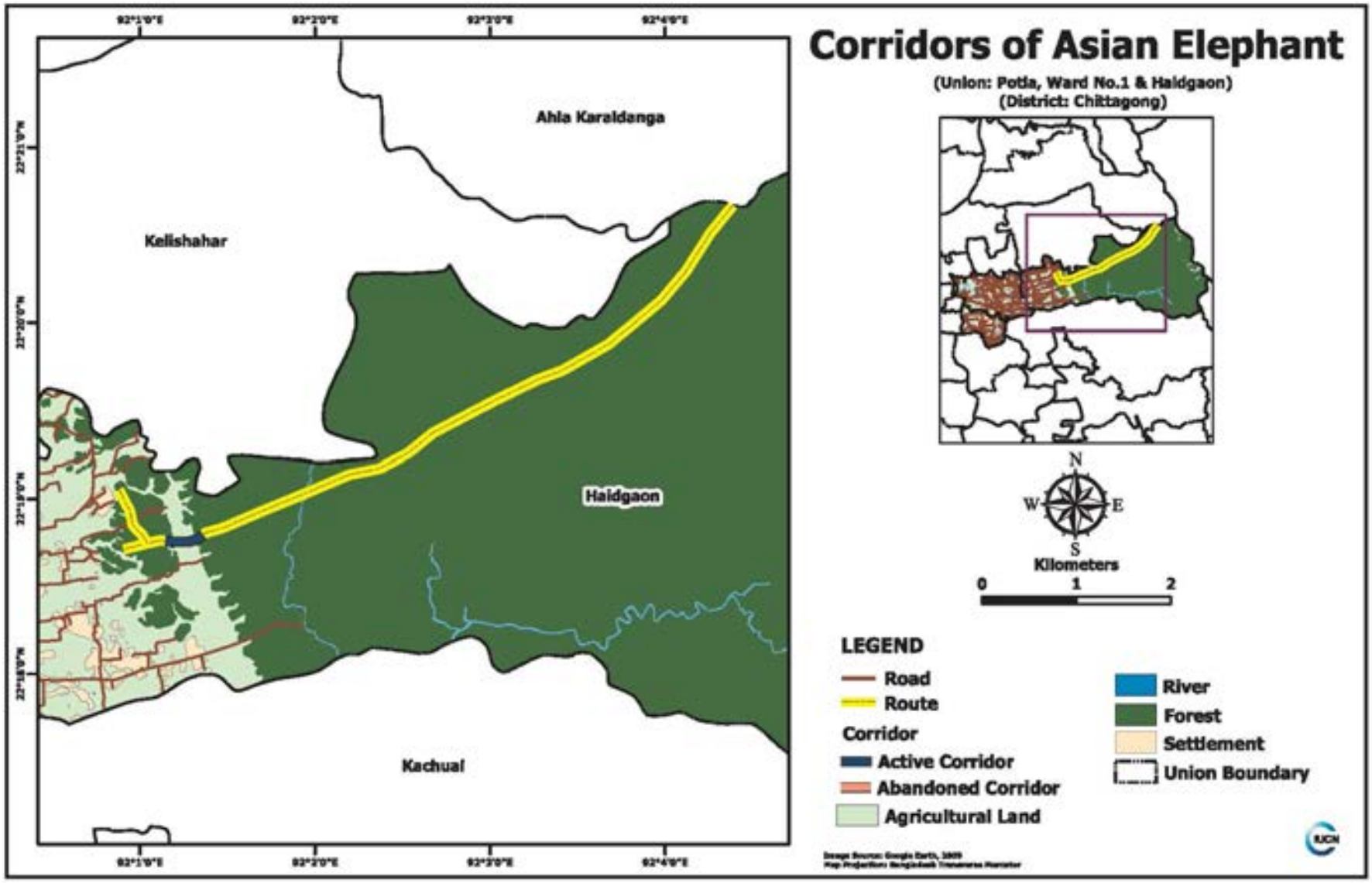
Map 4.47. Crop damage by elephant at Pablakhali



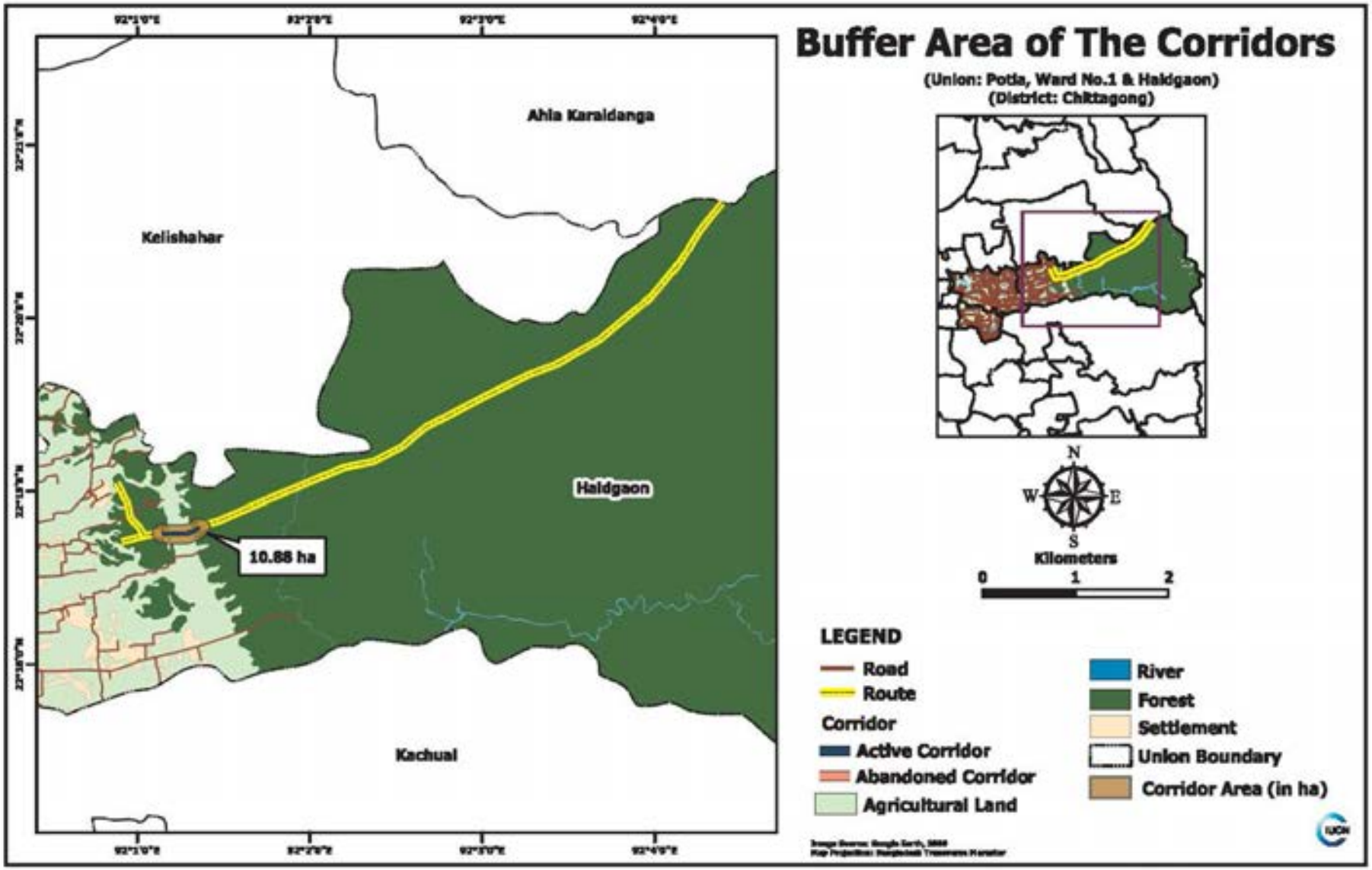
Map 4.48. Base map of Asian elephant at Potia



