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A Microsite Analysis of Resource Use Around Kaziranga National Park, India

Implications for Conservation and Development Planning

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We used a semistructured social survey of 590 households in 37 villages along the southern boundary of Kaziranga National Park and World Heritage Site, Assam, India in late 2000 and early 2001 to assess resource use and demographic and socioeconomic conditions. Kaziranga, recently expanded in size in a region with a large and diverse human population, is globally important for the conservation of several critically endangered species. This was the first in-depth study of its kind in Kaziranga. The results showed highly variable resource use patterns as a function of caste/ethnic group, educational level, socioeconomic and immigration status of households, and location with respect to the park and wildlife corridors. We highlight the importance of and present a basis for electing a microsite planning approach for conservation and development in areas characterized by (1) high ethnic diversity, (2) high human population densities, and (3) endangered, land-dependent large mammal populations that pose economic risks. Individualized development schemes and participatory approaches to management at the local level are critical to achieve conservation and development goals in these cases.

Keywords: *Assam, India; Kaziranga National Park and World Heritage Site; microsite analysis; park–people relations*

Introduction

Most of India's one billion plus citizens are dependent on natural resource extraction to various degrees, and species (e.g. tiger, *Panthera tigris*, elephant, *Elephas maximus*, Indian rhinoceros, *Rhinoceros unicornis*) targeted for protection are land-dependent megavertebrates that can pose economic hardship. With 22 officially recognized languages and all major religious groups, the human population of India

is very diverse. During nineteenth century British rule, the movement of labor from tribe-dominated areas to remote labor-deficient but resource-rich areas, such as Assam, resulted in significant internal migration accompanied by ethnic and cultural enrichment of the receiving areas. Their descendants and the more recent immigrants, both from within India and neighboring countries, often live in close proximity to Assam's parks and forests, and compete with people of different ethno-religious groups of long-term residency, which can further complicate resource management (e.g. Sah & Heinen, 2001; Shrivastava & Heinen, 2005). The social and demographic landscape is thus complex and dynamic, rural lifestyles are often marginal, and resource competition can induce conflict. This is among the most difficult situations for the conservation of protected areas and wildlife populations (Heinen, 1996).

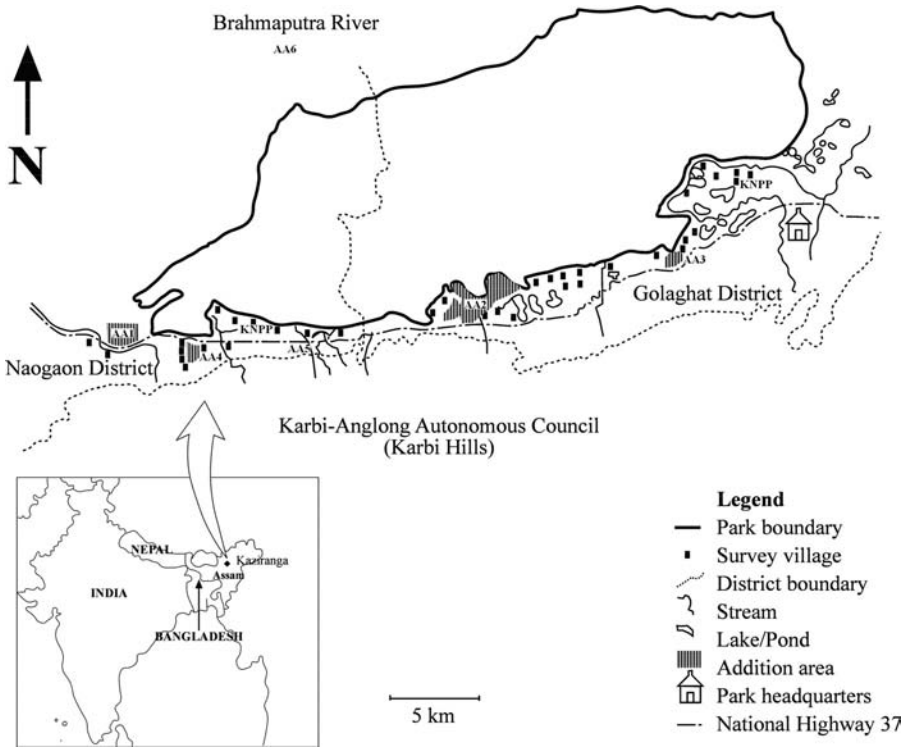
As a thriving and developing democracy, and progressive for conservation and social causes, India has implemented a national ecodevelopment program that strives to improve socioeconomic conditions and conserve resources in locally acceptable ways (Rao, 1998; Rodgers, 1991). In the early 1980s, the Government of India (GOI, 1983) recognized the multiple-use nature of lands bordering protected areas and recommended that they be granted greater development inputs. In 1991 to 1992 the federal Ministry of Environment and Forests launched a national ecodevelopment program, followed in 1996 with World Bank funding for India's Ecodevelopment Project. Project reviews have since revealed major differences in implementation success among parks, inadequate capacity within state governments and the need for site-specific research to achieve better implementation (Woodward, 2002; WWF, 1999).

