ECOLOGICAL INVESTIGATON OF HUMAN - ELEPHANT CONFLICTS IN SOUTH WEST BENGAL

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CERTIFICATE

I feel pleasure in certifying that all work presented in this thesis has been done by Shri Anil Kumar Singh under my guidance and supervision. The thesis or any part of it has not been utilized or submitted for any degree or diploma so far.

Dated 28th March 2006

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Prologue

The Asian elephant *Elephas maximus,* since time immemorial captures the imagination of people in the oriental realm as an object of worship, love, value, danger and destruction. In recent years, the endangered status and degree of threats on elephant unequivocally reflect the extent and kind of habitats they are currently occupying for their own survival. The gradual loss of habitat marred with changing landuses and increasing human population, influences the degree of elephant movement for frequent interactions with human being resulting to a conflict situation. In India, survival of over 60-70% of elephants outside the protected areas is seemingly uncertain unless spatial vulnerability and access of these through intervening non-forest areas is ensured.

The 'Project Elephant' document 1993 enlists several problem elephant populations, facing a threat of their survival, and being a reason for man-elephant conflicts. One among them is the elephants residing in south West Bengal adjoining to Dalma Wildlife Sanctuary, Jharkhand from where annual flux of elephants are received annually during monsoon with the advent of paddy crop. On an average annual basis, 13 people fall victim of elephant trampling and huge losses incurred for crop and property. People often also retaliate by inflicting injuries or killing or using deliberate methods to displace elephants from their crop and properties. The compensations paid for human kill, crop and property loss and anti-depredation measures to keep elephant away from human habitation had has a heavy drain on State exchequer, and are often unsustainable on economic terms.

There is increased agreement in conservation and political circle to evaluate and ascertain the magnitude of such conflict for initiating conservation and management action for the species. Ecological information on habitat, population, ranging pattern, range requirement and utilization, identification of conflict zones and assessment of crop and property losses are the basic issues for scientific investigation. The present study is an effort to correlate economic values and ecological importance of elephants for their conservation in the region. The laid out objectives of this study is as follows:

- To know the present population status, demography and interactions of residential and migratory groups of elephants in south West Bengal.
- To overlay the locations of elephants on classified image to delineate movement, range size and habitat utilization in GIS domain.
- To study the seasonal habitat-elephant interactions.
- To know various landuse influences and their role in crop depredation.
- To collect conflict incidences and establish the role of individual/ group (elephant) in various seasons.
- To quantify crop and property losses and relating their socio-economic implications.

It is hoped that the findings of this study will provide understanding on several spatial elements, sensitive to the landscape resulting in human-elephant conflicts. The wildlife managers need to have better understanding of these elements, public perception and strategies that can be implemented to address those challenges.

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CHAPTER 1

Human-elephant conflicts - perspective in Asia and Africa: a review.

1.1 Introduction

Human-elephants conflicts are generally referred as negative interactions between wild elephants and human beings throughout existing ranges of the former. Elephants habitually frequent in to the proximate human settlements and destroy crops, raid stored food grains, damage house and properties and occasionally in the process injure or kill people too. On the contrary, people retaliate by deliberate measures to keep elephants away and often in extreme, injuring or killing to them. The poaching of elephant for ivory though is negative interaction but does not constitute a part of human-elephant conflict as it largely related to the wildlife trade. This therefore is precluded from any discussion.

In recent years, the increasing dimensions of direct conflict between human and elephants become a serious political issue, which requires proper understanding and mitigation to win elephant conservation support in Asia and Africa. The present chapter is a review to the historical and ecological perspective of human-elephant conflicts in Asia and Africa in relation to the changing human demography and socio-economic scenario.

1.2 Sources of human- elephant conflict

The sources of human-elephant conflict are the adverse factors that disturb environmental equilibrium for coexistence between human and elephant. In recent years, this disproportion resulted in Asia and Africa primarily due to increase in human populations (Tchamba, 1996; Johnsingh and Joshua, 1994; Santiapillai, 1994), unplanned developments and landuse changes (Tchamba, 1996; Singh et. al., 2002). The processes of land adjustments to meet them have contributed in reduction and fragmentation of elephant habitats (Caufield, 1984; Santiapillai, 1994; Santiapillai and Ramono, 1993; Santiapillai and de Silva, 1994; Sukumar, 1989a; Balasubramanian et. al., 1993) and truncated its populations due to corridor disruptions leading to genetic isolation.

In true sense there is no elephant habitat, which is free from man-elephant conflict at any human interfaces. Newmark et. al. (1994) and Thouless (1994) reported occurrence of problem elephants incidence in settlement areas of Africa with the wide range of human densities varying from < 5 km^2 to > 150 km^2 even. Low conflicts do exist at tolerable limit wherever elephant habitat is still large. High conflicts are common in fragmented habitats (Barnes et. al., 1995; Sukumar, 1991a), surrounded or interspersed with incompatible landuse and disturbed with biotic factors. The poverty and economic hardship of small farmers tilling on marginal landholdings could aggravate the situation due to economic, social and political reasons.

Scientific understanding is still lacking on the land attributes and the reasons for human-elephant conflicts on quantified terms. Nonetheless, such conflicts bring numerous negative interactions both for human and elephant.

1.3 Forms of negative interactions

The most common kind negative interactions of man-elephant conflict reviewed through literature can be grouped in six categories**:**

1.3.1 Damage to agriculture and plantation

Large numbers of wild herbivore are known for their damage to crop at the forest-agriculture interface in Asia and Africa. However, damage inflicted by elephants on such interface is widely concerned due to high crop loss through consumption and trampling (Thouless, 1994; Sukumar, 1989a; Balasubramanian et. al., 1993; Datye, 1995). In semi arid African countries, Zimbabwe and Kenya, elephant alone account for more than 70 % of the total crop damage incidences (Hoare & Mackie, 1993; Taylor, 1993; Waithaka, 1993). This severity however does not list elephant as an agriculture pest (Bell and McShane - Caluzi, 1984; Lahm, 1996) when the damage is evaluated on the total arable agriculture area. Taylor (1987) reported 0.2 % a low crop depredation in Niger, West Africa but a local farmer even could lose his entire annual harvest during a single night incursion by elephants.

Crop raiding by elephant is reported exclusively a nocturnal activity (Bell and McShane - Caluzi, 1984; Thouless, 1994; Hillman – Smith et. al., 1995; Hoare, 1995) to avoid the associated risk of harassment. Similar

observation on elephants in South India was reported for crop raiding by Sukumar (1989a). In fragmented and densely human populated areas elephant are exceptionally bold, and are encountered to raid crops even during the day hours (Chowdhury et. al., 1997).

Crop depredation by elephants occurs sporadically throughout the year with the availability of crop (Thouless, 1994; Sukumar, 1989a; Chowdhury et. al., 1997). Damiba and Ables (1993) reported elephant impact in the villages around the Nazinga Ranch (Burkino Faso) peaked in the rainy season while in dry season elephants raided more to millet granaries. The intense depredation were reported close to harvest usually in August-September in Northern Kenya (Thouless, 1994). Hoare (1995) reported a seasonal peak depredation when crops were mature corresponding with late wet season.

In different parts of India, intensive raiding is reported between September to December (Sukumar, 1989a; Datye and Bhagwat, 1993a; Chowdhury et. al., 1997) during major cropping season. Kumar (1995) reported sporadic crop depredation from Hosur and Dharmapuri Forest Divisios, Tamil Nadu between February and August when most of the croplands remains fallow. He further added that the intensity of depredation increased between September and January with crop cover and distinct peak in November. Nath and Sukumar (1998) have reported two peak crop-raiding seasons in Kodagu district, Karnataka during July-September and November-January respectively. Earlier report by Balasubramanian et. al. (1993) also correspond more or less similar peaks of depredation in the periphery of

Bandipur Tiger Reserve. He further reported only one peak raiding in Mudumalli Wildlife Sanctuary with the availability of single crop. A more systematic study carried out in the northern part of West Bengal quantified depredation frequencies, 57% for paddy between August to January, 21% for maize between March to June and 22% for other minor mixed crops between February and July (Chowdhury et. al., 1997).

Depredations on large number of crops and non-crops grown in and around elephant habitats have been reported from Africa and Asia. In western Laikipia, Kenya, Irigia (1990) recorded damage between 10 to 24 % of the total maize crop. Azika (1992) recorded more than 50% of crop damage around the Kakum forest in Ghana. In Laikipia and Samburu, northern Kenya, Thouless (1994) quantified crop depredation of maize (45%) as staple crop, followed by beans (13%), wheat (11%), potat (5%) and banana (5%). He further listed depredations on sugarcane, millet, pumpkins, wild spinach, onions, tomatoes, carrots, and fruit trees such as orange and others. While working in Waza-Logone, Cameroon, Tchamba (1996) reported frequent damage to millet (35%) in dry season and sorghum (30%) in wet season. The other affected crops reported were, cotton (11%), corn (9%), peanut (9%) and vegetables (3%). He further quantified elephant damage to crops represented through browsing (52%), trampling (38%), and uprooting (10%). From northern Sbungwe, Zimbabwe, Hoare (1999) reported damage to maize, millet, sorghum, cotton, beans, groundnuts, melons and sunflower.

The reported information available from Malaysia by Oliver (1978) and Blair et. al. (1979) indicated damage to oil palm and rubber plantations. In India damage to several crops, such as Paddy, finger millet (ragi), Maize, wheat, horse gram, sugarcane, niger, pepper, zinger, cotton, vegetables and plantations, like Coconut, coffee, banana, jackfruit, mango, mulberry, papaya, citrus, have been reported by various authors (Sukumar, 1990; Balasubramanian et. al., 1993; Datye and Bhagwat, 1993a; Sivaganesan and Kumar, 1993; Kumar, 1995; Chowdhuary et. al., 1997; Nath and Sukumar, 1998). While working on the elephants in Nilgiri Biosphere Reserve, South India, Balasubramanian et. al. (1993) quantified an overall damage of paddy (54%), ragi (24%) and maize (22%). Nath and Sukumar (1998) have quantified depredation of major crops *viz.*, paddy (48%), coffee (17%), cardamom (10%), coconut (9%), and banana (6%) in Kodagu district of Karnataka.

Elephant group sizes and sexes involved in for crop depredation has been reported through African and Asian accounts. Hoare (1999) based on the work carried out in northern Sebungwe, Zimbabwe, reported 19% of total crop raiding due to lone males. He further added that the range of raiding group size was 1 – 47 with 89% of raiding groups consisting of 10 animals or less. Sukumar (1991a) working on Asian elephant in South India reported frequency of males as being more than 5 times those of females in crop raiding. Kumar (1995) also reported a significantly higher frequency of crop raiding by bulls. Balasubramanian et al. (1993) and Datye (1995) also have observed significantly higher frequency of raiding by males than the herds.

However, they have ascertained more damage through herd in terms of area. The formation of large mean group sizes and their role in crop raiding has been reported by Chowdhury et. al. (1997), in north West Bengal, where bimodal peaks coincides with two major cropping seasons i.e., *rabi* and *kharif*.

The available scientific documentation suggests increase in human-elephant conflicts over the years in Asia and Africa. However, National or State statistical summery is still incomprehensive and speculative to account them on economic terms. Thouless and Tchamba (1992) estimated crop damage by elephant in Northern Cameroon more than US$ 200,000. Irigia (1990) assessed the crop damage in Ol Ari Nyiro Ranch in western Laikipia, Kenya more than KSh 100,000 (US$ 33,000). In South East Asian countries Blair and Noor (1981) reported damage of oil palm and rubber plantations in a tune of over million dollars. Santiapillai and Li (1990) assessed economic loss of 250 quintals of rice in 21 villages of Mengyang Sub-reserve, in China. In India such crop losses at local level are also estimated by Mishra (1971), in a tune of Rs. 40,000 (US$ 1000) in Palamau, Bihar and Sukumar (1989a) US$ 18,960 in the selected villages of three forest divisions of south India. Datye (1995) estimated a loss of Rs. 0.18 million in 1989- 90 and Rs. 0.16 million in 1991 in and around the Dalma Wildlife Sanctuary, Bihar. Kumar (1995) estimated a crop loss of Rs. 6,05,749 and 6, 60, 240 in 1989-90 and 1990-91 respectively.

1.3.2 Damage to property

This negative interaction results into several nuisance and actual physical damage to personal and public properties. Though this has not been documented exhaustive but some representative examples illustrate the kind and range of these problems. In northern Kenya loss of livestock and inconvenience caused by competition for water has been reported by Thouless (1994). He further reports other kind of property damage *viz* destruction of wire fences, damage to dam wall, drinking troughs, tanks and pipes.

In India, Lahiri Choudhury (1980) has reported demolition of human hutment by elephants in North Bengal. Dey (1991) also reported destruction of average 800 hutments per year in north West Bengal. However, in the year 1985, an unusually high destruction of more than 2000 hutment was reported by him. Barua and Bist (1993) mention a herd of wild elephant damaging property in Lankapara Tea Estate and Titi Reserve Forests of Cooch Behar division in north West Bengal. Williams and Johnsingh (1996a) reported destruction of 9 hutment and a concrete house in Garo hills, Meghalaya, during the months of July and August 1995. Destruction of dwellings of the people en route elephant movement has also been reported in Sri Lanka due to periodical movement from Kahalla/ Pallekelle Reserve to Gakiriyagama forest (Santiapillai and de Silva, 1994).

1.3.3 Human kill and injury

A variety of direct interactions by elephants leading to human injury and killing have been widely reported from Africa and Asia. Thouless (1994) opined that people injury and killing by elephant in Laikipia district, Northern Kenya has increased in last few years. He reported killing and injury of 21 and 18 people respectively between 1989-1992. In the same period he recorded 9 human kill and 13 injuries from Sambauru district. An exceptional high kill and injury of human being in 1992 might have been partly due to draught conditions, resulted with elephant staying in well-watered southern areas close to human settlements (Thouless, 1994). From Cameroon, West Africa, Thouless and Tchamba (1992) reports killing of 2 people between July 1992 to November 1992, whereas killing of 4 people was reported from Cameroon in June 1993 (Tchamba, 1993).

In India, Sukumar (1989a) reported killing of 30-50 people every year in Southern region containing largest elephant habitat and population. He further analyzed killing of adult men (77%) constituting mostly farmers, grazers and laborers. While working in Kodagu district, South India, Nath and Sukumar (1998) recorded average 6 human deaths by elephants per year. Dey (1991) reported human deaths ranging between 28 – 59 per year, from fragmented habitats of north West Bengal between 1980 –90, through only 1% of the total wild elephant population in India. Similar reporting by Barua and Bist (1993) from the same region accounts killing of average 47 people per year since 1981. Datye and Bhagwat (1993b) reported a total of 208 human deaths between 1980 and 1991 from south Bihar (134) and south West Bengal (74) through pocketed elephants on a fragmented landscape.

Occasional dispersal and straying of elephants to the unknown habitats has also taken toll of human lives in Andhra Pradesh, south India, Madhya Pradesh and south Bihar in Central India (News paper reports). One such incidence, where 30 human deaths occur due to ignorance of local people unaccustomed to wild elephants has been reported by Sukumar (1991a). Williams and Johnsingh (1996a) recorded total death and injury of 115 human from three districts of Garo hills, Meghalaya between 1984-95. From other Asian country in Sri Lanka Jayawardene (1993a) and Santiapillai and de Silva (1994) also have accounted killing of human being in Mahaweli Project area and Hadapanagala area in Sri Lanka respectively.

The accounts of the circumstances in which people have been killed or injured by elephants include, farmers / dwellers attempting to defend their crop near settlements, entering forest for collection of fire wood and forest produce, passing through forest and bush and often intoxicated unaware of proximity of elephants (Thouless, 1994; Datye and Bhagwat, 1993b; Sukumar, 1989a). Information available on types of elephants causing human killing is scanty. Several authors have accounted bulls more responsible for human killing (Thouless, 1994; Sukumar, 1989a; Williams and Jhonsingh, 1996a; Chowdhury et. al., 1997) due to their bad temperament and boldness, while others also have reported the herds involvement (Thouless, 1994; Datye and Bhagwat, 1993b; Kumar, 1995) particularly with young calves.

1.3.4 Impact on ecosystem

Various authors have documented selective damage to several tree species by elephants leading to alteration of habitat on a long-term basis (Savidge, 1968; Thomson, 1975; Guy, 1976; Leuthold, 1977; Eltringham, 1980; Sivaganesan and Sathyanarayana, 1993). This situation Occurred due to population compression (Eltringham, 1982), overabundance (Jachmann and Croes, 1991) and denial of access for movement (Douglas Hamilton, 1973). In Africa tree species like *Acacia albida, A. gerrardii, A. tortilis, A. Xanthophloea, Colophospermum mopane, Commiphra ugogensis* and *baobabs* are particularly reported to damage due to debarking, pushing and uprooting (Savidge, 1968; Croze, 1974; Harrington and Ross, 1974; Sherry, 1975; Leuthold, 1977; Barnes, 1983). Thomson (1975) has reported severe damage to *Brachystegia* woodland on Siamagogas Ridge in Chizarira Game Reserve, Zimbabwe due to excessive debarking.

In dry deciduous forest of South India *Grewia tiliaefolia* and *Zizyphus xylopyrus* have been severely damaged due to uprooting (Sivaganesan and Sathyanarayana, 1993). In Sri Lank, Mueller-Dombois (1972) reported damage of several tree species due to crown distortion in Ruhuna National Park. Among which *Feronia limonia* was recorded particularly most affected with crown distortion in thorny evergreen forest.

1.3.5 Injury and killing of elephants

Like humans, elephants do suffer due to the negative interactions inflicted on them through injury and killing. Several kinds of equipment,

devices and chemicals are being used for such purposes. In Africa, Thouless (1994) mention that the number of elephants shots on control in Laikipia district of Kenya has increased largely in response to the increasing number of human kill by elephants. He further mentioned that illegal killings by the pastoralists are due to spearing, snaring and poisoning. Control killing of elephants at several places in Africa was also been done to reduce crop damage and conflict by elephants (Laws, *et.al.*, 1975; Thouless and Sakwa, 1995; Tchamba, 1996).

In India, Sukumar (1989a) recorded death of at least 3-8% male and 17-19% female in crop protection measures out of the total elephant death from state of Tamilnadu and Karnataka between 1975-87. Killings were done by gun shoots or electrocution. Killing of elephants through electrocution has also been reported from Chittoor district of Andthra Pradesh, South India (Rao, 1993). Barua (1993) reports killing of at least 3 elephants in North Bengal during 1992 in crop protection measures possibly through gun shoots. Williams and Johnsingh (1996a) reports killing of 28 elephants in Garo hills, Meghalaya between 1984-1995 out of which 32% were killed by gun shots. Several cases of killing to problematic elephants after declaring rogue have been reported from North Bengal (Lahiri Choudhury, 1980; Barua, 1993; Barua and Bist, 1993) and Haldwani, Uttaranchal (Nestrong and Smetacek, 1972). Barua (1993) also reported 13 cases of calf abandoning due to continuous stress in North Bengal between 1986-92, of which 12 died.

In other part of Asia elephant killing in conflict incidences has also been reported from Sri Lanka by several authors through gun shoots (McKay, 1973; Jayawardene, 1993a; Jayawardene, 1993b; Santiapillai, 1994; Santiapillai and de Silva, 1994) and poisoning with insecticides (Jayawardene, 1994). Santiapillai (1994) gives a detail account of elephant mortality in Sri Lanka between 1951-1969, showing that a total of 639 elephants were killed in defense of crop during that period.

1.3.6 Disease transmission

An account of several cattle-borne diseases and their transmission has been a major cause of elephant mortalities in Africa and Asia (Ramiah, 1935; Gee, 1955; Mcgaughey, 1961; Sinha, 1975; Pyakural *et. al.*, 1976; Boshe and Malima, 1986; Panickar, 1990; Lindeque and Turnbull, 1994; Spinage, 1994; Chandrasekharan *et. al.*, 1995; Grobler *et. al.*, 1995). Outbreak of deadly bacterial and viral diseases like anthrax and foot and mouth disease respectively can affect large section of wild population in short span of time. Elephants too have suffered due to such outbreaks in past (Ramiah, 1935; Gee, 1955; Boshe and Malima, 1986; Spinage, 1994). Gee (1955) reported death of 150 elephants due to anthrax in 1949 in North Cachar hills of Assam, India. In India, cattle borne diseases (anthrax, haemorrhagic septicaemia and trypanosomiasis) account for death of 20 elephants annually (Bist, 2002).