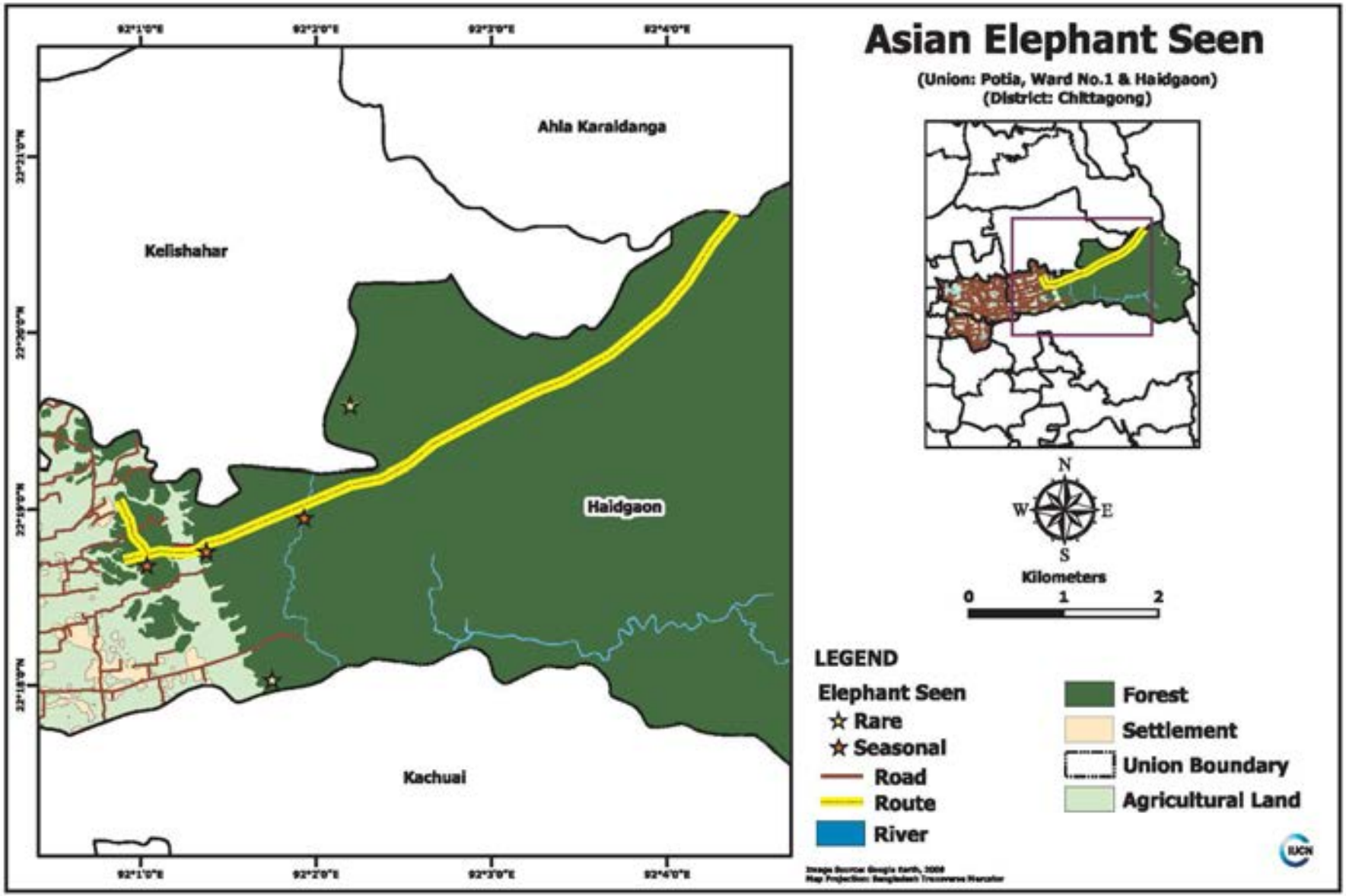
Map 4.49. Routes of Asian elephant at Potia



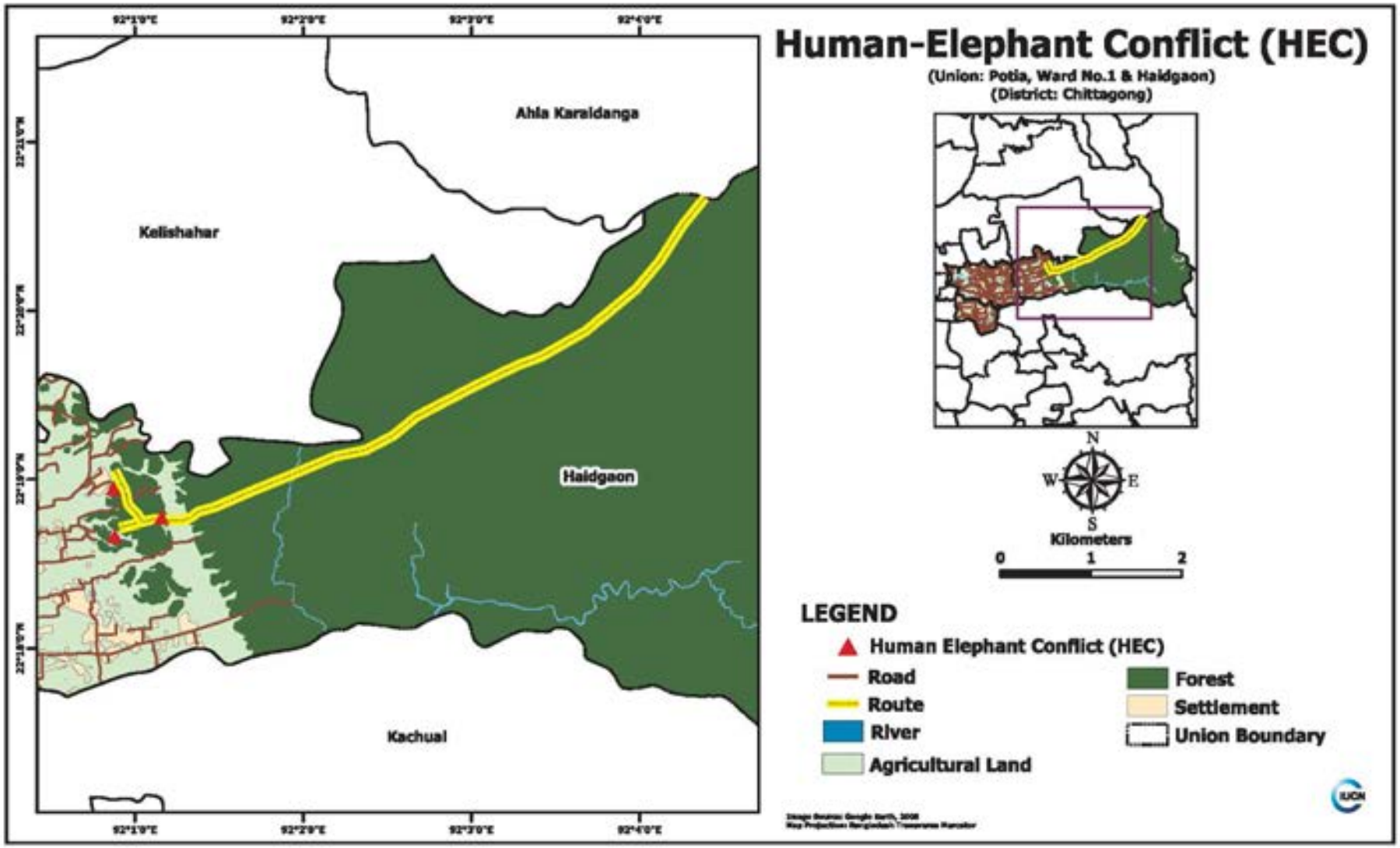
Map 4.50. Corridors of Asian elephant at Potia



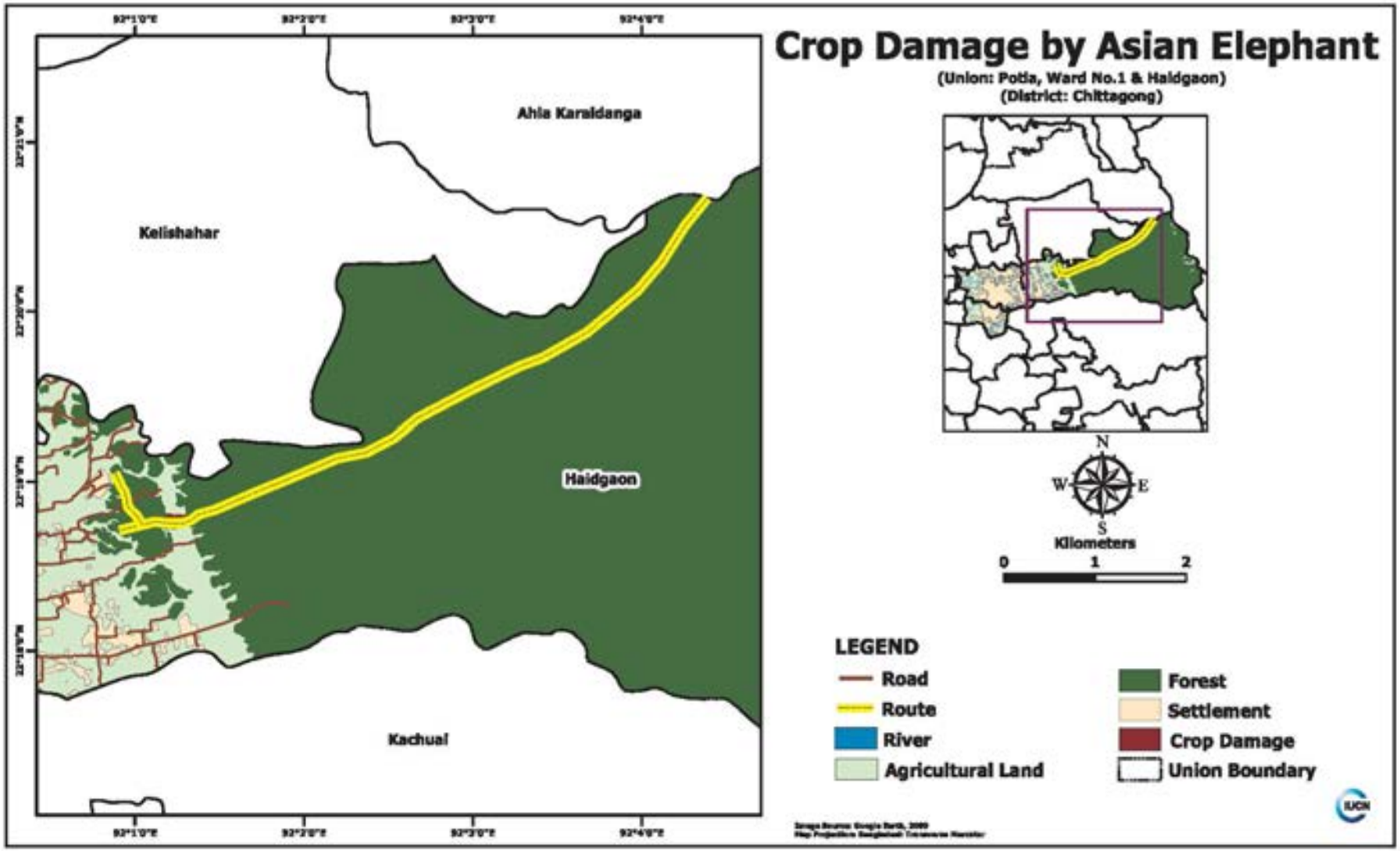
Map 4.51. Buffer area of corridor at Potia