Research Questions

Given these proposals, the large numbers of human settlements affected, and the lack of baseline natural resource use data for most protected areas, the objective of this research was to determine patterns of resource use and the extent of resource dependence, by developing household-level demographic and resource use profiles of residents living in the southern periphery of Kaziranga National Park (KNP) located in Assam (see Figure 1). At the time of this survey, a number of nearby forested

Authors' Note: We thank all respondents and village elders for agreeing to voluntary interviews and P. K. Malik for graciously facilitating this fieldwork. The Assam State Forest Department granted permission for the study and we especially thank D. M. Singh, U. Bora, P. S. Das, D. D. Boro, and R. Sarma of Kaziranga National Park for assistance and discussion that provided valuable insights into park issues. N. Ahmed and family extended gracious hospitality to the first author during visits to Guwahati, while Debajit, Jyotishmita, and Ronjoy proved able field assistants. We thank the anonymous reviewers for suggestions that improved the manuscript. The National Geographic Society funded the fieldwork, and Florida International University and the WWF Education for Nature fellowship supported the first author.

Figure 1
Location of Kaziranga National Park and the Survey Villages in Assam State



Source: Adapted from GOA (1998).

wildlife-corridors (microsites, see Study Area) were in the process of being formally merged with KNP and were protected by forestry staff, but to a lesser degree compared to KNP. This provided an opportunity to study resource use dynamics in these microsites by selecting peripheral settlements for the survey. We restrict the research to existing patterns of resource use, irrespective of specific property rights and assuming that general trends of legal and illegal resource extraction hold true. We consider timber, fuelwood, and fisheries in relation to household income, recency of origin and ethno-religious diversity as independent and co-associated variables for respondents living near the microsites. These microsites, although small, are important corridors for elephants, rhinoceros, and many other species, especially during seasonal floods that inundate the low-lying KNP (GOA, 1998). The following general questions formed the basis for this study:

Table 1
Ethno-Religious Profile of the Study Area and the Two Districts in Which Kaziranga National Park and the Villages in the Southern Periphery are Located (Figures are in Percent)

	Golaghat	Naogaon	
Ethno-Religious Groups	Households Sampled $n = 372$	Households Sampled $n = 218$	Total Households in the Study Area $n = 590$
Brahmin	2.4	1.8	2.2
Kshatriya	3.2	6.9	4.6
Kayastha	28.2	6	20
Scheduled castes	17.2	9.6	14.4
Tribal	46	40.8	44.1
Muslim	0.8	34.9	13.4
Christian	2.2	0	1.3

- What is the demographic structure and socioeconomic status of people living in the periphery of KNP and microsites?
- What are the patterns of natural resource use and which areas are used?
- What can be predicted about the effects of prohibitions on resource extraction from the microsites on local people?
- Do the demographic and resource use patterns support site-specific sustainable development interventions?

Study Site Description

KNP is situated in Naogaon and Golaghat Districts in central Assam on the south bank of the Brahmaputra River, with the river to the north and the Karbi Hills to the south (Figure 1). Assam shares international borders with Bhutan and Bangladesh. Its population (26.6 million; GOI, 2001a) is more than twice the total of the other six northeastern states and its population density of 340/km^2 is higher than India's average (324 persons/km^2; GOI, 2001b). The inhabitants are a heterogeneous set of three social groups: hill tribes, plains tribes, and nontribal people (Singh, 1987; Table 1). Immigration and resident–immigrant relations have been a matter of sociopolitical concern for some time (Hazarika, 1994).

The climate is subtropical and the rainy season is from May to October. High mean annual rainfall (to 3,750 mm) influences vegetation patterns and floods occur frequently, displacing people and wildlife. Agriculture is the single largest occupation, followed by employment on Assam's ubiquitous commercial tea estates,

first established by the colonial British for tea leaf (*Camellia sinensis*) production. Fishing in the park periphery is a common secondary occupation and sporadic conflicts have occurred over access and control of fisheries (Shrivastava, 2002).

KNP, of global importance for conservation (Rodgers & Panwar, 1988; GOA, 1998), is classified as IUCN category II – National Park (UNEP, 1991) and has received formal protection since 1908; in 2001 to 2002 over 46,000 tourists visited the park (UNESCO, 2002). It now supports the world's largest population of Indian one-horned rhinoceros and is critically important for other fauna, such as tiger, elephant, wild buffalo (*Bubalus arnee*), swamp deer (*Cervus duvaucelli*), Hoolock gibbon (*Hylobates hoolock*), and many reptiles, birds, and fish (GOA, 1998).

A diverse set of habitats are represented in the Brahmaputra River Valley including open marsh, grassland, swamp, and evergreen and semi-evergreen forests. The area is rich botanically, with the earliest plant collections undertaken in 1912 to 1915 (Kanjilal & Bor, 1997) and later contributions by Lahan and Sonowal (1973), Hajra and Jain (1994), and Patar (1977). The belt of thick forests that once existed between the Brahmaputra River and the Karbi Hills has been fragmented by tea estates and settlements. This, together with widespread cultivation and annual flooding that causes soil erosion and habitat loss, were among the reasons behind proposals to protect and add new areas to KNP (GOA, 1998).