In Zaire on the flat land to the west of L. Alberta, 1000 elephant died due to anthrax in three months from December 1960 to February 1961 (Spinage, 1994). In 1983, an anthrax outbreak affected several large mammalian species including elephants in Lake Manyara National Park,

Tanzania, which reduced the park impala population by 69% (Boshe and Malima, 1986). In Etosha National Park, Namibia, 811 wild animals died due to anthrax, which constituted 13 % of the total animal deaths recorded during same period (Berry, 1993). Besides elephants, other animals died due to Anthrax were zebra, wildebeest and springbok (Berry, 1993). Grobler *et. al.*, (1995) reported encephalomyocarditis virus in killing several elephants in the Kruger National Park between December 1993 and November 1994. Pyakural *et. al.* (1976) reported an outbreak of foot and mouth disease in 16 elephant out of 30 elephants brought to Kathmandu. Study on seasonal pattern of anthrax outbreak in African elephant showed a peak during dry season (Berry, 1993; Lindeque and Turnbull, 1994; Spinage, 1994).

1.4 Modes of Conflict management

The options for reducing conflict have been documented by numerous studies across Asia (Sukumar, 1991a; Williams and Johnsingh, 1996a; Nath and Sukumar, 1998) and Africa (Barnes, *et al.*, 1995; Hoare, 1995; Wunder, 1996; Osborn, 1998; Osborn and Rasmussen, 1995; Osborn, 2002; Osborn and Parker, 2002). No single management measures have been found effective and full-proof in dealing conflict situation alone (Hoare, 1999; Taylor, 1999). However, several kinds of measures varying from ecological approaches to use of deterrents, repellents and aversion techniques and compensatory measures to enhance human tolerances have been used which in combination provided better chances for their applicability.

1.4.1 Ecological approach

1.4.1.1 Population control

A large number of population control measures have been adopted as a tool for conflict resolution. Traditionally, problem elephants involved in the crop raiding or human killed have been reported to the wildlife personnel for the location to assess damage and to eliminate the offending animal through shooting (Nestrong and Smetacek, 1972; Laws, *et.al.*, 1975; Taylor, 1993; Garai, 1997; Hoare, 2001). While this method is still practiced throughout the elephant ranges many wildlife mangers feels that it is generally of little long term effect for resolving the conflict (Hoare, 1995; Lahm, 1996; Tchamba, 1996; Osborn, 1998; Hoare, 1999; Hoare, 2001). The traditional capture methods of elephant in India through ‘Khedda’, ‘Mela Shikar’ and ‘Pit method’ (Barua and Bist, 1993; Barua, 1996; Basappanavar, 1998; Sukumar, 2003) and their captive utilization were the process by which elephant populations used to be managed is no longer in use beyond 1980s.

For better utilization of the valuable resources selective capture of problematic elephant either through domestication and translocation to far off places have been undertaken (Jones, 1975; Hofmeyr, 1979; Cheeran and Panicker, 1990; Stracy, 1991; Williams and Johnsingh, 1996b; Jayewardene, 1986; Stuwe *et. al.*, 1998; Mikota *et. al.*, 2003; Sukumar, 2003; Khan, 1987; Lahari-Choudhury, 1991). These practices also had limitations as elephant being long ranging animal have potential to come back to its original capture site (Hofmeyr, 1979; Lahiri-Choudhury, 1993; Santiapillai, 1996). Elephant capture and translocation required to be done on well planned manner as in

past elephant suffered high post capture mortalities in these operations (Jones, 1975; Mikota *et. al.*, 2003; Sukumar, 2003). Translocation certainly has a role in elephant management especially to build up the areas with depleted elephant densities but their role in conflict mitigation has limited scope.

1.4.1.2 Habitat improvement

Fragmentation and habitat reduction have been identified as most threatening factor for elephant conservation (Parker and Graham, 1989; Anon, 1999; Hoare and du Toit, 1999) leading to human-elephant conflicts (Johnsingh and Joshua, 1994; Osborn and Parker, 2003a; Christy *et. al.*, 2005). Maintaining habitat connectivity and corridor links for movement and dispersal on the landscape are important elements for reducing conflict and also to maintain population and habitat viability (Johnsingh et. al., 1990; Johnsingh et. al., 1991; Dey, 1991; Sukumar, 1991b; Williams and Johnsingh, 1996c; Johnsingh and Williams, 1999; Osborn and Parker, 2003a). Dey (1991) suggested improving mono-cultivated habitat with enriched plantations of fodder species for better utilization of habitats by elephants in northern West Bengal. Maintaining a diverse habitat type has been suggested as best suitable approach of habitat management for elephant (Sukumar, 2003).

1.4.1.3 Alternate crop strategy

Replacement of palatable crops with several unpalatable crop species close to the forest boundary has been visualized to reduce crop depredation and economic loss to the people (Santiapillai, 1996; Osborn and Parker,

2003a; Boafo, et. al., 2004). Several workers have advocated maintaining a buffer zone of reduced attractiveness between forests and surrounding crops as a tool to reduce crop depredation by elephants (Seidensticker, 1984; Thouless, 1994; Santiapillai, 1996). Osborn and Parker (2002) reported that in Zimbabwe farmers cleared 5 meter wide area between forest and crop field to make a buffer zone. Landscape planning through alternate cropping pattern has been suggested as a permanent viable solution to resolve human-elephant conflict on long term basis by several workers (Barnes, 1996; Hoare, 2000; Barnes, 2002).

1.4.2 Deterrent, repellants and aversion

1.4.2.1 Tactical measures

The common traditional methods for deterring crop-raiding elephants are beating drums, use of fire, lighting torches/ spotlight, exploding crackers (Mishra, 1971; Lahhiri-Choudhury, 1991; Santiapillai, 1996; Tchamba, 1996). Active deterrent to chase the elephants away included locally made fire crackers and burning dried chilies to produce irritating smoke (Osborn and Parker, 2002). These methods have their limitations for short term and temporary effect (Tchamba, 1996) and soon get habituated if exposed for longer time (Thouless, 1994; Osborn, 1998; Nyhus et. al., 2000). To avoid eventual habituation it is required to develop new deterrent methods (Osborn and Parker, 2002; Osborn and Parker, 2003a). A rotating guard duty system of night patrolling can help in proper management of saving crop with less effort (Osborn and Parker, 2003a). Alarm system using cowbells mounted on a string fence may be utilized that reduces the time a farmer must spend

awake at night and help in reducing number of incidence of crop damage (Osborn and Parker, 2002; Osborn and Parker, 2003a). Combination of increased vigilance and effective deterrent help in reducing crop damage (Osborn and Parker, 2002). In India, West Bengal State Forest Department has been using captive elephant squared to drive back wild elephant (Dey, 1991; Lahiri-Choudhury, 1991).

1.4.2.2 Physical and pulsating barriers

Successful physical barriers used against elephants to prevent their entry in crop field or habitations are, construction of stone walls (Thouless and Sakwa, 1995), digging elephant-proof trenches (Mishra, 1971; Santiapillai, 1996), and steel pole fences. Thouless and Sakwa (1995) reported that dry stone walls constructed on the farm boundaries in few areas of Laikipia were proved ineffective, and were broken so frequently that repairs were seldom carried out. The traditional elephant-proof trench, if well constructed and maintained, can be useful in minimizing elephant depredation (Mishra, 1971; Santiapillai, 1996).

The traditional methods of deterring elephants and physical barriers are cost prohibitive and ineffective in want of recurring maintenances. On contrary, the electric fences are cost-effective and found suitable barrier to be used in several countries including India (Schultz, 1988; Sukumar, 1989a), Sri Lanka (Katugaha, 1992), Malaysia (Blair et. al., 1979), China (Santiapillai, 1991), Kenya (Woodley and Snyder, 1978; Thouless and Sakwa, 1995), Malawi (Bell and McShane-Caluzi, 1984; Mkanda, 1992), Zimbabwe (Taylor,

1993) and Mozambique (De Boer and Ntumi, 2001). The species specific design, voltage input and maintenance of the fence line and other equipment are important for effectiveness of this barrier (Thouless and Sakwa, 1995; Chauhan and Chowdhury, 2002). Fences are breached by uprooting or pushing the post with legs, head or by using trunk (Thouless, 1994; Thouless and Sakwa, 1995). It is necessary that fence breaking intensity should be recorded systematically so that elephant pressure on them can be evaluated and compared for in modification and reinforcement. Thouless and Sakwa (1995) reports that electric fences have been found less effective in African situation as compared to Asia. They further predicted the reasons for this success in Asian situation are due to presence of high soil moisture in Asian ranges which enhance the conductivity and makes electric shocks more effective and secondly, absence of tusk in all females and many male Asian elephants. Maintenance and theft of the fence component has been found major problems with the power fences (Thouless, 1994; Osborn and Parker, 2003a). Lack of information to the farmers regarding ownership and responsibility is also one of the reasons for its ill maintenance (Osborn and Parker, 2003a).

1.4.2.3 Chemical as repellants

The use of specific repellents for elephants, both olfactory and auditory is still in experimental stages. The olfactory repellents have been used with some success in conflict management of elephant (Osborn and Rasmussen, 1995; Osborn, 2002). Bell and Mcshane-Caluzi (1984) tested the effect of a deer repellent, HATE-C4 on elephant in Malawi, Africa which gave a negative

results in decreasing crop damage. Gorman (1986) found an ambiguous result of elephant temporal gland secretion as an elephant repellent. Osborn and Rasmussen (1995) reported that aerosol made from capsicum is an effective short-term repellent. Osborn (2002) found that capsicum spray can repel elephants from field more quickly than traditional deterrent methods. Combination of chemical repellents and the use of traditional methods may be an economically viable solution of the problem (Osborn, 2002).

1.4.2.4 Acoustic deterrents

Elephant produce a wide range of calls, both in human audible and infrasonic levels. On going research is attempting to categorize these calls and play back on the conflicting elephants for manipulating their behavior through the recorded vocalizations. Kangwana (1993) noticed retreat of elephants after playing back recordings of cattle owned by Massai, a tribe that usually hunt or injure elephant. Osborn and Parker (2003a) has also suggested the possibility of using low frequency distress call for repelling elephants which needs to be identified and require expensive equipments to record and playback.

1.4.3 Compensatory measures

Demand of compensation for crop damage, property loss, and human kill is the very first reaction to the human tolerance (Mishra, 1971; Tchamba, 1996). Though this measure of paying compensation is important yet problem of fraudulent claims for losses are major problems and shortcomings of this scheme (Taylor, 1993; Hoare, 2001). The farmers view on this is that the

compensation paid is disproportionately low and takes longer time to settle the claims. In real sense the scheme does not help to reduce conflict nor promotes a good relationship to with the local people.

1.5 Conservation approach in India

In the year 1992, Government of India launched “Project Elephant” – a major initiative to ensure long term survival of elephants in all major landscapes (Bist, 2002). A number of measures since have been taken for strengthening of enforcement machinery, protection and improvement of habitat and corridors, reducing human-elephant conflicts, care of domesticated elephants (Bist *et. al*., 2001), creating education awareness among people and various other matters related to conservation.

Looking at the range need of elephant populations and current protected area networking it was evident that the elephant management has to be carried out on basis of identified landscapes. The Task Force of Project Elephant identified 11 viable elephant ranges in the country, of which 9 of them being inter-state in their extent and recommended that this to be constituted into ‘Elephant Reserves’. At present there are 11 elephant ranges comprising 25 designated Elephant Reserves in India (Bist, 2002), which gives a conservation protection of about 58,000 km^2 and target to harbor 19,000 elephant within it. The State Governments have been asked formally to notify these Elephant Reserves and appoint field coordinators who can interact with various landuse stake holders falling in the landscape.

CHAPTER 2

Historical changes in landscape and conservation of elephants in south West Bengal

2.1 Introduction

The southern West Bengal elephant range extends from the civil districts of Purulia in the west to Midnapore on the east as well as in the south to Bankura in the north. Occasional elephant range extensions however have occurred as far as district Hoogly towards east, and Bardawan on the north. This range gets annual augmentation of elephants moving from adjoining Dalma Wildlife Sanctuary, Jharkhand situated 50 km west from the western limit of the study area. A scattered group of residential elephants, however, remain in the range throughout the year (Chapter 4).

From biogeographic standpoint, the entire southern elephant range falls at the meeting edges of two major biotic provinces i.e., Deccan plateau (north) and lower Gangetic plain in Deccan Peninsula and Gangetic plain biogeographic zones respectively (Rodgers and Panwar, 1988).

The present chapter investigates historical accounts of south West Bengal landscape changes in terms of forest and non forest covers and landuse changes which possibly have influenced elephants to re-colonized and creating conflict in the area. Understanding these elements of landscape changes is essential to investigate and establish elephant conflicts in the region.

2.2 Past history of forests and wildlife management

During the British period the forests in this tract were held under the *zamindari* (local landlord) and tenurial systems. Following permanent land settlement, in the year 1793, the land revenue taxes saw a steep upward revision (Palit, 1991). The tax compulsions forced the landlords and small land holders to progressively clear the forest lands into cultivations. The local tribes *Santhals* were displaced by the hill agronomist tribe *Malpaharias*, migrating from Chotanagpur and Palamau regions of Bihar, for converting forest lands into agriculture (Palit, 1991).

A greater destruction of forests was observed after opening of the Bengal - Nagpur railway line, in 1889, followed by the railway track through Midnapore in 1903 (Palit, 1991; Malhotra, 1995). The access and transportation facilities brought better return for the forest produce. Felling became more intensive in plain *sal* forests, which responded to better regeneration through coppicing. The crop rotation varied from 5 to 15 years based on economic dependence of the landholders. The statistics presented by West Bengal Forest Committee 1938, showed a very alarming picture of forest degradation in Midnapore district where majority of these were worked with a rotation of 5 to 6 years cycle (Palit, 1991).

The denudation and maltreatment of forest resulting into severe soil erosion prompted the Government to set up a committee in 1938. On the recommendation of the committee, Bengal Private Forest Act, 1945 was passed, which made it mandatory for landowners to work forests on approved

working plan prescriptions. The Act also made provisions for voluntary or compulsory vesting of the forest lands (Palit, 1991).

The enactment of Estate Acquisition Act, 1953 made it possible to take over formerly held *zamindari* forests for vesting in the Forest Department, in the year 1955. The reckless destruction of forests took place during this critical period of transition by private landowners to reap the last profit. Following vesting of the forests with Forest Department, all rights and privileges of the people, existing earlier, were also suspended. Plantation forestry was also started in a big way for afforestation during the same period.

After independence, the region saw a period of migration of refugees from erstwhile East Pakistan now Bangladesh. Phenomenal population growth beyond 1960's further vitiated the land resources as the demand for timber, fuel wood and fodder increased. The continuous and repeated hacking of the *sal, Shorea robusta* forests converted the productive forests into stunted and degraded jungle (Malhotra *et al*, 1993).

The wildlife in this region also suffered losses along with the forests. Records available in the district gazetteers during British period indicate presence of large elephant herds in this region. O'Malley (1911) reported presence of large elephant herds in the dense *sal* forests of Midnapore and adjoining areas. Besides elephants, other wildlife such as leopard, tiger, barking deer, spotted deer and sambar were also reported from Midnapore forests (O'Malley, 1911). In earlier account Blanford (1888-91) reported presence of

wild buffalos and black buck from Midnapore forests. In recent past annual tribal hunts and repeated forest fires have been responsible for gradual disappearance of rich wildlife from south West Bengal (Rao, 1960). Gradual decline in the forest cover quality beyond 1960's limited the recording of elephants only on the border areas of West Bengal with Jharkhand, till mid 1980's.

2.3 A new initiative

After the vesting of forests under Government control, the forest depletion continued unabated because of the suspension of rights and privileges of local people which they used to enjoy during *zamindari* system. This was the major point of hostility and apathy towards forest and forest staff, which made the local people to extract timber, pole and firewood surreptitiously from the forests.

With this scenario in background a new initiative for forest protection and restoration through community participation emerged in West Bengal way back in 1970's. For this, a pilot project was taken up in Arabari Forest Range of east Midnapore Forest Division in the year 1971-72 (Palit, 1991; Malhotra, 1995). Demographic survey of 11 villages and their dependencies on forests were evaluated. Formation of forest protection committees and forest base employment generation schemes through resource sharing basis were adopted. The experimental success of `Aarabari' project could motivate 1266 villages to bring 1,52,000 ha of degraded forests under protection and restoration, in a span of 8 years. By 1989, 37% of the existing 4,27,000 ha forest area of

Western Circle came under participatory forest protection. In the three districts, Midnapore, Bankura and Purulia, 67,300 ha, 49,315 ha and 38,500 ha of forests respectively were protected through Forest Protection Communities (Palit, 1989). The State Government's declaration of sharing 25% of timber sale and providing non-timber forest produce access to the communities further boosted up the entire programme (Malhotra, 1995).

The Social Forestry Project was introduced in West Bengal in 1981 with an objective of having afforestation programmes on public and private lands to meet the fuel demand of the local people with some fast growing species (Malhotra and Poffenberger, 1989).

2.4 Historical landuse changes

The south West Bengal landscape has also seen drastic landuse changes in terms of water development and crops to need the aspirations of increasing human population. The major water development project for the irrigation purposes is from Kangsabati Reservoir located on the north-western side of the study area, commissioned in the year 1965-66. The network of the irrigation canals increased phase wise over several decades, and transformed the area from rain dependent to arable cropping with substantial canal dependent irrigations. In 1965-66 the command area of this Reservoir was 71,000 acres which over three decades has enhanced to 7.6 times of the initial irrigated area (Fig 2.1).

The development of irrigation facilities also transformed traditional rain dependent cropping to highly irrigated cash crops. In the year 1920-21 the cultivation land in Midnapore district was 825000 ha. which increased to 1268000 ha. in 1992-93, registering an increase of 1.5 times in nearly 70 years. The cropping pattern in the region has not changed much in paddy (monsoon) whereas other two paddy Aus and Boro during non-monsoon period has shown substantial growth with increased irrigation facilities. The cash crops such as oilseeds, potato, vegetables and miscellaneous food crops have shown a remarkable increase over several decades. These changes in the crop pattern have been shown in Table 2.1.

2.5 Movement of elephants in recent past till present

After 1960's, forest denudation in south West Bengal forest ranges was quite extensive and hardly any residential wild elephant groups were known to be present in south Bengal. A few scattered individuals however occurred in Ajodhya *pahar* or hill, Bandawan range of Purulia district, Banspahari area of Midnapore district and Ranibundh area of Bankura district. The movement of herds from Dalma Wildlife Sanctuary, Jharkhand used to take place between October and December, when paddy crop was available to the elephants. However, these movements were always remained restricted to areas west of Kangsabati river. The movements of these elephants through Banspahari - Belpahari tract around September end had been reported by Shahi (1980). He further reported limited incidence of crop damage only in west Midnapore and Patamda areas in erstwhile Bihar, now Jharkhand. Once in 1976, 42 elephants

went eastward into Purulia district up to Sindri, stayed there for 20 days and caused damage to paddy and killed two human beings (Shahi, 1980).

The first long distance movement by elephants from Dalma Wildlife Sanctuary to east Midnapore district beyond the Kangsabati river was recorded in the year 1987 (Dey, 1993). According to him 50 elephants from Motgoda range of Bakura district moved southward crossing the river Kangsabati and entered the Lalgarh range of east Midnapore forest division. This exploratory movement of elephants in successive years continued and expanded deeper and deeper to the east.

The general movements of the migrated elephants though are mostly confined to the forests of Lalgarh, Aarabari, Garbeta, Humgarh, Goaltore and Nayabasat ranges of East Midnapore and Rupnarayan Forest Divisions yet several unprecedented straying movements have also been recorded in different years. In July 1989, one male elephant strayed to north 24 Parganas district from Bankura and Burdwan via Riana, Jamalpur and Pandua (Dey, 1991). This elephant was immobilized and translocated to north Bengal. Similar movements of elephants for short duration were also recorded in Bishnupur range of Bankura district in 1989 and Panagarh range of Burdwan Division in 1990. In the year 1993 elephants, further strayed eastward to Hoogly district and created much havoc for public.

Datye (1995) based on his studies on elephants in Bihar (now Jharkhand) and south Bengal identified 9 sub-populations of elephants out of which 3 sub-populations have been reported to be interacting with West Bengal.

According to them these sub-populations besides Dalma are: Mosabani and Chakulia sub-population (Fig 3.3; Chapter 3).

2.6 Present conservation problem and management

The recolonisation of elephants in vast areas of south Bengal, migrating from Dalma Wildlife Sanctuary, Jharkhand is a major cause for increased man-elephant conflict in the region. This has also led to increased human casualties on an average around 13 persons per year from 1987 onward. The crop compensation paid on account of elephant depredation has also shot up from Rs.6.2 lakh in 1987-88 to Rs.39 lakh in 1994-95 according to the Forest Department records. Dimensions of this conflict has not only strained the relationship of local people with Forest Department but also was a reason for apathy towards participatory forest management programmes for restoration of degraded forests (Dey, 1993).

To tackle this situation several steps were initiated by the Forest Department to stop elephant movements beyond the river Kangsabati but all turned them failed. Energised fences were installed but they could not effectively contain the elephants, not so much because of technical flaws but more due to the social problems associated with theft of fence wire, uprooting of poles etc. Other deterrent method through *Koonkie* operations (chasing with trained elephants) and driving through scaring techniques could not provide effective control to the damage.