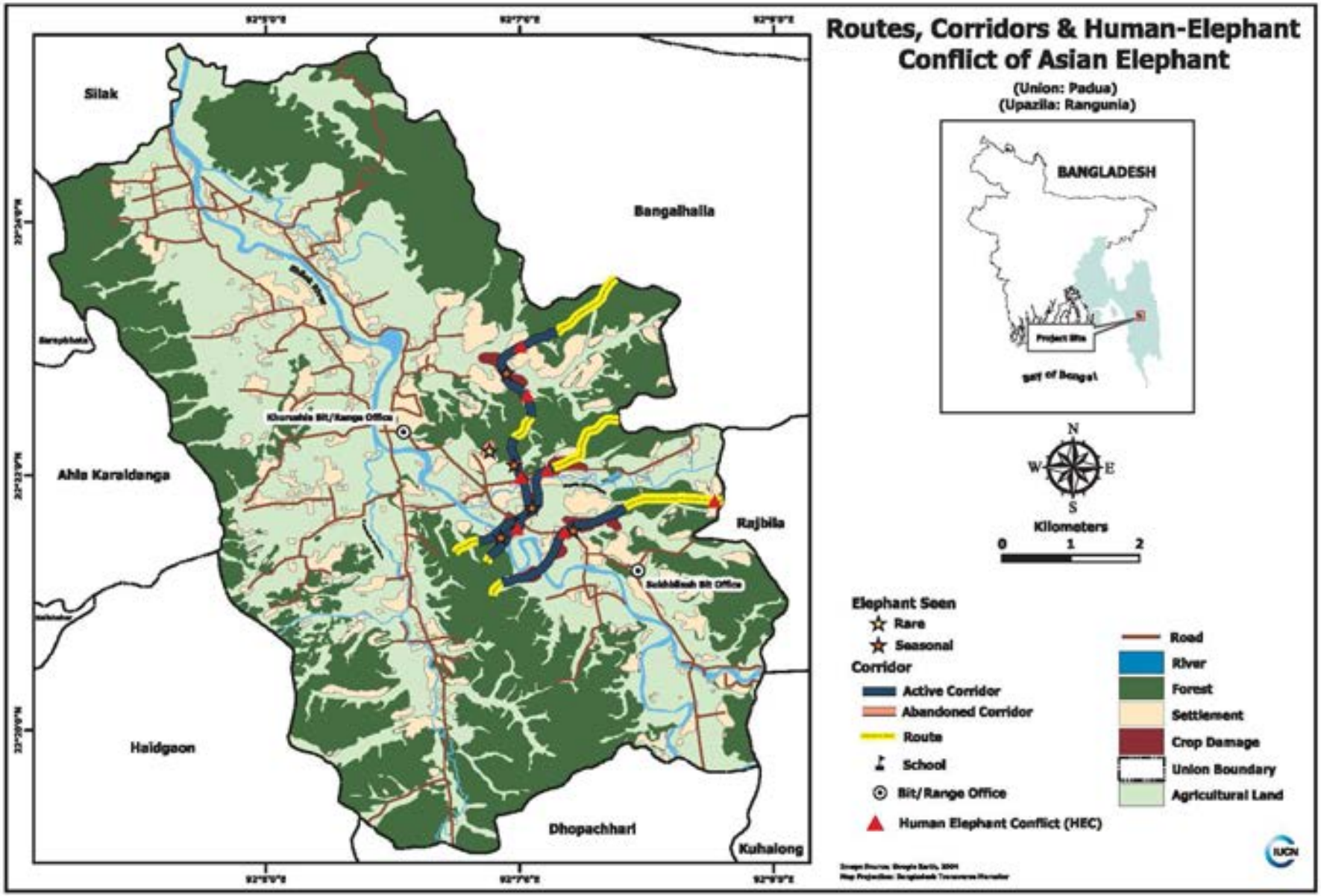
Map 4.52. Elephant seen at Potia



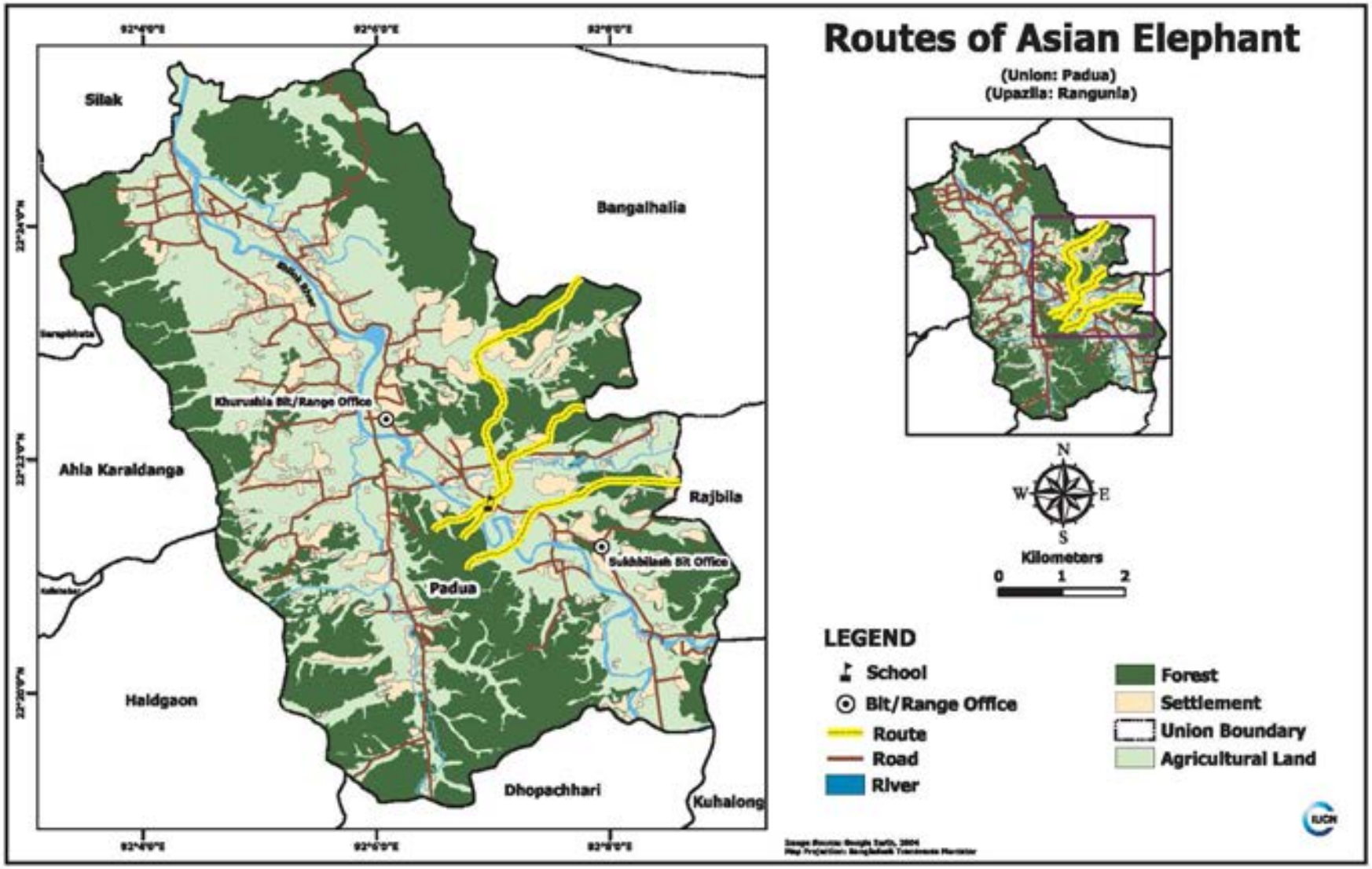
Map 4.53. Human elephant conflict at Potia