Addition Areas: The Microsites in the Periphery of Kaziranga

The status of the Addition Areas (AAs), which we term microsites, in January 2001 when this survey was completed, is described here. Of the six microsites being added to KNP, AA1 through AA4 and one other area (below) were chosen for the study (Figure 1). AA1 is the westernmost tract of land added to KNP and 43.79 km^2 were notified by the GOA in 1997. AA2 is grazed by wild ungulates and livestock and is also important for fishing. Preliminary notification and compensation for 6.47 km^2 were posted in 1985; however, eviction was slow and in 1996 residents lost a legal challenge against it; final notification of AA2 was stalled pending court orders. AA3 (0.69 km^2) lies between the national highway and KNP. It is an elephant migratory corridor linking KNP with a reserve forest and preliminary notification was published in 1985. Compensation had been acquired but had not yet been disbursed to affected households. AA4 (0.89 km^2) was notified in 1989. No compensation had been paid pending a court case. The fifth and sixth AAs were not included for study. AA5 is a small (1.15 km^2) tract of land adjacent to KNP and located near a tea estate. AA6 (367.5 km^2), the largest, consists of a long stretch of the Brahmaputra River forming the park's northern boundary, while this study centered on the southern boundary along wildlife migration corridors. A fifth microsite (Kaziranga National Park Periphery [KNPP]), comprising villages within 2 km of the park's southern periphery but not bordering any AA, was included for comparative purposes.

Methods

Area Stratification and the Questionnaire

The geography of KNP, the location of microsites and project objectives dictated that sampling be concentrated in a 40 km long by 2 km wide belt along the southern periphery. To locate villages, we obtained district revenue maps for the years 1989 to 1990. Villages closest to, and situated within 2 km of KNP and microsites were identified. Selection of the most proximal locations resulted in a final sample of 37 villages: 14 in Naogaon and 23 in Golaghat. These were grouped into five microsites based on their proximity to KNP or the AAs (Figure 1; KNPP, and AA1 through AA4).

Two local field assistants and the first author made up the field team. The male assistant was a high school graduate fluent in Assamese and Hindi. The female assistant, fluent in Assamese, Hindi, and English, had a master's degree. A semistructured questionnaire, adapted from Sah (1997), was pretested and reviewed by KNP authorities; comments were then incorporated.

Reconnaissance and discussions with KNP staff were held in September 2000, and household interviews initiated in October. When possible, a meeting was held with village headmen prior to village surveys. The chronological sequence of villages sampled was random and interviews were completed in January 2001. We randomly sampled 10% of households per village. Interviews lasted 30 to 40 minutes and were voluntary; no monetary incentive was offered. Collecting quantitative information on incomes and farm production in marginal economies can be problematic. Respondents may be reluctant to give information if engaged in illegal activities or depending on how strictly laws are enforced (Leones & Rozelle, 1991; Heinen 1993). They may not know details of household income, may not accurately remember past income, or may hesitate in reporting certain types of income that the community looks down upon. We also recognize that, in general, response psychology may at times be motivated by sociopolitical or economic considerations in areas with high numbers of immigrants and where people's relationships with government and local institutions, such as KNP, may not be independent of respondent's socioeconomic status.

Data Categorization

A literate respondent was defined as having at least one full year of schooling and illiteracy was defined as less than one full year. Farm income was the mean of incomes for 1999 and 2000, if income was shown for both years. Otherwise, income for either year was used, if any. Livestock were converted into standardized units based on the mean sale price for each species during 1999 to 2000. The mean sale price of a cow (Rs. 2204) was considered equal to one unit and other standardized units were: buffalo 2.9; bull 1.5; calf 0.8; pig 0.4; goat 0.25; duck 0.05; and cock/hen

0.03. Farm fisheries income was based on the 6-month fishing season and a mean local market fish sale price of Rs. 40/kg. Only 1% of the respondents reported farm fisheries income, 9% obtained income from farm bamboo, and one household cultivated tea leaf for sale.

Off-farm income included business earnings and handicraft sales, private and government salaries, income from agricultural or nonagricultural labor, and pensions. The 'Labor' category included full-time work, such as daily wage in agriculture, stone quarries, and road maintenance. Tea estate workers comprised those provided with on-site accommodation and others living in nearby villages; only the latter were administered surveys. An immigrant was defined as a respondent not born in the village of current residence. Respondent's year of immigration ranged from 1917 to 2000; origin and ethnic background are discussed in Shrivastava and Heinen (2005). Land in shifting cultivation was not included in land holdings. Under the Assam Land Revenue Act of 1953, two categories of land tenure are recognized: annual-lease allows a period of occupancy of up to one year with no right of land transfer or sublet, while periodic-lease confers the right to occupy the land for up to 30 years with heritable and transferable rights subject to tax payments (Bhattacharjee, 1994).

Timber use estimates were restricted to poles measuring at least six feet in length and all poles recorded were harvested from within the study area. Annual demand was estimated by dividing the number of poles in use in a home with the frequency (per year) at which poles were harvested or purchased. Locations of timber and fuelwood harvest were recorded for households harvesting greater than 50% of their need from: (1) KNP, (2) village commons, (3) Karbi Hills, (4) own farm, and (5) other (e.g. reserved forest, river bank, and road side). Data were analyzed using SPSS 10.0 and Statistica '99 Edition; a significance level of 0.05 was used.