In the year 1995, capture and removal of elephants was thought of as a strategy to tackle increasing crop depredations and man-elephant conflicts. Accordingly, 6 elephants were captured for their subsequent utilization in the captivity (Fig 2.2). For providing training to the captured wild elephants, a camp was established around Arabari range (Fig 2.3). One male tusker was captured from Manikpara range of west Midnapore. Subsequently, 5 more elephants from migrated herds (3 females and 2 males) were captured from East Midnapore and Rupnarayan Forest Divisions. Two males and one female were captured by using chemical immobilization, whereas 2 females and 1 male were captured through *mela* shikar (or noosing). In the year 1996, again one sub-adult female was captured through *mela* shikar which totaled removal of 7 elephants from south Bengal.

The large number of mortalities (3 out of 7) during the training and post training period were major concern for the success of this operation. However, impact of elephant captures on reduction of crop damage and human kill have yet to be evaluated.

The south Bengal elephant range does not have any protected area or Wildlife Division for looking into the elephant conservation problem in the region. Forests here are managed by 10 territorial Forest Divisions *viz*. Midnapore (east), Midnapore (west), Kharagpur Bankura (north), Bankura (south), Bishnupur Panchet Soil Conservation, Purulia and Kangsabati Soil Conservation I & II. Ranging of elephants take place in all these forest divisions except Kangsabati Soil Conservation Division I.

Table 2.1 Crop pattern changes in Midnapore district of south West Bengal

Type of Crop	Crop pattern of 1920-21		Crop pattern of 1992-93	
	Area under cultivation (in 1000 ha.)	% 0f the total area	Area under cultivation (in 1000 ha.)	% 0f the total area
Paddy	736.48	89.24	1022.16	80.5
Wheat	32.89	3.99	5.77	.46
Oilseed	13.72	1.66	59.53	4.69
Sugarcane	4.24	.51	1.95	.15
Fibers	6.15	.75	10.53	.83
Dyes	.05	.006	-	-
Drugs/narcotics	.29	.04	.07	.006
Fodder crops	.04	.005	-	-
Fruits/Vegetables	4.86	.59	77.92	6.12
Misc. food crops	10.21	1.24	74.98*	5.91
Non food crops	16.28	1.97	15.62	1.23
Total	825.26		1268.59	

*** Includes Potat-53.14 ha., Pulses-19.05 ha., Maize-00.83 ha. and Other cerals-1.94 ha.**

(Source: BRP/Agri./Agri. and Industry Dept. 1921)

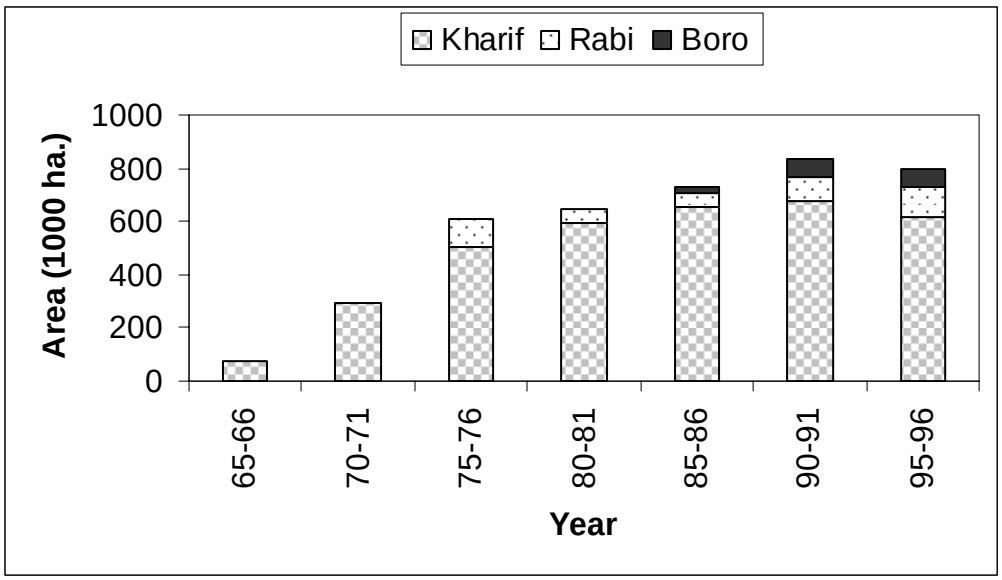

Fig 2.1 **Increase in command area of Kangsabati Irrigation Project in south West Bengal.**

Fig 2.2 Showing initiation of training to a captured sub adult female

Fig 2.3 Showing training of captured elephant by the help of trained elephant or 'Koonki'

CHAPTER 3

The study area and methods

3.1 The study area

The study area lies in the south western part of the West Bengal between 21°30' N to 23°42' N and 85°49'25" E to 88°15 E extending on 10 Forest Divisions in three districts of Purulia, Bankura and Midnapore (Fig 3.1). The hilly and undulating western part of the study area is an extension of Chotanagpur Plateau of Deccan Peninsula. It encompasses areas of western and southern Purulia, south-western Bankura, and north-western portions of district Midnapore. The flat eastern part consisting of the Gangetic Plains stretches into central Midnapore and eastern Bankura.

IRS-1C FCC through Wide Field Sensor (WFS) shows the linkage of south Bengal elephant habitat with adjoining Dalma Wildlife Sanctuary on the west, Ajodhya pahar on north-west and Musabani and forests of Chakulia on south-west (Fig 3.2 and 3.3). Chapter 4 deals with the residential and migratory elephant populations in the region and their interactions with each other.

Geologically, the western part of the south West Bengal consisting of the districts Purulia, Bankura, Midnapore has the oldest rocks, the granites and schist of Precambrian age (Das Gupta, 1989). The uplands of south-western part of the State consist of crystalline rocky areas. Presence of thick deposits of clay below the lateritic mantle serves as potential source of ground water.

3.1.1 Topography and soil

The general topography is undulating, with small hills in the western side and a stretch of flat lands towards east. Contour spacing reveal that eastern elevation is still gentler. Elevation becomes prominent as it approaches Chotanagpur plateau. The Ajodhya hill is the highest peak having an altitude of 670 m. The second highest peak is Lakaisini pahar, which has an altitude around 500 m, and is located westward, on Jharkhand -Bengal border.

Soils are mainly red sandy, lateritic and alluvial type covering most of the portion of the study area mixed with red and black soils in few pockets (Ghosh, 1992).

3.1.2 Hydrology

All the rivers of this region flow from north-west to south-east direction and ultimately drain in Bay of Bengal. The four major river systems which draining the area from south to north are: Subernarekha, Kangsabati, Silabati and Darkeshwar (Fig 3.4). There are few minor rivers and perennial streams which traverse the tract are: Kumari, Totko, Tarafeni, Tamal and Kubai etc. The area has innumerable man made water bodies and ponds in the villages, some of which were created for the purpose of soil-moisture conservation. Water table is at the depth of 15 m generally but during summer it goes down steeply. A major source of irrigation is the Kangsabati dam at Mukutmanipur in Bankura district (Fig 3.5). The canal network emanating from this dam is a major source of irrigation in the region.

3.1.3 Climate

A general climatic condition is hot and dry with three distinct seasons i.e. summer, monsoon and winter. The summer is intense and lasts from middle of March to middle of June. High day temperature is the characteristics of the area, while April, May and June are the hottest months. During this period hot dry wind blow in the area. Thunderstorms occur during the drier months. The maximum temperature fluctuates between 42^{o}C - 46^{o}C during summer months and the minimum temperature varies between 8^{o}C-13^{o}C during winter months. The mean monthly temperature is presented in Fig 3.6.

The monsoon period is from mid June to end of the September. Rainfall generally is moderate. The rainfall in the months of June through September constitutes 75% of the total annual precipitation. The average annual rainfall varies from 1428 mm in Midnapore, 1271 mm in Bankura and 1180 mm in Purulia (Ghosh, 1992). Rainfall decreases from October onward and dry winter sets in. The mean monthly rainfall based on 10 years data from 1986-95 is depicted in Fig 3.7.

The winter is less severe with short duration, lasts from November to February and frost is unknown.

3.1.4 Vegetation

The overall vegetation type is Tropical Dry Deciduous dominated with *sal (Shorea robusta)*. According to Champion and Seth (1968) the forest belong to category 5B of group 5 and are represented by types C_1/1C, C_2, DS_1,E_5, E_7, and

$2S_1$. On the basis of composition forest types can be divided into four broad categories i.e. sal-coppice, open scrub forests with sporadic *sal* and thorny bushes and plantations (Fig 3.8 to 3.10).

In *sal* coppice forest, *sal* is the dominating species along with miscellaneous associates. Its composition varies from 82% in western hilly tract to 95 % in the eastern undulating plains (FSI, 1985). The major associates are: *Pterocarpus marsupium, Madhuca latifolia, Diospyros melanoxylon, Lagerstomia parviflora, Terminalia tomentosa, Anogeissus latifolia, Bombax ceiba, Adina cordifolia, Buchanania latefolia, Garuga pinnata* etc. Excepting hilly and undulating areas *sal* coppice patches are found in scattered manner. Occurrence of bamboo is very limited (FSI, 1985).

The understorey shrubs and herbs are: *Hollarrhena antidysentrica, Flacortia spp., Zizyphus jujuba, Woodfordia floribunda, Cassia tora, Lantana camera, Carisa opaca, Andrographis paniculata* etc. Common climbers and creepers are: *Butea superba, Combratum decandrum, Bauhinia vahlii and Smilax macrophylla* etc.

Regional Remote Sensing Service Centre (RRSSC), Kharagpur has mapped the entire forest area of three districts of south Bengal viz. Midnapore, Bankura and Purulia by using remotely sensed digital data IRS-1A, LISS II of 1988 and 1991 for detecting the changes in the forest cover (Sudhakar and Raha, 1994). Based on RRSSC, Kharagpur report a summarized data of forest

cover available in three districts and changes detected in various categories of forests between 1988 and 1991 digital data are presented in Tables 3.1 to 3.3.

Fig 3.5 shows classified image of various forest categories and land use of elephant ranges in West Bengal and adjoining areas prepared using IRS LISS-III data of 1996.

3.1.5 Legal status of forest

Legal status of forests in three districts of Midnapore, Bankura and Purulia is given in Table 3.4. It can be seen that Reserve Forests are very less. Major chunk of forests fall in categories of Protected Forests and Unclassed Forests. Legal status of some areas is ambivalent due to improper notifications.

3.1.6 Landuse pattern

Agriculture is main landuse in the study area. FSI (1985) reported net-cropping areas in Midnapore and Purulia as 66.09% and 48.14% of geographical area, respectively. This is further categorized through digital image processing techniques by Regional Remote Sensing Centre Kharagpur (Sudhakar and Raha, 1994). According to this study 62.18%, 50.13% and 49.24% areas were under cultivation in respect to the total geographical areas of Midnapore, Bankura and Purulia districts respectively.

Economic activities based on agricultural practices are the main source of livelihood, and above 70% human population is dependent on this activity in the region. Average land holdings are very small. Number of marginal farmers

cultivating on land 0.2 to 1 ha are very high. Based on Agriculture Statistical data 1996-97, in Midnapore (east), Midnapore (west), Bankura and Purulia the percentage of marginal farmers is 87.86, 75.88, 62.30 and 62.29 respectively.

The main crops in the region are paddy, wheat, potato, vegetables, pulses and oil seeds. Paddy has the largest share in cultivation and production of the total crop (Chapter 2). Sugarcane is also cultivated in few well-irrigated areas of Purulia district.

After commissioning of the Kangsabati dam, and its canal network in the year 1965-66, tremendous changes in the agricultural prospects have been seen in this region. More and more unproductive lands are brought under the plough and crop rotation could be possible. At present three paddy crops - *Aus, Aman* and *Boro* are being taken in the study area. Cultivation on increased extent has also been seen for cash crops like potato and vegetables.

After agriculture the second major land use is forestry in the region. Joint Forest Management and Social Forestry Project programmes initiated in all the three districts - Midnapore, Bankura and Purulia have taken considerable steps in restoring and revegetating forest lands, since 1970.

3.1.7 The People

The total human population in three districts of Midnapore, Bankura and Purulia is 12.33 million. As per the 1991 census population densities respectively are 591, 408 and 355-person/km^2. In all 3 districts around 90%

population are rural dwellers with an occupation of cultivation and agricultural labourers. The western hill region of study area is occupied by various tribes viz. Santhals, Munda, Mahalis, Kora, Bhumij, Lodha and Mal Paharia etc. Land marginalization is a major factor for their dependencies on the forest and forest resources. Collections of miscellaneous non-timber forest produces are the major economic activities of the rural poor. The literacy rate in rural sector in the region is low.

3.2 Study methods

3.2.1 Collection of animal habitat data

3.2.1.1 *Immobilization*

Large animal Immobilon (C-Vet Limited, U.K.) containing 2.45 mg Etorphine hydrochloride and 10 mg Acepromazine maleate per ml was used to immobilize and restrain wild elephants. Distinject Mod. 60N rifle was used as a syringe projector. Sterilized disposable plastic syringe was used for drug filling in 4 ml projectile aluminum syringe fitted with a special elephant needle (51 mm long). The drug administration was tried deep intramuscularly from a distance 25-50 m. Large animal Revivon containing 3 mg Diprenorphine Hydrochloride/ ml was used as specific morphine antagonist for animal, after the operation of radio-collaring was completed. The antidote was given intravenously in the ventral side of the ear. Several vials of human antidote Naloxone Hydrochloride 0.4 mg/ml were carried to reverse any accidental contamination through spillage.

3.2.1.2 *Data collection of radio-collared and randomly sighted elephants*

We could radio-collar only one male elephant (Fig 3.11 and 3.12) in south Bengal at Barodiha, Midnapore on 22.12.95. More elephants could not be captured and radio-collared because of the local people antagonism. The elephant locations data were augmented through homing and whenever not possible through indirect locations.

Large number of random sighting on elephant groups and herds, male groups and associated and dissociated males were obtained throughout the elephant range. Randomly sighted elephants were categorized into four size classes of adult (>7'), sub-adult (>5'-<7'), juvenile (<5'->4') and calves (>3'-<4'). Individuals were sexed in the adult and sub-adults segments of the population but categorization of sexes in juvenile and calf stages were not done due to chance of inaccuracy.

3.2.1.3 *Crop depredation, human killing and other conflicts*

Data on crop depredation were recorded through direct observation during crop raiding or visiting the crop field after raiding information. The time of raiding, area, distance from forest, number of involved elephants, sex and structure, type of crop, season etc were recorded. To asses the damage and economic losses permanent plots of 10 x 10 m were laid in different damage sites. The damaged areas were also measured and percentage damages were calculated comparing with undamaged area in the plots. A total of 32 crop fields of various sizes were assessed for crop depredation. Frequencies of crop damage were recorded for each crop separately and in all three seasons. In

case when two or more crops were damaged in single raiding attempt, the frequency for each crop were recorded separately.

With the help of overlaid 421 elephant locations area under elephant range and area prone to damage (in 500 m buffered) were calculated in GIS domain. Each locations were buffered by 500 m, expecting maximum losses within it and area under various landuse categories were calculated. Actual area damaged was calculated with the help of agricultural area prone to damage (GIS output) and percentage damage (ground data). With the help of actual area damaged and average yield, the quantity of damage were measured and then by market value of crop, the total economic losses were calculated.

Detail information on human kill or injuries, house damages, elephant deaths and cattle kill were also recorded simultaneously during study period. Date and time, site of incident, age and sex of elephant involved, age and sex of person died etc were recorded. In case of house damage information on age and sex of elephants involved, structure and number of elephants, time and date, site, and reason of damage were recorded. For elephant death information on age and sex of elephant, reason of death etc were recorded. Postmortem reports on elephant death were also cross checked. Secondary information of human kill, elephant deaths and cattle kill of last 10 years were also collected from various levels of forest offices and crossed checked by local people.

3.2.1.4 *Landuse and socioeconomic information*

Data on cropping season, type of crops, yield, market value and area under cultivation etc were collected from local people. Secondary data on agricultural pattern, irrigation facilities, human population, market forces and socioeconomic condition were collected from District Agriculture Offices, Irrigation Department, District NIC offices, District Livestock Offices.

3.2.2 Creation of spatial data base in GIS

Remotely sensed digital data of IRS-IC, LISS-III was used for creating the spatial data base. Image classification for landuse and land cover was done through Maximum Likelihood classification (MLS). Major landuse and landcover categories identified from multispectral classification. Input layers from analysis in GIS/ARCINFO domain were generated from the topographic maps (1:50,000) on various them, such as contour, drainage, human habitation, forest boundaries etc. Data on elephant locations were capture through GPS for necessary overlaying and analysis. A 500 m point buffering technique data of elephants was used for extracting features of landuse and land cover within it.

Table 3.1 Forest types and landuse categories of Mindapore district with cover changes.

District Midnapore	Forest Divisions		Total area km^2
	Midnapore (East) Km^2	Midnapore (west) Km^2	
Total geog. area	9595.69	4485.00	14080.69
Total forest area	1101.65	1129.02	2230.67
Forest categories			
Dense sal	307.97 +10.37 *	201.18 +59.28	509.15
Dense mixed	-	80.46 +18.37	80.46
Open sal	593.44 -1.18	528.83 -112.17	1122.27
Open mixed	-	226.16 +52.52	226.16
Plantation	200.24 +116.46	92.39 +8.11	292.63
Agriculture	6242.37 +253.63	2513.54 -19.74	8755.91
Water bodies	1258.02 +288.46	117.14 +36.74	1375.16

* Changes detected in area between 1988 to 1991 source (Sudhakar and Raha, 1994)

-Absent

Table 3.2 Forest types and landuse categories of Bankura district with cover changes.

District Bankura	Forest Divisions		Total area km^2
	Bankura (South) km^2	Bankura (North) km^2	
Total geog. area	3899.31	2983.11	6882.42
Total forest area	927.39	887.83	1815.22
Forest categories			
Dense sal	156.31 -1.34 *	130.22 +27.16	286.53
Dense mixed	25.00 +2.23	75.77 -10.92	100.77
Open sal	576.03 +48.00	493.37 +105.05	1069.94
Open mixed	115.42 -60.57	138.87 -65.42	254.29
Plantation	54.63 +39.49	49.62 +35.16	104.25
Agriculture	2074.12 +228.36	1376.01 +207.29	3450.13
Water bodies	177.51 +72.05	182.38 +16.95	359.89

* Changes detected in area between 1988 to 1991 source (Sudhakar and Raha,1994)

Table 3.3 Forest types and landuse categories of Purulia district with cover change

District Purulia	**Forest Division Purulia Total Area km^2**
Geographical area Total Forest area	6257.78 1158.56
Forest Categories	
Dense sal	36.69 -11.38 *
Dense mixed	151.53 -43.75
Open sal	104.36 -7.58
Open mixed	752.82 -5.96
Plantation	113.16 +113.16
Agriculture	3081.53 +304.15
Water bodies	230.46 +5.56

* Changes detected in area between 1988 to 1991 source (Sudhakar and Raha, 1994)

Table 3.4 Legal status of forest (area in km^2)

District	**Reserved forest**	**Protected forest**	**Unclassed forest**	**Total**
Midnapore	2.36	1700.95	18.10	1721.41
Purulia	103.27	728.78	78.84	910.89