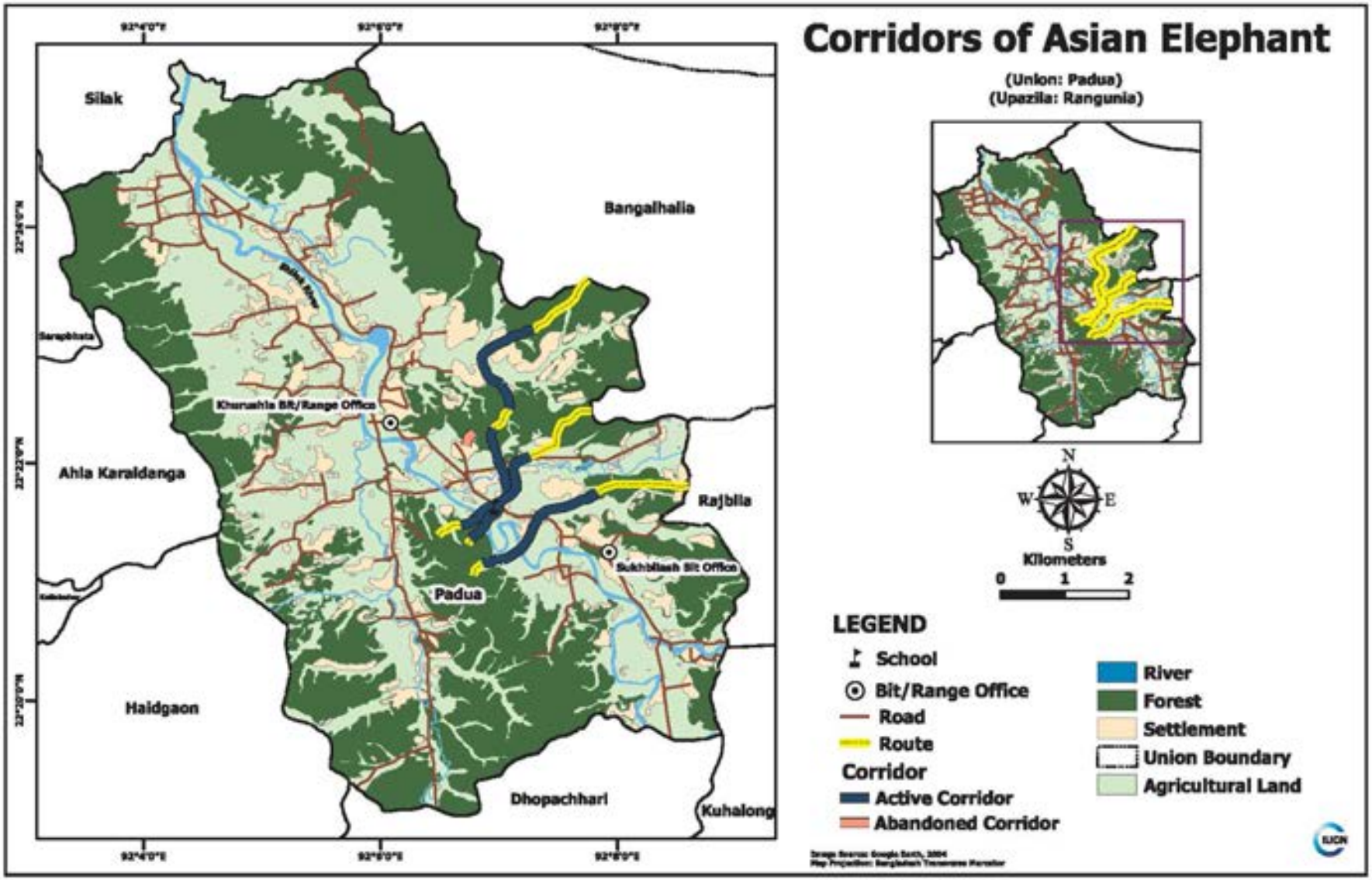
Map 4.54. Crop damage by elephant at Potia



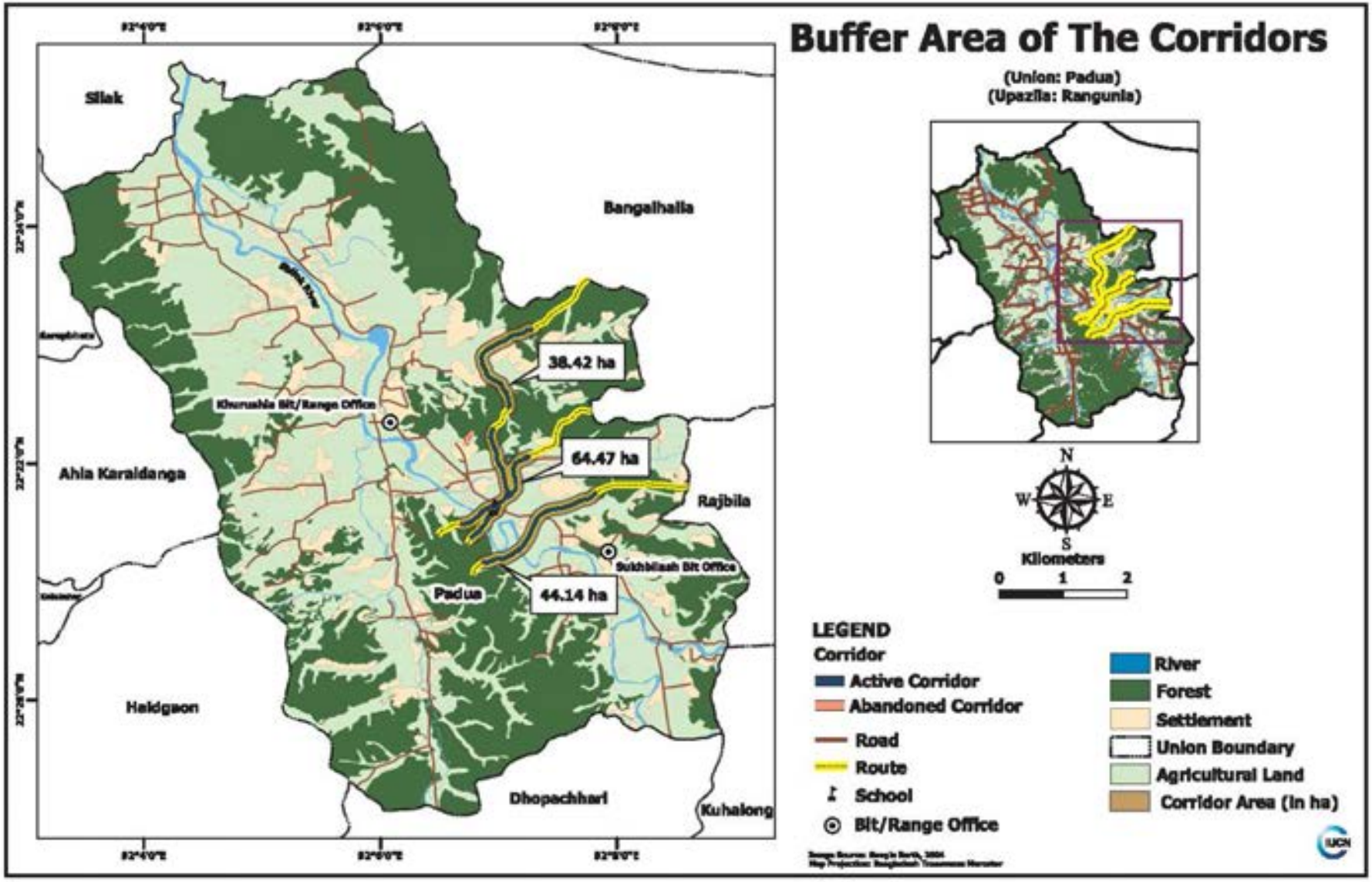
Map 4.55. Base map of Asian elephant at Sukhbilash



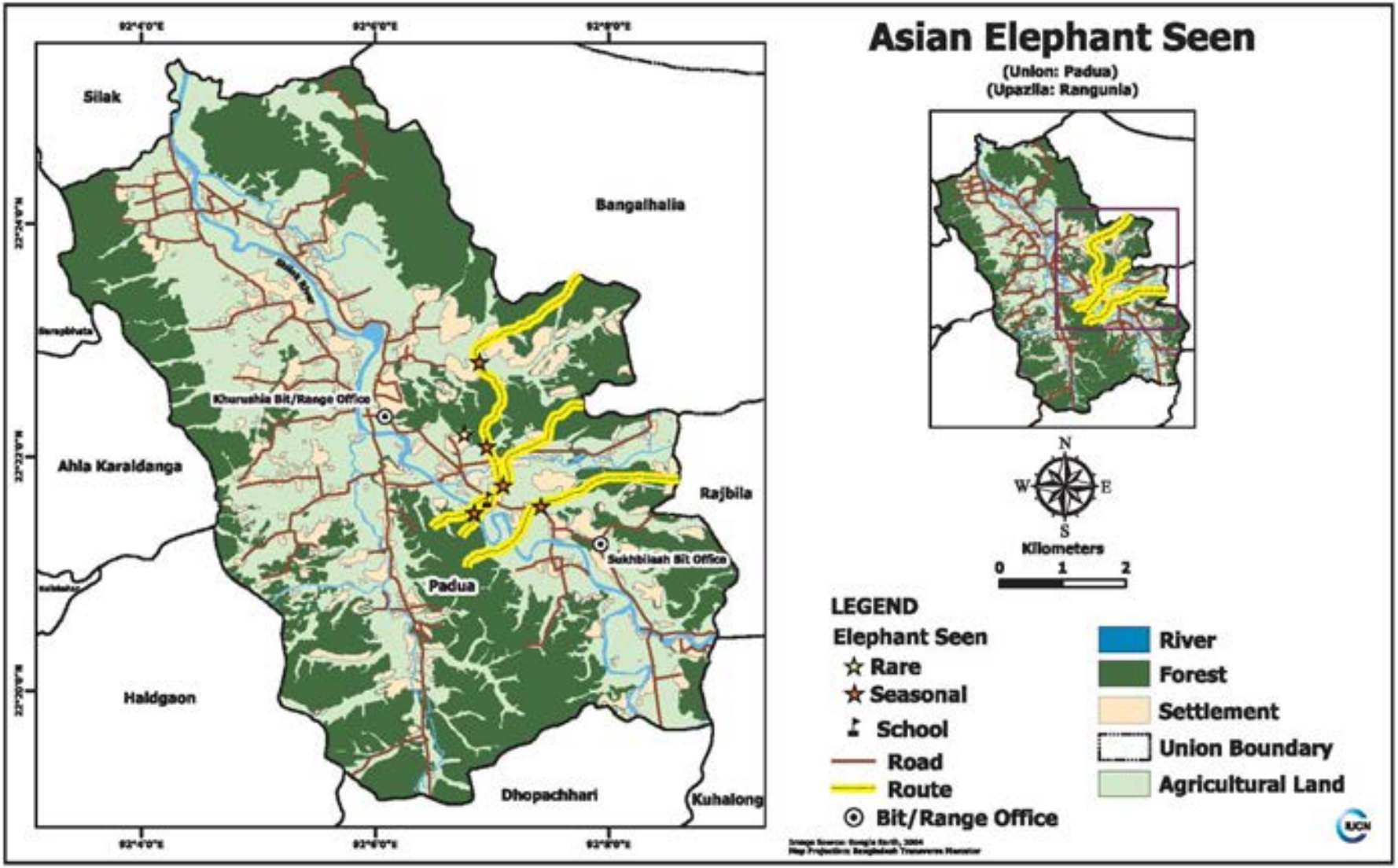
Map 4.56. Routes of Asian elephant at Sukhbilash