Results

Demography and Socioeconomics of the Study Area

Of the 590 households sampled, 63% were located in Golaghat District and 37% in Naogaon. The districts had significantly different ethno-religious profiles ($\chi^2 = 168.3$, $df = 6$, $p < 0.01$; Table 1). Mean household size was 6.18 compared to 5.92 for rural Assam (GOI, 1991). Almost half of female and one-third of male respondents were illiterate. Of all respondents, only 2.9% were educated beyond 10th grade and illiteracy was highest among tribals. Only a fraction of the population was employed in occupations other than agriculture, yet ethno-religious groups differed based on occupation ($\chi^2 = 94.16$, $df = 20$, $p < 0.01$). Household farm income varied significantly among ethno-religious groups ($F_{6,583} = 7.2$, $p < 0.01$), with Muslims reporting the highest. The post-hoc Tukey HSD test of farm income indicated that Muslims differed

Table 2
The Ethno-Religious Composition of the Five Microsites (Addition Areas) Indicates the Geographically Skewed Distribution of the Groups in the Study Area*

Microsite	Brahmin & Kshatriya	Kayastha	SC[a]	Tribal	Muslim	Christian
KNPP	5.1	23.4	14.4	36.4	20.6	0
Area 1	36.4	12.1	6.1	30.3	15.2	0
Area 2	5.2	21.6	14.9	51.5	0.7	6
Area 3	0	3.7	25.9	70.4	0	0
Area 4	7.1	2.4	11.9	78.6	0	0

*KNPP was closest in composition to the study area (Table 1, column 4), while AA3 and AA4 were the most dissimilar. Figures are in percent. [a] Scheduled castes.

from Kayastha, Scheduled Castes (SC; a category created by an order of the Constitution of India in 1950), and tribals, but not from Brahmin and Kshatriya.

Livestock holdings varied among ethno-religious groups ($F_{5,563} = 10.3, p < 0.01$) with half of all households owning less than five standardized livestock units. Land holdings and household size were positively correlated ($r = 0.22$, $p < 0.01$) and only six households neither owned nor used land for any purpose other than homesteading. Mean land holdings varied significantly among ethno-religious groups ($F_{5,585} = 3.03, p < 0.05$). Land ownership was highest among Brahmin (84.6%) but Kshatriya had the largest land holdings (1.2 ha). Although only 62% of Muslims were landowners, their cropped land area as a percent of total holdings was the highest (80.5%) among all the groups.

Demography and Socioeconomics of Microsites

After combining the upper three Hindu castes (Brahmin, Kshatriya, and Kayastha) and excluding the eight Christian households due to small sample size ($n = 8$), ethno-religious differences were significant among microsites ($\chi^2 = 82.6$, $df = 12$, $p < 0.01$; Table 2); tribals dominated all microsites except AA1. In KNPP, Kayastha and Muslim groups together formed a majority of the population, while AA3 and AA4 were predominantly tribal. Neither literacy nor household income varied significantly among microsites. When tea estate employment and off-farm labor were combined into one category, and business and service were similarly combined, the sites differed in occupation type ($\chi^2 = 66.3$, $df = 12$, $p < 0.01$). AA3 differed from the other sites in having tea estate employment as the major occupation while AA1 had the highest percent of respondents engaged in small business.

Farm incomes were highest in KNPP, AA1 and AA4, while off-farm incomes were highest in microsites where more respondents worked on tea estates or in off-farm labor. Differences among microsites were found in the proportion of lease-holders and landless ($\chi^2 = 24.6$, $df = 4$, $p < 0.01$) and in mean landholdings ($F_{4,585} = 2.87$, $p < 0.05$). AA1 had the lowest percentage of lease-holders while KNPP had the highest. AA1 also had the highest percentage of respondents in the small-landholding category (0.0 to 0.49 ha). Microsites also differed in the frequency of periodic, annual, and landless categories of land tenure ($\chi^2 = 47.8$, $df = 8$, $p < 0.01$); KNPP had the highest percent of periodic-leaseholders and the lowest percent of those occupying land without lease. Livestock holdings also varied among microsites ($F_{4,585} = 4.81$, $p < 0.01$), with AA1 having the highest; livestock and land holdings in the study area were positively correlated ($r = 0.25$, $p = 0.01$).

The frequency of residents and immigrants varied significantly among microsites ($\chi^2 = 20$, $df = 4$, $p < 0.01$). Percentage of immigrants was highest (66.7) in AA1 and lowest in AA4 (26.2). However, 86.3% of all immigrants in AA1 had relocated from within KNP as a result of enforcement of park regulations prohibiting settlement. No microsites were exactly similar with respect to immigrant's place of origin. KNPP had the highest percent of migrants from villages within the same district, while AA2 had the highest percent of migrants from other districts in Assam.

Natural Resource Use

Fishing, prohibited in KNP but difficult to control, occurred largely in wetlands in the Brahmaputra floodplain and the Mora Diffalo River. A majority of respondents (67%) fished and harvests ranged widely from 0.22 to 345 kg/month with a study area mean of 12.7 kg/month. Fish harvests did not vary among microsites, although fishing incidence varied significantly ($\chi^2 = 18.8$, $df = 4$, $p < 0.01$). KNPP accounted for 62% of the total fishing incidence, but AA2 had the highest proportion of fishermen relative to other sites. Fishing incidence did not vary with income but varied with occupation (Table 3); full-time laborers had the highest incidence (79%), followed by agriculturist-laborers (76%), while those engaged in business had the lowest (46%). Incidence varied among ethno-religious groups; Scheduled Castes and tribals reporting the highest. A weak inverse relationship was found between incidence and education ($r = -0.12$, $p < 0.05$) and quantities harvested declined with increasing education but the relationship was not significant. Of the immigrants who arrived before 1971, 58% fished, compared to 72% of those who arrived later.