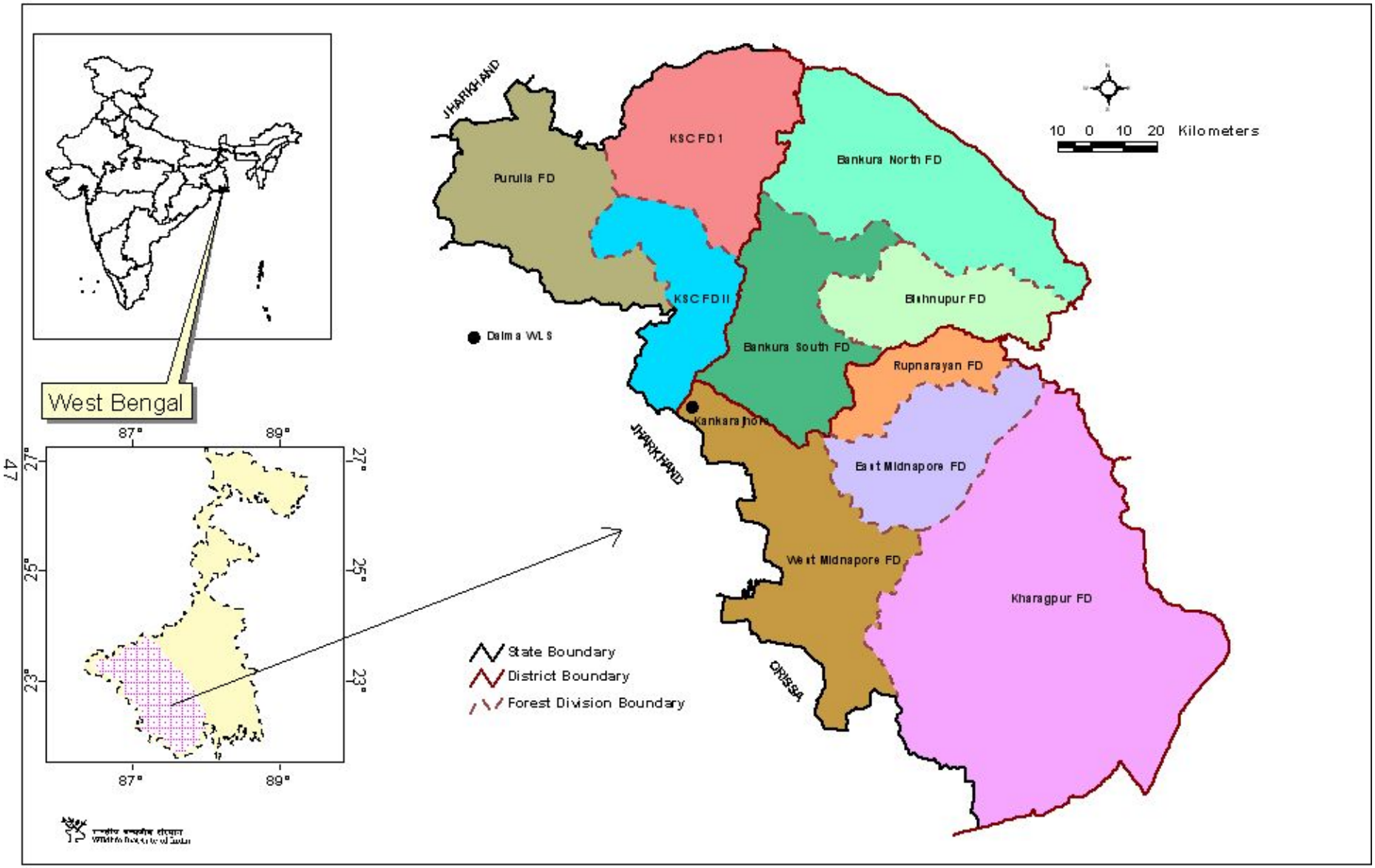

Fig. 3.1 Study area showing Forest Divisions in south West Bengal

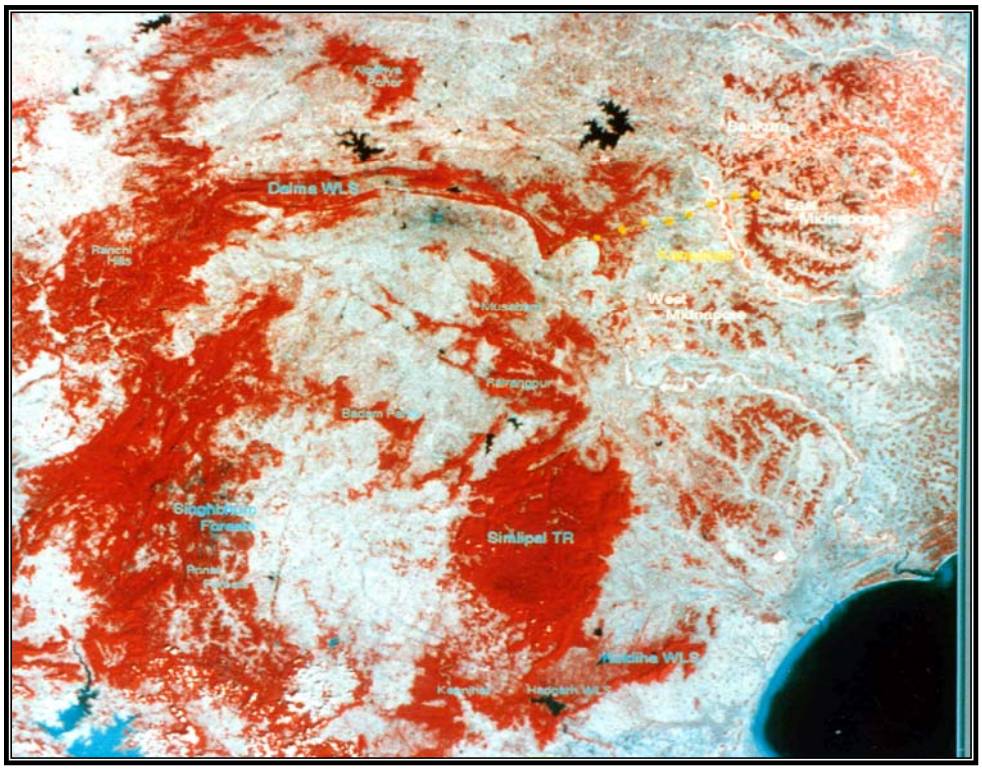

Fig 3.2 Wide Field Sensor (WFS) image showing linkage of south West Bengal elephant habitat with adjoining areas of Jharkhand and Orrisa.

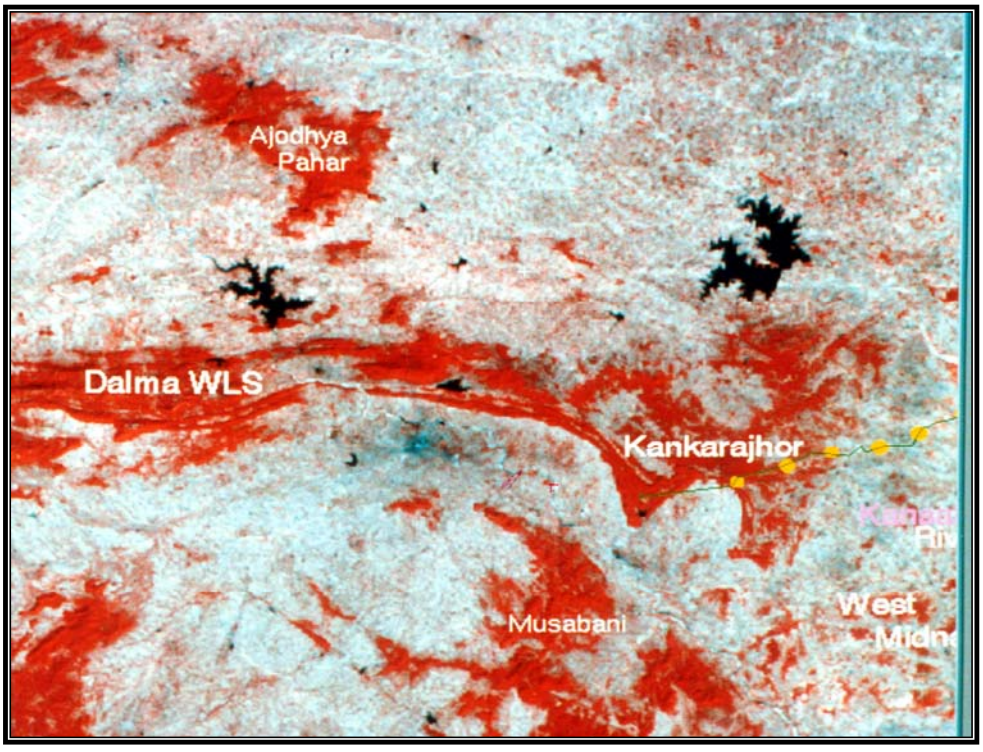

Fig 3.3 Wide Field Sensor (WFS) image showing linkage with Ajodhya Pahar and Musabani, forests in Jharkhand

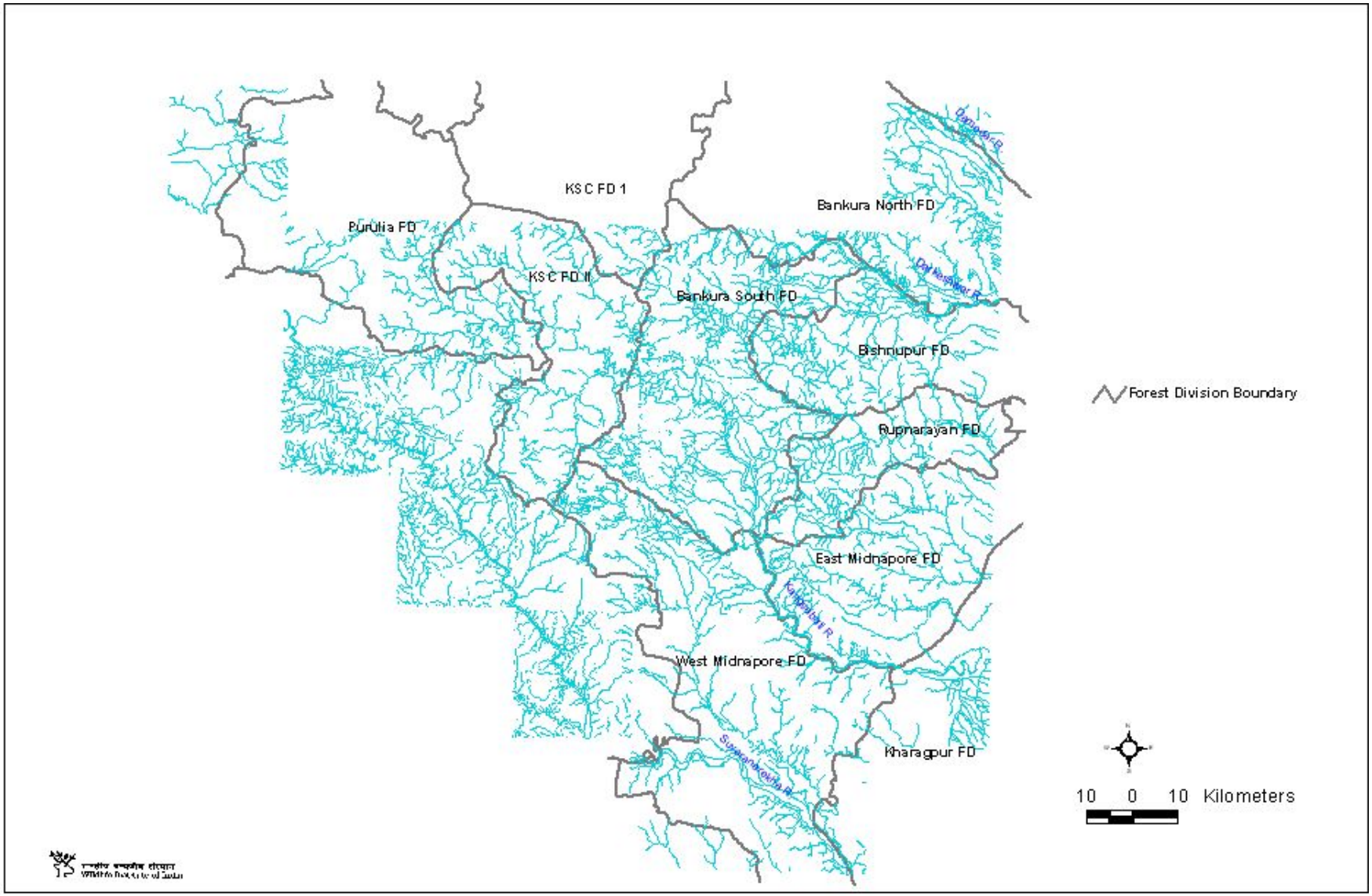

Fig. 3.4 Showing drainage pattern in study area

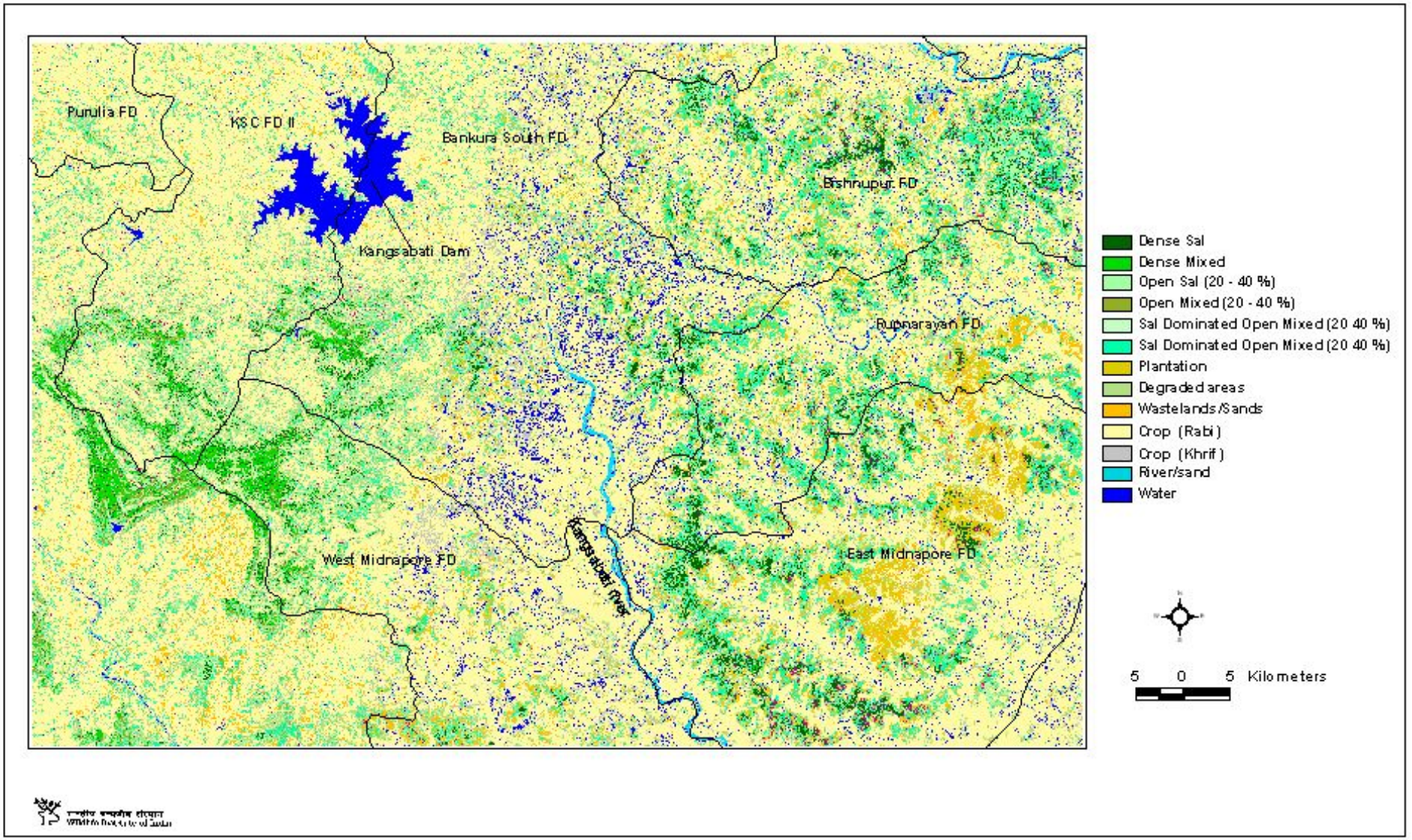

Fig. 3.5 Classified image showing forests, agriculture, water bodies and Kangsabati Dam

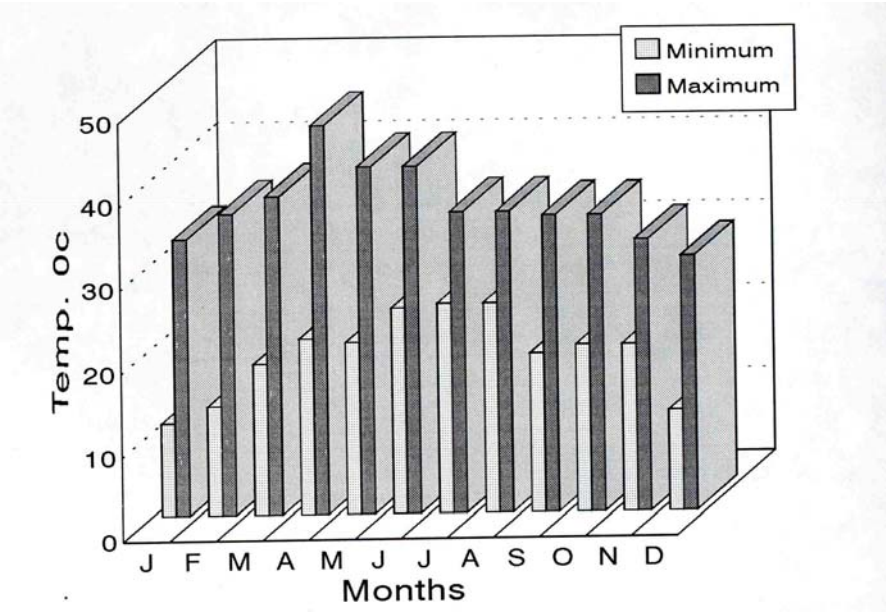

Fig 3.6 Mean monthly temperature variations in south West Bengal

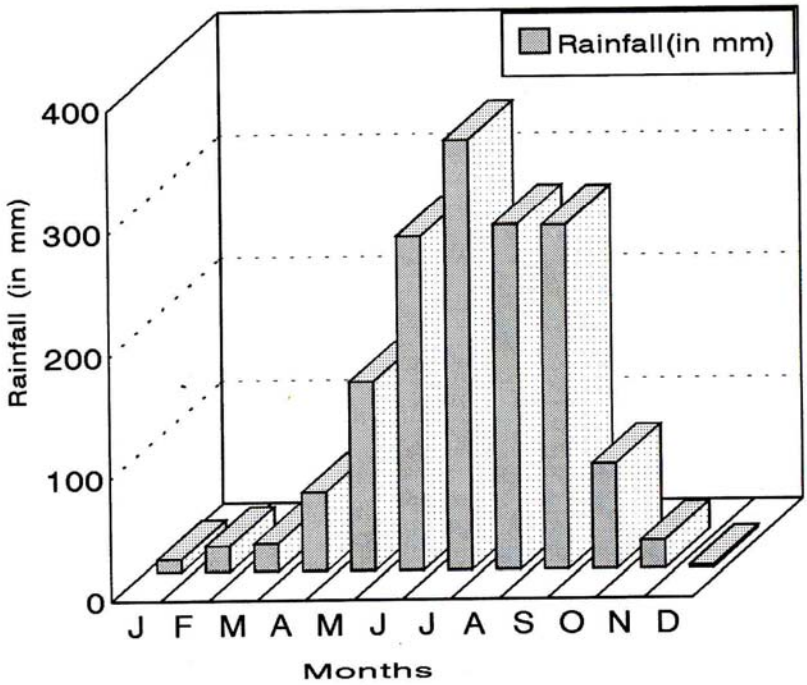

Fig 3.7 Average monthly rainfall variations in south West Bengal

Fig 3.8 Showing dense coppice sal forests

Fig 3.9 Showing open coppice sal forests

Fig 3.10 Showing plantation forests of *Acacia auriculiformis*

Fig 3.11 A male elephant immobilized at Midnapore for radio-collaring

Fig 3.12 A collared male located in the forests through radio-tracking

CHAPTER 4

Status and ranging pattern of elephants in south West Bengal

4.1 Introduction

The conservation and management of elephant populations which moves over long distance and different land uses are particularly problematic. In south West Bengal elephants were once decimated, started re-colonizing through movement of elephant from Dalma Wildlife Sanctuary, Jharkhand (Chapter 2). The current elephant population of south West Bengal is constituted by resident elephants and migratory influx annually coming from Dalma Wildlife Sanctuary, Jharkhand. The movement and ranging behaviour of resident and migratory elephants on south West Bengal landscape is essential to know the preferred area of elephants and their interactions for the better management.

Ranging behaviour of elephant has been studied in different part of Africa and Asia. In Africa studies on movement, home range and habitat utilization pattern have shown remarkable variations in different habitats and ecological conditions (Viljoen & Bothman, 1990; Eltringham, 1980; Douglas-Hamilton, 1972; Moss, 1988). Similar studies on movement and home range of Asian elephants were also conducted in Malaysian rain forest (Olivier, 1978) and deciduous forests of India (Sukumar, 1989b; Easa, 1988; Desai, 1991) which showed home range in relation to environmental factors, land attributes and spatial distribution. Though the reasons for the ranging of elephants have been widely studied (Mckay, 1973; Eisenberg and Lockhart, 1972; Sukumar,

1985) but the implications of ranging for management have not been addressed adequately (Desai, 1991).

The question of sustaining viable population of a long ranging species like elephant has always been associated with the challenges of managing land, resources and the people (Eltringham, 1980; Hanks, 1979; Ishwaran, 1983; Cumming, 1982; Owen-Smith, 1988; Sukumar, 1989b). Complexities in life history features,, ecological interactions with sparsely distributed populations can further lead into demographic and genetic vulnerability within the population (Ralls *et. al.*, 1979; Soule and Wilcox, 1980). For conserving and managing elephants, it is imperative to know the interaction of population in the landscape to obtain the trends of increase stability and decline (Owen-Smith, 1988).

This chapter describes the seasonal/ annual movements of elephants on the landscape of south West Bengal, frequency of utilization of habitat in different Range and Divisions, group sizes, and demography to understand their conservation significance.