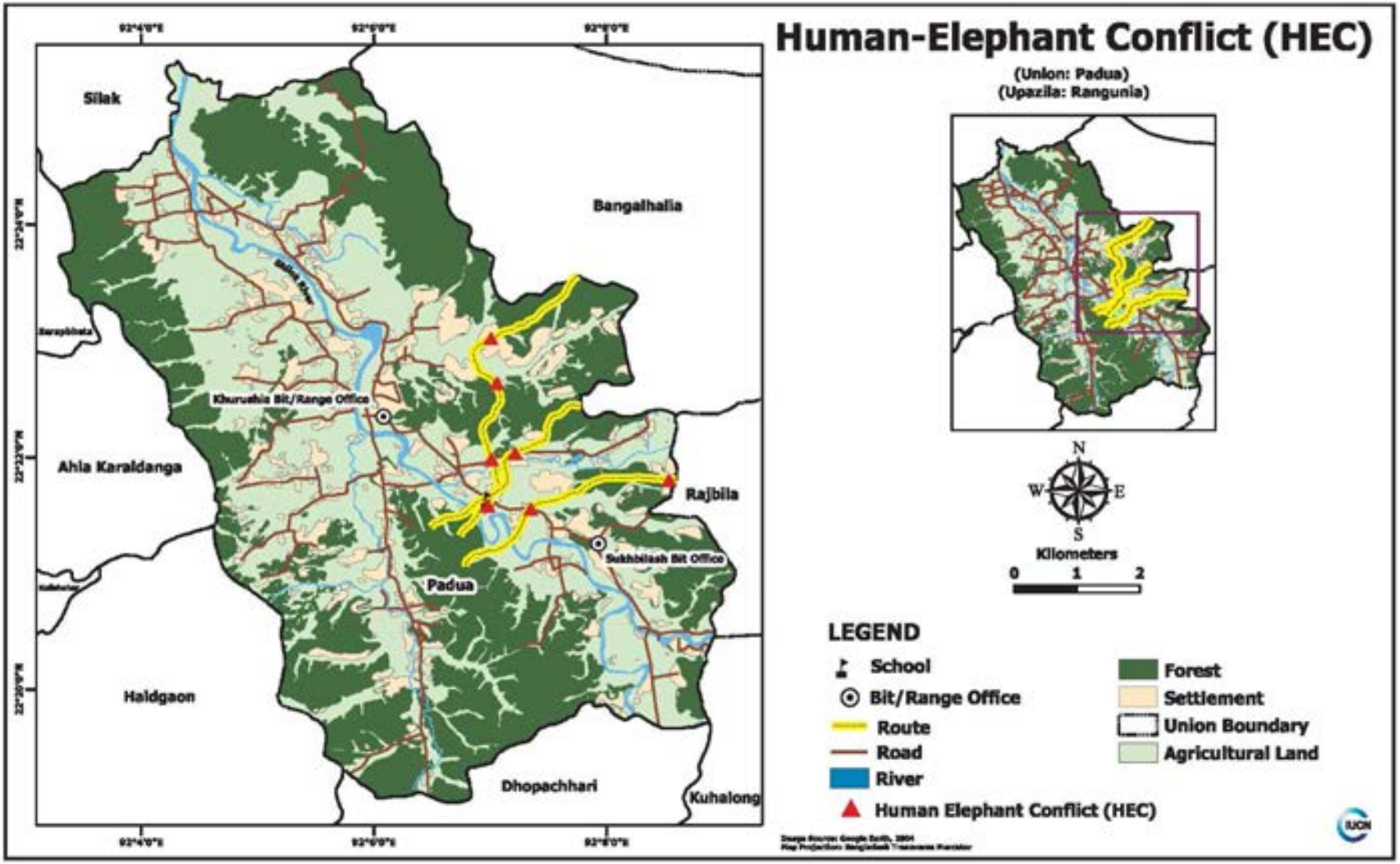
Map 4.57. Corridors of Asian elephant at Sukhbilash



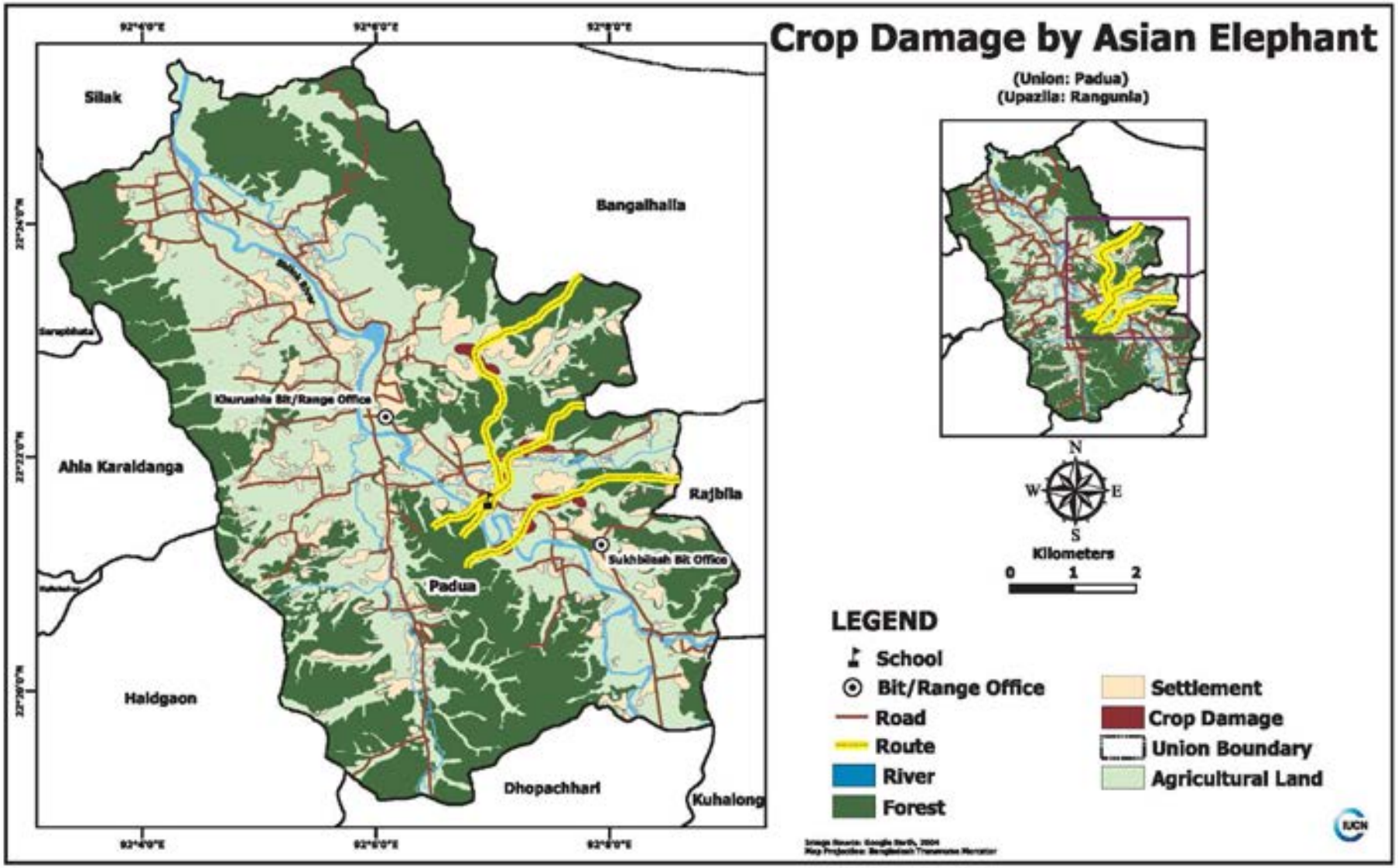
Map 4.58. Buffer area of corridor at Sukhbilash