Mean household fuelwood consumption in the study area was estimated at 12 kg/day, with 99% of all respondents using fuelwood every day. Daily consumption varied among microsites ($F_{4,590} = 2.9$, $p < 0.05$); it was highest in AA4 (14.4 kg) and lowest in KNPP (11.4 kg) and in AA3 (11.2 kg). Consumption and household size

Table 3
Incidence of Fishing as a Function of Demography and Socioeconomics*

Variables	Pearson's Chi-square	*df*	*p*
Ethnicity	15.16	5, 590	0.01
Literacy	9.8	3, 590	<0.05
Occupation	18.04	5, 590	<0.01
Income	1.66	3, 590	ns[a]
Livestock	5.92	2, 569	0.05
Land owned (yes/no)	1.85	1, 590	ns
Land holdings	2.96	3, 590	ns
Land tenure	2.15	3, 584	ns
Resident or immigrant	0.27	1, 590	ns
Place of origin[b]	10.27	3, 256	<0.05
Year of immigration	5.19	1, 256	<0.05

* Demography, livestock and migrant-associated variables proved influential compared to the land holding-related variables. [a] ns, not significant; [b] of immigrants.

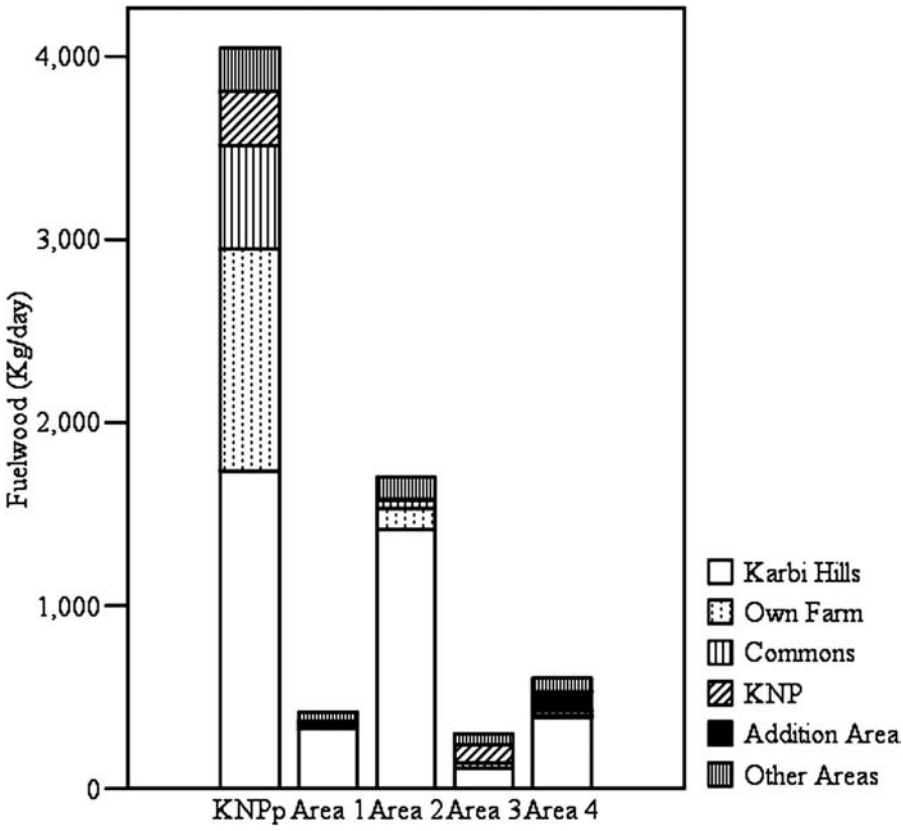
Table 4
Fuelwood Consumption as a Function of Demography and Socioeconomics*

Variables	*F*	*df*	*p*
Ethnicity	1.59	5, 579	ns[a]
Literacy	1.41	3, 581	ns
Occupation	0.73	5, 579	ns
Income	2.71	3, 581	<0.05
Livestock	20.79	2, 566	<0.01
Land owned (yes/no)	4.7	1, 583	<0.05
Land holdings	4.92	3, 581	<0.01
Land tenure	2.68	3, 580	<0.05
Resident or immigrant	2.24	1, 583	ns
Place of origin[b]	0.57	3, 249	ns
Year of immigration	0.18	1, 251	ns

* Unlike fisheries, demography and migration were inconsequential when compared to economically linked parameters, such as income, livestock, and land holdings. [a] ns, not significant; [b] of immigrants.

were positively correlated ($r = 0.31$, $p < 0.01$). Ethnicity, literacy, occupation, and immigration-related variables did not influence fuelwood consumption (Table 4). Consumption was positively correlated with total household income ($r = 0.14$, $p < 0.01$), farm income ($r = 0.18$, $p < 0.01$), livestock holdings ($r = 0.22$, $p < 0.01$), and land holdings ($r = 0.25$, $p < 0.01$). Consumption also varied with land tenure; periodic leaseholders used the most, followed by annual leaseholders, squatters, and

Figure 2
Spatial Distribution of Fuelwood Harvest in Villages Comprising the Five Microsites



Note: Extracted quantities from KNP and the Addition Areas were comparatively low, although of significance to specific households and long-term conservation efforts.

sharecroppers. The Karbi Hills accounted for 56% of fuelwood harvested in the study area and on-farm fuelwood accounted for 19%. Fuelwood harvest is prohibited from KNP, yet 5.6% of the total was from within the park, and is likely an underestimate. Of the respondents collecting fuelwood from KNP, 40.5% were tribal, 38.1% Kayastha, and 21.4% SC. Other groups did not report harvest from KNP.