4.2 Methods

Data on elephants movement, population structure and habitat utilization were collected through one radio-collared elephant only as more radio-collaring was not possible due to local people antagonism. Similar data collection was also carried out on several randomly sighted identified elephant groups and individuals during the entire study period.

The locations of the residential subpopulations were recorded throughout the year however the location data of migratory herd were carried out during Aug/Sept. to Feb/Mar. Members in the identified herd/ indusials elephants were categorised into four size classes i.e. adult (>7ft), sub-adult (>5ft - <7ft), Juveniles (>4ft - <5ft), calves (>3ft - <4ft). Members were also sexed whenever it was possible.

4.3 Results

4.3.1. Elephant population

Table 4.1 presents composition of elephant population in south West Bengal. The Migratory population had member of 36 individuals constituting of 6 adult tuskers, 14 adult females, 4 sub-adult male tusker, 5 sub-adult females, 5 juvenile and 2 calves. The residential populations were constituted of 4 sub-groups i.e. Jhargram sub-group, Ajodhya hill sub-group, Banspahari-Belpahari sub-group and East of Kangsabati sub-group (Table 4.1 and Fig 4.1). The compositions of the individuals in different sub-groups are given in the Table 4.1. The entire population of migratory and residential elephants was 62, constituted through 22 adult males, 19 adult females, 8 sub-adult males, 5 sub-adult females, 6 juveniles and 2 calves (Table 4.1). The residential elephants sub-groups were mostly constituted by adult males (tusker or tuskless) except Jhargram and Ajodhya hill sub-groups.

The calf born and their subsequent death are presented in Table 4.2 for the migratory herd. It can been seen from the table that 42% calf mortality took place during the long distance movement of elephants in south West Bengal, from 1992 to 1997.

The group size of elephant seen during 1995-97 is depicted in Fig 4.2. The group size distribution clearly indicates preponderance of migratory herd between September and February.

4.3.2. Movement of Migratory herd

The movement of migratory herd and their arrival in south West Bengal have been monitored for two years and presented in the Table 4.3. It can be seen from the Table that the elephants from Dalma Wildlife Sanctuary entered in the month of August however, in 1996-97 arrival was earlier by a week time (Table 4.3). The migratory elephants use the Kankarajhore corridor through Belpahari-Banspahari tract of West Midnapore Forest Division for entering in south West Bengal (Fig 4.3). The journey further to East Midnapore Forest Division, a distance of 70 km is covered overnight through the mosaic of forest and croplands. As observed in 1995-96 and 1996-97 elephant from Dalma Wildlife Sanctuary, Jharkhand arrived at Kankarajhore in 3 and 4 herds respectively (Table 4.3). However, before crossing the Kangsabati River to reach East Midnapore these herds usually combines and moves overnight. The migratory elephants usually leaves south west Bengal at the end of January however, in 1995-96 a small group of 17 elephants stayed until March end.

Annual date of arrival of migratory elephants and occurrence of cumulative rainfall in four months (June to Sep) from 1987 to 1995 was plotted in Fig 4.4. This shows a gradual progression in dates of arrival of elephants without any significant correlation with rainfall.

The frequency of movement of migratory herd in the south West Bengal landscape in three districts Midnapore, Bankura and Purulia is given in Table 4.4, which were significantly different in Forest Divisions of three districts (χ^2 =142.68; df =6; p<0.001). The fidelity of migratory elephant was higher in the districts of Midnapore (86.45%) followed by Bankura (12.26%) and Purulia (1.29%). In Midnapore district two forest divisions, East Midnapore and Rupnarayan was highly utilized by the migratory group however, West Midnapore Forest Division was moderately utilized. Migratory herd less utilized the Bishnupore and Bankura South Forest Divisions in Bankura district. In Purulia district only Forest Division that was really utilized by migratory herd was K.S.C.D.-II Forest Division.

4.3.3. Movement of Residential sub-groups

The frequency of movement of East of Kangsabati residential elephants have been monitored thoroughly and presented in Table 4.4. However, for rest other three sub-groups this information is not complete due to limitations of man power and vehicle. It can be seen from the Table 4.4 that frequency of fidelity of the residential elephant in two districts Midnapore (50.81%) and Bankura (49.20%) was near equal. However, Rupnarayan Forest Division in Midnapore district and Bishnupore Forest Division of Bankura district were highly frequented by the East of Kangsabati residential elephants. The break up of frequency of movement of East of Kangsabati residential elephants is presented in Table 4.5. This shows frequency of seasonal utilization between January-April and May-August when there is no paddy and also migratory herd have returned to the Dalma Wildlife Sanctuary, Jharkhand. In January to April utilization by East of Kangsabati sub-group was higher in Rupnarayan Forest Division

(50.72%) followed by Bishnupore (31.88%) (Table 4.5) but May to August Bishnupore Forest Division (50.91%) was much more utilized than Runarayan Forest Division (40%).

The movement and range of the Jhargram sub-group is confined to the southern half of the West Midnapore Forest Division. This sub-group is composed of 8 elephants (Table 4.1) through a family unit of 6 and 2 male groups. The movement of this sub-group is confined to Gidni, Jhargram, Lodhasuli, Manikpara, and Jamboni ranges of West Midnapore Forest Division and Chakulia Range in Jharkhand.

The Belpahari-Banspahari residential sub-group is all male group of 3 elephants (Table 4.1) and their movement is restricted within the Bhulabeda and Banspahari ranges of West Midnapore, Bandwan Range of K.S.C. II Forest Division, Bandwan range of Purulia and Jhilimili and Ranibandh ranges of Bankura South Division.

The Ajodhya hill residential sub-group constituted of 9 elephants (Table 4.1) through a family unit of 7 and a male group of 2 tuskers. The movement of this group is confined to hilly tract of Ajodhya hill within Baghmundi, Matha, Balrampur, part of Jhalda and Arsha ranges of Purulia Forest Division.

4.3.4 Home range

One male tusker was radio-collared for the purpose of data collection on various aspects on 22nd December 1995. Unfortunately, we could get only 24 locations within a period of three months. The radio-collar was pulled down by

other male tusker through inserting tusk between neck and collar gap. The home range of this elephant was constructed by taking the 24 location data in CALHOME program, which indicated range occupancy of 230 km^2 at 95% MCP (Fig 4.5).

The data collected on this radio-collar adult male elephant showed its frequency of association with family herd (33%) and remain alone for 66% (Fig 4.6). The habitat utilization in various ranges by this radio-collar has been shown in Fig 4.7. The movement pattern of this radio-collar elephants within the limited time period has shown similar pattern as of migratory group in Rupnarayan and East Midnapore Forest Divisions. This particular elephant has also been located in depredating potato crop (Fig 4.8).

The locations of 421 randomly sighted herd/individuals and radio-collared elephant were plotted by taking their GPS locations in the GIS layer. The analysis reveals elephants to occupy an overall range of 3368 km^2. The land cover and land use category utilized by elephants within the range is given in Chapter 5, Table 5.1.

4.4 Discussion

The long-distance movements of elephants are so as to be energy efficient in keeping with their large body need (Eisenberg, 1981). Therefore, elephant incursions of this kind are only possible with the onset of monsoon and availability of crops. Occurrence of increased rainfall may initiate early

incursion. The forest divisions of Midnapore district were more prone to crop depredation and conflicts by migratory herd movements compared to the other two districts. This was primarily because of the better juxtaposition of the large forest patches with crop fields. Small range requirements of males (Chowdhury et al., 1997) enable them to remain localized even on marginal forest habitat to do crop raiding. Both the districts of Midnapore and Bankura were equally affected through the movements of residential males for high man-elephant conflicts even after retrieval of migratory herds to DWLS, Bihar.

The habitat of 62 migratory and residential groups of elephant in the human dominated landscape of south West Bengal is sub optimal and highly fragmented. Future persistence of these elephants depends on the dynamics of the groups and their spatial interactions resulting in birth and death of the young. In south West Bengal 42% calf mortality in the migratory herd is a major concern for the population. A continuous monitoring on this aspect will be essential to know the rigor of these meta-population units.

The overall of range of the elephants in south West Bengal came out to be a size of 3368 km^2. The radio-collar male had a home range of 230 km^2 with limited period of data. However, such information would have been much better to understand several ecological issues but due to the limitations of further radio-collaring this work remains unaccomplished.

Table 4.1 Composition of migratory and residential elephants in south West Bengal

	Groups	FU/MG	Adult		Sub-adult		Juvenile	Calf	Total
			M	F	M	F			
Migratory									
Seasonal group from DWLS.	1	FU	6^{t}	14	4^{t}	5	5	2	36
Residential									
Ajodhya hill subgroup	2	FU	2^{t}	3	1^{a}		1		7
		MG	2^{t}						2
Jhargram subgroup	2	FU	3^{t}	2	1^{a}				6
		MG	2^{t}						2
Banspahari-Belpahari subgroup	1	MG	$2^{t}+1^{m}$						3
East of Kangasabati subgroup	1	MG	4^{t}		2^{t}				6
Total	7		22	19	$6+2^{a}$	5	6	2	62

M: Male; F: Female; FU: Family unit; MG: Male group; ^{t} : Tusker; ^{m}: Tusk less male; ^{a} Either tusk less male or female; DWLS: Dalma Wildlife Sanctuary

Table 4.2 Calf born and died in the migratory herd in south West Bengal

Year	Calf born	Calf death
1992	2	0
1993	4	3
1994	1	0
1995	1	0
1996	3	2
1997	1	0
Total	12	5
Percent	100	41.67 %

Table 4.3 Arrival and return of migratory group in south West Bengal from the Dalma WLS, Jharkhand

Year	Date	Arrival from Jharkhand			Return to Jharkhand			
		Locality	No. of Elephant	No. of Group	Date	Locality	No. of Elephant	No. of Group
1995-96	29.08.95	Kankarajhore, W. Midnapore	11-14	3	13.01.96	Bandwan-I, KSCD- II	24	2
	08.09.95	Kankarajhore, W. Midnapore	18		28.03.96	Kankarajhore, W. Midnapore	17	
	14.09.95	Kankarajhore, W. Midnapore	14/16					
1996-97	21.08.96	Amlasole, W. Midnapore	8	4	31.01.97	Bandwan-I, KSCD- II	36	1
	03.09.96	Makarbhula, W. Midnapore	9					
	11.09.96	Kankarajhore, W. Midnapore	12					
	13.09.96	Makarbhula, W. Midnapore	10					

Table 4.4 Frequency of movements of migratory herd and residential group (East of Kangsabati)

District	Forest Division	Herd		Residential	
		No. of locations	**%**	**No. of locations**	**%**
Midnapore	West Midnapore	29	18.71	-	-
	East Midnapore	48	30.97	6	4.84
	Rupnarayan	57	36.77	57	45.97
Bankura	Bishnupure	12	7.74	50	40.32
	Bankura (S)	7	4.52	08	6.45
	Bankura (N)	-	-	03	2.42
Purulia	K.S.C.D-II	2	1.29	-	-
Total		155		124	

K.S.C.D-II: Kangasabati Soil Conservation Division.

Table 4.5 Frequency of movement of residential groups (East of Kangasabati) in two seasons.

District	Forest Division	January - April		May - August	
		No. of locations	%	No. of locations	%
Midnapore	West Midnapore	-	-	-	-
	East Midnapore	03	4.35	03	5.45
	Rupnarayan	35	50.72	22	40
Bankura	Bishnupure	22	31.88	28	50.91
	Bankura (S)	06	8.7	02	3.64
	Bankura (N)	03	4.35	-	-
Purulia	K.S.C.D-II	-	-	-	-
Total		69		55	

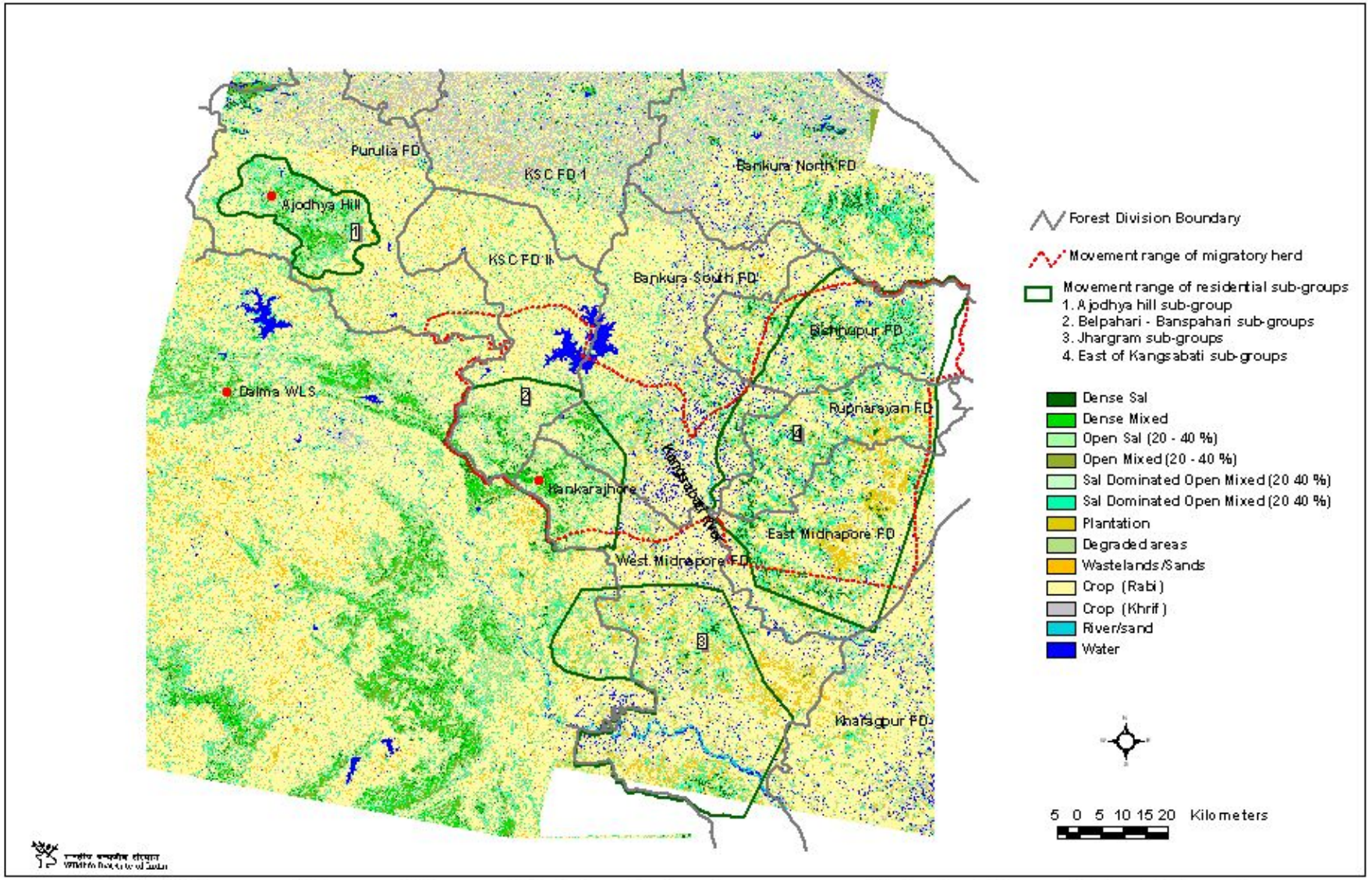

Fig. 4.1 Movement Range of four residental and migratory groups of elephant in south West Bengal

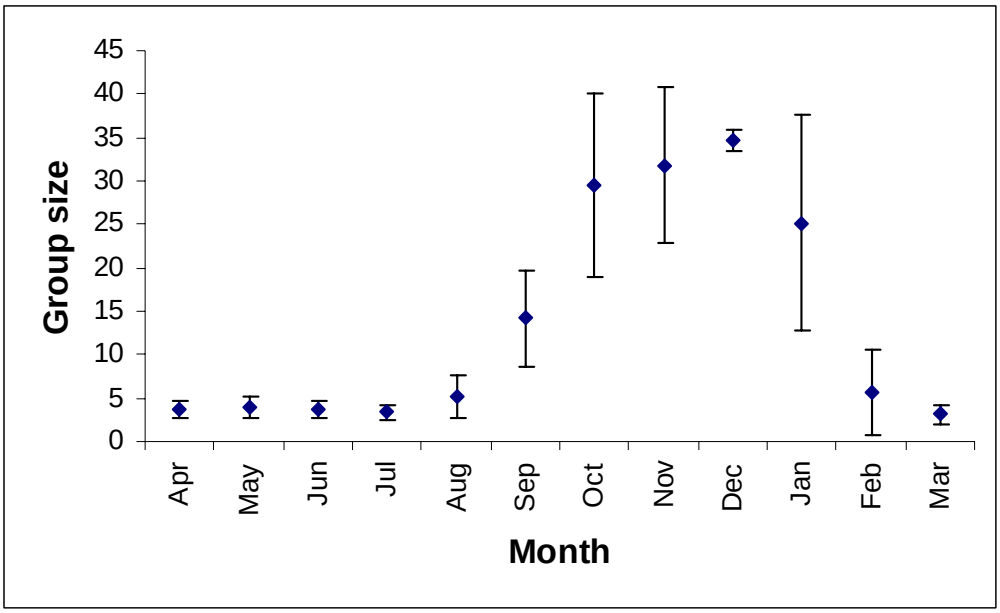

Fig 4.2 Group sizes of elephants in south West Bengal

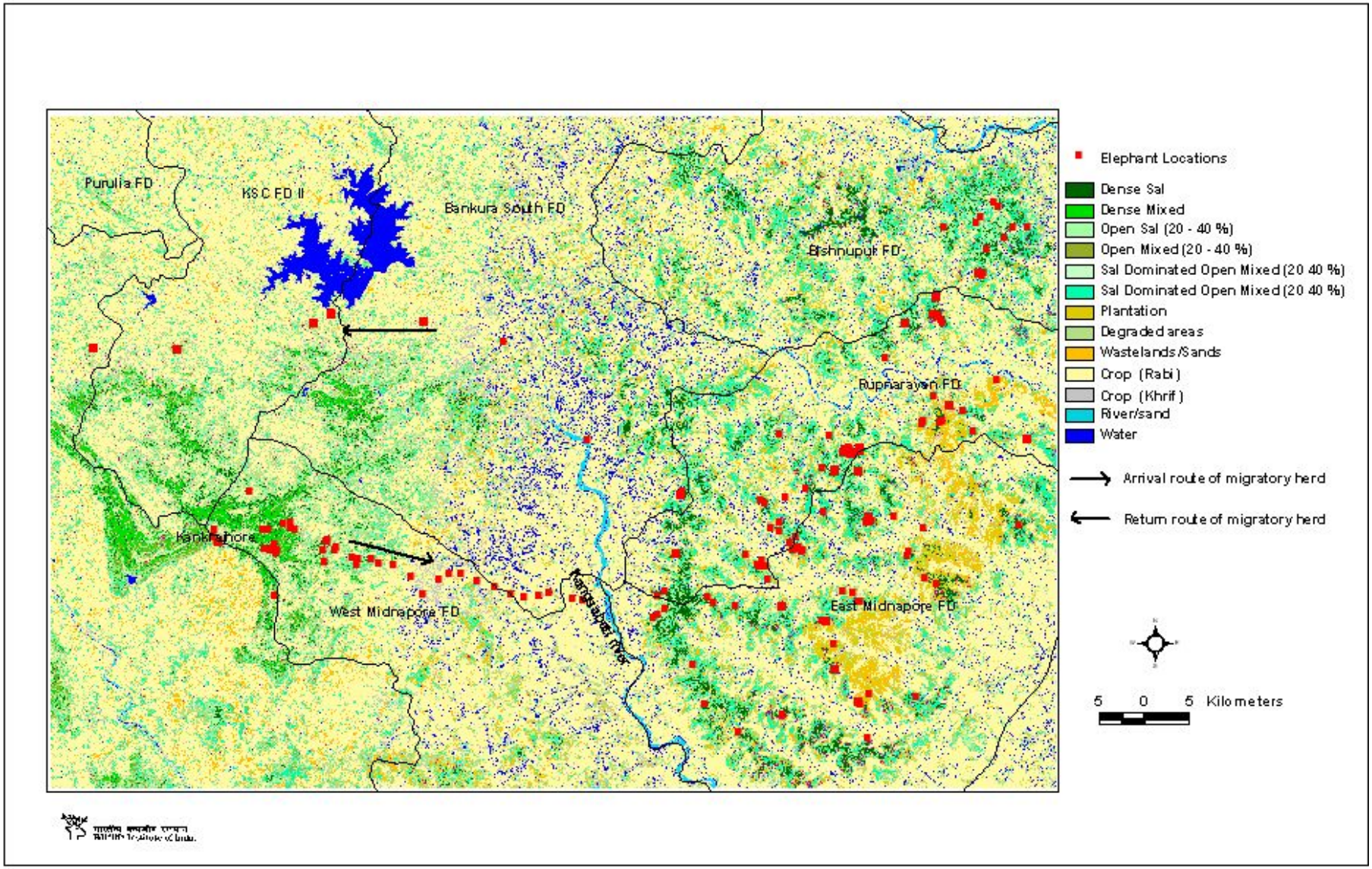

Fig. 4.3 Locations of migratory and residential elephant groups in south West Bengal