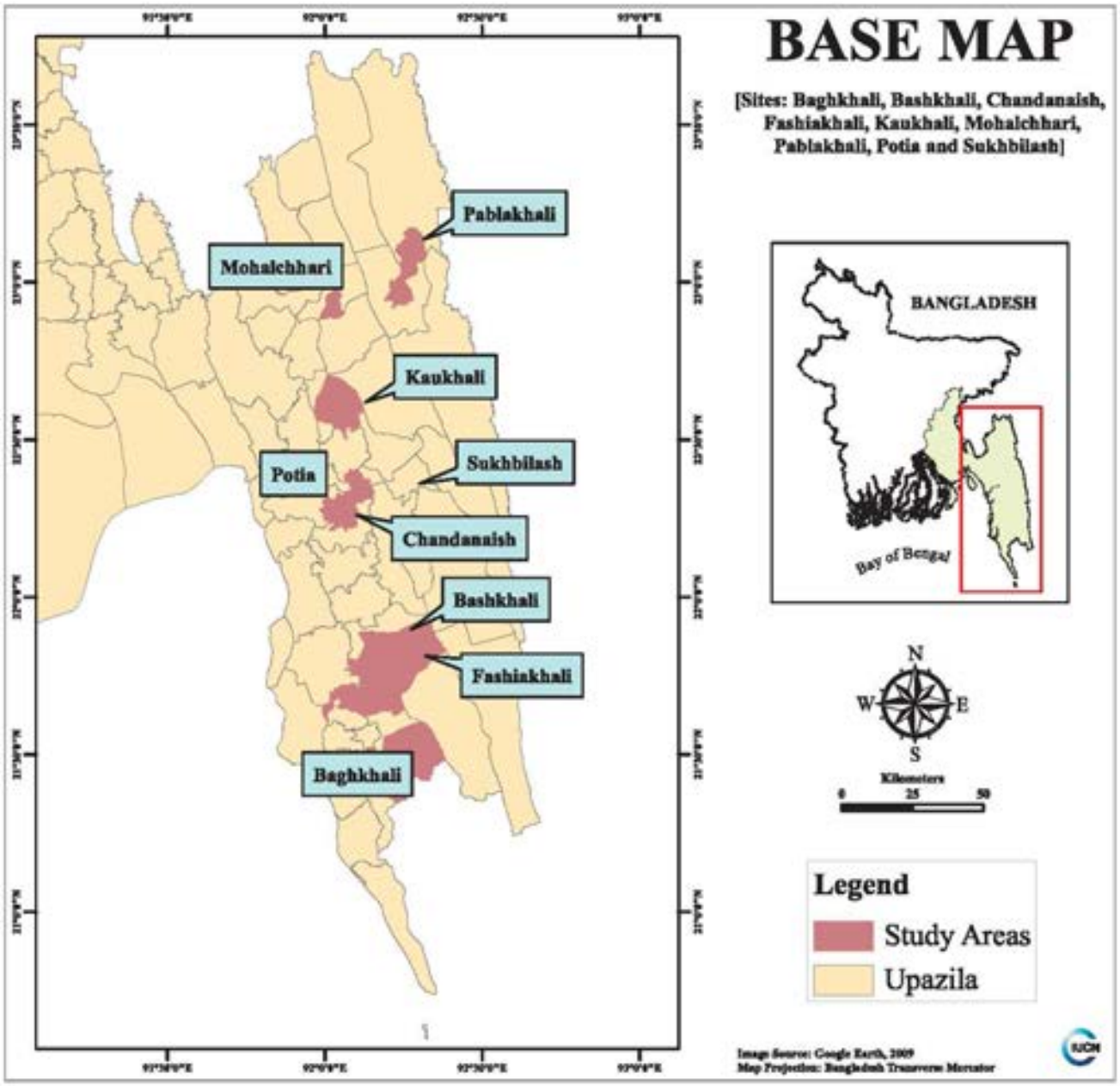
Map 4.59. Elephant seen at Sukhbilash



Map 4.60. Human elephant conflict at Sukhbilash



Map 4.61. Crop damage by elephant at Sukhbilash



Map 4.62. Base map showing the Upazila boundaries and the nine study sites

CHAPTER FIVE: PRESENT SCENARIO OF HEC IN BANGLADESH

In addition to detailed study in selected areas IUCN Bangladesh has also conducted a baseline survey on human elephant conflict at all the active elephant habitat of the country to collect the historical data and present status of HEC of the whole Bangladesh. All data has been collected from the respective forest beat and range offices and from local people. These results will not only help to take future course of action to conserve this majestic animal in the context of Bangladesh but also will provide baseline information of HEC, which is a prerequisite to reduce this conflict.

The study was conducted in different ranges of eight Forest Divisions of Bangladesh namely, Mymensingh, Sylhet, Chittagong South, Cox's Bazar North, Cox's Bazar South, Rangamati North, Rangamati South and Unclassed Stated Forest Division. The above mentioned Forest Divisions broadly fall under the administrative district of Sherpur, Jamalpur, Netrokona, Moulavibazar, Chittagong, Rangamati, Khagrachari and Cox's Bazar. Ranges under different forest divisions are given below.

Serial No.	Forest Division	Ranges
1	Chittagong South	Khurushia, Potia and Bashkhali
2	Cox's Bazar North	Fashiakhali and Baghkhali
3	Cox's Bazar South	Teknaf
4	Mymensingh	Modhulita, Rangtia, Balijuri and Durgapur
5	Rangamati North	Pablakhali
6	Rangamati South	Kaukhali
7	Sylhet	Juri 1 and Juri 2
8	Unclassed Stated Forest	Mohalchari

5.1. Methods of data collection

Information on HEC was collected through consultation with the local people and officers of local beat and range offices. A semi-structured questionnaire was tested and developed to collect information. FGD was conducted to collect information about economic losses, elephant movement, human and elephant dead and injury, damage to home and agriculture and local people perception about elephant. One to one discussions were conducted with the local people; including man, woman and children and forest officers who frequently observe elephants and attacked by elephants. The written data available with forest department was compiled and information gaps of the forest department's data were adjusted by FGD and one to one discussions. Damaged crop areas were estimated according to local units. The economic loss was computed by taking the market value of the potential crop yields (Paddy, grains, vegetables) that were damaged by elephants and additional 15% of the value was added as cost of cultivation. The house damage was assessed by computing the market cost of the damaged house building materials by elephants. Data on both the human and elephant deaths were recorded during field visits from local people and forest officials. The assessment of the economic loss of the damage of crops and properties was made following Sukumar (1990), Islam et al. (1999) and Aziz (2002).

5.2. Consequences of HEC

This section concentrated mainly different kinds of damages and losses done by elephant in the fifteen elephant areas of Bangladesh.

5.2.1. Human casualties

Human casualty is one of the common results of HEC. In the present study, 15 most elephant prone forest ranges of Bangladesh have been studied. Large number of casualties had been recorded in Potia range where 32 people had died from elephant attack, followed by Khurushia range (16 deaths), Modutila (8 deaths) and Rangtia (8 deaths). And lowest casualty was recorded in Pablakhali, Kaukhali and Juri 1 range where there is elephant but no death of human occurred by elephant for the last 11 years (Figure 5.1, Table 5.1).

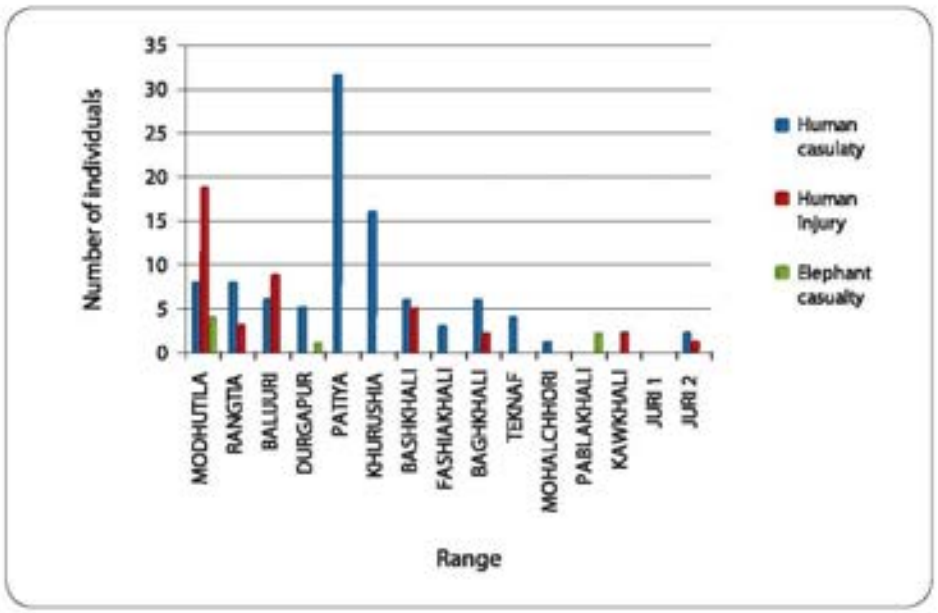


Figure 5.1: Human casualty, human injury and elephant casualty in 15 Forest ranges from 2000 to 2010

Table 5.1: Human casualty, human injury and elephant casualty in 15 Forest Ranges from 2000 to 2010

Division	Forest ranges	Year	Human casualty	Human injury	Elephant casualty
Chittagong South	Potia	2001-2010	32	0	0
	Khurushia	2001-2010	16	0	0
	Bashkhali	2008-2010	2	5	0
Cox's Bazar North	Baghkhali	2006-2010	6	2	0
	Fashiakhali	2009-2010	3	0	0
Cox's Bazar South	Teknaf	2010	4	0	0
Mymensingh	Rangtia	2001-2010	8	3	0
	Balijuri	2002-2010	6	9	0
	Modhutila	2005-2010	8	19	4
	Durgapur	2002-2010	5	0	1
Rangamati North	Pablakhali	2010	0	0	2
Rangamati South	Kaukhali	2010	0	2	0
Unclassed Stated Forest	Mohalchhari	2005	1	0	0
Sylhet	Juri 1	2010	0	0	0
	Juri 2	2000-2010	2	1	0

(Source: respective forest range offices)

5.2.2. Elephant casualty

Reduction of elephant number is one of the alarming consequences of HEC. According to FD and local people of the studied areas, 7 elephants were killed/died due to the cause of HEC during last decade. The total number of elephant death throughout the country may be higher but in this count natural death has not been considered. Figure 5.1 and table 5.1 showed that Modhutila range possess the highest number of elephant death (4) followed by Pablakhali (2) and Durgapur (1). No casualty of elephant has noticed in rest of the ranges.

5.2.3. Human injury due to elephant raid

Human injury is another major consequence of HEC. A large number of people became disabled and injured due to the elephant attack. In this study it was revealed that between 2000 to 2010 highest number of human injury took place at Modhutila forest range (19) followed by Balijuri (9) and Bashkhali (5) ranges. The lowest was observed in Juri 2 range (1) and no injury was evident in the rest eight forest ranges during the last 11 years (Figure 5.1).