The spatial harvest of fuelwood also varied among microsites ($\chi^2 = 129.4$, $df = 12$, $p < 0.01$; Figure 2). AA1 and AA2 were similar, with 80% collected from the Karbi Hills. In contrast, in AA3, the Karbi Hills accounted for only 36%. The

Table 5
Incidence of Timber Use as a Function of Demography and Socioeconomics*

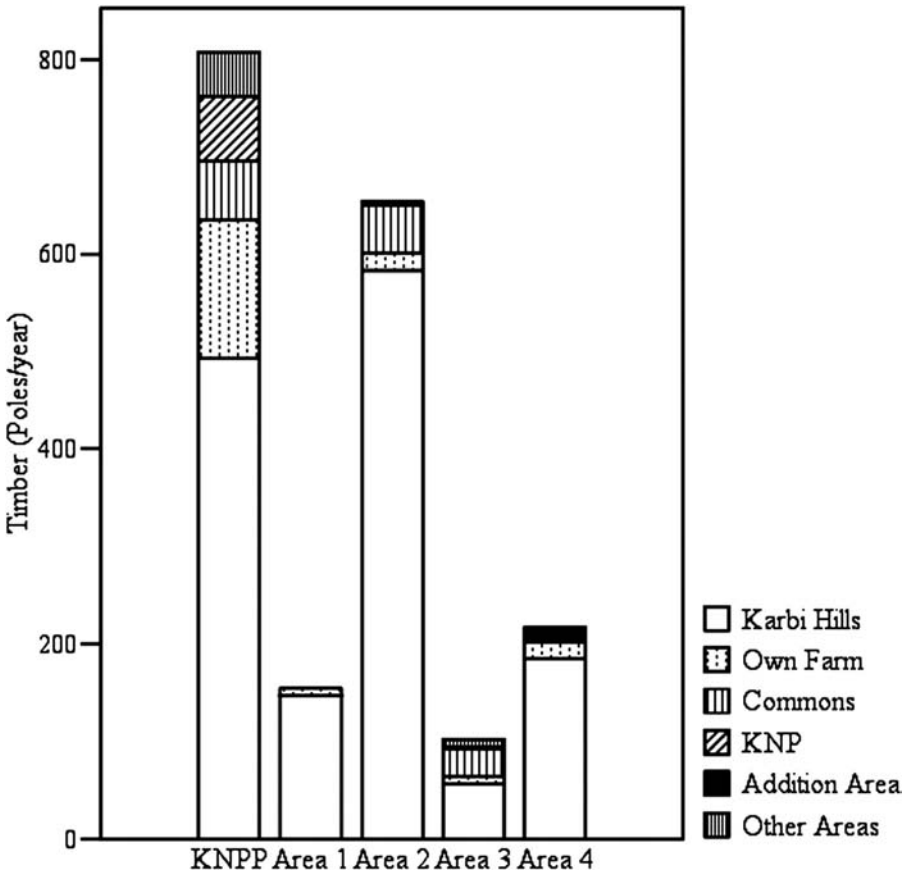
Variable	Pearson's Chi-square	*df*	*p*
Ethnicity	47.04	5, 590	<0.01
Literacy	2.15	3, 590	ns[a]
Occupation	6.01	5, 590	ns
Income	8.25	3, 590	<0.05
Livestock	1.09	2, 569	ns
Land owned (yes/no)	0.2	1, 590	ns
Land holdings	4.24	3, 590	ns
Land tenure	0.75	3, 584	ns
Resident or immigrant	12.09	1, 590	<0.01
Place of origin[b]	19.45	3, 256	<0.01
Year of immigration	0.44	1, 256	ns

* Compared to fisheries and fuelwood, significant differences in timber use were present in a smaller set of variables. Thus, timber plantations can be a starting point for community-level conservation and development programs. [a] ns, not significant; [b] of immigrants.

only households that extracted fuelwood from an Addition Area were those near AA4, with 17% of the demand being met from AA4 forests. KNPP villages reported the greatest use of fuelwood obtained from farms and village commons. Of those using on-farm fuelwood, Kayastha comprised the largest group (37.2%) and Muslims the smallest (6.4%). As education increased, respondents were increasingly likely to use on-farm fuelwood and less likely to use the Karbi Hills.