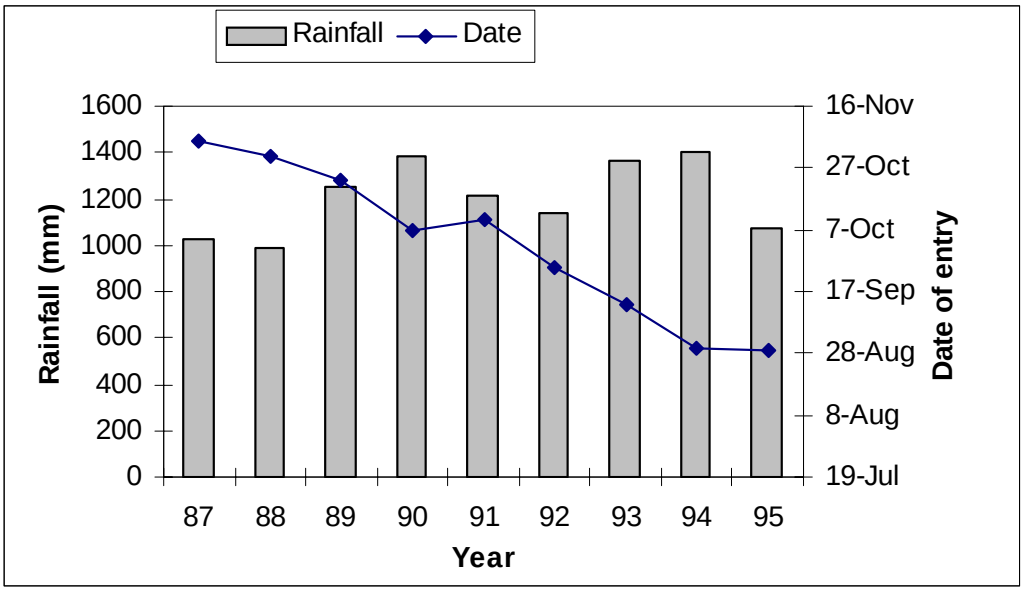

Fig 4.4 Migratory elephant arrival in south West Bengal and rainfall in different years

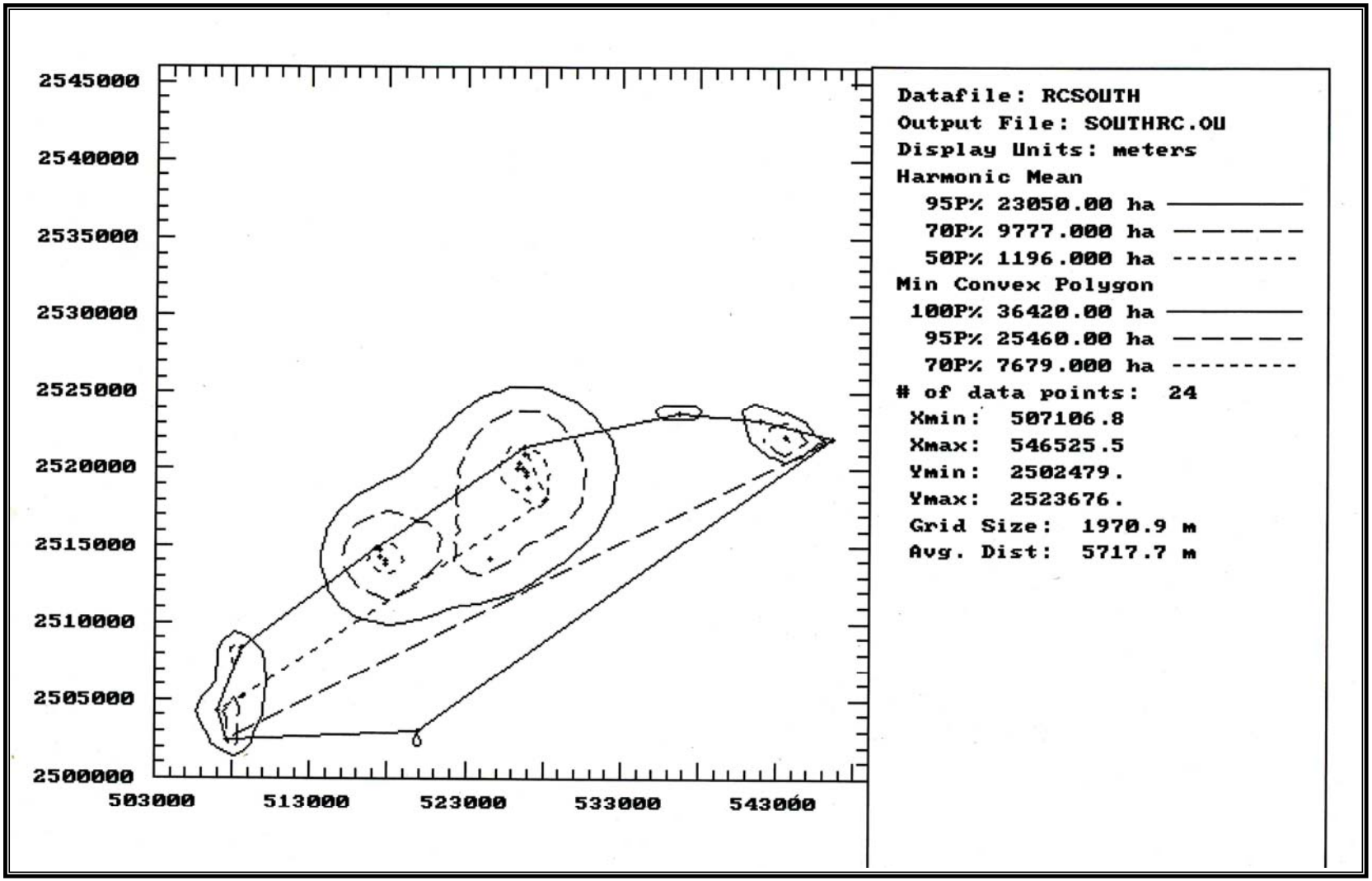

Fig 4.5 Showing home range of a male radio-collared tusker in south West Bengal

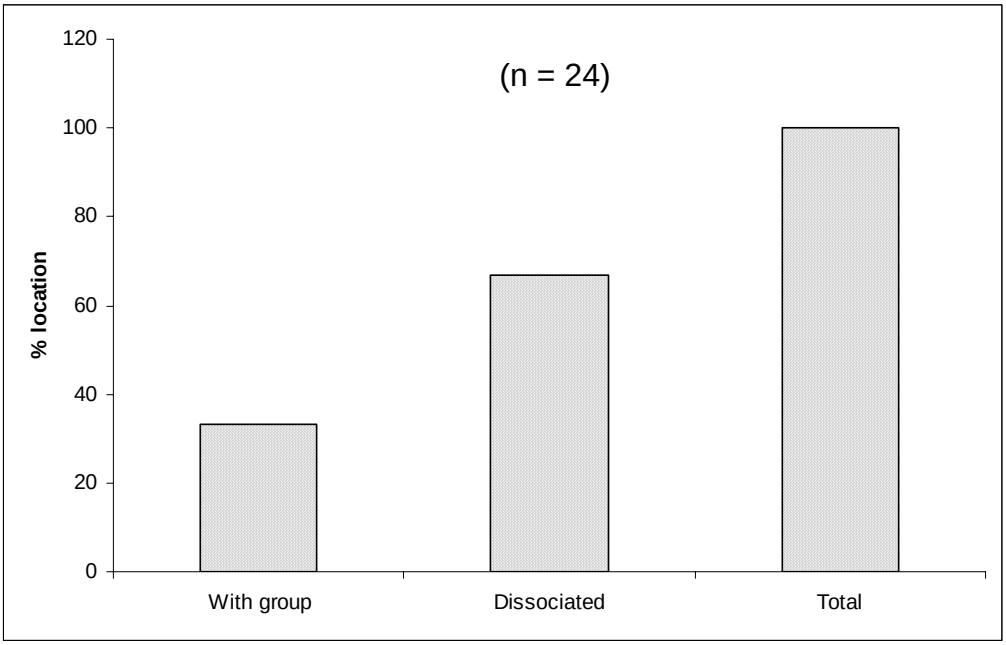

Fig 4.6 Social association and dissociation of radio-collar male elephant

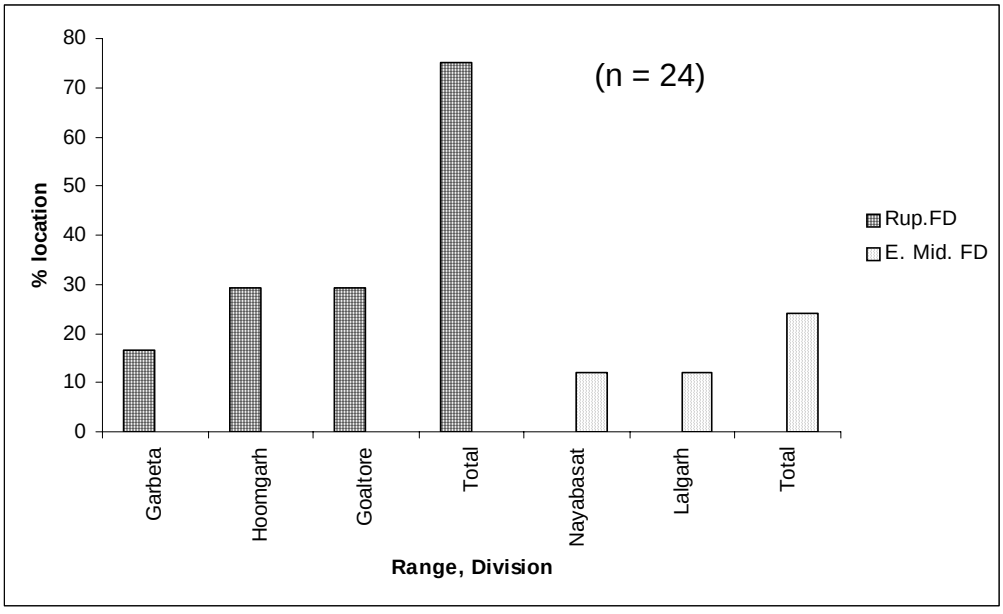

Fig 4.7 Movement of radio-collar male elephant in different ranges of Rupnarayan and East Midnapore Forest Divisions

Fig 4.8 Radio-collar elephant depredating potato crop in south West Bengal

CHAPTER 5

Changing landscape attributes and elephant conflict for crop depredations

5.1 Introduction

In recent years, increasing human-elephant conflict has been a major issue for managing wild elephant populations in India (Sukumar, 1990; Dey, 1991; Johnsingh & Panwar, 1992; Daniel *et. al.,* 1995; Nath & Sukumar, 1998). In south West Bengal, enormity of this problem is a unique situation, historically associated with the landcover, landuse and socio-economic changes in this region. In the beginning of the nineteenth Century elephants were abundantly found in the dense *sal* forests of Midnapore district (West Bengal) and its adjoining areas (O'Malley, 1911). However, they become rare and less reported from this area till early 1980s. The reason for the disappearance of elephants from this region was primarily because of the forest losses and sustenance of poor cover quality of coppice *sal* forests, kept low through repeated hacking (Chapter 2). The rapid urbanization, large scale timber felling for Railways, short crop rotation of *sal* forests for quick economic gains, changing rights of the land ownership from colonial to post-independent period, migration and settlement of refugees from East Pakistan (now Bangladesh) and human population increase were responsible for forest destruction in south West Bengal (Palit, 1991; Malhotra, 1995; Panda, 1996).

The availability of published materials on the occurrence of elephants in south West Bengal prior to 1980's is obscure. In subsequent years they

were known through their occasional crop raiding incidences in Patamda and west Midnapore (Shahi, 1980) areas bordering Bihar and West Bengal respectively. Public reporting also for such incidences were rarely drew media attention. The exploratory movement of elephants for re-colonization to its former range, towards east commenced after 1986, with the revival of forest cover. This probably has happened due to decade old participatory forest protection initiatives with local communities (Palit, 1991; Malhotra, 1995) in restoring the degraded sal forests and its subsequent improvement of cover quality. The programme took momentum with the State Forest Department's declaration of resource sharing from timber sale and access for non-timber forest produce to the local communities (Palit, 1989; Malhotra, 1995). Afforestation programme on public, private, degraded and waste lands through Social Forestry Projects (Malhotra and Poffenberger, 1989) beyond 1981 also created additional forest patches in the landscape of south Bengal.

The conflict dimensions of elephants in this region started showing up beyond 1986 with successive yearly incursion of elephants from Dalma Wildlife Sanctuary, Jharkhand, and their progression further deep in West Bengal to the eastern part of Midnapore and adjoining districts- Bankura and Purulia (Chowdhury *et al.,* 1985; Datye & Bhagwat, 1995). The subsequent prolong stay of migratory and resident elephants ever since become a growing concern to the local people due to their economic and human loss of life. Similar concerns also prevailed in sustaining elephant conservation by the Forest Department on account of heavy drain of State exchequer to pay

compensations for crops, property damage, loss of human life and anti-depredation measures.

The present chapter deals the magnitude of human-elephant conflicts with the changing land-cover and landuse attributes on the south West Bengal landscape. The cropping pattern and the intensity of crop depredation losses were evaluated for developing strategies for mitigation.

5.2 Methods

The study was conducted from September 1995 to August 1997. Elephant locations were obtained from radio-collared male, other sighted and confirmed locations through fresh footprints or feeding signs. Locations were marked on topographic maps (1:50,000 scale) or Global Positioning System (GPS) for inputting in GIS domain.

Digital data of IRS-IC, LISS-III was used for creating the spatial database. Image classification for landuse and land-cover was done through Maximum Likelihood Classification (MLC). Major landuse and land-cover categories were identified from the multi-spectral classification. Input layers for analysis in GIS/ARC INFO domain were generated from the topographic maps (1:50,000 scale) on various themes i.e., contour, drainage, human habitations, forest boundaries and elephant locations, etc. A 500 -m point buffer was generated on 421 elephant locations to extract habitat utilization by overlying it on classified map. The utilized range of the elephant was quantified from the plotted locations.

The damage of paddy was assessed in the field at six different sites by taking 23 randomly selected plots constituting a total area of 2.99 ha. Measurements of damaged area within the sampled plots were recorded to obtain mean percentage damage in the sampled area. Information on climatic data, agricultural landuse, demography and economic profile of local residents, human kill and property loss were collected from the records of various concerned agencies.

Chi-squire test was performed to analyze significant utilization of various habitats by elephants and finding significant frequency of crop depredations. Regression analysis for best-fit model in SPSS (SPSS, 1998) was generated for finding relationship between landscape features and crop depredation by elephants.

5.3 Results

5.3.1 Landscape and socio-economic changes beyond 1980's

The south West Bengal has undergone through a process of severe landscape changes in the recent past which has not been properly recorded. The first systematic inventory on land-cover and landuse using remotely sensed digital data of 1988 and 1991 for detecting changes in different classes was done by the Regional Remote Sensing Service Centre (RRSSC), Kharagpur (Sudhakar and Raha, 1994). The data taken from this source depicts the changes in the forest and non forest classes between 1988 and 1991(Fig.5.1). Analysis of this data source further indicated that the land-

cover classes in dense forest, open forest and plantation together in three districts - Midnapore, Bankura and Purulia has registered an increase 314.68 Km^2 over existing 4889.77 km^2 in 1988. The land-cover class increase in the category of dense forest by 0.27% and reduction of open forest by 0.17% clearly indicates improvement in stand and cover quality over 3 years. The same trend of forest recovery might have been started after 1971 following the initiative of participatory forest protection with the communities (Palit, 1991; Malhotra, 1995) but never been captured properly due to paucity of modern techniques. The increase in various plantations by 1.14% between 1988 and 1991 also provided additional forest cover in the entire landscape.

The non-forest landuse in south West Bengal is mainly represented through the agriculture (56.16% of total land area). The other landuse categories are degraded forests, wastelands and water bodies. According to the RRSSC report (Sudhakar and Raha, 1994) agriculture landuse has increased by 3.58% (973.69 km^2) in 1991 over 1988. In the same period increase in water bodies by 1.54% (420.06 km^2) shows enhancement of irrigation capabilities in the area. The commissioning and gradual enhancement of canal system of Kangasabati Reservoir Project since 1965-66 has brought the changes in the agriculture pattern in the area. The irrigation facilities through this reservoir project provided intense agriculture opportunities for taking double cropping pattern in 1973-74 to triple in 1985-86 onwards (Fig 2.1; Chapter 2). With the commencement of social forestry programmes initiated in 1981 the degraded and wasteland areas showed a reduction in their extent by 1.04% and 4.44% respectively (Sudhakar and Raha, 1994).

According to the human census 1991 the three districts of south West Bengal had a population of 12.33 million with range of density from 355 – 591 person/ km^2. Arable land marginalization is a major constraint for the local communities for their dependency on forest resources (Anon, 1985). The district agriculture data of 1996, reports marginal farmers cultivating on the agriculture land of 0.2 – 1 ha, varied from 87.86, 75.88, 62.30 and 62.29 % in Midnapore (east), Midnapore (west), Bankura and Purulia respectively (Chapter 3).

5.3.2 History of elephant movements and conflict

Prior to 1986, the movement of elephants from Dalma Wildlife sanctuary (DWLS), Jharkhand were only restricted to the adjoining areas of Bihar and south West Bengal, between September to October (Shahi, 1980). The range extension of elephants further eastward took place since 1987 (Datye & Bhagwat, 1995) beyond river Kangasabati. The records available from the Midnapore Forest Division showed that the entry of elephants from DWLS to Midnapore across river Kangasabati during 1987 - 92 took place in the month of October/November every year. This movement in subsequent years till present preceded in the August/September every year. However, their return to DWLS is influenced by driving through chase between January and March after paddy harvest season.

Until 1987, elephant crop raiding behaviour of minor nature was reported only in the vicinity of bordering areas of Bihar and south Bengal.

Shahi (1980) reported the paddy crop losses of 80 tons in an area of 61 ha affecting 400 families. Human-elephant conflicts started escalating progressively beyond 1987 with the arrival of elephants from DWLS and also with localized individual or groups. With the increasing conflicts six elephants were captured in 1995 form this region as a part of population management and to reduce the crop depredation (Raha, 1996).

5.3.3 Land-cover and landuse utilization by elephants

The GIS analysis based on the 421 locations of elephants overlaid on classified digital map of south Bengal to calculate the range availability to elephants and categories of landcover and landuse within it (Table 5.1). A point buffering of 500 m in GIS domain was generated on all locations to calculate out the area utilized under various categories of landcover and landuse (Table 5.1). Elephants occupied an overall area of 3368 km^2 but intensive range utilization was restricted to 243 km^2. The habitat utilization pattern showed selective usage (χ^2 =29.00; df =10; $p<0.005$) of different forest and non-forest habitat. However, habitat utilization of croplands was significantly less in proportion to its availability. The overall utilization pattern in case of south West Bengal was found 41.86% in the cropland, 37.34% in forests and rest other utilization in degraded and wasteland areas.

5.3.4 Lands-cape attributes and crop depredation

Seven elephant depredation zones (Z_1 to Z_7) were delineated in GIS on the clustering pattern of 273 locations of elephant out of total 421. Balance 148 elephant locations (35%) were scattered. Table 5.2 presents the analysis

of land composition ratio of forest and crop queried through GIS and depredation rate/ km^2 in each zone. The ratios of forest and cropland were plotted against the depredation/ unit area to develop a quadratic term of regression through best-fit model {$y = 0.077 +(0.32 * x) + (- 0.15 * x^2) ; r^2 = 0.327; df = 4; p = 0.453$}. This showed a decreasing trend of crop depredations with the response of increasing crop field or forest cover above 1: 1 ratios (Fig. 5.2). However, this regression is limited through the statistical values for r^2 and *p,* which need further revalidation of this model with large sample size of forest and cropland matrices.

High crop depredation above the rate of 0.3/ km^2 took place when forest to cropland ratio was 1: 1.2 respectively. Moderate depredation to a rate of 0.15 – 0.03/ km^2 took place when forest and cropland ratios fluctuated between 1: 3.5 and 1: 0.6 respectively (Fig. 5.2). Low depredation at a rate of 0.13 - 0.09/ km^2 occurred when forest and cropland ratios move further on either side through increased forest or cropland.