5.2.4. Affected home and family due to elephant attack

Beside loss of life and injury, a large number of homes have been destroyed and thus families have been affected from elephant attack. Financial loss and psychological trauma develops due to this attack. Elephant raid at a very high rate is observed in Rangtia range where 823 homes were destroyed within last one decade followed by Balijuri range where 11 homes have been affected. In Potia 24 homes were affected followed by Fashiakhali (25 homes), Khurushia (20 homes), Modhutila (98 homes), Kaukhali (6 homes) and in Teknaf 11 homes were destroyed (Figure 5.2 a).

On the other hand due to attack on home, crop field and even on human life, a large number of families have also been affected. From this survey it was revealed that the highest number of family affected in Rangtia (805 families) followed by Balijuri (201 families), Potia (61 families), Fashiakhali (50 families),Khurushia (35 families), Modhutila (18 families) and Kaukhali (10 families). Such affects were not noticed in rest of the ranges (Figure 5.2 b)

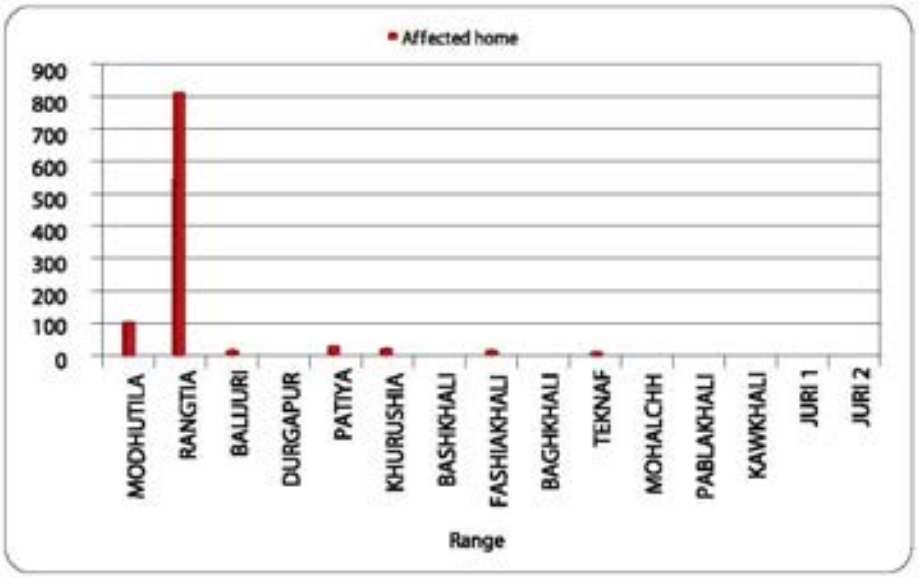


Figure 5.2a: Affected home in 15 ranges from 2000-2011

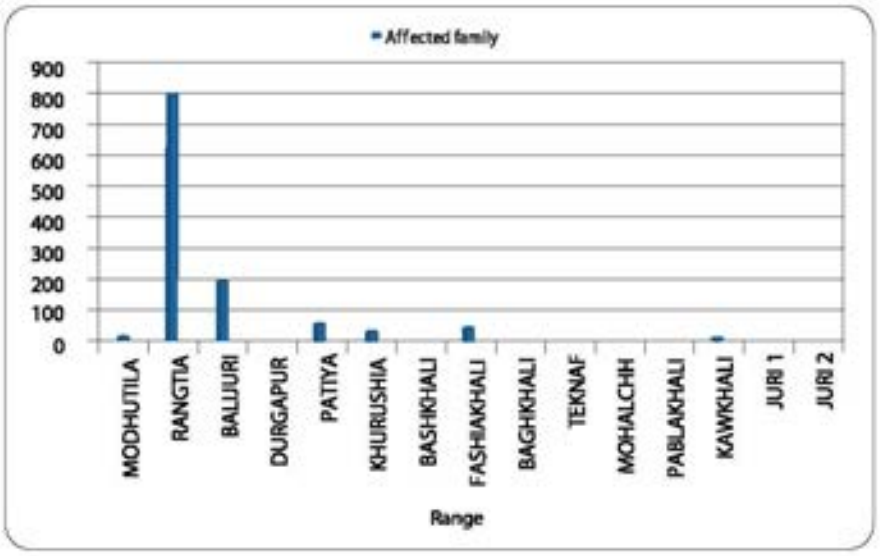


Figure 5.2b: Affected family in 15 ranges from 2000-2011

5.2.5. Affected cultivated land due to elephant raid

Crop loss is one of the major consequences of HEC. Financial loss is directly involved with crop loss. Other than this, many people involve to guard their crop to protect from elephant raid which also demand physical loss. People awake overnight to protect their crops. Though people took efforts to protect crops, a large amount of crops has ruined due to elephant attack. In the present study, it was found that Rangtia range under Sherpur district is the most affected area in terms of crop damage due to elephant attack. About 2072.04 acre crop field have been destroyed by elephant during the last ten years. Rangtia is highly affected because every year huge number of elephants (according to forest department 100-120) visit this area during paddy season from India. From this study it was found that most of the cultivated land was located just beside the forest area of India and thus the crop field is easily accessible and vulnerable as well. That is why raiding intensity is too much high at this location. Modhutila of the same district holds the second position in crop damage due to elephant raid. About 274.5 acre crop land has raided by elephant in last six years. Figure 5.3 shows the picture of the crop loss in different elephant prone area during the last eleven years.

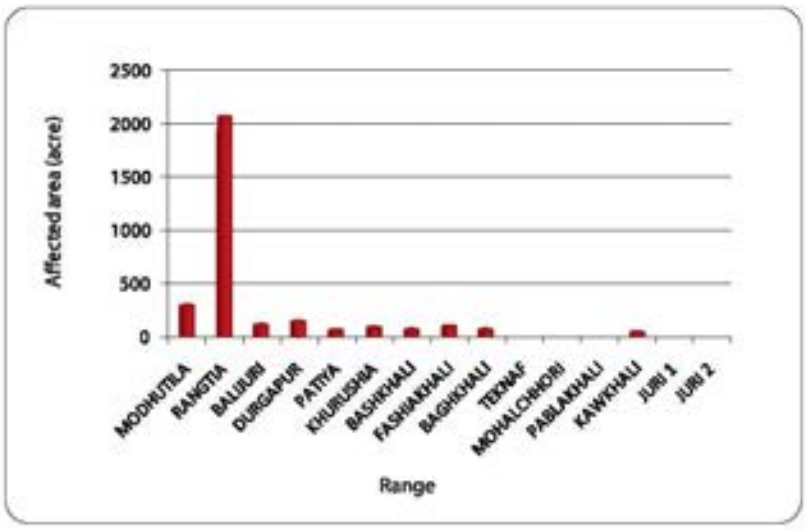


Figure 5.3: Amount of crop loss from 2001-2011 in 15 forest ranges

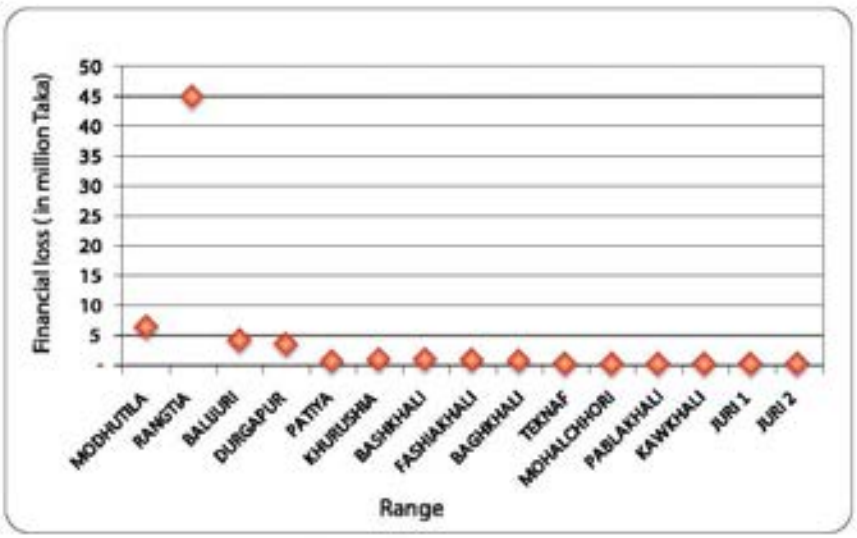


Figure 5.4: Financial loss of 15 ranges from 2000-2011

5.2.6. Financial loss due to HEC

The loss has been calculated considering both crop loss and damage to homesteads related to elephant raid. It was found that financial loss is highest at Rangtia range followed by Modhutila, Balijuri, Durgapur, Khurushia, Fashiakhali, Bashkhali, Baghkhali, Potia, Kaukhali, Teknaf and Juri 2. Figure 5.4 shows the details of this financial loss of the 15 forest ranges.

5.2.7 Crop raided by elephant

This survey revealed that elephant predominantly raid paddy, sugarcane, potato, corn, sweet potato, different type of seasonal vegetables, cucumber and betel leaf. However, in most cases, spices like Chilli, onion, turmeric, ginger are not liked by elephant.