Timber poles for dwelling construction were used by 68% of respondents, 64% of whom harvested poles every year, while 36% used them at intervals of 2 years or more. Mean annual household use in the study area was 3.3 poles, while among microsites it varied from a low of 2.3 poles in KNPP to a high of 5.2 poles in AA4 ($F_{4,590} = 12.65,\ p < 0.001$). Incidence of timber use varied significantly among microsites ($\chi^2 = 31.7$, $df = 4$, $p < 0.001$), ranging from a low of 59% in KNPP to a high of 85% in AA3. Incidence varied with ethnicity as well, with 81% of tribals and only 47% of Kshatriya using timber; income, resident/immigrant status, and origin were other determinants (Table 5). Microsites differed in the spatial pattern of timber harvest (Figure 3), but not in frequency or quantity used. Timber use also varied among ethno-religious groups ($F_{5,582} = 4.4, p < 0.01$); Kayasthas used the least while tribals used the most. Mean annual timber use per household did not vary with the level of education but varied with occupation type ($F_{5,584} = 2.87,\ p < 0.01$). There was a weak negative correlation between the size of land holdings and timber use ($r = -0.084,\ p < 0.05$) and use did not vary with land tenure type. Residents and immigrants did not differ with respect to timber use, but immigrant's place of origin influenced use ($F_{3,252} = 4.13,\ p < 0.01$); those relocated from within KNP reported

Figure 3
Spatial Distribution of Timber Harvest in Villages Comprising the Five Microsites



Note: Overwhelming dependence on the Karbi Hills was supplemented by household-specific extraction from KNP, and the limited but encouraging indication of on-farm timber use at all five microsites.

the highest incidence while migrants from other districts of Assam had the lowest. Timber use did not vary with time elapsed since immigration. The Karbi Hills were the most important timber source, accounting for 76% of all poles harvested. All ethno-religious groups met the majority of their timber needs from the Karbi Hills; Muslims obtained up to 91%, while Kayastha harvested the lowest (66%). Immigrants were twice as likely as residents to use KNP as a source of timber.

Discussion

Northeastern India represents the quintessential conservation-development challenge and opportunity. In spite of high biological diversity, charismatic wildlife, and a wealth of natural resources, the region is struggling to develop economically. Assam lags behind other parts of India on several development indicators (GOI, 2002) and HIV/AIDS and malaria are of increasing concern (Prakash, Bhattacharya, Mohapatra, & Mahanta, 1997).

The emergence of protected areas as institutions has led to the study of factors such as kinship, environmental history, cultural ecology, as well as the effects of modern forest management, international organizations, non-governmental organizations (NGOs), hunting and herding, on local people (Orlove & Brush, 1996). Many studies (e.g. Chaudhuri, 1982; Baruah, 1994; Singh, 1987) have shed light on social processes in Assam and the influence of immigration on polity and demography, yet few have explored relationships among migration, conservation, land use, and natural resources (e.g. Fearnside, 1997; Shrivastava & Heinen, 2005). In Assam, such studies are constrained by the sociopolitical sensitivity of immigration and responses to questions on migration cannot always be taken at face value.

There is debate on the relative impact of natural population increase and migration on sustainable use of natural resources. For example, competition by nontribals for gum collection is believed to lead the Chenchu tribe in central India to overexploit *Sterculia urens* to the point of endangerment (Devarapalli & Kumar, 1999). Mechanisms within tribal societies that prevent unsustainable resource use (Gadgil, Berkes, & Folke, 1993) are unable to function when users include those with no allegiance to tribal laws. Degradation can, however, be avoided by a change to another subsistence system with higher carrying capacity (Boserup, 1990). The wealth of natural resources in the Brahmaputra Valley has pegged carrying capacity at a high level for northeastern India, allowing productive year-round farming and home gardening, supplemented by fisheries. Given rapid demographic change, a need exists to monitor socio-environmental relationships in the larger KNP landscape.

Microsites: Demography and Socioeconomics

In a study of relationships between Hindu castes and three indicators of social status, that is, land holdings, income, and literacy in Sibsagar and Dibrugarh districts of Assam, caste hierarchy and land holdings were positively but insignificantly correlated, but the correlation was positive and significant with income and literacy (Chauhan, 1980). The conclusion was that caste hierarchy and socioeconomic development were not independent. We looked at more complete ethnoreligious profiles and found that groups differed among each other based more on physical assets such as land and livestock resources. The study area was not homogeneous ethnically and we distinguish two broad geographic units, the first

consisting of KNPP and AA1 where no single ethno-religious group constituted more than half of the population, and the second comprising AAs 2, 3, and 4, all with tribal majorities. Indigenous tribes and tribes originating from central India formed the single largest group in the area, accounting for 44.1% of the population. Differences in ethnic composition of microsites were due to local geography, availability of and access to cultivable land, and the sequence and pattern of settlement. Upper caste Hindus and Muslims settled the floodplain (Chaudhuri, 1982), while tribals tended to settle the Karbi foothills.

Our data show that different sets of variables are responsible for variation among ethno-religious groups on one hand and microsites on the other. For example, literacy varied among groups but not sites. Variables found to be important in distinguishing both ethno-religious groups and microsites were: occupation, livestock, land ownership and holding size, and proportions of residents to immigrants. We identify these variables as the most importance in elucidating patterns for development planning.

The 2-km belt around the park periphery reflects contradictions and inequalities. Residents had larger land holdings mostly under a formal lease agreement. Although recent immigrants had smaller land holdings and tended to settle within 500 m of the park, immigrants in general were also more likely to be sharecroppers, renters, and squatters. Cultivable land had all been appropriated and immigrants had little option but to homestead on small plots near the park. Any land not cultivated or occupied was prone to seasonal flooding or fit only for grazing or grass harvest. The implications are twofold: an increasing number of households in low-lying KNPP are at risk of flood damage, and conflict among wild mammals, livestock, and people will require more intervention.