5.3.5 Cropping Pattern and Regimes of Crop Depredation

South West Bengal has three distinct cropping seasons – June/July to October/November; *Kharif,* November/December to February/March, *Rabi,* and January/February to May/June, summer crops. Three varieties of Paddy *Oryza sativa* (*Aus*, *Aman* and *Boro*) are cultivated year round in different seasons. *Aman* constitutes the major paddy in terms of extent and production during the monsoon season. The combination of crops grown in different seasons are: *Aus*, *Aman* and vegetables in *Kharif*; Wheat *Triticum aestivum*,

Potato *Solanum tuberosum*, vegetables and *Boro* paddy in *Rabi*; and *Boro* paddy (in low lands) and vegetables in Summer.

The agriculture pattern in south West Bengal has undergone changes from a rain dependent to irrigated cropping for cash crops. Data collected on crop pattern, extent and its changes between 1987-88 and 1995-96 from district agriculture office of Midnapore and Bankura are presented in Table 5.3. The A*man* (Monsoon) paddy has not much increased in its extent whereas other two *Aus* and *Boro* have shown substantial growth with increase in irrigation facilities. Cash crops such as oilseeds, potato and vegetables also increased substantially over the years (Table 5.3). The transformation of traditional cultivation pattern to cash oriented cropping was found to be related to net profit through the input and output cost as has been presented in the Fig 5.3. Though input cost of the cash crops is higher than the traditional crops, the output determines their selection by the majority of the marginal farmers.

The frequencies of crop damage by elephants during the three cropping seasons are presented by taking 378 incidences for such cases in Table 5.4. The paddy is frequently damaged (68%) followed by potato (16%), vegetables (10%), Wheat (5%) and Maize (1%). Crop depredation showed selective usage (χ^2 =88.45; *df* =4; $p<0.001$) on an annual basis. However, arable land extent of paddy crop is significantly less utilized ($p < 0.001$) in proportion to its availability (Table 5.4). A reverse trend was seen in case of potato cultivated area, which was significantly more utilized ($p < 0.001$) to its

availability. The seasonal crop damage pattern was greater in September to December (51.8%) followed by January to April (33.6%) and May to August (14.5%). The damage to orchard and granary occurred more in both the seasons except for September to December (Table 5.4).

5.4 Discussion

It is seemingly evident that the displacement of elephants from south West Bengal has been related to the diminished land-cover in past. Recovery in land-cover and subsequent landuse changes in the recent years have created a habitat less-than-favorable to elephants for re-colonization. The elephant's sensitivity to this kind of habitat for crop depredation on broad spatial scale was mainly related to the arrangements of the landscape through forest and agriculture matrices. This variable alone explained 33 % (r^2 = 0.327) influence on crop depredation (Fig. 5.2). The remaining unexplained factors on small spatial scale might have been through landscape built related to patch sizes, edge density, contagion and proximity indices (Wallin *et al*., 1994; McGarigal and Mark, 1995; Gustafson and Parker, 1992; Hargis *et al.,* 1998). These, however, were beyond the scope of the present study.

High depredation resulted in the areas where forest and cropland ratio matrices were near equal or in favor of increased cropland (1:1.2). Availability of moderate to high forest cover in such fragmented situation is a strategic requirement for elephants to avoid human induced interference. Crop depredation in low intensities resulted when forest and cropland ratios were inadequately represented either through their increase with vast crop areas or

enlarged forest cover (Fig. 5.2). While the former is a desired farming scenario without elephants, the latter is essential to conserve them in an intact or less fragmented habitat.

Conflict between elephants and humans is a key issue in south West Bengal in terms of recurring economic losses of crop and property and killings of human beings. While for the conservation agency it is an annual drain on the State exchequer to provide anti-depredation measures for gaining local community support, crop compensation and compensation to the loss of human life. The estimation through GIS analysis indicated that only 5.5 % of total cultivated area (1840 km^2) within the elephant range is currently affected through elephant depredation. An evaluation of 23 sampled plots (2.99 ha.) at six different sites revealed occurrence of average 40% crop loss within it. The projection of this damage to the total affected area with current cost of paddy per unit area estimated a total economical loss of 3.2 crores. Though this economic loss is not a very severe concern in the provincial and national perspectives but it matters at local level to the majority of the farmers (< 60 – 88%) tilling small land holdings. However, despite this hardship, majority of the local people still maintains high regards for elephant conservation except for a few cases of elephant mortality due to poisoning.

Local strategies for keeping the elephants out of the crop areas are mostly tactical. The most common among them are beating drums, scaring them with fire crackers, chase them away through lightening torches and often by domestic elephants. All these have only limited affect since the elephants

soon get habituated to this. Uses of effective barriers have also their limitations due to excessive interspersion of crop field and forests in core areas of depredations. However, a good possible solution could be developing electric fences through reinforced trenches in border areas with Jharkhand, thereby denying the accesses of migratory elephants into the West Bengal. Although the options of power fencing were tried but have been a failure due to lack of proper maintenance and social problems associated with stealing of fence materials. Local level cooperation and participation for such an activity through regular monitoring of fence line and its maintenance is extremely essential. The present expenditure on deterring elephants from crop depredation which is to the tune of 4 million Indian Rupees = 95 thousand US$ annually is high and unsustainable in terms of available budgetary provisions.

Table 5.1 Land categories and their utilization by elephants in south West Bengal

Land categories	Area available Km^2	Area utilized Km^2	Proportional usage		
			Expected	Observed Minimum	Observed Maximum
Landcover					
Dense sal	122.66	15.49	0.036	0.019	0.108
Dense mixed	62.77	4.45	0.019	0.000	0.043
Open sal	217.18	25.67	0.064	0.050	0.161
Open mixed	12.93	1.17	0.004	0.000	0.017
Open mixed (Sal dominated)	359.22	39.85	0.107	0.097	0.231
Plantation	51.34	4.13	0.015	0.000	0.040
Landuse					
Degraded Area	330.04	23.11	0.098	0.042	0.148
Waste lands	231.35	21.1	0.069	0.036	0.138
Croplands	1840.36	101.73	0.546	0.329	0.508*****
Sandy area	16.39	0.33	0.005	0.000	0.008
Water bodies	123.80	5.98	0.037	0.000	0.053
Total	3368.04	243.01			

* Denote significant use

Table 5.2 Land cover and land-use composition ratios and rate of crop depredation

Depredation zones	Land composition in the zones				Elephant Locations (n)	Depredation rate/ km^2
	Total area (km^2)	Forest area (km^2)	Crop area (km^2)	Forest to Cropland ratio		
Z_1	304.59	110.66	133.60	1: 1.2	96	0.31
Z_2	391.12	113.35	195.58	1: 1.7	69	0.18
Z_3	117.22	21.90	65.83	1:3.0	23	0.20
Z_4	118.31	21.22	74.15	1:3.5	19	0.16
Z_5	107.18	52.17	34.05	1: 0.6	18	0.17
Z_6	149.86	11.67	114.98	1: 9.9	20	0.13
Z_7	325.84	73.61	154.10	1: 2.1	28	0.09
Total	1514.12				273	

Table 5.3 Changes in the crop pattern in two districts of south West Bengal between 1987/88 to 1995/96

Crop	Midnapore (W)			Bankura		
	Cultivated area*		%	Cultivated area*		%
	1987/88	1995/96	Change	1987/88	1995/96	Change
Aus Paddy	34.4	69.2	+101.2	29.8	38.8	+30.2
Aman Paddy	429.1	442.4	+3.0	312.8	338.1	+8.0
Boro Paddy	52.8	96.0	+81.8	18.3	61.2	+234.4
Wheat	7.3	16.8	+130.1	13.8	15.8	+14.5
Maize	1.5	2.4	+60	2.6	2.1	-19.2
Pulses	14.0	16.4	+17.1	12.7	7.0	-44.9
Oilseeds	21.2	43.4	+104.7	35.1	54.1	+54.1
Fibers	3.0	3.0	0	1.9	1.9	0
Potato	16.3	44.9	+175.4	12.4	31.6	+154.8
Vegetables	31.1	41.4	+33.1	26.3	36.1	+37.2

* in '000 ha Source: District Agriculture Offices of Midnapore (W) and Bankura

Table 5.4 Crop depredation frequencies of elephants in three cropping seasons in south West Bengal.

Crops	Depredation frequency				Cultivation Area ('000 ha.)	Proportional depredation		
	Jan - Apr	May – Aug	Sep – Dec	Total		Expected	Observed minimum	Observed maximum
Paddy	57	24	177	258 (68%)	1045.6	0.846	0.621	0.744*
Wheat	20	-	-	20 (5%)	32.6	0.026	0.023	0.083
Maize	-	2	-	2 (1%)	4.5	0.004	0.000	0.015
Potato	47	-	13	60 (16%)	76.4	0.062	0.110	0.207*
Vegetable	3	29	6	38 (10%)	77.4	0.063	0.061	0.140
Total = (%)	127 (33.6)	55 (14.5)	196 (51.8)	378	1236.5			
Others								
Jack fruit	2	18	-	20	-	-	-	-
Granary	10	20	2	32	-	-	-	-

* Denotes significant depredations

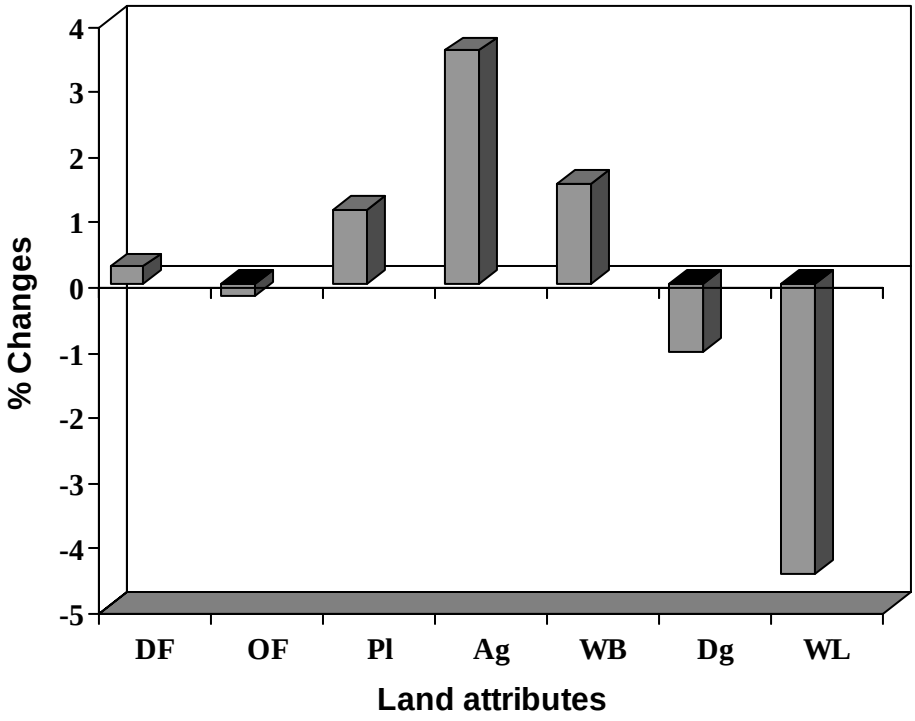

Fig 5.1 Land-use and land-cover changes in south West Bengal

(Source: Sudhakar and Raha, 1994)

DF – Dense Forest, OF – Open Forest, PL – Plantation,
Ag – Agriculture, WB – Water bodies, Dg – Degraded, WL - Wasteland

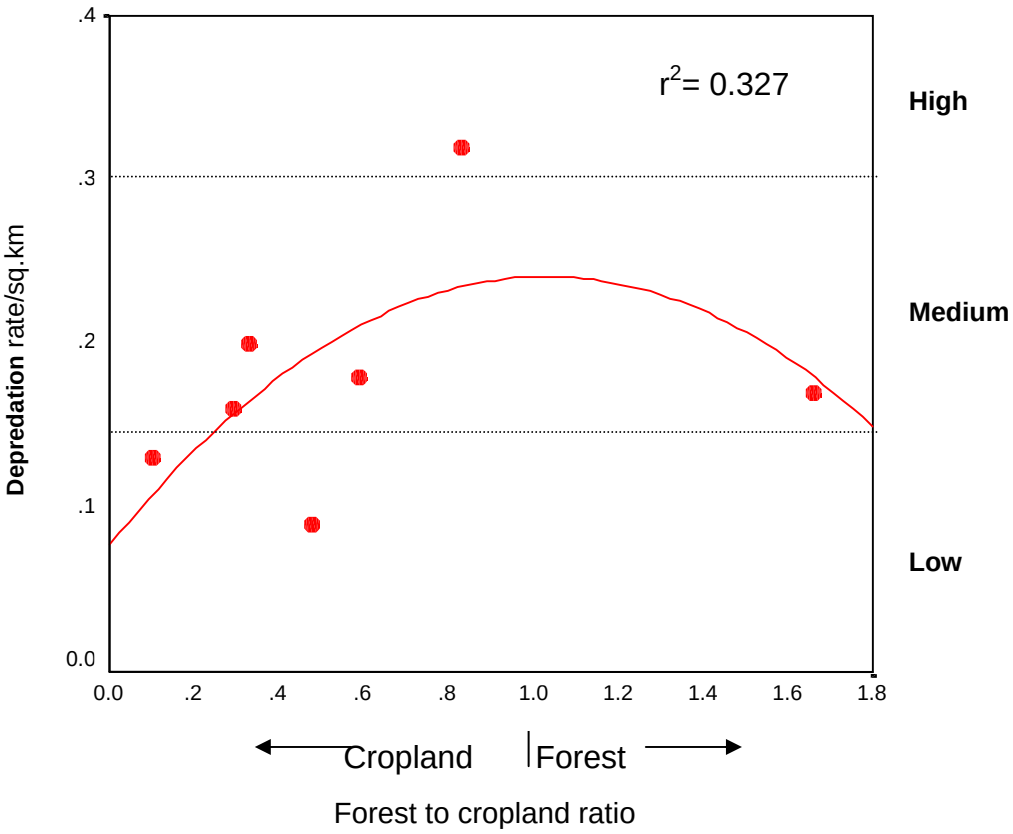

Fig 5.2 Landscape attributes (Forest to cropland ratio) and crop depredation relationship

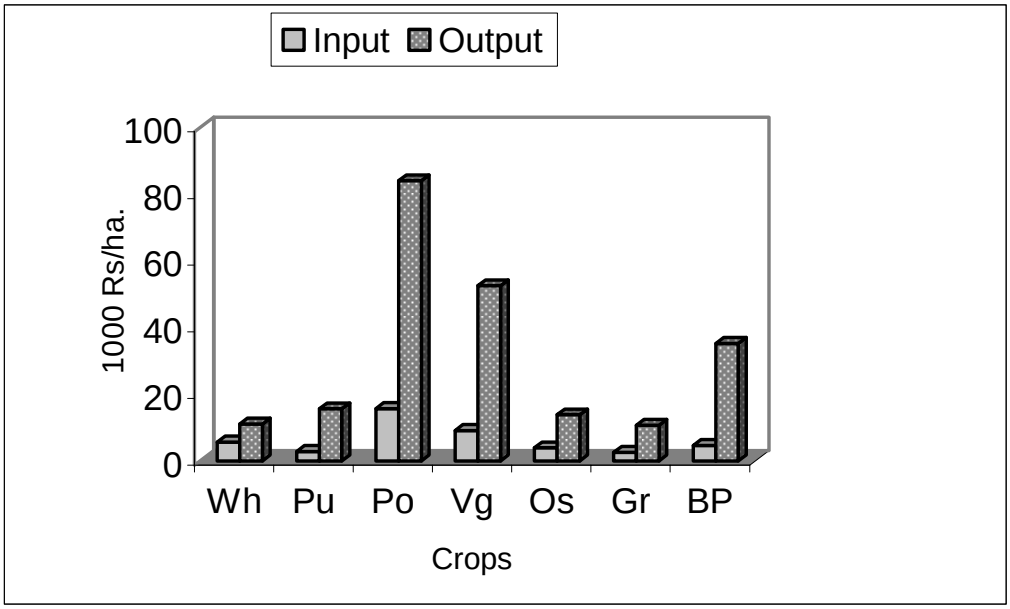

Fig 5.3 Input-output cost of various crops in south West Bengal

Wh – Wheat, Pu – Pulse, Po – Potato, Vg – Vegetables, Os – Oilseeds, Gr – Gram, BP – Boro paddy

CHAPTER 6

Dimensions of human-elephant conflicts

6.1 Introduction

Several hundred people are being killed by elephant every year on the landscapes of Africa (Thouless and Tchamba, 1992; Tchamba, 1993; Thouless, 1994) and Asia (Sukumar, 1989a; Dey, 1991; Balasubramanian *et. al.,* 1993; Kumar, 1995; Chowdhury *et. al.,* 1997; Nath and Sukumar, 1998; Sukumar, 2003; Zhang and Wang, 2003). This concern is serious in Asian elephant ranges with high human density and fragmented landscapes compare to the African situation. Asian elephants, in India, alone kill on an average 200 people every year (Bist, 2002), on this record Sri Lanka possibly is next to India (Sukumar, 2003). Elephants on such landscape also suffer on several ways with people antagonism and retaliation. Generally people are tolerant to crop losses by elephants but human kill politicise the whole issue and bring negative impacts to elephant for its conservation.

An understanding of conflict between human and elephant is important for developing a better conservation planning on the landscape. The co-existence can only be achieved through reducing level of conflicts and enhancing opportunities to people through the benefits of elephant conservation (Messmer, 2000).

This Chapter presents the study undertaken in south West Bengal to analyse the magnitude of crop damage, compensations paid, human killing

and involved elephants, house and property losses and elephant losses. All these information are important for managing elephants and suggesting possible solution to minimise them.

6.2 Methods

Basic information on crop damage in few of the highly impacted forest divisions were collected through the complaint received from the local people and compensation paid to them on the annual basis. This information was collected from the records of the ranges of concerning forest divisions. Data on human kill, injuries, house damage, property losses, cattle kill and elephant kill during study period were collected by visiting the incident site and interrogating local people and forest staff. Involvement of elephants in killing human being was confirmed through public investigation, site investigation and confirmation through foot prints identification.

6.3 Results

6.3.1 Crop damage reporting and compensation paid

Reporting for crop damage was collected from three forest divisions, East Midnapore, Runarayan and Bankura South (Table 6.1). The range of reporting of crop damage from the year 1990-91 to 1994-95 in East Midnapore, Rupnarayan and Bankura South varied from 2388 - 6852, 3116 - 6704 and 2083 - 10,163 respectively. On yearly basis though the trend of crop damage reporting is generally increased but no definite trend was observed in all the three divisions.

The year wise compensation paid for crop losses in four divisions from the year 1990-91 to 1994-95 is presented in Table 6.2. This shows approximately doubling of the compensation amount paid for the crop losses in all the four divisions.

6.3.2 Seasonal human killing pattern

Data collected from the records of the forest department indicated that between 1976 and 1986, 13 peoples were killed by elephants all from the bordering area of south West Bengal with Jharkhand.

The year wise human kill from 1988 to 1996 in south West Bengal is presented in Fig 6.1. The Range of human killed varied from 8 in 1992 to 23 in 1989; mean 13.55. These conflicts records from 1988 to 1994 were collected from the record of the forest department and segregated them in to three seasons (Table 6.3). For the year 1995 and 1996 this data was systematically collected in same three seasons to compare the variations in the trend (Table 6.3). A comparison of both these data sets indicate occurring of maximum human kill in post paddy seasons that is January to April and May to August (1988-1994; χ^2 =16.71; df =2; p<0.001 and 1995-96; χ^2 =3.72; df =2; p<0.10)). Human injuries for the period of 1995 and 1996 also showed similar trend of increased pattern in post paddy season (Table 6.3).

Table 6.4 presents information on kind of elephant involved in human killing and injury from the period 1988 to 1996 based on confirmed cases only. It can be seen from the Table that in all the three seasons lone males were

mostly responsible for doing human kill. On cumulative terms this constituted 91.6% for human kills by the loners and remaining by herd/group. The seasonal analysis further revealed that 26 (72.2%) human kills occurred by residential males in January to August. However, 7 (19.4%) human kill through males in the period September to December has taken place either from the loner of migratory herd or residential elephants.

Information on human kill and injury on various sites have been recorded based on the data from 1988 to 1996 (Table 6.5). This revealed that the human kill and injury in two seasons September to December and January to April has taken place on the two major localities of forest and village. However, in May to August most of the cases of human kill and injury took place in the villages when the crop field mostly remained fellow.

6.3.3 Seasonal house and property damage

Data for house damage incidences for damaging 110 and 133 houses in 48 and 74 incidences for the year 1995 and 1996 respectively are presented in Fig 6.2. Maximum house damage 60 % took place between May to August through residential elephants when availability of the crops in the field was less.

The seasonal house damage through herd and loner in three seasons has been presented in Table 6.6. It can be seen that contribution of loners are high in such incidences in all the season but in May and August such damages are exclusively done by males. The cumulative contribution of male in house damage was 90.98% and remaining 9.02% by the herds.

Elephants were also recorded for damaging domestic livestock, house hold properties and equipments related to agriculture farming. Fig 6.3 shows various livestock killing by elephants between the period 1991 and 1996. Table 6.7 includes other property damage by elephant on the various items of house hold and farm equipments.