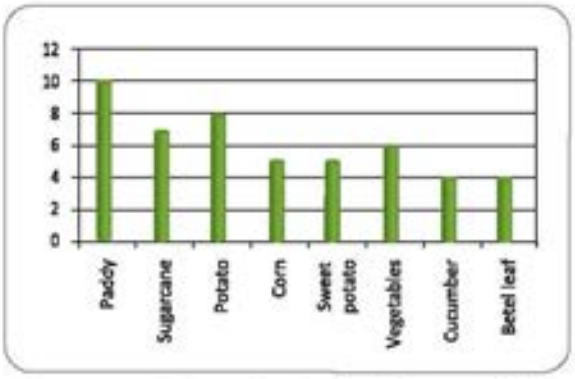


Figure 5.5a: Rating of agricultural crop raided by elephants in the study sites from 2000-2011

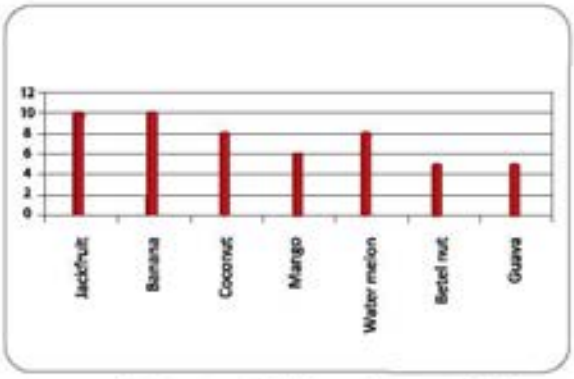


Figure 5.5b: Rating of different fruits raided by elephants in the study sites from 2000-2011

Depending on attraction and raiding intensity, a rating has been developed to categorize crops and fruits. Here, rating range 1-3 represent low damage, 4-6 represent medium damage and 7-10 is high damage. Figure 5.5a showed that among crops, rate of paddy raiding is high (10), followed by potato (8), sugarcane (7), vegetables (6), sweet potato, corn (5) and Cucumber and betel leaf (4). So, raiding intensity is high in paddy, sugarcane and potato; medium in vegetable, corn, sweet potato, cucumber and betel leaf.

On the other hand it was observed that fruits namely, jackfruit, banana, coconut, mango, water melon, betel nut, guava, pine apple, wood apples etc. were affected by elephants. But intensity of raiding was highest in jackfruit and banana (10), followed by coconut and watermelon (8), mango (6) and betel nut and guava (5) (Figure 5.5b).

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

Asian elephant is an endangered animal in its global ranges (IUCN, 2011) and categorized as Critically Endangered in Bangladesh (IUCN Bangladesh, 2000). It is listed in the third schedule of the Bangladesh Wildlife (Preservation) Act (1974) and also included in CITES Appendix I. However, continued declining trend of its population throughout the habitat ranges, including Bangladesh, indicates that meaningful and effective protection may not be easily attainable.

HEC in terms of crop and house damage, injuries and deaths of both humans and elephants in the present day elephant ranges of the country are found to be increasing. According to various authors it is clear that the isolation of elephant population occurs largely due to the degradation and fragmentation of habitats caused by human enchroachment and activity throughout the elephant ranges (Sukumar, 1990). In the present study areas, increasing settlements, agricultural fields, fuel wood and fodder collection beyond sustainable level, habitat encroachment, human interference, construction of roads in reserved/protected forests are the major long term anthropogenic threats to elephants; similar problems are also apparent in all elephant ranges across the world (Sukumar, 1990).

All these biotic factors have led to the destruction, degradation, fragmentation of resulting in the loss of corridors and connectivity between habitats. (Islam *et al.*, 1999; Aziz, 2002; Khan, 2004; Feeroz, 2004 and Aziz *et al.*, 2005). Within our study area for example, corridors, namely the Teknaf-Cox's Bazar-Nikheongchahari, Chunati-Nikhongchhari, Pablakhali-Mahilla-Shishok have been completely abandoned due to the reduction of forest cover, human settlement, extensive agricultural practices, road construction, tea and, rubber plantations etc. (Feeroz, 2004). It is widely recognized that corridors facilitate the movement of elephants between habitats, reduce the impact of fragmentation and enhance their viability (Bist, 2002). Therefore, the protection and maintenance of corridors is an essential part for elephant conservation. Unfortunately, no serious attempt has yet been made to identify, demarcate and protect elephant corridors in the elephant ranges of Bangladesh.

IUCN Bangladesh, under current initiative, has taken the initiative to map elephant corridors and routes for the first time in the country. This study revealed that there are 54 potential elephant corridors in the study areas, of which 53 are active while one is completely disrupted.

Protect existing forests and protected areas

Major habitats in the CHT have already been inhospitable for elephants in terms of forest coverage and fodder due to excessive and widespread shifting cultivation and illegal tree felling. The remaining forest cover also suffers from serious degradation in terms of habitat quality. Reports suggested that slash and burn agriculture in the hilly regions is the single most important factor for large scale destruction of elephant habitats in the CHT (Islam *et al*., 1999; Aziz, 2002 and Aziz *et al*., 2005). Given the circumstances, prevention of further degradation and destruction of natural forests including protected and reserve forests is urgently needed. In addition, protection of existing forest cover from illegal tree cutting, over-exploitation of Non Timber Forest Products (NTFP), fuel wood collection and encroachment of habitats also need to be addressed seriously.

Many of the natural forests have been converted into commercial forests through monoculture plantations. However, diversity of the habitats in terms of plant variety is crucial for ensuring adequate fodder to elephants. Thus, further raising of *Eucalyptus* and *Teak* plantations in grasslands or degraded areas should be urgently arrested for the long term survival of elephants in Bangladesh. In addition, clear felling management practices by the FD should be replaced with selected felling method.

Restore degraded habitats

Habitat improvement can be one of the most long lasting and viable solutions to reduce HEC in the study areas. The paradigm shift of production forestry to conservation forestry is now a timely necessity. Preference of monoculture crop through commercial plantations in the natural forests is one of the major causes responsible for the depletion of preferred elephant fodder. Increasing trend of monoculture in the past led to loss of natural herbs and shrubs, consequently influencing biodiversity of the ecosystem. Invasion of native as well as exotic weeds is also creating an adverse impact of monoculture besides other impacts on elephant corridors. Bamboo and reed plantations can be one of the best options in the degraded habitats/corridors which can provide food to elephants. Artificial regeneration of bamboo and other browse species can also be initiated. The invasion of grasslands in the degraded habitats may be arrested by woody regeneration through suitable manipulation of fodder plants. Some of the most important corridors such as, corridors found in Shukhbilash, Potia, and Bashkhali should be restored by rehabilitation of settlements and regenerative plantations.

Regulate extraction of NTFP

The elephants do prefer many of the plant species, which are largely collected by local inhabitants as fuel wood. The predominant species in the elephant habitats in the study areas are bamboo and reeds which is proffered by elephants for fodder and as fuel wood to humans. Given the current habitat conditions in the study areas, the extraction of NTFP, especially bamboos, have already gone beyond sustainable levels and should be described as 'over-exploited'. Hence, extraction level of these plant species from the elephant habitats must be scientifically justified and managed.

Create conservation awareness

People living in and around the elephant habitats and corridors should be taught about HEC and its causes. At least, they can be trained to live with a problem which may not have an immediate solution. More important is to educate the future generations about the significance of elephants as well as nature conservation through informal environmental education and outreach programs in local elementary and high schools located in and around the elephant ranges.

Build capacity to deal HEC

One of the major challenges to deal with HEC lies in the issue of understaffing in the BFD. In addition, sufficient logistics and proper skill to tackle HEC by elephant and crowd management are also missing. Thus, these crucial areas of capacity needs should be addressed properly and urgently. In particular, Nature and Wildlife Conservation Circle of the BFD should be improved through recruiting adequate and skilled staff in the field. Further, there is a huge gap of understanding between BFD staff and local villagers in terms of forest protection and resource extraction. However, a strong mutual relationship between these two groups is crucial to ensure sustainable benefit sharing from the protection of forest and wildlife. For this to happen, both BFD officials and local people need to be trained to deal with HEC effectively.

Provide legal protection of corridors

Some experts suggested that there need to formulate a framework to provide legal backup for the protection of elephant corridors. They argue that elephant corridors are vital in ensuring migrations between connecting habitats which ultimately help reduce HEC in the elephant ranges. Thus, legal status of corridors can facilitate the mechanism for restoration and maintenance of the existing and degraded corridors for long term elephant conservation in the country.

Introduce of eco-development measures

It is now widely recognized that the current land use of slash and burn agriculture is no longer an economically viable solution for crop production in the hilly areas of CHT. Thus, alternative livelihood options for the local people living in and around the elephant ranges should be introduced. Some of the suitable viable options can be horticulture, piggery, beekeeping, handicrafts and ecotourism development. In addition, improved chula (stove) and production of biogas from household waste could be introduced to the local people to reduce the pressure of fuel wood collection from the forest.

Compensate for elephant victims

Elephants come into conflict with humans by damaging crops and houses, and killing people, which creates antagonistic feelings towards elephant conservation among locals. It is thus important to promote compensation schemes to farmers for losses in the elephant ranges. The Wildlife Compensation Policy 2010 is recognized as an important supportive initiative for the elephant victims in the country. However, it has been already stated that lengthy bureaucratic procedure to get compensation is rather disappointing.

Promote bio-fencing and unpalatable crop production

In the areas of regular HEC, bio-fencing may be developed to deter elephants from frequently raiding houses and crops. In addition, farmers need to be encouraged to cultivate crops not proffered by elephants to reduce recurrent HEC. However, both of these measures again require identifying appropriate plant species and crops through further site-specific research.

Develop Elephant Conservation Action Plan (ECAP)

An action plan to guide future management interventions for the long term conservation of our elephants should be developed. Involvement of all stakeholder groups including local people of the elephant ranges and high level policy makers are essential for a focused and implementable guideline stating the short-term, medium term and long-term action oriented objectives.

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