Fishing, Fuelwood, and Timber

Large wetlands are controlled and leased out by Assam's Fisheries Development Corporation set up in 1977, and there is huge local demand for fish. The management system favors well-off middlemen to the detriment of traditional fishermen (Baruah, Bhagowati, Talukdar, & Saharia, 2000). Only in AA1, the community with the largest livestock holdings, was fishing incidence below 50%. The high incidence of fishing in AA2 was likely due to the presence of a large, well-stocked pond and a nearby town that provided a ready market. Fishing in KNPP as a major income source puts people and the park in confrontation. However, fishing is a viable mechanism for lifting rural incomes (Das & Goswami, 2002) and there is a need and opportunity for sustainable management. The Assam Directorate of Fisheries is mandated to promote farming in artificial ponds and provides extension services. A World Bank credit to Assam includes investment for farm fisheries (World Bank, 2007). Park authorities could incorporate local expertise to address fisheries management as a development option to reduce demand from wild sources.

The Karbi Hills were the most important fuelwood source and daily consumption varied among microsites. Most of those harvesting from the park were residents of KNPP and the remaining demand came from AA3. The implication for conservation is that, despite KNP's protected status and availability from nearby forests, illicit harvest is done mostly by those with easy access and management alternatives (e.g. farm forestry projects) should focus on this population.

For construction, timber, thatch, reed, bamboo, and mud plaster were commonly used. Based on significant variation in the incidence of timber use among microsites, AA1, 2, 3, and 4 are classified as high-use zones and KNPP as a low-use zone. Over half of all timber was harvested from the Karbi Hills, which underlines their buffering functions for the park. We determined that timber use could function as a useful variable for classifying areas based on use gradients. Such classification can help identify areas requiring development inputs such as community timber plantations and on-farm production.

We extrapolated our findings to the 50,000 households within the park's zone of influence (Mishra, 2005), and keeping in mind that household natural resource use varies widely, derived the following extraction estimates: fisheries 635 tons per month; fuelwood 600 tons per day; and timber 165,000 poles per year. The emerging picture is of a productive, resource-rich ecosystem heavily taxed due to high population densities and growth.

Recommendations

The microsites around KNP differed with respect to most variables studied. Local variability in factors such as ethnicity, demography, livestock holdings, land holdings, land tenure, and immigration will be important in developing conservation and development proposals for peripheral villages. KNP is a small but representative remnant of the larger Brahmaputra floodplain, hence forested linkages to the Karbi Hills are crucial for the conservation of many endangered species, and especially AAs 3, 4, and 5. The Karbi Hills were also the single most important source of timber and nontimber forest products. In India, wood, dung, and agricultural residue meet 95% of rural fuel needs and timber demand is likely to increase three to four times over the next 30 years (Kumar, Saxena, Alagh, & Mitra, 2000). Karbi Hill forests function as de facto buffer zones to KNP and, in the absence of alternatives, their degradation due to increases in resource extraction would increase pressure on AAs and the park.

Community involvement in resource conservation and management activities needs to be strengthened. The integrity, contiguity, and diversity of Karbi Hill forests must be maintained and enhanced to promote conservation. To achieve these results, managers should focus on areas nearest KNP to address timber, fuelwood, fishery, and other NTFP needs. High fishing incidence is likely to continue as a source of

park–people conflicts and pond fisheries development as a community microenterprise needs to be explored. We suggest a microsite planning approach to ecodevelopment given significant intersite demographic, socioeconomic, and resource use variability. Such an approach incorporating economic incentives into overall managerial goals and objectives (e.g. Heinen, 1996) is necessary due to: (1) differences in resource use patterns throughout the area, (2) extractive patterns among sites resulting from population growth, (3) great ethnic and religious diversity, and (4) growing wildlife populations.

Following a resolution on Joint Forest Management (JFM) in 1990 (GOI, 2005), the government of Assam adopted guidelines for the constitution of Forest Protection and Regeneration Committees with the involvement of NGOs and village panchayats. Although the efficacy of JFM in the field (Jagannadha, Janaki, Kerr, & Mercer, 2005) and its ability to empower (Bhattacharya & Basnyat, 2003) remain uneven, the framework is an example of a strategy for constituting user group committees for development planning and resource management. However, ethnic diversity, high population densities, and different needs and uses of natural resources in local areas require much greater efforts in order to achieve conservation and development goals.

Conclusions

Our goal was to answer four general research questions. The first two involved determining (1) the demography and socioeconomic status, and (2) the resource use patterns, of local residents around KNP. The third was to determine what could be predicted about the effect of prohibitions on resource extraction from AAs and the park on local people. The fourth was overarching: do demographic and resource use patterns support site-specific sustainable development interventions? The data show enormous complexity in demographic makeup and socioeconomic status of people in the area based on factors such as caste, ethnic group, religious background, land tenure, and immigration status.

Resource use patterns varied both by demographic and socioeconomic factors, as well as by geographic locality of households, with different patterns of abundance or scarcity (and different levels of illegal extraction) in different sites. With this complexity comes the general conclusion that prohibitions will affect different people very differently and thus highly site-specific development interventions are warranted throughout the region. These include but are not restricted to farm fisheries development especially for those living within KNPP and near microsites without access to water bodies outside of KNP, and farm forestry programs especially for those living in KNPP who rely on illegal extraction from the park. The ecological integrity of forest corridors must be maintained for the conservation of large mammals, but this will require a great deal of specific intervention to remove pressures

from the park and AAs. This is especially the case in areas such as KNP due to the heterogeneity and growth in human populations living nearby, and human dependence on extraction of natural resources.

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