6.3.4 Killing of elephants

Table 6.8 presents killing, poisoning, capturing and occurrence of natural deaths of elephants in south West Bengal from 1987 to 1996. The 66.6% of elephant mortality have been found to be related with human conflicts. Adult male segment was much higher for this. Analysis has also shown that the two Forest Divisions, East Midnapore and Rupnarayan had 45.8 % and 29.1 % of elephant respectively killing due to conflict incidences.

6.3 Discussion

The human elephant conflict occurring through 62 migratory and residential elephant groups in human dominated landscape of south West Bengal is very high and unsustainable. Recurring economic losses for crop depredation, property and loss of human lives is much higher than the amount compensated. People in south West Bengal are still tolerant to the other losses, but the loss of human lives average 13 persons per year is a matter of great intolerance with present small size of elephant population. National comparison on the risk of human life due to conservation of 25,000 elephant

in India is 0.8% per elephant, which in south West Bengal is more than 25 times higher.

The human kill by elephants were mostly in forest and village sites. Occurrence of these incidences was perhaps related to availability of crop and their subsequent harvest and storage to the village sites. From the studies undertaken in southern India (Sukumar, 2003) reported similar pattern of 55 % incidents occurring in the forest and a significant, 45 % took place within human settlement and agriculture land. In the present study record of human killing by elephants for men (60.5 %) was higher than female (39.5 %), this is a similar pattern that has been reported by Sukumar (2003) and Datye and Bhagawat (1995). The men venture more often to the forest and their exclusive guarding cultivated field at night might be a reason for higher occurrence of male mortalities. In present study, human kill in working age group between 21-60 years constituted 75% corroborated with Sukumar (2003) reporting.

Sex biasness in the elephant responsible for human killing was comparable with several studies undertaken on Asian elephants in India and Sri Lanka. In south West Bengal 91.6 % human kills were through loner or male elephants. However, on seasonal context, 26 (72.2%) human kill through resident male elephants occurring in non-paddy season was much higher than 7 (19.4%) that occurred during paddy season. In southern India 82 % man slaughter incidents are attributed unambiguously to male elephants

(Sukumar, 2003). de Silva (1998) also recorded similar kind of observation in case of man slaughter in Sri Lanka through the male elephants.

The contribution of loner or male elephants (90.98%) in house damages in south West Bengal was much higher than that occurred through family unit or herds. In the month of May to August such damages are exclusively occurred through males alone. However, this could not be compared in view of paucity of study literatures on this aspect. Elephants in south West Bengal were also seen killing livestock in the village sites.

The current loss of elephants at a rate of 3 % per annum is high an can off set the positive growth rate of this meta-population due to likely increase of conflicts, in future.

Table 6.1 Crop damage reporting from three Forest Divisions of south West Bengal

Year	Crop damage cases reporting			Total
	Rupnarayan	East Midnapore	Bankura South	
1990-91	4446	3610	2083	10139
1991-92	3116	2388	4166	9670
1992-93	6704	3690	3125	13519
1993-94	3870	4517	10163	18550
1994-95	4022	6852	3343	14217

Table 6.2 Crop compensation paid during various years in four Forest Divisions of south West Bengal

Year	Crop compensation paid				Amount (Rs. Lakhs)
	Rupnarayan	East Midnapore	Bankura South	Bishnopur	
1990-91	6.424	6.610	1.000	-	14.034
1991-92	7.000	5.577	1.925	1.764	16.266
1992-93	8.799	7.441	1.425	2.683	20.348
1993-94	6.684	10.647	4.803	1.935	24.069
1994-95	5.095	16.961	1.605	2.180	25.841

- Data not available

Table 6.3 Seasonal pattern of human kill and injuries by elephants in south West Bengal between 1988-1996

Year	Season						Total
	Sep – Dec		Jan – Apr		May – Aug		
	No.	%	No.	%	No.	%	
Human death							
1988-94	26	25.7	53	52.4	22	21.7	101
1995-96	3	14.2	10	47.6	8	38	21
Human injuries							
1995-96	10	43.4	8	34.7	5	21.7	23

Table 6. 4 Seasonal involvements of elephants in human kill and injury from 1988 to 1996 in south West Bengal (n= 71)

conflict	Kharif (Sep to Dec)			Rabi (Jan to Apr)			May to Aug			Cumulative		
	Herd	loner	Total	Herd	loner	Total	Herd	loner	Total	Herd	loner	Total
Killed	1	7	8	2	13	15	0	13	13	3	33 (91.6%)	36
Injured	6	5	11	5	6	11	0	13	13	11	24 (68.5%)	35
Total	7	12	19	7	19	26	0	26	26	14	57	71

Table 6.5 Seasonal involvements of elephant in human kill and injuries at various sites from 1988 to 1996 in south West Bengal (n= 60)

Site	Kharif (Sep to Dec)				Rabi (Jan to Apr)				May to Aug			
	Killed	Injured	Total	%	Killed	Injured	Total	%	Killed	Injured	Total	%
Forest	4	3	7	36.84	8	6	14	56	1	0	1	6.25
Forest road	0	0	0	0	1	1	2	8	3	0	3	18.75
Cropland	0	2	2	10.52	2	1	3	12	0	0	0	0
Village	3	6	9	47.36	1	4	5	20	8	4	12	75
Village road	1	0	1	5.26	1	0	1	4	0	0	0	0
Total	8	11	19	100	13	12	25	100	12	4	16	100

Table 6.6 Seasonal involvement of elephants in house damage cases in south West Bengal

Year	Kharif (Sep to Dec)			Rabi (Jan to Apr)			May to Aug			Cumulative		
	Herd	loner	Total	Herd	loner	Total	Herd	loner	Total	Herd	loner	Total
1995	2	4	6	6	4	10	0	32	32	8	40	48
1996	3	14	17	0	10	10	0	47	47	3	71	74
Total	5	18	23	6	14	20	0	79	79	11	111	122
%	21.74	78.26	100	30	70	100	0	100	100	9.02	90.98	100

Table 6.7 Property damage by elephants in south West Bengal

Division	Type of property						
	Bicycle	Pump set	Television	Battery	Steep pipe	Diesel engine	Tractor trolley
Rupnarayan	11	0	1	1	2	0	1
East Midnapore	2	1	0	0	0	0	0
Bishnupore	3	0	0	0	0	0	0
Bankura South	0	0	0	0	0	1	0
Total	16	1	1	1	2	1	1

Table 6.8 Elephant deaths due to various reasons in south West Bengal from 1987 to 1996

Elephant	Elephant death					Natural death	Total
	Rouge killing	Pesticide poisoning	Capturing	Accidental*	Total		
Adult male	4	1	1	1	7	3	10
Adult female	-	1	1	-	2	3	5
Sub-adult	-	-	1	1	2	1	3
Juvenile	-	1	-	-	1	-	1
Calf	-	-	-	4	4	1	5
Total	4	3	3	6	16	8	24
%					66.67	33.33	100

* Falling in well and deaths due to injury during chase

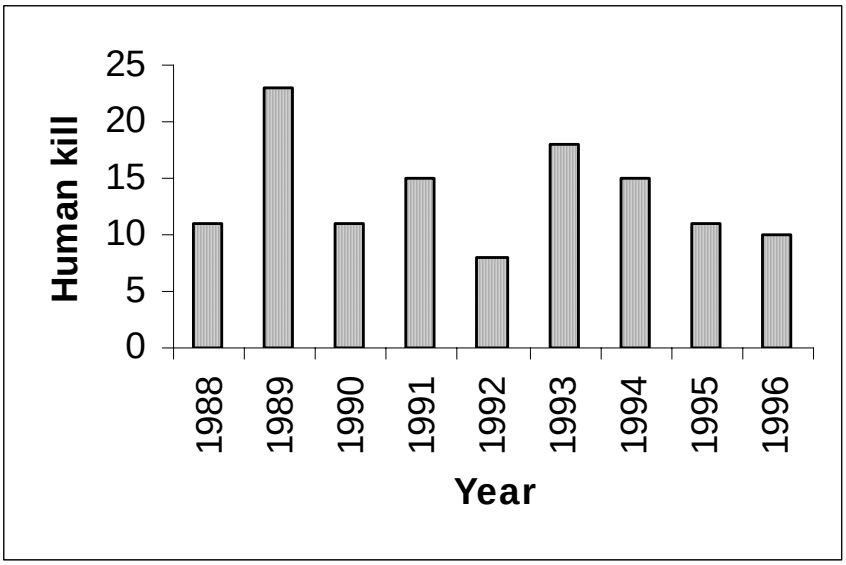

Fig 6.1 Human killing by elephants in various years in south West Bengal

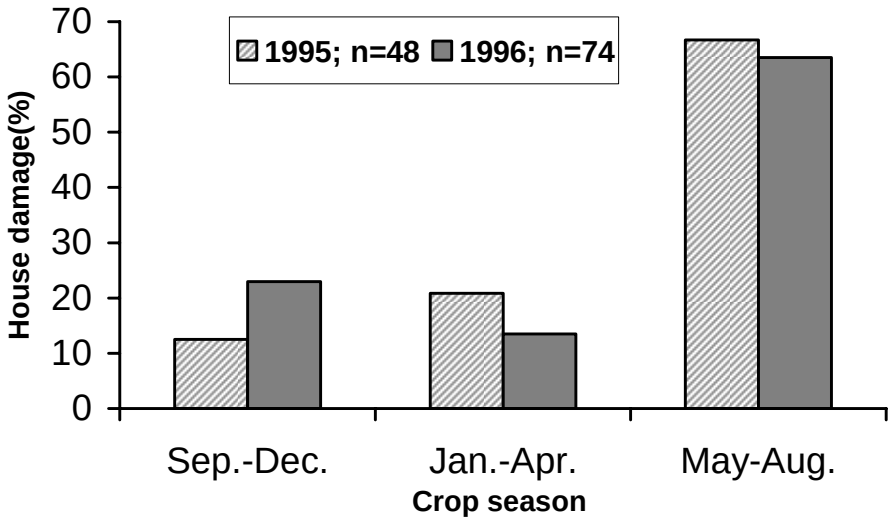

Fig 6.2 Seasonal house damage incidences by elephants in south West Bengal

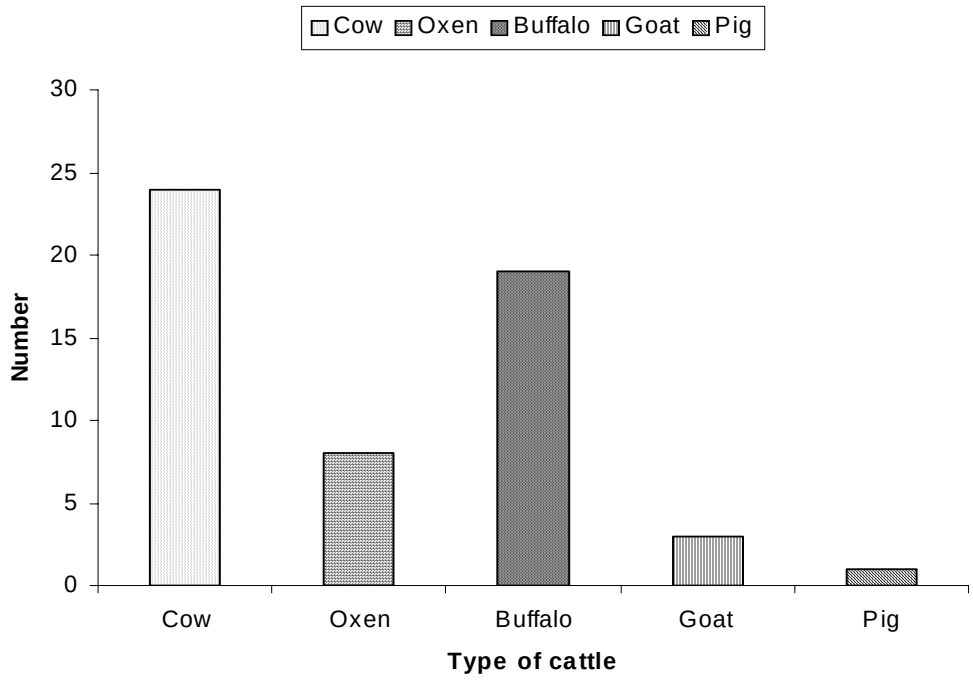

Fig 6.3 Livestock killing by elephants for a period 1991 - 1996 in south West Bengal

CHAPTER 7

Recommendations

In historical perspective, forests on the northern catchments of the Subernarekha river, Jharkhand, to the forests of south West Bengal in east was a single contiguous elephant range. In early 1900's, forest destruction in south West Bengal displaced the elephants towards the west (Chapter 2). The reappearance of elephants in south West Bengal started beginning beyond the year 1986. During this period greater landscape changes with forest recovery, plantations, human settlements, water and agriculture development has created a patchy habitat, less-than-favourable for elephants.

The interaction of elephants in south West Bengal landscape is due to 36 migratory elephants from Dalma Wildlife Sanctuary, Jharkhand and 26 resident elephants localized in four sub groups (Chapter 4). Fundamental considerations for elephant conservation and management in south West Bengal are viability of elephant population, habitat and reduction of human-elephant conflicts.

The natural ranging urge of the elephant tends to take them to south West Bengal, where changes of non forest landuses including agriculture, over four times of forests bring more chances of elephant vulnerability due to increased human interactions (Chapter 5). Low population growth rate due to mortality of individuals and young may impact the population viability through density dependent regulations.

The land parcels with matrices of agriculture and forests favour elephants for crop depredation because of the food and shelter mosaics respectively (Chapter 5). The three Ranges (Garbeta, Hoomgarh and Goaltore) of Rupnarayan Forest Division and one Range of Bishnupore Forest Division (Bankada) were highly impacted with crop depredation due to forests and agriculture mosaics (Chapter 4). A moderate crop depredation resulted in Bhulabeda Range of West Midnapore Forest Division, three Ranges, Lalgarh, Nayabasat and Arabari of East Midnapore Forest Division and Bishnupore Range of Bishnupore Forest Division (Chapter 4).

The recorded human kills average 13 person per year is very high in comparison to the present size of the elephant population. In majority (72%) of the human kills, males of the residential sub groups were involved. House and property damages were also mostly occurred through males of the residential subgroups (Chapter 6).

Options and strategies for Management

The very first management option of this small population is to restrict and insulate their movement in extending to the habitats of south West Bengal, which is now human-dominated and completely altered. A good possible solution would be not allowing the migratory elephants to enter in south West Bengal beyond river Kangsabati. Power fences reinforced with trenches in the bordering area of Jharkhand will deny the access of migratory elephants in to south West Bengal. However, local level people cooperation

and participation for such an activity through regular monitoring of fence line and its maintenance are extremely essential.

Reduction of human elephant conflicts especially the human kills in south West Bengal landscape will be essential to elicit people's support for elephant conservation. Once the strategies for disallowing the migratory herds to come to south West Bengal landscape is implemented, the major remaining problem will be with the male resident groups solely responsible for 72 % human kills. Selective removal of males from the localized subgroups seems to be only alternative for reducing the current human casualties. The present provisions under the Wildlife (Protection) Act 1972 provide capture options for managing such ecological dislocates. However, suitable strategies need to be firmed up to utilize such capture resources through proper training of elephant and integrate this to overall national planning. Translocation of such males can also be thought of for enriching depleted habitat of elephants and should always be done many times away beyond the range of the elephant so that the chances for returning to the original site should be remote.

So long the migratory and residential groups remains in south West Bengal landscape measures for driving, paying *ex-gratia* to raise tolerance of local people and other depredation measures need to be continued and should be strategically taken up to the high and moderately affected ranges as mentioned above. Because of the prevalence of large sink habitat in the landscape of south West Bengal the cost for managing human elephant conflict can be presumed to increase in future.

Summary

The thesis consists of a Prologue illustrating the importance of this study and acknowledgements followed by seven Chapters including recommendations.

Chapter 1 is titled “Human-elephant conflicts- perspective in Asia and Africa: a review” contains an account of human elephant conflicts and its negative interactions both for elephant and humans in Asia and Africa. This chapter provides an illustrative account of sources of human elephant conflicts and different forms of negative interactions resulting damage to agriculture and plantations, damage to property, human kill and injuries, impact on ecosystems, killing of elephants and diseases transmissions. The modes of conflict management through ecological approach, habitat improvement, alternate crop strategies, deterrent, repellents and aversion, physical and pulsating barriers, acoustic deterrents and compensatory measures as adopted in Africa and Asia on both the genus of elephants are discussed and reviewed. The initiatives for long term survival of elephants in all major landscapes through ‘Project Elephant’ have been discussed along with all its major objectives.

Chapter 2 is titled “Historical changes in landscape and conservation of elephants in south West Bengal” tries to find out a historical account of changes in the land-cover and landuse in south West Bengal for human elephant conflicts. The land ownership pattern was one of the major causes of destruction of forests in south Bengal during pre-British and British period. The rapid development, access and transportation facilities brought the pace of intensive felling of forest for timber in early 1900. The short crop rotation of

forests for rapid economic gains further degraded the forests. After acquisition of *zamindari* forests in 1955, human population increased and migration exerted enormous pressure on land resources. This was further aggravated by prevalent tribal hunts, cattle pressure and forest fires. All these factors decimated several important species in the region and forced the mega-herbivores especially elephants to abandon the areas, in which they were once abundant.

With initiation of the participatory forest protection and restoration, the forests in this region responded well in the last three decades. At the same time development of irrigation facilities also have brought a colossal change in the landuse pattern in this region, which has become one of the prime agricultural areas in West Bengal. This response never went un-witnessed by elephants for their re-colonization in this area and has now become a point of conflict between human and elephant interests. Understanding this problem on sound scientific ground is critical for developing strategies which help to conserve elephants and also reduce the conflicts.

Chapter 3 is titled “Study area and methods”. In this chapter hydrology, vegetation, land-cover and landuses were quantified and GIS database was created by using remotely sensed digital data of IRS-1C, LISS- III with other spatial information. Regional linkages of south West Bengal elephant habitat with adjoining forest areas have been mapped through IRS- 1C Wide Field Sensor data. The methodology for immobilization and radio-collaring are provided. Data collection method for radio-collared male elephant and other identified herds and individuals have been discussed. The location data of elephants were transferred in to GIS database and overlaid with classified landuse categories. Point buffering technique was used for analyzing

available land-cover and landuse categories for elephant interactions on the landscape. Information on crop depredation, human kill and injuries, house damage, elephant death, cattle kill and property damage were recorded through investigation and also from records of the Forest Department.

Chapter 4 is titled “Status and ranging pattern of elephants in south West Bengal” investigates occurrence of 62 elephants constituted through 36 migratory and four residential groups of 26 elephants in south West Bengal. The migratory herds were found to enter in south West Bengal landscape annually in the month of August and retreat to Dalma Wildlife Sanctuary, Jharkhand usually at the end of January but often in small group remain till March end. The fidelity of migratory elephant were recorded higher in Midnapore district (86.45%) followed by Bankura (12.26%) and Purulia (1.29%). During the south West Bengal incursion the migratory herd suffers a loss of 42% new born calf mortality which is great concern for their population viability. The fidelity patterns of residential elephants were near equal in two districts, Midnapore (50.81%) and Bankura (49.20%). The overall range of the 62 elephants utilizing south West Bengal landscape was 3368 km^2 in which home range of one radio-collar male quantified was 230 km^2. The radio-collared male was quantified to remain dissociated for 66% time while 33% time it was found associated with family herd.

Chapter 5 is titled “Changing landscape attributes and elephant conflicts for crop depredation” investigated arrangements of spatial elements in the south West Bengal landscape and their role in creating conflicts for crop depredation. The elephant sensitivity to crop depredation in south West Bengal on broad spatial scale was mainly related to the arrangements of

landscape matrices through forest and agriculture. High crop depredation resulted on the landscape where forest and cropland ratio matrices were near equal or in favour of increased cropland (1: 1.2). Low crop depredation intensity resulted when forest and cropland ratios were inadequately represented either through their increase in vast crop area or enlarged forest cover. The paddy was recorded as frequently damaged crop (68%) followed by potato (16%), vegetable (10%), wheat (5%), and maize (1%). The seasonal crop damage pattern recroded higher in September to December (51.8%), followed by January to April (33.6%) and May to August (14.5%). The GIS quantification showed 5.5 % of total cultivated area (1840 Km2) within elephant range is currently affected through elephant depredation, economic loss for which was approximate 3.2 crores.

Chapter 6 is titled “Dimensions of human-elephant conflicts”, quantified human kills 13 person annually and property losses in south West Bengal landscape through a small size of elephant population. The risk of human life in this fragmented and human dominated landscape is 25 times higher than the National risk due to elephant conservation. The majority of the human kills (72%) were with the residential sub groups occurred during the post paddy season. The contribution of lone males for human kills (91.6 %) and house damage (90.98%) were significantly high in all seasons.

Chapter 7 is titled “Recommendations” provides management options and strategies for managing elephants in south West Bengal landscape.

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